SEAM Programme

Cleaner Production for Secondary Aluminum Sector for Utensils in Egypt

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency

Entec UK Ltd., ERM
UK Department for International Development

Report on the Secondary Aluminium Sector for Utensils in Egypt

SEAM PROGRAMME
Implemented by:
MINISTRY OF STATE FOR ENVIRONMENTAL AFFAIRS
EGYPTIAN ENVIRONMENTAL AFFAIRS AGENCY
Entec UK Ltd
ERM
UK Department for International Development

GUIDANCE MANUAL PRODUCED BY THE SEAM PROGRAMME

WITH CONTRIBUTIONS FROM:
Mr. Philip Jago (SEAM Programme Manager)
Dr. Linda Timothy (SEAM consultant)
Eng. Shahenaz Fouad (SEAM consultant)
Prof. Dr. Sayed Khater (SEAM consultant)
Dr. Prasad Modak (SEAM consultant)
Eng. Rahul Datar (SEAM consultant)
Ms. Mahazareen Dastur (SEAM consultant)
Dr. Eng. Aly Mostafa El Booz (Aluminium Cooperative in Meit Ghamr)
Dr. Salah El Haggar (SEAM consultant)

SEPTEMBER 2004

Egyptian Environmental Affairs Agency (EEAA)
Support for Environmental Assessment and Management (SEAM)
30 Misr Helwan Agriculture Rd, Maadi
Tel: 20(02) 5259648 Fax: 20(02) 5246162
http://www.seamegypt.org

Table of Contents

List of Boxes

List of Figures

List of Tables

Chapter

1

1.0 Background

Chapter 1: Background

1.1 SEAM Programme

Support for Environmental Assessment and Management (SEAM) is a major environmental programme implemented by the Egyptian Environmental Affairs Agency (EEAA), Entec UK Ltd and ERM with support from the UK Department for International Development (DfID).

The SEAM Programme is made up of four components focussing on environmental management issues. These include developing Governorate Environmental Action Plans (GEAPs) in four Governorates in Egypt (Sohag, Dakahleya, Qena and Damietta), delivering community environmental projects (CEPs) that benefit the poor, improving solid waste management (SWM), and implementing cleaner production (CP) projects in industry to enhance competitiveness and reduce pollution. SEAM I (1994-1999) developed GEAPs for Sohag and Dakahleya, built environmental capacity and demonstrated the tangible benefits of improved environmental management. SEAM II (2000-2004) will build on SEAM I successes by improving environmental planning and services for the poor and strengthening decentralized environmental management.

1.2 The Cleaner Production Component

Cleaner Production was one of the core activities of SEAM I. The main goal of the Cleaner Production component was to show that significant financial savings and environmental improvements can be made by relatively low-cost and straight-forward interventions. These might include such things as good housekeeping, waste minimization, process modification and technology changes. This approach was recognized as having two benefits – valuable materials can be recovered and reused, rather than being wasted, and industries move towards environmental (legislative) compliance.

<u>1994-99</u> - Cleaner Production initiatives were successfully undertaken in medium to large scale Egyptian industrial units in the textiles, food processing and edible oil and soap sectors. 32 factories were audited and 21 Demonstration Projects implemented at a cost of LE 16 million, with an average pay back of 6 months. Examples of interventions included water and energy conservation, ecolabelling for textile exports, oil and fats recovery, Hazard Analysis Critical Control Point (HACCP), and recovery of cheese whey, etc.

<u>2000-2005</u> – The programme focused on micro, small and medium size enterprises (MSMEs) in Egypt. It focused on 4-5 main priority sectors in five governorates which are the food, metal foundries, textiles, furniture and other miscellaneous small industries. About 100 audits and 30 demonstration projects have been undertaken in MSME priority sectors including food processing, metal foundries, furniture, textiles, and other miscellaneous projects. The aim here is to enhance efficiency, reduce pollution, yield financial savings and improve the environment for surrounding communities.

Within the foundries sector, three demonstration projects have been implemented in as follows:

- Case study: Energy Conservation in the Annealing Furnaces at Aluminium Foundries Pays. Case of Tiba Company for Aluminium, Meit Ghamr, Egypt.
- *Case study:* Closed Furnace to Improve Smelting of Aluminium Scrap Metal and Ingots. Case of Technical Foundry for Melting and Rolling Aluminium, Meit Ghamr, Egypt.
- *Case study:* Improving the Aluminium Finishing Processes and Reducing Particulate matter. Tiba Company for Aluminium, Meit Ghamr, Egypt. Mattar Company for Aluminium, Meit Ghamr, Egypt.

1.3 About This Report

The Foundry Sector Report collates baseline information on the secondary aluminium sector for utensils industry in Egypt, including statistical data, current manufacturing practices, technology inputs, environmental issues, regulatory, institutional and policy frameworks. The focus throughout is to enhance and improve the quality of production in MSMEs in order that they may perform a vital role in supporting the economic success of the dairy industry in Egypt through both domestic and overseas sales.

1.4 The Structure of the Sector Report

The Foundry Report is divided into 5 sections a brief summary of each section is provided below.

- Section 1.0 provides background information.
- Section 2.0 presents a profile of the secondary aluminium sector. It includes an overview of secondary aluminium production activities, the product range, the secondary aluminium cycle at the MSME scale, policy, regulatory and institutional framework, and concludes with a discussion as to why MSMEs are critical to the secondary aluminium sector.
- Section 3.0 provides information on secondary aluminium processing procedures and waste generation. Process descriptions are presented for typical MSME-scale secondary aluminium products.
- Section 4.0 covers environmental standards, regulations relevant to the dairy sector, institutional framework for environmental management and their application to MSMEs.
- Section 5.0 introduces the concept of Cleaner Production, why MSMEs should adopt Cleaner Production, barriers faced and issues for sustaining Cleaner Production in MSMEs.
- Section 6.0 analyses Cleaner Production opportunities using selected case studies from around the world, provides a short overview of the status of MSMEs in Egypt with respect to each stage of the secondary aluminium cycle, and summarises Cleaner Production interventions implemented by SEAM.

The Report is accompanied by a number of Annexes, which include statistical information and recommended reading material.

Some of the material researched for the Report was obtained from the World Wide Web; it should be noted that such information can change, given the dynamic nature of the Internet.

Chapter

2

2.0 A Profile of the Secondary Aluminium Sector for Utensils in Egypt

Chapter 2: Profile of the Secondary Aluminium Sector for Utensils in Egypt

2.1 Introduction

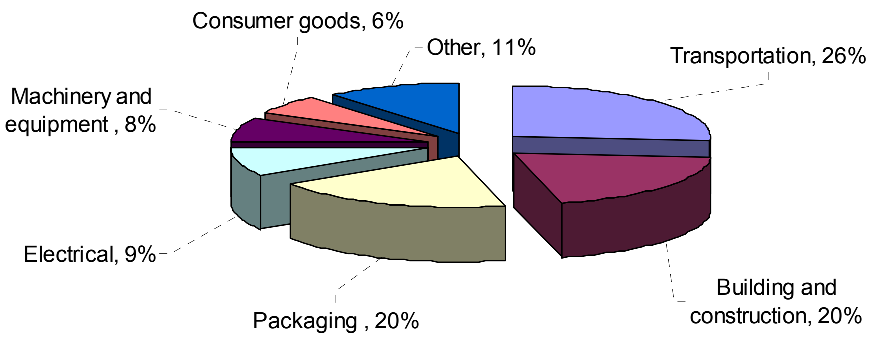
2.1.1 About Aluminium

Aluminium is the most abundant metallic element and the third most abundant of all elements in the earth's crust, making up 8% of the crust by weight. Bauxite is the main source of aluminium and it does not occur by itself in nature as a metal. Guinea and Australia have about one-half of the world's reserves. Other countries with major reserves include Brazil, Jamaica, and India. Worldwide sources of bauxite are large enough to supply the demand for aluminium for some time to come[1].

Aluminium is ductile - it can be drawn into wires or pressed into sheets or foil. The lightness, strength, and corrosion resistance of aluminium are important considerations in its application. It has numerous applications in the home and industry and is a familiar metal to nearly everyone. Metallic aluminium is used in transportation, packaging such as beverage cans, building construction, electrical applications, and other products. Aluminium is primarily used to produce pistons, engine and body parts for cars, beverage cans, doors, siding and aluminium foil. It may also be used as sheet metal, aluminium plate and foil, rods, bars and wire, aircraft components, windows and door frames.

Combining aluminium with other metals to produce alloys enhances its characteristics and increases its versatility. The most common metals used in combination with aluminium are copper, magnesium, manganese, silicon and zinc. Aluminium's tensile strength, hardness, corrosion resistance, and heat treatment properties improve when alloyed with one or more of these metals. Some copper-aluminium alloys, for example, can exceed the tensile strength of mild steel by as much as 50%. In both its pure and alloyed forms, aluminium is used to make a variety of products for the consumer and capital goods markets. Figure 1 shows the various uses for aluminium.

Figure 1: Uses of Aluminium



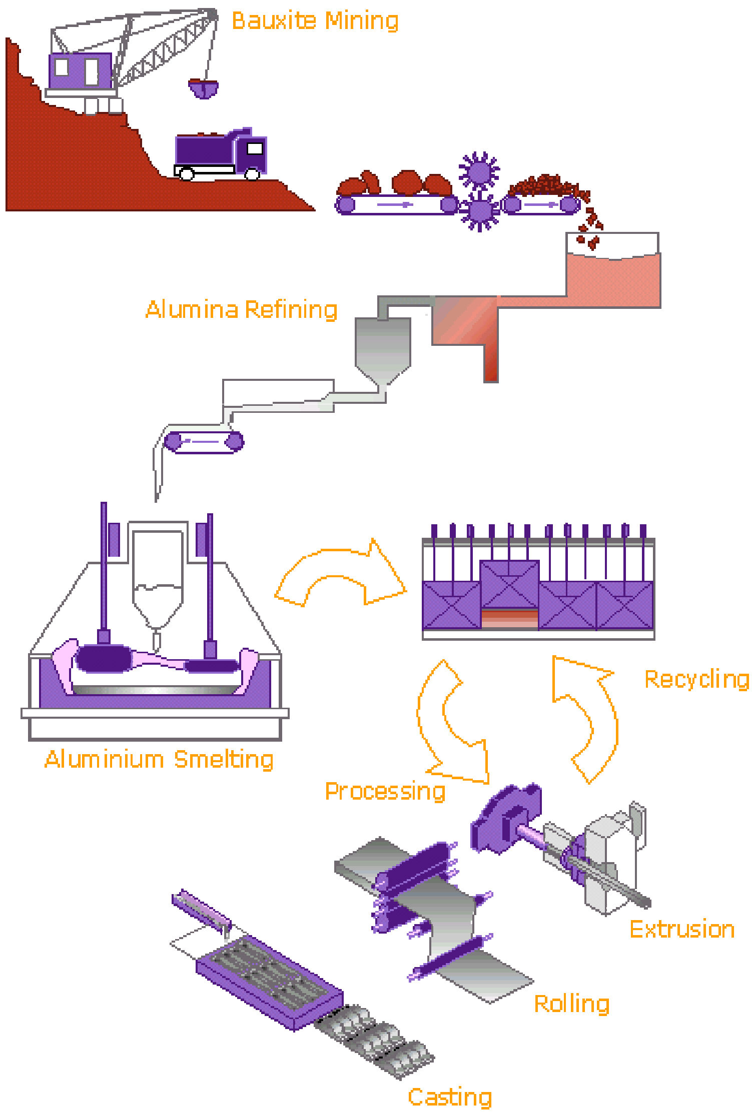
As requirements for lighter vehicles increase, it is likely that demand for secondary aluminium in the automotive industry will also increase significantly. Geographically,

[1] Mineral Information Institute: Aluminium and Bauxite. http://www.mii.org/Minerals/photoal.html

North America is the largest consuming region accounting for 33% of total Western world consumption, followed by Europe at 25% and Asia at 26%[2].

Primary aluminium production facilities are located all over the world, often in areas where there are abundant supplies of inexpensive energy, such as hydro-electric power. The life cycle of processing aluminium is shown in Figure 2.

Figure 2: The Life Cycle of Aluminium



It can be seen that at the end of one journey (i.e. as primary produced aluminium), aluminium can be recycled eventually into secondary produced aluminium – i.e. aluminium which is recycled. The following section in this chapter will discuss the secondary aluminium industry.

[2] Canadian Minerals Yearbook, 1997. Available at: http://www.nrcan.gc.ca/mms/cmy/content/1997/09.pdf

2.1.2 The Secondary Aluminium Industry

As mentioned earlier, aluminium can be produced from bauxite ore. This form of aluminium is also known as "primary aluminium". Another source for the production of the metal is aluminium scrap. The latter industry is known as the "secondary aluminium" industry. Refinement of aluminium ore is sufficiently expensive that the secondary production industry commands much of the market. For instance, about 40% of aluminium in the United States is recovered for secondary refining[3]. Box 1 provides arguments as to why recycled aluminium plays such an important role today.

Box 1: Reasons Why It Makes Sense to Recycle Aluminium
Aluminium has been recycled since the days it was first commercially produced and today recycled aluminium accounts for one-third of global aluminium consumption world-wide. The growth of the market for recycled aluminium is due in large measure to economics. Today, it is cheaper, faster and more energy-efficient to recycle aluminium than ever before. For instance, only about 5-8% of the energy required to produce primary aluminium ingot is needed to produce recycled aluminium ingot. This roughly translates into an annual energy saving of 13 million gigajoules, the equivalent of 2.1 million barrels of oil[4]. In addition, to achieve a given output of ingot, recycled aluminium requires only about 10% of the capital equipment compared with primary aluminium[5]. Thus, recycling is an essential part of the aluminium industry and makes sense economically as well as environmentally. Further, at the end of their useful life, all aluminium products retain some worth which guarantees that it is possible to create value by recycling them into new products[6].

Sources for recycled aluminium include automobiles, windows and doors, appliances and other products. For the United States, however, it is the recycling of aluminium cans that seems to have the highest profile[7]. In 1996, the largest secondary aluminium producers were the United States at 3.21 million MT, Japan at 1.19 million MT, and Germany at 0.42 million MT[8].

The future of the secondary aluminium industry is bright. In general, in the global scenario, as the demand for aluminium continues to grow, secondary aluminium appears to be fulfilling more and more of the total demand (see Figure 3).

---

[3] Source - Aluminium smelting and refining. Available at: http://www.p2pays.org/ref/01/text/00778/chapter4.htm

[4] Energy Efficient Recycling of Aluminium. Available at: http://www.nrcan.gc.ca/es/etb/cetc/cetc01/htmldocs/factsheet_energy-efficient_recycling_of_aluminium_e.html

[5] Aluminium -- a great economic story by The Aluminium Association Inc. http://www.aluminium.org/Template.cfm?Section=In-depth_information&NavMenuID=758

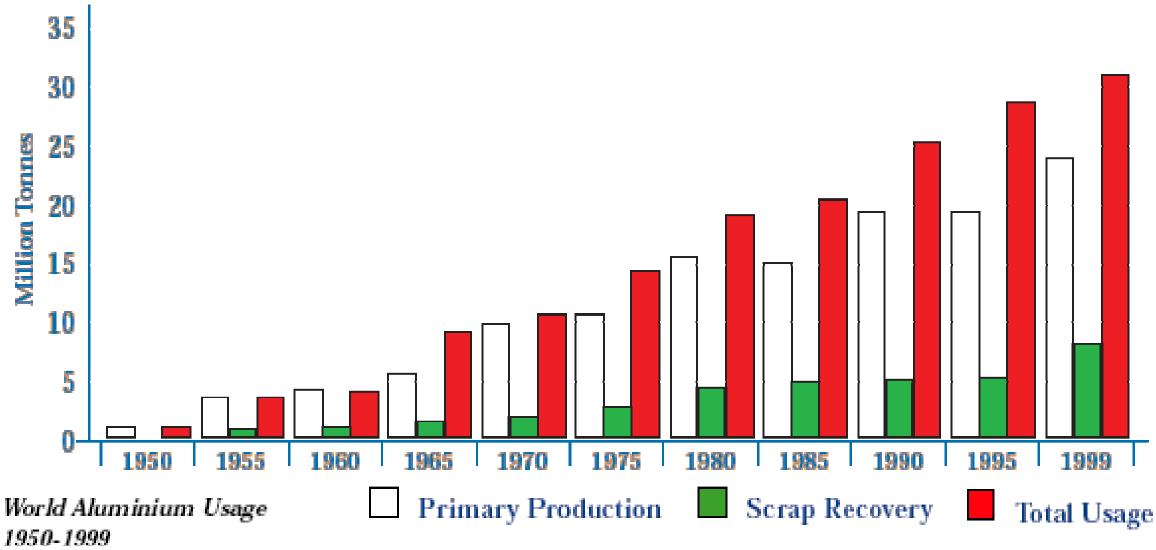
[6] Source – Recycled Aluminium by the European Aluminium Association.

http://www.aluminium.org/material/recycled.asp

[7] Source – "Aluminium -- A Great Economic Story" by The Aluminium Association Inc. http://www.aluminium.org/Template.cfm?Section=In-depth_information&NavMenuID=758

[8] Canadian Minerals Yearbook, 1997. Available at: http://www.nrcan.gc.ca/mms/cmy/content/1997/09.pdf

Figure 3: World Aluminium Usage Trends (1950s – 1990s)



For instance, for the United States in 1972, secondary aluminium accounted for 19% of the nation's total aluminium supply. However, over the next 27 years, production of recycled aluminium rose 242% to 3.4 million MT. In comparison, in those same 27 years, the country's total aluminium metal supply increased just by 91%[9]. Along similar lines, in Europe, 32% of the aluminium demand is now satisfied by recycled material[10]. Such increases in secondary production have been attributed largely to continuing improvements in scrap collection systems, increased recycling rates due to improved technologies, less energy intensive requirements for the sector and also the efforts of local governments to promote recycling.

2.2 An Overview of the Aluminium Industry in Egypt[11]

2.2.1 A Brief History of the Aluminium Industry in Egypt

Prior to the 23rd of July revolution (1952), copper was the main raw material used in the manufacture of kitchen utensils, not just in Egypt, but also in other Arab countries. The aluminium industry gained a foothold in Egypt after the revolution. The industry's activities were concentrated amongst three main companies, namely:

---

[9] Source – "Aluminium -- A Great Economic Story" by The Aluminium Association Inc. http://www.aluminium.org/Template.cfm?Section=In-depth_information&NavMenuID=758

[10] Source – "Recycled Aluminium" by the European Aluminium Association. http://www.aluminium.org/material/recycled.asp

[11] Source - Dr. Aly El Booz (Aluminium Cooperative in Meit Ghamr)

1. The Public Company for Metals in Cairo - This company specialized in producing copper and aluminium discs to be used in manufacturing kitchen utensils in addition to other products.
2. The Egyptian Copper Company in Alexandria (at Hagar El Nawatia) - This company specialized in manufacturing different metals, especially aluminium discs and red and yellow copper discs in addition to reinforced steel and copper pipes.
3. Helwan Company for Military Industries (Factory 36) - This company specialized in producing non-ferrous metals including aluminium sheets with a graduated thickness of 2 mm to 3 mm, in addition to aluminium discs.

After the 1967 war between Egypt and Israel, the resulting economic environment and shortage of copper as a raw material, the Egyptian Government had to seek an alternative metal to copper for the production of kitchen utensils. The Egyptian Ministry of Industry realized that aluminium could be used as an alternative for copper. Thereafter, the Chamber of Egyptian Industries in cooperation with the Federation of Egyptian Industries and the Industrial Monitoring Authority allocated monthly shares of aluminium discs to be distributed amongst manufacturers, depending on the scale of their production. This relatively low cost of aluminium (as compared to copper) helped in popularising the use of aluminium as a substitute for copper for kitchen utensils industry. Box 2 provides some interesting information as to the use of aluminium as cookware.

Box 2: Some Interesting Facts about Aluminium as Cookware[12]
The use of aluminium in cookware reportedly began when Napoleon III served the King of Siam at a state banquet with plates and cutlery made of aluminium, then a rare and precious metal. Less important guests had to eat from plates of pure gold. Aluminium is light and strong, so even a large sturdy pan is easy to handle. It imparts no taste or odour to food, is durable and, best of all, has excellent cooking characteristics. With proper care, aluminium cookware can last a lifetime. More than *half* the cookware sold each year is made of aluminium. Ever since aluminium became readily available, the public, professional chefs and commercial food processors have welcomed its advantages for food preparation. It loses only about 7% of the heat it receives, leaving 93% of the heat to cook food. This means that aluminium cookware transfers heat very efficiently and evenly to the food inside, rather than to the air outside.

[12] Source – The World Aluminium Institute. Available at: http://www.world-aluminium.org/applications/packaging/cooking.html

The subsidized aluminium shares were distributed by the Government to three areas in Egypt, which are:

1. Greater Cairo including Giza and Qalubia Governorates – The aluminium shares allocated here fulfilled the production scale of the factories in these areas. However, the number in this case was very small.
2. Alexandria area including El Behera and Rashid Governorates – This area was also allocated a share of subsidized aluminium to encourage the use of aluminium in the manufacturing kitchen utensils.
3. Meit Ghamr area including the rest of Governorates from Upper Egypt to Delta – These areas were allocated a share of subsidized aluminium discs used in manufacturing what is known as local 'matt' aluminium[13]. This industry here performed very well, to the extent that the entire allocated aluminium shares was utilized during the short span of a week. The manufacturers in this area requested extra shares of aluminium and the number of factories grew. Gradually, the production of aluminium kitchen utensils from 'matt' aluminium in this area represented 85% of Egypt's total production of aluminium utensils.

Subsequently, a new feeding industry emerged which is rolling and manufacturing semi-final products, which are then used in he manufacturing and forming of kitchen utensils. The number of rolling factories in Meit Ghamr reached 5 factories whose price competed with the three public sector factories specializing in the production of aluminium discs. As of 1980, 70 factories in Meit Ghamr were dedicated to metal forming (towards manufacturing kitchen utensils) alone, while 8 rolling factories converting aluminium sheets to discs as semi-final products.

In 1967, an association known as the Aluminium Cooperative was established in Meit Ghamr, with the objectives to distribute aluminium shares as a quota amongst the members of the association as well as render basic services such as the procurement of a license for new factories. The Aluminium Cooperative used to manufacture utensils, which were tax-free, but it was the main competitor to its own members. The association was subsequently was shut down in 1991, since members were no longer interested to support the association. In 1998, due to the new international economic system and after Egypt joined the GATT agreement, MSMEs owners identified the need for the Association Cooperative's support and the importance of forming industrial agglomerates to strengthen their companies. The association's role changed and it stopped manufacturing kitchen utensils, and started providing different services like solving taxation problems, training technicians, etc.

2.2.2 The Emergence of the Secondary Aluminium Sector in Egypt

By 1984, aluminium scrap generated from houses and aluminium factories started increasing due to the widespread use of aluminium as kitchen utensils. This scrap had accumulated over 17 years since the introduction of aluminium kitchen utensils since 1967. However, the factory owners producing aluminium utensils lacked the storage space required for collecting and storing scrap aluminium. Thus, the scrap was used on a very

[13] i.e. with a dull finish or unpolished.

small scale towards melting, casting and production of "non-traditional" aluminium products[14].

Ultimately, the availability of an abundant and cheaper scrap aluminium material brought about the creation of foundries dedicated towards melting the scrap for reuse in future aluminium products. The foundries started re-melting this scrap together with electric cable waste and the aluminium trimmings generated from factories in new industrial zones such as 6th October and 10th Ramadan cities. The foundries gradually increased in number, such that by the year 2000, there were 25 foundries dedicated towards re-melting aluminium scrap, purifying it and producing semi-final rolled aluminium products.

The availability of the recycled aluminium also helped in increasing the number of factories manufacturing kitchen utensils, to an estimated 120 MSMEs and more than 300 showrooms. The labour capacity in these foundries and factories swelled to about 4,000 technical workers and 1,000 administrative employees - a sizeable number indeed at the MSME scale.

2.2.3 *The Scenario of the Secondary Aluminium Sector in Egypt Today*

As of today, Egyptalum, also known as Misr Aluminium Complex is the nation's primary aluminium producer. It currently operates an aluminium smelter at Nag Hammadi. Production output in 1999 and 2000 reportedly amounted to 193,000 and 195,000 MT per year. The company plans to expand its production capacity to about 300,000 MT per year by 2008[15]. According to the definition of industry scale/size[16] adopted by the Egyptian Ministry of Foreign Trade, this company is regarded as a large scale industry.

The recycling of aluminium scrap provides the foundation to a highly lucrative industry. Low-priced products manufactured from the scrap have high economic and environmental value, and also generate job opportunities in foundries. Having recognized this fact, the Egyptian government is keen to promote the secondary aluminium industry, instead of exporting aluminium scrap outside Egypt, as is done by many other countries. In fact, Egypt not only recycles aluminium scrap generated locally, but also imports it from other Arab countries and the Middle East. This causes the prices of the finished secondary aluminium products to be competitive with those from other countries such as the USA, Libya, Yemen and Algeria. For example, U.S. companies wishing to sell aluminium utensils may find it difficult due to the local competitors - a 3 mm thick locally produced aluminium cooking pot is sold for as low as USD 2.50[17].

[14] i.e. products which were not kitchen utensils.
[15] "The Mineral Industry Of Egypt" by Philip M. Mobbs. Available at: minerals.usgs.gov/minerals/pubs/country/2001/egmyb01.pdf
[16] The Egyptian Ministry of Foreign Trade defines micro-enterprises as those operating with between 1 to 4 workers, small enterprises as those operating with between 5 to 14 workers and medium enterprises as those operating with between 15 to 49 workers. Source: www.sme.gov.eg/sme_statistical_information.htm
[17] Hotels and Restaurant Utensils by Heba Abdel Aziz. Available at: http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr-73205e.html

In general, the aluminium recycling industry is divided amongst public sector factories and private foundries. The public sector factories are represented by the Public Company for Metals in Cairo and Tibbin, the Egyptian Company for Copper in Alexandria, and the Helwan Military Company for non-metal industries. The public sector factories produce two types of aluminium discs – the first type of a high purity (99.7%) and the second type of a lower quality (95%). The latter is produced from the trimmings left over after the production of high quality discs and the aluminium scrap collected from local and external market.

Conversely, as mentioned earlier, several medium-small scale secondary aluminium producers/foundries also exist in Egypt. They are typically denoted as MSMEs (i.e. micro-, small-, medium scale enterprises). These units account for about 75% of the aluminium industry in Egypt. The various activities undertaken at the secondary aluminium foundries include smelting, annealing and forming. These are privately owned enterprises engaging in secondary aluminium production at a much smaller scale than the public sector factories, and service the Egyptian market mainly.

Aluminium is recycled in Egypt to the extent of about 50-60% in the majority of the Governorates, i.e. those serviced by the public sector factories. However, in the private foundries spread in the two main areas of Cairo and Meit Ghamr, this number reaches a very high proportion - about 95 to 100%.

However, at present, the secondary aluminium industry is sensitive to the economic slowdown and the competition from abroad, especially from China which exports particularly cheap stainless steel. Due to this, several workshops are producing below their capacity.

It is notable that Egypt is one of the few Arab countries involved in the recycling of scrap aluminium. Today, the secondary aluminium industry in Egypt has a strong foothold indeed, more so amongst the smaller privately-owned MSME-scale factories/foundries. However, the industry is experiencing hard times due to competition from abroad which is threatening the survival of the MSMEs. Overall, sector reforms must try to identify what factors should be addressed on a priority basis to alleviate this situation.

2.2.4 Geographical Distribution and Size Distribution of the Secondary Aluminium Industry in Egypt

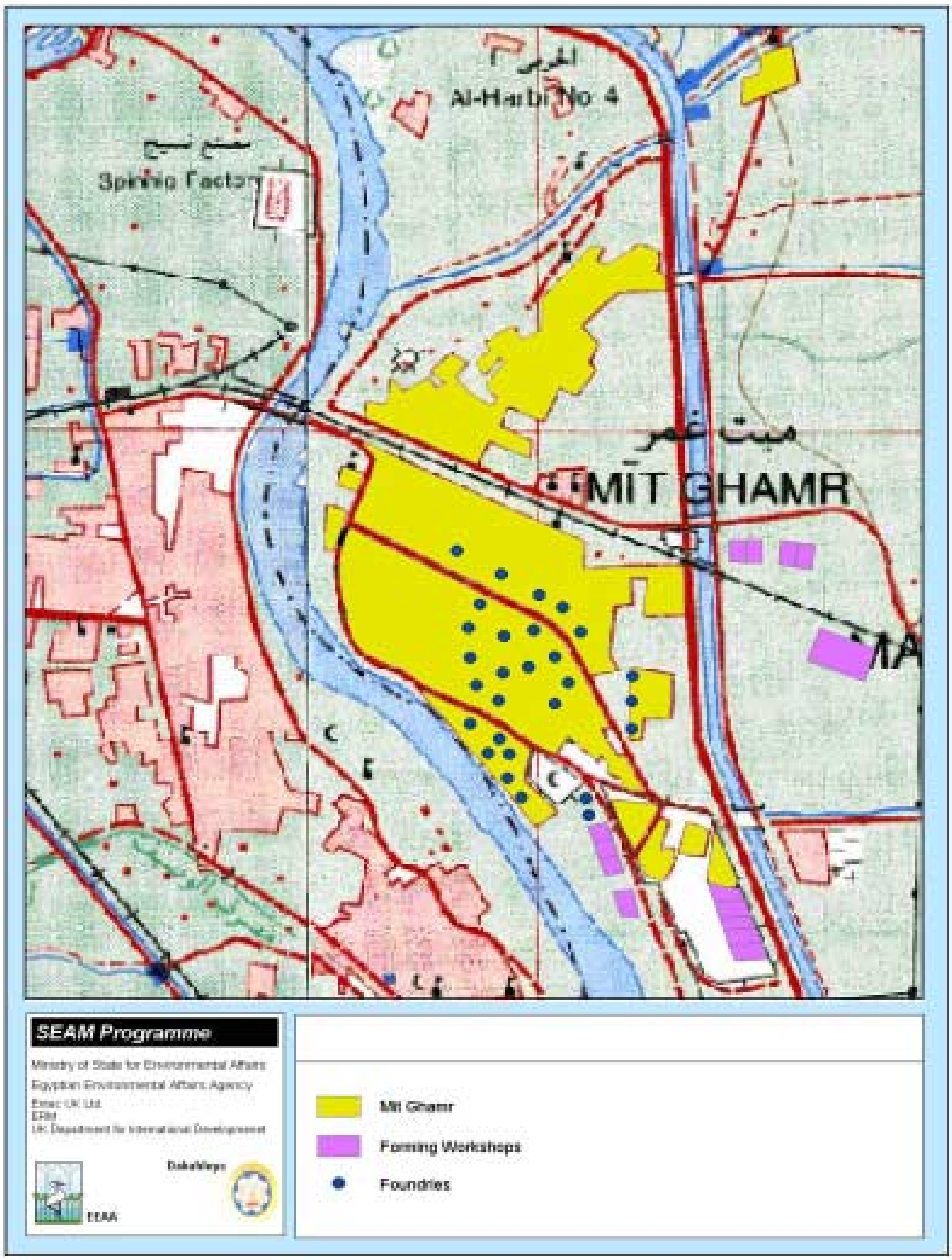
The clusters of secondary aluminium industries exist in two main areas of Egypt – (a) Meit Ghamr in Dakahleya and (b) El Deweaa in Cairo, especially in the Gabl Akhdar and Basateen areas. 60% of these facilities are located in Meit Ghamr and the other 40% in Greater Cairo. In Meit Ghamr area, there are 30 foundries in total, of which 20 belong to the MSME scale. The number of forming workshops is about 120.

On an average, there are about 60 employees per foundry and about 20 employees in each forming workshop. Thus, there are an estimated 1,200 employees in the foundries, while the forming workshops employ about 2,400 employees in the Meit Ghamr area alone. An impressive 78% of Egypt’s secondary aluminium production reportedly takes place here. A very small percentage of the employees in this sector are women - about 1%. They perform functions related to sales, packaging and training. The number of young trainees are up to 20%.

The cluster formation of the MSME-scale factories in this sector is very prominent. The number of employees working in this sector is also significant. As a result, changes in government policies, environmental regulations, etc. can have a strong impact on this sector and have the potential to affect the livelihoods of many people.

Figure 4 shows the geographical distribution of foundries and forming workshops in Meit Ghamr.

Figure 4: Geographical distribution of foundries and forming workshops in Meit Ghamr .



2.2.5 Type of Ownership in the Secondary Aluminium Industry in Egypt

As mentioned earlier, the aluminium recycling industry is divided amongst public sector factories and private foundries. The public sector factories are represented by the Public Company for Metals in Cairo and Tibbin, the Egyptian Company for Copper in Alexandria, and the Helwan Military Company for non-metal industries.

In Cairo and Meit Ghamr, all the enterprises are private/family-owned businesses. In many cases, the enterprises serve as the only source of income to these families.

It becomes very significant to note here that the role of the private sector in the secondary aluminium industry is quite prominent.

2.2.6 Product Range in Secondary Aluminium Products

The MSMEs in the secondary aluminium sector in Egypt produce kitchen utensils and cooking pots mainly. As the name suggests, cooking pots are used for cooking and their use mandates that the finished product specifications coincide with relevant Egyptian and international standards for cooking pots. Finished cooking pots should be of an extremely high level of purity (at least 99.7%), and it is mandated that the proportion of impurities and lead should not exceed 0.3% and 0.10% respectively.

Kitchen utensils are products used for serving only and not for cooking purposes. They may be used to store fruit, grains, trays for serving food and also as containers for washing clothes. Kitchen utensils are not subject to meet any standards. Thus, the finished product in this case does not require as high a level of purity as that needed for the cooking pots.

2.2.7 Resource Base for the Secondary Aluminium Sector in Egypt

The resource base for production activities comprises of fresh aluminium ingots (from primary aluminium production at the Nag Hammadi factory in Egypt), as well as scrap aluminium material, which is obtained from various sources. This old scrap is generally material which is recovered when an aluminium article has been produced, used and finally discarded at the end of its useful life. Such sources include scrap aluminium wastes such as kitchen utensils and cooking pots from hotels, youth centres, clubs, etc. Other sources of scrap aluminium include surplus material that is discarded during certain manufacturing activities, such as trimmings generated from aluminium sheets used in manufacturing kitchen utensils, and trimmings from aluminium sheets used in lining air ducts in central air conditioners and large refrigerators, and ground and aerial electrical cables. The latter type of scrap material is generally composed of ductile aluminium with a very high degree of purity and thus forms the preferred resource base for the foundries. Cooking pots are generally made using such scrap aluminium metal with high levels of purity.

Other sources of scrap aluminium include scrap from factories manufacturing metal window frames of 'keratal' (an alloy of iron and aluminium), television antennas, "mechanical scrap" consisting of car engine compressors, airplane and car bodies and electrical appliances. Such scrap material contains alloys with traces of silicon, iron, lead and antimony compounds, which are regarded as impurities damaging the quality of the final product. Therefore, only kitchen utensils (and not cooking pots) may be made using scrap material containing alloys. Thus, the type of product to be produced must be identified before classifying the scrap.

The standards for aluminium purity used by the factories for cooking pots is using aluminium with purity not less than 95% pure aluminium and in some cases a aluminium purity of not less than 97.7% (max. allowable impurities is 3% and percentage of lead (Pb) should not exceed 1%) is needed for products which will be exported to Arab countries and Africa.

Sometimes, aluminium of a low purity may also be used unknowingly as a raw material. This is mainly due to the large distance between the foundries and analysing laboratories which can confirm the level of purity of the scrap material. This can eventually lead to the manufacture of secondary aluminium products of an unacceptable quality. In fact, there have been demands for the location of suitable testing facilities for raw material / scrap purity nearer to the MSME cluster areas of Meit Ghamr in particular. However, much infrastructure and training support would be required to be put in to make this possibility a reality.

Used aluminium cans also form another source of scrap aluminium. However, recycled aluminium cans do not form the resource base for the MSME-manufactured product range of kitchen utensils and cooking pots.

Supply of available aluminium scrap meets the demand for manufacturing utensils from scrap. Supply comes from various emerging industries such as cooling and refrigeration factories, cars assembling factories, radiator manufacturing, etc.

Scarp is collected by central dealers located all over the country. Scrap is first collected by small dealers from the different sources and they then sell the scarp to the central dealers. Central dealers sell the collected scarp to smelters and the public factories.

2.2.8 Issues Concerning Export of Secondary Aluminium Products

Secondary aluminium products are regarded as a “non-traditional” export sector – i.e. exports from this sector have started in recent years only[18].

The Arab markets of Saudi Arabia, Algeria and other Gulf Countries provide export avenues to the secondary aluminium products made by the MSME industries. However, a mere 10-15% of the finished products are currently being exported. One of the main reasons for this state of affairs is believed to be the lack of market information.

The countries of Dubai, South Korea, India and China are regarded as the main export competitors to the secondary aluminium sector in Egypt. These countries compete directly with the Egyptian enterprises for export and often fare better since they use more modern technology, better production lines/applications, operate on a continuous scale (as opposed to batch scale by the MSMEs) and hence offer products of better quality and at affordable prices. In the bigger picture, the governments of these competing countries are also seen as being more supportive of the MSMEs. For instance, most of these governments host ministries devoted specifically to the concerns of the MSMEs.

The acceptance or rejection of Egyptian products exported to some African and Arab Countries is not subject to fixed standards due to lack of communication and coordination between Egypt and these countries. Getting high value market contacts is essential.

[18] SME Statistical Information. Available at: http://www.sme.gov.eg/sme_statistical_information.htm#_ednref11

Furthermore, the MSMEs must aggressively seek out new customers and adapt product and service lines accordingly. However, in order to do this, there is a need to undertake studies on technical and design aspects and marketing tactics as well. It is particularly important to study the Arab and African market needs in order to upgrade and refine Egyptian aluminium products according to specific customer needs as well as the standards mandated by those countries.

Clearly, while an export market exists for MSME secondary aluminium products, limitations concerning overall product quality, out-of-date technology and lack of market information require to be addressed before the market share can grow and benefit the local MSME-scale producers to a greater extent. Businesses and government have to work together to remove these obstacles. One area of the secondary aluminium sector reforms in Egypt could focus on these aspects.

2.2.9 *Line Ministries Responsible for Regulating the Secondary Aluminium Sector in Egypt*

A number of line ministries are responsible for regulating the secondary aluminium sector in Egypt

The Ministry of Foreign Trade and Industry requires that these industries maintain an Industrial Register. It is also responsible for setting the standards for required purity levels in the finished secondary aluminium products.

1. The Ministry of Trade requires that the industries maintain a routine Trade Register.
2. Ministry of State for Local Development is concerned with licensing for the enterprises.
3. The Ministry of Finance acts as the tax authority for the industries in this sector.
4. Ministry for Environmental Affairs, the Egyptian Environmental Affairs Agency (EEAA) mandates the conduct of a Grey Category Environmental Impact Assessment for all industries in this sector.

2.2.10 Policy Developments Affecting the Secondary Aluminium Sector in Egypt

Taxation

Policy developments affecting the secondary aluminium sector in Egypt concentrate mainly on the issue of taxation. Historically taxation was done based on the tax collector's estimate. Therefore, the principles mentioned below were needed to be developed. There have been some attempts to ease the burden of taxation in this sector. In response to these issues, the Canadian International Development Agency (CIDA), Chamber of Engineering Industries and the Aluminium Association have managed to develop accounting principles for the calculation of taxes - general tax as well as sales tax. The following rules are applicable for calculation of sales tax. This applies for the forming workshops:

- The consumption of 300 kilowatt of power is equivalent to production of 1 ton low grade matt kitchenware.
- The consumption of 400 kilowatt of power is equivalent to production of 1 ton high grade (polished) kitchenware.
- The consumption of 450 kilowatt of power is equivalent to production of 1 ton kitchenware produced in "modern" factories using electric finishing.

The general tax is calculated as 20% of the overall profit. There are currently efforts underway to reduce this figure as well.

As for foundries, the tax is calculated based on the number of crucibles available in the factory. The estimate for the production rate one crucible is 5.75 ton kitchen ware. In factories where there are smelting and forming, taxation is calculated on this basis as well.

2.2.11 Support Facilities Available to the Secondary Aluminium Sector in Egypt

The Aluminium Cooperative at Meit Ghamr

The Aluminium and Copper Industry Cooperative was re-instituted in Meit Ghamr in 1998, following the improvements in the overall economic scenario for the industry[19]. The cooperative provides technical as well as administrative assistance to its members, which include foundries as well as forming workshops. Moreover, it helps members in matters concerning upgrading in their factories, product quality, adherence to relevant environmental standards and also in solving problems concerning taxes. To date, the cooperative includes 113 MSME members. New MSMEs wishing to obtain a license for their facility can approach the cooperative for assistance[20].

[19] Refer also to **Section 2.2.1** for details on the original establishment of this cooperative.

[20] The cooperative also boasts of members like factories forming other metals (i.e. copper), doors locks and stoves.

Training facilities

Several training institutes/centres serve the secondary aluminium sector in Egypt – (1) the Aluminium Industrial Partnership unit (IPU). And (2) the Centre for Technical Training for MSMEs at Mansoura University Aluminium.

(1) The Aluminium Industrial Partnership Unit (IPU)[21]:

The Aluminium Cooperative at Meit Ghamr identified a need for training technicians in the sector for working on the old and new production lines. Therefore, in co-ordination with the Egyptian Ministry of Labour Force and Immigration and CIDA, the cooperative created a unit called the Development Centre for Aluminium Training. Established in 1999, the IPU was the first initiative ever to offer specialized training to MSMEs in this sector, previously training being only on-the-job. The IPU offers technical training to graduates of the Technical High Schools, as well as MSME workers and technicians. The IPU comprises of three categories of member organizations:

(i) Vocational training institution,
(ii) Business organizations (in this case aluminium manufacturing),
(iii) Individual MSMEs operating in the sector.

The activities of the Centre reportedly focus on:

- Technical assistance and solving problems experienced by the MSMEs
- Linking the aluminium industry with different authorities working in the industrial sector
- Assisting factories to comply with Egyptian Environmental Regulations
- Developing the aluminium production line to obtain competing products in the international market
- Offering workshops and training

Its primary mandate was to foster training in the sector. It was planned to be financially sustainable, by charging fees to participating members and by selling the products it produces on a profit margin basis. The training plan is spread over 400 hours (i.e. 3 months). Training curriculum consists of the following features:

- Distinguishing between the various types of raw materials used by the sector
- Occupational health and safety guidelines
- Operating hydraulic and mechanical presses
- Cutting metal (longitudinal and circular fashions)
- Operating finishing, lathing, polishing and grinding machines

[21] Country Development Programming Framework: 2001; Egypt (June 2001). Available at: www.acdi-cida.gc.ca/CIDAWEB/webcountry.nsf/ vLUImages/Egypt/$file/Egypt-Programming_Framework.pdf

(2) Support Centre for SMEs - Mansoura University

The Support Centre for SMEs was established in 2000 by the Mansoura University to support SMEs in Dakahleya Governorate. The centre's main objective is to provide training to SMEs, undertake research and development for problems faced by the SMEs, assist in creation of business networks to link SMEs, create database and information systems that could support SMEs, hold seminars and conferences to serve SMEs and disseminate research results and studies related to establishing and developing SMEs. The centre supports various sectors such as the aluminium recycling utensils sector, textile sector, dairy and brickworks sector.

Testing facilities

In order to help the factories in this sector meet the mandated levels of purity of recycled aluminium products[22], the Egyptian Government established a specialized institute known as the Central Metallurgical Research and Development Institute (CMRDI) in Cairo, which focuses on the upgrade and purification of ferrous and non-ferrous metals depending on their ultimate usage. The other scientific institute is TIMS (Tibbin Institute for Metallurgical Studies) at Tibbin. Helwan, which is a research institute and its also specializes in testing the purity of recycled metals. Thus, the services offered by these institutes are thought to help MSME owners towards the development of their products based on set criteria.

However, these testing facilities and institutes are located at a far off distance from the MSME clusters, so much so that many times, production is continued on the batch of aluminium scrap for which the enterprise is yet to receive testing purity results. As a result, at most times, MSMEs are likely to be "working blind" when it comes to ascertaining the purity of the raw material and thus, the enterprise may not meet quality requirements for purity of aluminium in the final product. No doubt this causes problems downstream, especially owing to rejects in semi-final or even finished aluminium products on account of insufficient purity levels (i.e. less than 99.7% for export and less than 95% otherwise). There have been demands for the establishment of a common infrastructure testing facility at the MSME cluster location itself – i.e. in Meit Ghamr. Establishing such infrastructure would require serious thought about the required funding and the means to keep such a facility financially sustainable in the long run. One area of sector reforms could focus on this aspect.

[22] According to the standards set by the MoI, the purity of kitchen utensils should be 99.7% while the percentage of accumulated impurities and lead should not exceed 0.3% and 0.1% respectively.

Research and development (R&D) focused towards providing technical assistance

The requirement for assistance in technical issues appeared as a result of the emergence of the recycled/secondary aluminium industry in Egypt. Such issues chiefly includes:

- Purification of the resource base (i.e. the removal of impurities to as great an extent as possible), we do not have details for this issue at all. Please comment on how this issue affects the semi-final / final rolled products?
- Identification of the types of smelters to be used for the best results,
- Identification the suitable fuels which do not generate harmful emissions into the neighbouring environment,
- Solving the problem of incomplete combustion of fuel which ultimately results in the consumption of larger fuel quantities in the melting or annealing process,
- Operation of preparation (i.e. annealing) furnaces which require a set temperature of between 450ºC and 550ºC for a set period, in order to achieve a product that could be formed with minimal wastage and losses, and
- Improving the poor work conditions (noise and particulate emissions) in the finishing and polishing areas

2.2.12 Issues Concerning the Secondary Aluminium Sector in Egypt

Environmental issues become important in this sector, not due to non-compliance with environmental standards alone, but also due to the associated worker (and neighbourhood) health and safety concerns. Thus, environmental issues cannot be ignored and require deep consideration.

Environmental and worker health and safety issues in foundries[23,]

One of the environmental problem faced here is that of air pollution in the smelting process. The smelter ovens are generally inefficient due to poor (i.e. incomplete) fuel combustion, which causes the release of air pollutants such as particulate matter and hydrocarbons. The concentration of particulate matter near typical MSME smelters has been reported to be 15 parts per million (ppm) or higher, a number which is over the allowable limit of 10 ppm as per Egyptian Law 4/1994 and ER 338/1995.

Excessive slag is generated as a result of the formation of aluminium oxides from direct burning in smelters. Additionally, the current practice in handling of degassing chemicals to be added during the smelting phase has also been reported to be unsafe, particularly from the point of view of worker health. Frequent incidences of flying ash are also a problem for worker safety.

In the foundries, environmental problems also take on the form of heat emissions/heat stress from furnaces and smelter ovens, owing to poor heat insulation. All this causes immense discomfort to workers and also create compliance problems for the industry in

[23] Information for process steps such as smelting, etc. is provided in **Chapter 3** of this report.

terms of the mandated worker health and safety laws. There have been reports of temperatures inside the immediate work space reaching an extremely uncomfortable point of 36OC, far exceeding the allowable limit of 28OC mandated by Egyptian Law 4/1994.

Environmental and worker health and safety issues in forming workshops24

In the forming workshops, noise pollution and the aluminium dust produced during the grinding and polishing operations poses serious risks not just to the surrounding environment, but also to the workers. The workers suffer from frequent dust inhalation and hearing loss problems, as there is little or no protective equipment. Box 4 provides an idea of the health hazards possible through exposure to aluminium on account of unsafe working practices.

Box 3: Other Varieties of Finished Aluminium Products Offered by the Secondary Aluminium Industry[25]
Aluminium particles, when in dust, powder, or flake forms from operations such as manufacturing powder, grinding, finishing, and processing, may be suspended as a dust cloud in air and consequently may ignite and cause serious damage. Aluminium particles deposited in the eye may cause local tissue destruction. Aluminium dust may cause nodular lung fibrosis, interstitial lung fibrosis, and emphysema as indicated in animal experimentation. Aluminium is not generally regarded as an industrial poison, although inhalation of finely divided aluminium powder has been reported as a cause of pneumoconiosis. Aluminium in aerosols has been referenced in studies involving Alzheimer's disease, although those studies have been recently disproved.

During the finishing process, caustic soda (also called "sodium hydroxide"), a toxic and hazardous chemical is used as the primary material. The caustic soda baths are inefficient and poorly controlled often generating noise, fumes, aerosols, and other nuisance emissions. Generally, the spent baths are discharged without further treatment into the sewers and the sludge from the bath is dumped into the street and collected for dumping at the landfill. This adds to instances of non-compliance with Egyptian environmental regulations. Further, the operators working the hot baths are exposed to noxious caustic soda fumes. The situation is aggravated by a lack of surfactants and lack personal protective equipment.

Solving the environmental problems related to this sector requires an upgrade in technology as well as the installation of certain pollution control equipment. Such matters require technical know-how and financial support, both of which appear to be lacking at the present time. On area of sector reform could thus focus on the

[24] Information for process steps such as grinding, polishing, finishing etc. is provided in **Chapter 3** of this report.

[25] Source – "Reference Data Sheet for Aluminium" by William D. Sheridan. Available at: http://www.meridianeng.com/aluminium.html

provision of adequate research and development through a technical institution/authority and also the provision of some form of financial aid to support the industries to enable them to take steps towards meeting environmental standards and improving the worker health and safety situation.

Issues related to productivity

Primary productivity concerns in foundries centre around energy consumption issues in the annealing process and direct burning practiced in smelters. The annealing process is normally carried out using inadequately insulated ovens leading to very large heat losses and hence, excessive energy consumption. Heat losses of up to 80% have been recorded, with related wastage in fuel consumption amounting to LE 24,000 per year.

In addition to increasing the production costs, the quality of the final product also suffers due to improper annealing. Typical annealing ovens do not have proper temperature control. The aluminium sheets/discs do not undergo annealing to the required extent, thus making the shaping of semi-final products very difficult. Due to this, the volume of aluminium returned to the annealing oven often increases.

On the downstream side (i.e. once the semi-final product has been passed on to the forming workshops), the volume of rejects from the forming process also increases due to the non-homogeneous distribution of hardness in the annealed metal. This causes disintegration of the metal and contributes to worker injuries in about 50% of the cases. Material wastages and rejects of about LE 40,000 per year have been recorded. Thus, production capacity cannot be met.

The direct burning practiced in smelters leads to the generation of excessive amounts of slag, as a result of the formation of aluminium oxides. More aluminium scrap material is lost in the slag as a consequence, thus indirectly leading to loss of production. This undesirable practice could cost the unit a loss of up to LE 108,000 per year26.

Additionally, due to their inherent inefficiency, both the smelter and annealing ovens require frequent maintenance, repairs and replacements of working parts, which could come up to LE 2,000 to 8,000 per year. This adds to the downtime of the unit and increases production costs.

These aspects point to the need for improved operating conditions as well as technology upgrades in the annealing and smelting operations. Once more, this underlines the requirement for improvements in technology/overall production line and provision of financial assistance to test and eventually adopt such new technology in this sector. A future improvement in the current benchmarks (see below) will show the extent of gradual improvement once such sector reforms are in place and fully instituted.

[26] Assuming an average production capacity of two tons of semi-final aluminium each day.

Current benchmarks in the secondary aluminium sector in Egypt

The following are the benchmarks currently reported for secondary aluminium production in Egypt. A future improvement in the current benchmarks (see below) will show the extent of gradual improvement once such sector reforms are in place and fully instituted.

- Inputs and outputs: For every ton of aluminium material recycled, 920 kg o moulded aluminium is produced for dragging and rolling[27]. About 80 kg of slag is produced in the process. After the dragging and cutting operations, 65% o scrap material is converted to 2-3 mm thick discs. This number decreases slightly (to 62%) in the case of 1.5-2 mm thick discs.

- Production in tons: For one crucible of 250 kg, production rate equals 2 tons o smelted aluminium per day, in a working period of not less than 15 hours.

- Energy consumption: Thermal heat; one smelter requires 6-7 butagas cylinders The electric power requirement for one smelter ranges from 10-15 KW. However these requirements may differ from one equipment to another, depending on the working practices followed, preventive maintenance, etc.

- Oil and grease consumption: Differs from season to season. For one ton o aluminium smelted, oil and grease equivalent to LE 30 is consumed in the summer. In the winter season, this number reduces to LE 20.

Issues related to technology and infrastructure

The smelters and annealing ovens are built locally in factories. Typical smelters use a direct flame (causing excessive slag generation), and are often brick-lined without adequate insulation and temperature control mechanisms (leading to heat losses). The locally built annealing ovens also lack adequate insulation and temperature controls. As remarked earlier, the results of the processes are unsatisfactory and impede productivity.

Rolling equipment and forming machines are also built locally. Their efficiencies depend greatly on operator skills; this implies that the final results of the process cannot be consistent and quality specifications cannot be met frequently. The products produced by these machines are of low quality, which is known as the ."شعبي"Some of this production is exported to some Arab countries like Libya and Sudan. It is necessary to change/modify the current production line and replace with more efficient machines to get a product with higher quality to compete with the European markets after the application of the GATT agreement. However, the more sophisticated forming machines available at the Training Centre offer better results. These machines are also called "lathing machines" and

[27] The process steps concerned with secondary aluminium production lines are discussed in detail in **Chapter 3** of this report.

are generally used only for the manufacture of the high grade aluminium products (i.e. those of 99.7% purity).

There is also a need to conduct a comprehensive study for improving the rolling process in terms of the identification and use of light oils between the axes of the rolling machines.

In terms of infrastructure, the availability of uninterrupted/reliable power supply is also a point to be considered. This aspect arises with the adoption of new technologies such as use of indirect flames in smelter designs. The flames require electricity to operate.

On the whole, the secondary aluminium sector in Egypt finds itself struggling to keep pace with new technology available in the sector in other countries. The replacement of outdated production lines with cleaner and more efficient technology will help the secondary aluminium industry reform itself in many ways – i.e. with respect to meeting environmental regulations, being safe for workers, expanding markets abroad, etc.

Promotional financing initiatives and subsidies

Unfortunately, there have been no reported promotional financing incentives taken up for this sector to date.

Given the fact that there are no government subsidies offered to this sector either, one area of sector reforms must focus on the provision of some form of financial aid to this industry to ensure that it functions in an environmentally and socially responsible manner.

2.3 The Criticality of Addressing MSMEs within the Secondary Aluminium Sector in Egypt

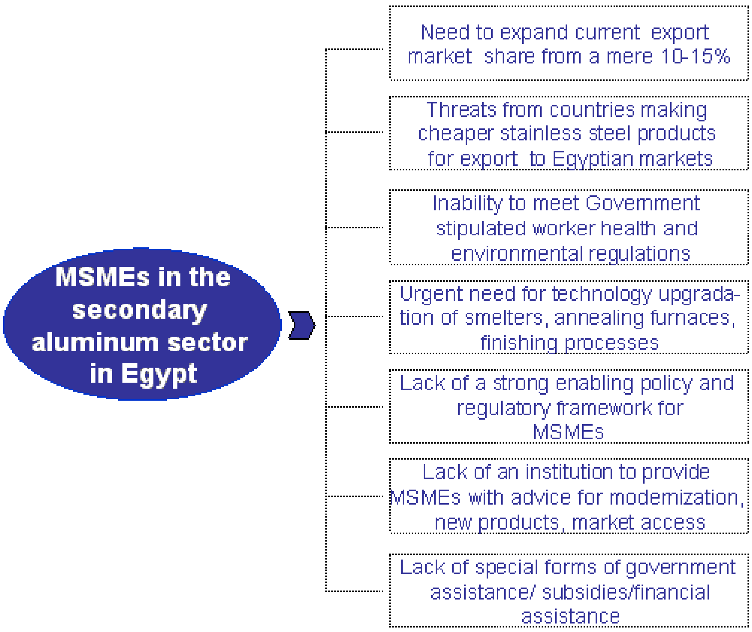
A general but brief summary of what has been learnt so far is presented in below.

- About 75% of Egypt's secondary aluminium production occurs in the MSME segment.
- Low-priced products manufactured from the scrap have high economic and environmental value, and also generate job opportunities for this sector.
- Aluminium is recycled in Egypt to the extent of about 50-60% in the majority of the Governorates, i.e. those serviced by the public sector factories. However, in the private foundries spread in the two main areas of Cairo and Meit Ghamr, this number reaches a very high proportion - about 95-100%.
- While an export market exists for secondary aluminium products made by MSMEs, a number of limitations require to be addressed (e.g. product quality concerns, technology upgrade issues, understanding market potential etc.), before this market share can grow and benefit the local MSME-scale producers to a greater extent. At the present time, only 10-15% of the export market share appears to have been tapped.
- At present, the secondary aluminium industry is sensitive to the economic slowdown and the competition from abroad, especially from China which exports particularly cheap stainless steel. Due to this, several workshops are producing below their capacity.

- Local secondary aluminium production is not subject to subsidies or any other form of special government assistance.
- The inability to meet relevant environmental and worker health-related legislations poses a threat to the operation of the MSME units, which is the sole source of employment to a large segment of the population.
- The absence of a strong enabling policy, regulatory and institutional framework has been hampering MSMEs in the secondary aluminium sector.

Figure 5 shows the threats facing MSMEs in the Secondary Aluminium Sector in Egypt

Figure 5: Threats Facing MSMEs in the Secondary Aluminium Sector in Egypt



However, this unique set of circumstances has led to both challenges and opportunities for the MSME units. A holistic strategy is required to protect and promote secondary aluminium sector activities at the MSME scale.

The concept of Cleaner Production can serve this purpose very well. Through this concept, practical, cost-effective and sustainable solutions can be provided to address environmental, worker health and productivity concerns of the MSMEs in the secondary aluminium sector in Egypt.

Consequently, the remaining sections of this report will seek to:

- Illustrate the different steps involved in the production of secondary aluminium products at the MSME scale in Egypt, and enumerate the types and quantities of wastes generated at each stage within each process (refer to **Chapter 3**),
- Describe the current environmental and regulatory framework associated with the sector and the response of MSMEs to this framework (refer to **Chapter 4**),
- Provide a brief introduction to the concept of Cleaner Production and examples of what it can offer specifically to MSMEs within this sector (refer to **Chapter 5**),
- List and critically analyse the various SEAM and non-SEAM related Cleaner Production opportunities in this sector, practiced around the world as well as in Egypt and present some promising strategies embodying the concept of Cleaner Production for the betterment of sector practices (refer to **Chapter 6**) and
- Underline the importance of sustaining Cleaner Production throughout the MSMEs in the secondary aluminium sector in Egypt and explain how this can be achieved (refer to **Chapter 7**).

Chapter

3

3.0 Process Description and Waste Generation by MSMEs in the Secondary Aluminium Sector for Utensils in Egypt

Chapter 3: Process Description and Waste Generation by MSMEs in the Secondary Aluminum Sector for Utensils in Egypt

3.1 Introduction

Chapter 2 of this report discussed the profile of the secondary aluminium sector for utensils in Egypt, focussing especially on the MSMEs. Chapter 2 also highlighted the criticality of focusing on MSMEs within this sector, so as to:

- Pinpoint the environmental, economic and productivity-related challenges currently faced by them,
- Alleviate these challenges and
- Consequently, allow for their sustained productive growth.

In order for us to effectively understand these stresses, we need to have a glimpse of the core day-to-day functioning of MSME operations. Knowledge of the processes involved in the production line and service units will offer an understanding and prediction of:

- The pollution hazards involved with it,
- Expected violations to allied regulatory framework[28],
- Economic, social and environmental losses and scope for improvement.

This understanding will ultimately help to determine avenues for implementing the concept of Cleaner Production[29] amongst the MSMEs in the secondary aluminium sector in Egypt. Hence, Chapter 3 will focus mainly on process descriptions of the MSME-scale secondary aluminium sector operations and their subsequent waste generation.

3.2 Process Overview for Different Production Lines

As mentioned in Chapter 2, the secondary aluminium sector activities are divided amongst foundries and forming workshops. The foundries manufacture semi-final aluminium products such as aluminium discs and/or sheets, which are then worked into final products such as kitchen utensils and/or cooking pots at the forming workshops. Accordingly, the processes for the foundries and forming workshops are discussed in detail below[30].

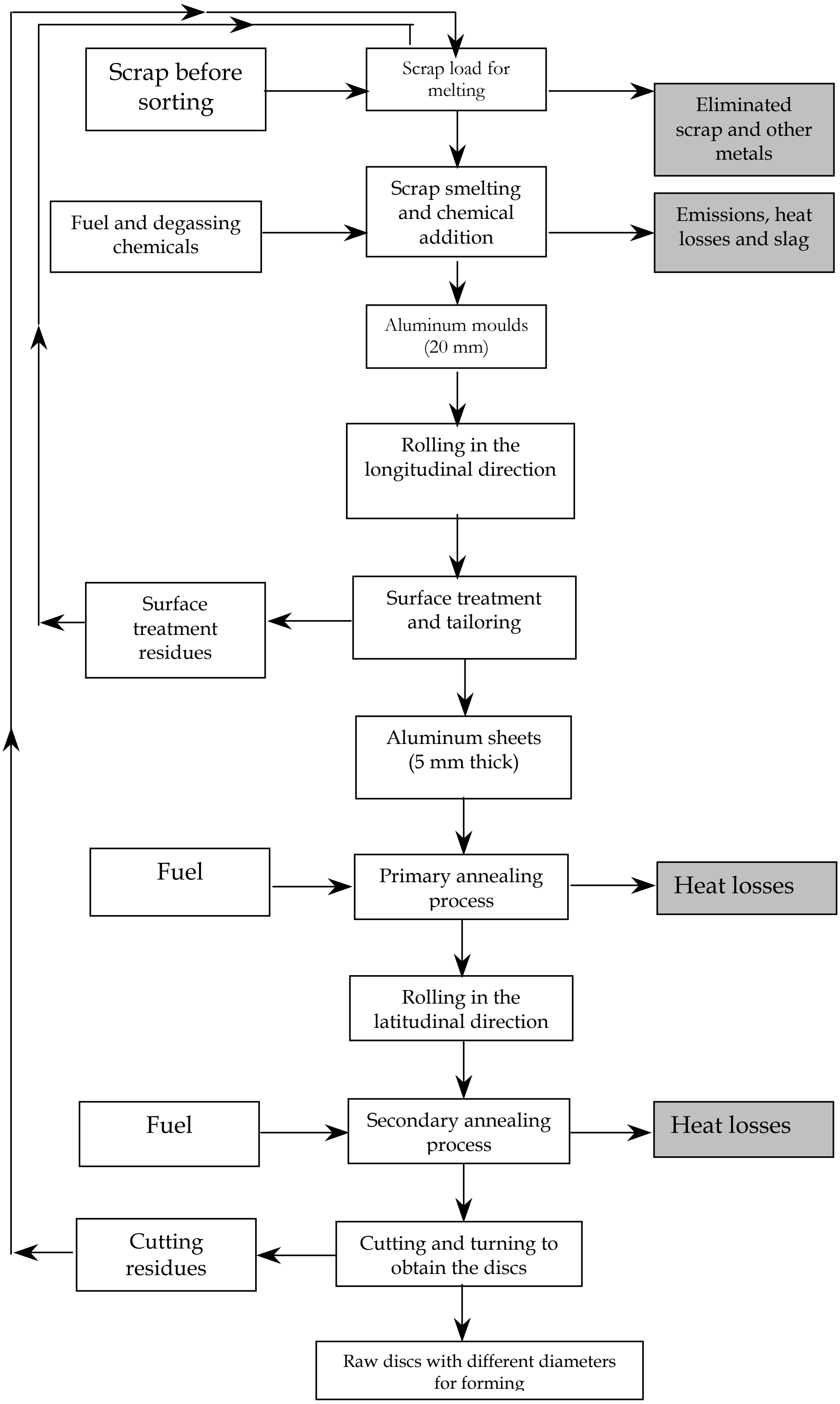
3.2.1 Manufacturing Semi-Final Products in Foundries

The process steps employed for the manufacture semi-final products by aluminium re-melting foundries in Meit Ghamr area are shown in Figure 6. Semi-final products include aluminium discs or rectangular aluminium sheets which are ultimately manufactured into the final/finished product; kitchen utensils and/or cooking pots. There may be some slight differences from one foundry to another in terms of production line efficiency. However, by and large, the process steps remain the same across the MSME industries.

Figure 6 shows the process steps for manufacturing aluminium discs in foundries.

[28] This aspect is dealt with in more detail in **Chapter 2** of this report.
[29] This aspect is dealt with in more detail in **Chapter 5** and **Chapter 6** of this report.
[30] Dr. Aly El Booz (Aluminium Cooperative in Meit Ghamr)

Figure 6: Process Steps for Manufacturing Aluminium Discs in Foundries

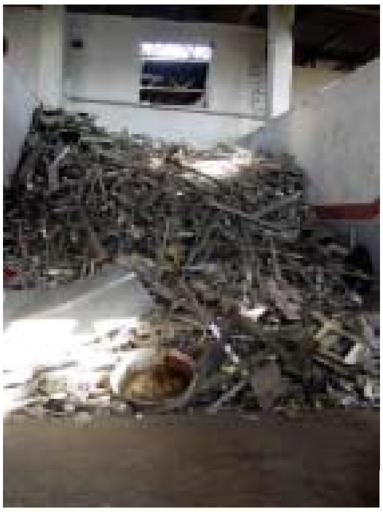


The steps appear in order as below:

1. Sorting aluminum scrap
2. Forming and preparing the scrap for melting according to product requirements
3. Melting scrap and pouring into moulds
4. Rolling in the longitudinal direction
5. Surface treatment and tailoring
6. Primary annealing
7. Rolling in the latitudinal direction
8. Final or secondary annealing
9. Cutting and turning to obtain aluminum discs
10. Collecting the generated wastes/residues

Step 1: Sorting aluminium scrap

In Chapter 2, the resource base for production activities comprises of fresh aluminium ingots (from primary aluminium production at the Nag Hammadi factory in Egypt), as well as scrap aluminium material, which is obtained from various sources. On an average, 25% ingots and 75% scrap aluminium is used. The scrap aluminium consists of trimmings generated from aluminium sheets used in manufacturing kitchen utensils, and trimmings from aluminium sheets used in lining air ducts in central air conditioners and large refrigerators, and ground and aerial electrical cables. The latter type of scrap material is generally composed of ductile aluminium with a very high degree of purity and thus forms the preferred resource base for the foundries. Other sources of scrap aluminium include scrap from factories manufacturing metal window frames of 'keratal' (an alloy of iron and aluminium), television antennas, "mechanical scrap" consisting of car engine compressors, aeroplane and car bodies and electrical appliances. Such scrap material contains alloys with traces of silicon, iron, lead and antimony compounds, which are regarded as impurities damaging the quality of the final product. Thus, the type of product to be produced must be identified before classifying the scrap – the lower quality products requiring scrap material of less purity and the higher end products demanding the use of scarp material of higher purity levels (see Step 2). The sorting operation is done manually and it takes 1 hour to sort 2 tons of scrap.



Scrap storage

Step 2: Forming and preparing the scrap for melting according to product requirements

The two main products made by the secondary aluminum industry in Egypt are cooking pots and kitchen utensils. Cooking pots are generally made using such scrap aluminium metal with high levels of purity. This is because the finished product should have a purity of 99.7%, while the proportions of impurities like lead, arsenic and antimony are not to exceed 0.1%. Kitchen utensils, on the other hand, are not subject to any standards at the present time. This is mainly because these products are used for auxiliary purposes such as storage of fruits and grains, as serving trays, washing utensils, etc. Therefore, only kitchen utensils (and not cooking pots) may be made using scrap material containing alloys.

Step 3: Melting scrap and pouring into moulds

Once the scrap load is ready, the burners of the smelter need to be prepared by burning the fuel gas and adjusting the air-to-fuel ratio to an appropriate extent. This has to be such that fuel combustion is complete so as to ensure safe/non-polluting working conditions and comply with environmental regulations. Complete combustion also results in lesser amounts of wasted scrap or “slag”, resulting in an economically as well as environmentally balanced product. After the burners of the smelter reach a temperature of about 670^{O}C to 700^{O}C, the melted scrap is poured into moulds measuring 20 mm by thickness and 330 mm by height[31], with a variable length ranging from 16 cm to 58 cm, depending on the required product size specifications. The moulds should ideally have as high a degree of smoothness as possible, which will give rise to a better semi-final product, especially when the final product to be formed is a high grade aluminum product.

At this stage, degassing chemicals are added to the melted scrap. This step helps in avoiding scrap metal oxidation due to the formation of an oxide layer over the surface of the metal, and additionally facilitates gas removal (especially that of hydrogen gas) from the melted

[31] This is a fixed measurement and is not altered.

scrap. The reduction of the amount of these impurities is necessary because they are at the origin of the formation of metal porosity in solidified aluminum that lowers the mechanical properties of the final product[32]. This process is also known as "scrap load purification from gases and impurities". The process has to be monitored very carefully so as to ensure that it forms as homogenous a layer as possible, i.e. free from air bubbles.

Typical Smelter in Meit Ghamr

Pouring the melt to the mould

Step 4: Rolling in the longitudinal direction

In this step, the moulded material is rolled in the longitudinal direction such that its thickness is decreased from 20 mm to 5 mm. This gives rise to the formation of 5 mm thick aluminum sheets. The aluminum sheet now becomes hard on account of the repeated rolling. In order for the sheet to undergo the forming process (see Step 7), it requires to some surface treatment and tailoring (see Step 5), followed by annealing (see Step 6). Light oil is required to lubricate the axes of the rolling machines. At times, kerosene or solar is also used for this purpose.

Rolling machine

[32] Source: Aluminum Degassing. Available at: http://www.airliquide.com/en/business/industry/metals/applications/foundry/al_degasing.asp

Step 5: Surface treatment and tailoring

The surface of the 5 mm thickness sheets resulting from the rolling process is likely to have some defects such as bubble formation, particularly on the surfaces exposed to air. This is generally due to non-homogenous pouring practices (see Step 3). This necessitates the cutting of such defective portions of the aluminum sheet depending on the requirements of the product. The aluminum sheets need to be strictly tailored so as to meet all the stated specifications. Since the sheets are hard, annealing is required so that the sheets may undergo the forming process successfully and thus meet the stated specifications for the final product.

Step 6: Primary annealing process

The annealing process is done to relieve the internal stresses that have occurred during the rolling process. The temperature inside the annealing furnace reaches 400-600˚C, which is sustained for 4.5-5 hours using LPG bottles or diesel as fuel. The annealing process is done twice or three times before reaching the cutting stage, after longitudinal stretching, after transversal stretching, and after cutting into circular discs. The number of times annealing process is repeated depends on production and furnace capacities.
Typically, the smelter for annealing is built to facilitate the entry and exit of products put on carts moving over iron rails. The smelter room walls and ceiling are lined with heat insulating material so as to retain its inner temperature between 440 OC to 550 OC. The treated and tailored aluminum sheets have to be properly stacked in the oven in a manner that permits the passage of air and combustion gases over the sheets. Efficient primary annealing requires a time period of not less than 4 hours; only then will the aluminum sheets become soft and suitable for undergoing the forming process. Unfortunately, typical annealing ovens do not have proper temperature control. The aluminium sheets and discs do not undergo annealing to the required extent, thus making the shaping of semi-final products very difficult. Due to this, the volume of aluminum returned to the annealing oven often increases.

Annealing Oven in Meit Ghamr

Step 7: Rolling in the latitudinal direction

This stage of the process involves rolling the aluminum sheets in the latitudinal direction, so as to reduce its thickness from 5 mm to 2.5 mm-1.5 mm, depending on the requirements for the forming stage. The rolling and dragging process is done in the direction opposite to that in the first rolling step (see Step 4) in such a manner so as to make the length of the aluminum sheet equal to its width. In doing so, this step is also referred to as the "squaring step".

Step 8: Final or secondary annealing

This process is not much different from the primary annealing process (see Step 6), the main difference being that the time period required for the product to be retained in the annealing oven might increase to 5 hours until an appropriate degree of softness is reached, which is decided by the worker based on his experience. Now, the sheets may be formed easily.

Step 9: Cutting and turning

In this step, the sheets are transformed into discs of certain sizes and diameters. The sheets resulting from the secondary annealing process are cut and turned into discs of a suitable thickness. These discs form the product needed for the manufacture of kitchen utensils. Alternatively, the aluminum sheets from the secondary annealing process could also be cut into rectangular shapes of variable dimensions to produce cooking trays. Mechanical and hydraulic compressors are used for this purpose.

Aluminium Discs

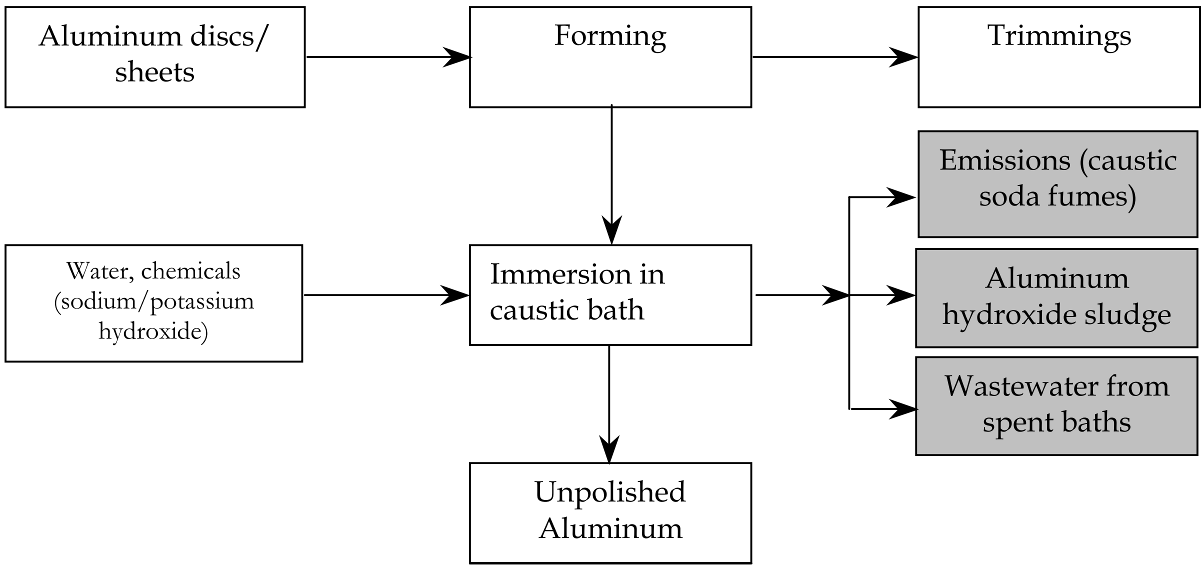
Step 10: Collecting the generated wastes and residues

Wastes and residues generated from the various stages of the manufacturing process (see Figure 6) are collected and then may be reused as raw material (i.e. aluminum scrap) for other secondary aluminum products, provided chemical analyses confirm that the purity of wastes coincides with the ultimate manufacturing purpose.

3.2.2 Forming Semi-Final Products into Final/Finished Products (Kitchen Utensils and Cooking Pots)

Forming workshops manufacture the final products (i.e. kitchen utensils and cooking pots) using the semi-final aluminium discs made by the foundries. There are two different types of forming workshops. In the first category, the forming workshop manufactures a low-grade product which is not polished. These products still retain their aluminium oxide layer and appear to have a dull (also called matt) finish. The process steps here include forming followed by immersion in a caustic soda bath. In the second type of forming workshop, the aluminium product undergoes three process steps, namely forming, grinding and polishing. The two process steps give rise to a higher grade product. The process steps employed at forming workshops can be summarized as shown in Figure 7 which illustrates the steps for manufacturing unpolished products and Figure 8 which illustrates the steps for manufacturing polished products.

Figure 7: Process Steps Used in Forming Workshops to Produce Unpolished Aluminium Products



1.FORMING THE ALUMINIUM DISCS/SHEETS

The aluminium discs produced from the smelters are then formed using manual spinning machines where the discs are spun into different shapes according to market and needs. Since the spinning in done manually, and in the case that the disc is not properly annealed, the disc can break and harm the workers. Other problems are the noise and vibration generated from the spinning machines.

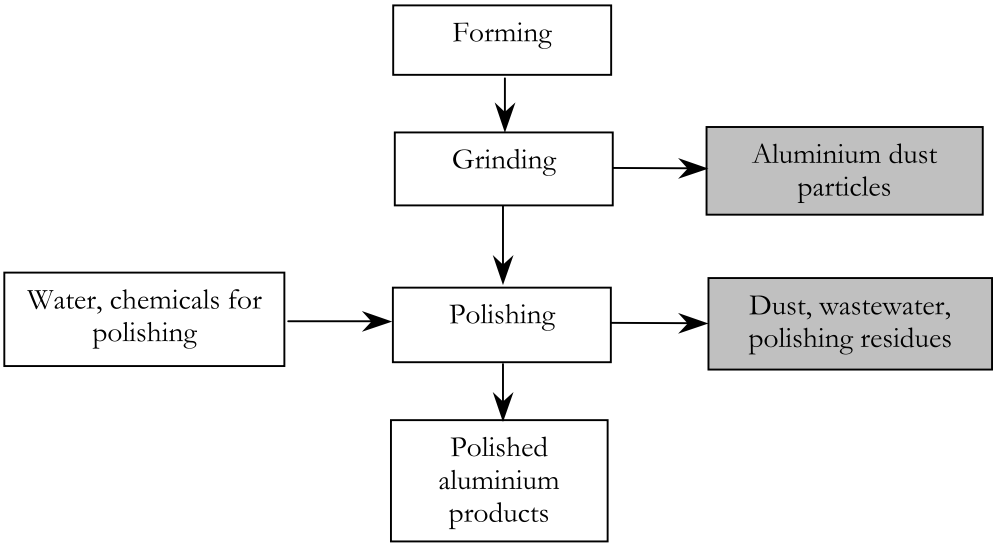
The types of oils used in forming machines differ significantly from one enterprise to another. This step requires light oil to lubricate the axes of the forming machines. Sometimes, kerosene or solar is used as a medium between the aluminium discs / sheets and the rolling surface. In some small workshops, recycled oil from car engines is also used for lubrication.

2.IMMERSION IN THE CAUSTIC BATH

The aluminium products are immersed in a caustic bath to remove any dirt or oil and grease. This is one of the most important steps for the finishing of the final aluminium product. Owing to this step, the aluminium hydroxide layer becomes inert (i.e. changes to a layer of aluminium oxide), which offers the product excellent corrosion resistance.

The aluminium product is immersed in caustic soda at a temperature not exceeding 60ºC. Then, the product is removed from the bath and immersed in a tank of water. Thereafter, the products is removed from the water tank and immersed in a third tank containing dilute nitric acid. Finally, the product is immersed in clean water and after the layer of aluminium oxide has been formed, the product is left to dry thoroughly in fresh air and sunlight.

Figure 8: Process Steps Used in Forming Workshops to Produce Polished Aluminium Products



1. FORMING THE ALUMINIUM DISCS/SHEETS

The aluminium discs produced from the smelters are then formed using manual spinning machines where the discs are spun into different shapes according to market and needs. Since the spinning in done manually, and in the case that the disc is not properly annealed, the disc can break and harm the workers. Other problems are the noise and vibration generated from the spinning machines.

The types of oils used in forming machines differ significantly from one enterprise to another. This step requires light oil to lubricate the axes of the forming machines. Sometimes, kerosene or solar is used as a medium between the aluminium discs / sheets and the rolling surface. In some small workshops, recycled oil from car engines is also used for lubrication.

2. GRINDING

The grinding process is used to produce a high surface finish with a close tolerance and for machining hard materials. Grinding is undertaken to remove any surplus material, and produce high quality surface finishes. It requires a rotary grinder with a bonded abrasive cup wheel or canvas wheel faced with suitable abrasives. It is used for grinding the surface of the bottom and the inner surface for the utensils.

3. POLISHING

Polishing is an important process for finishing aluminium product in order to obtain polished products. It is used for improving the surface of the outer surface of the utensils. Cloth brushes are used to clean aluminium products from oil, grease and aluminium oxides.

The finishing department consists of different polishing and sanding machines that are used for high quality products. The working environment is full with aluminium dust and other particulates and emissions. No ventilation system usually do not exist in the majority of factories in Meit Ghamr; which increases concentrations of indoor contaminants and reducing the life span of the machines.

3.3 Waste Generation from MSME-scale Secondary Aluminium Manufacturing Operations

Waste generation from secondary aluminium manufacturing operations at the MSME scale includes the generation of air emissions, wastewater, solid waste and nuisance due to noise. In terms of criticality, the generation of air emissions constitutes the major environmental concern. Primarily, the largest environmental problem faced in foundries is that of air pollution during the polishing and grinding stage . Currently, workers in most MSMEs lack basic protective equipment against excessive noise and are thus fully exposed to this form of pollution. No effective ventilation systems exist to collect the dust generated from the polishing and grinding machines. This would help improve the working environment for the workers and increase the lifetime of the motor and its accessories. The nuisance due to noise pollution in the grinding and polishing operations in the forming workshops is also reported to be of great concern.

Air emissions at the smelter oven is also a problem. The smelter ovens are generally inefficient due to poor (i.e. incomplete) fuel combustion, which causes the release of air pollutants such as particulate matter, fly ash and hydrocarbons. The concentration of particulate matter near typical MSME smelters has been reported to be 15 parts per million (ppm) or higher, a number which is over the allowable limit of 10 ppm as per Egyptian Law 4/1994 and Executive Regulations 338/1995.

After air emissions, wastewater may be considered as the next critical issue for environmental pollution, while solid waste (slag) may be classified as the least critical (but nevertheless important) issue. The wastewater is generated as a result of the spent caustic soda baths from the forming process. Caustic soda baths are inefficient and poorly controlled often generating noise, fumes, aerosols, and other nuisance emissions as well. Generally, the spent baths are discharged without further treatment into the sewers and the sludge from the bath is dumped into the street and collected for dumping at the landfill. This adds to instances of non-compliance with Egyptian environmental regulations.

The slag is generated as a result of the formation of aluminium oxides from direct burning in smelters. Although some MSMEs are switching to better designed smelters (i.e. those employing indirect burning), some amount of slag generation is inevitable. The slag is sent for dumping at the local landfill.

Quantification of waste generation at the MSME scale in the secondary aluminium sector in Egypt is still on-going and exists for some parameters only, as seen in Table 1.

Table 1: Quantification of Waste Generation at the MSME Scale for the Secondary Aluminum Sector in Egypt

Sr. no.	Process	Parameter	Measured quantity
1	Smelting (in foundries)	Particulate matter	15 ppm
2	Polishing (in forming workshops) [33]	Total suspended matter	30.6 mg/m^3
3	Grinding (in forming workshops)	Total suspended matter	25.2 mg/m^3

More often than not, the MSMEs are unable to meet the corresponding environmental regulations mandated by the authorities. This is mainly due to:

- Use of outdated equipment designs / lack of updated technology (mainly for smelters, annealing ovens, and rolling and polishing machines) and
- Reliance on worker/operator skills (i.e. "experience") rather than measuring devices such as temperature control mechanisms for smelters/ovens and hydrometers for caustic soda baths.

3.4 The Importance of Environmental Management and Allied Regulatory Framework in the Secondary Aluminium Sector for Utensils in Egypt

Having noted the various points of pollution generation at the MSME scale in the secondary aluminium sector operations, it becomes evident that environmental management and allied regulation have an important role to play. Chapter 4 of this report will provide detailed explanations on these aspects.

[33] Quantification for grinding and polishing taken from "Cleaner Production Case Study: Aluminum Foundries (Improving Aluminum Finishing Processes and Reducing Particulate Matter); Tiba and Mattar Companies for Aluminum" by the SEAM Programme, Egypt.

Chapter

4

4.0 Environmental Management and Allied Regulatory Framework

Chapter 4: Environmental Management and Allied Regulatory Framework

4.1 Introduction

Soil, surface groundwater and air may be defined as environmental sinks available to man for all his day-to-day activities. With each activity that man performs, there is some generation of waste matter. For instance, we have seen that the manufacture of secondary aluminium products results in wastes generated in various media (refer to Chapter 3 of this report); emissions from the smelters (medium being air), the wastewater from spent caustic soda baths (medium being liquid), and slag waste (medium being solid). While air emissions are released to the surrounding air, the wastewaters are generally discharged to receiving water bodies, and solid wastes tend to be buried (land filled). All such generated waste matter needs to be dealt with in an appropriate manner for principal purpose of restricting environmental pollution (i.e. protecting the environment), and thus maintaining public health and safety for present as well as future generations. *The application of environmental standards and regulations serves just this purpose.*

Therefore, this chapter will focus on environmental management and allied regulatory framework in Egypt, with a focus on the secondary aluminium sector for utensils shall form the core of this chapter of the report.. The following points shall be introduced and expanded on:

- The measures generally instituted in order to check the problems caused by waste generation, including:
  - The establishment of environmental standards and regulations,
  - The establishment of allied / associated regulations (e.g. regulations concerning worker health and safety),
  - The establishment of institutional framework in place for monitoring compliance with these regulations,
  - The use of waste treatment practices for the secondary aluminium sector
- The response of the MSMEs to the environmental regulatory framework,
- Perceived gaps in the environmental regulatory framework in Egypt from the MSME point of view, and
- Recommendations for addressing these gaps so that the implementation of environmental and allied standards by the MSMEs is possible and serves the purpose the regulations were ultimately intended for.

4.2 Aspects Governing the Characteristics of the Wastes Generated

Not all wastes are the same. Besides differences in the media (as remarked earlier), wastes also tend to have other differing characteristics. Therefore, it becomes important to appreciate several aspects concerning waste generation in general and waste generation with particular reference to MSME activities in the secondary aluminium sector in Egypt. With regard to secondary aluminium sector operations at the MSME scale in Egypt, waste generation tends to depend on one or more of the following features, such as:

- Technological variations: In cases where technologies used in the production line are out-of-date, there are bound to be greater pollution problems concerning air, water and solid waste generation.

- Variations as per the operations of the MSME unit: This aspect refers to whether the unit operates as a foundry or as a forming workshop as well[34]. As explained in Chapters 2 and 3, foundries mainly face pollution problems related to air pollution from smelters, while forming workshops will also face the add-on problems of pollution due to wastewater from the caustic soda bath and aluminium dust from the finishing operations of grinding and polishing.
- Quality of the raw material used during the smelting operation: As stated in Chapter 2, the resource base for production activities comprises of fresh aluminium ingots (from primary aluminium production at the Nag Hammadi factory in Egypt), as well as scrap aluminium material, which is obtained from various sources. The aluminium ingots are bound to be of better quality than the aluminium scrap material. Further, the quality of aluminium scrap material also differs – some types of scrap are of a better quality (i.e. higher purity) than others. A greater proportion of cleaner/higher purity raw aluminium material in the production process implies lower concentrations of harmful elements such as heavy metals (e.g. lead, mercury, etc.) in the air emissions from smelting operations[35].
- Variations as per the technology installed at the MSME unit: Experience has shown that sophisticated/up-to-date technology is bound to provide not just better product quality but also improved environmental conditions compared to out-of-date technologies. The improved environmental conditions generally result due to wastes that are not only fewer in quantity but also weaker in strength.
- Variations as per the operating procedure followed at the MSME unit: If the unit manufactures products in batches, waste generation will tend to be irregular , and hence quite unpredictable. However, if the unit employs a continuous processing operation, the wastes generated will also be at a continuous rate and it will be comparatively easier to predict waste strengths and quantities.
- Quantity of the end product: Larger quantities of the end product will generally entail larger quantities of waste generation and vice versa.

With the prospect of such variations in the characteristics of wastes generated, one starts appreciating the need for some mechanism which can adequately ensure the safe management of wastes. Indeed, environmental standards/regulations are a necessity if one is to protect the environment from irreparable damage.

A standard constitutes a prescribed limit, which, in the case of environmental pollution, is the permissible discharge of pollutants into the media, such as air, water and land, which in turn, sets the environmental quality criteria. Environmental standards are essential for managing the environment. To be effective as a management tool, environmental standards must be in consonance with the implementation capabilities of each country. Increasingly, standards are prescribed by Governmental authorities following consultations with the relevant stakeholders, including the private sector, to ensure an incremental advance towards higher standards of environmental quality.

[34] **Chapter 2** stated that not all foundries included forming workshops. Process manufacturing steps for forming workshops include rolling the aluminum discs/sheets from foundries to required product specifications, immersing them into a caustic soda bath to facilitate the formation of an aluminum oxide layer, followed by grinding and polishing to the final product.

[35] Source: Smells Like Money. Available at: http://www.ecocenter.org/200006/aluminum.shtml

Countries all over the world have some form of environmental standards in place. Egypt is no exception and also possesses an environmental regulatory framework.36

Given below is an examination of the overall concept of regulatory framework for environmental management.

4.3 Regulatory Framework for Environmental Management

4.3.1 Environmental Standards

Environmental standards can extend across the following 5 categories (see Figure 9), namely:37

1. Occupational health and safety standards: The standards under this category are applied to the work place and are intended to protect *the well-being of the workers within the workplace*. Occupational health and safety standards are generally specified as maximum limits of emissions in the work place in terms of pollutant concentration. The limits are further broken down into two sub-categories - exposure limits for short periods and those over an 8-hour worker shift.
2. Disposal / emission / effluent standards: The standards under this category are applied to solid wastes, liquid wastes and air emissions *after* they have been generated and *undergone treatment*. As the name suggests, disposal standards are intended to protect the *quality of soil, water bodies and air into which the wastes are discharged by limiting releases to the same.*

- Disposal standards tend to be dictated by techno-economic feasibility; i.e. the combination of the "best available technology" and the "best practical means" is the deciding factor during the establishment of disposal standards.

- Disposal standards may even extend to specify the *types of treatment technologies to be used* to ensure adequate treatment of wastes *before* they are disposed, and also the *modes of disposal of the wastes* so generated.

- At times, depending on the country where they are employed, *disposal standards may be concentration based or load based*; a load based standard would have the units cubic meter of wastewater generated per tonne of finished product (cu. m./tonne), while a concentration based standard would have the unit milligram of pollutant per litre of water the effluent is discharged to (mg/L). Thus, load based disposal standards mandate the measurement of effluent flows as well. In principle, load based

[36] **Annexes** provides details of the Egyptian environmental regulatory framework concerning the work environment, effluent, solid wastes, hazardous materials and wastes, the environmental register and emissions.

[37] Additional standards include standards for hazardous material and hazardous wastes.

standards are preferable to concentration based standards, since in the latter case, the industry can "meet" the standard through merely diluting the effluent. Since load based standards place limits on the quantity of wastewater generated in relation to the amount of finished product, they help the industry move progressively towards cleaner practices and technology.

- In some countries, disposal standards *also vary as per the age and size of the industry*, wherein newer and bigger industrial units are mandated to comply with more stringent disposal standards in comparison to their older and smaller counterparts.

3. Ambient standards: The standards under this category are concentration-based cumulative standards and are intended to *ensure the upkeep of environmental quality goals for a particular region* after effluent dilution / dispersion / mixing phenomena have been achieved (e.g. a country or, in cases where states within the country are allowed to prescribe their own separate environmental quality goals, even a state within the country. In such situations, ambient standards for the state tend to be stricter than ambient standards for the country). Ambient standards tend to be dictated by the assimilative capacity of the environment.

- *Location-specific standards* are one form of ambient standards. In this case, the environmental regulations prohibit the establishment of industrial units in locations other than the ones specified. Some countries employ this tactic to apply more stringent environmental standards to locations deemed as “sensitive”. Examples include locations close to sites designated as ecologically protected areas, particular sites where ambient air and quality standards have not been met consistently, etc. Ambient standards may also differ depending on the prevailing land zoning classifications, the mandate being that the standards in residential zones be stricter than those in industrial zones.

4. Process / technology standards: The standards under this category include restrictions and / or mandates on manufacturing processes in terms of manufacturing process technology and operating practices. These standards are intended to *limit the generation of wastes to as far an extent as possible*. By limiting the generation of wastes, the amount of waste matter which requires treatment is also reduced significantly. The extent of this limit is dependent on the prevailing manufacturing technology and operating practices in place at a particular time and therefore, these standards tend to be revised with advances in technology and / or operating practices.

- By their very definition, process / technology standards tend to be sector dependent; i.e. they vary across sectors. This is due to the fact that processes and technology differ from one sector to another. For instance, process standards for the oil refinery sector would be different from process standards for tanneries.

- Process standards may extend so far as to specify bans against the use of certain substances during the manufacturing process.

- Resource consumption standards are another variation of process standards. Here, limits are placed on the consumption of water and / or energy. However, the former is more prominently targeted by most countries.

5. Product design standards: The standards under this category mandate that the product be designed keeping in mind ecological criteria. Such standards require manufacturers to assess and take into account environmental attributes at *each stage* of a product's life cycle during its design process, in order to be able to market the product within the country / region that the standards are applied in. Therefore, product design standards *mandate life cycle assessment of the product before its manufacture.*

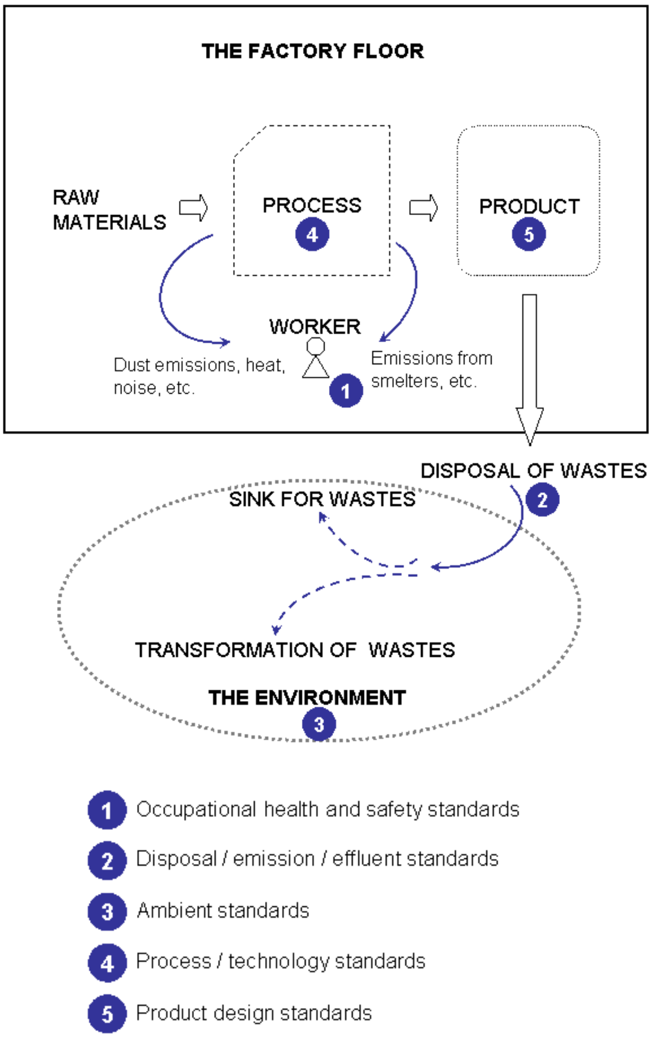
- Product design standards are intended to minimize or eliminate anticipated waste generation and resource consumption in all the phases of the life cycle; viz. raw material sourcing, production, product distribution, use, and disposal. They are a recent addition to the family of environmental standards. Due to their focus on LCA, they are also the most stringent of the prevailing environmental standards. Additionally, it is significant to note that adherence to product design standards is mandatory for export requirements. Thus, this particular category of environmental standards has the potential to affect trade between countries.

- Product design standards frequently extend to specifying packaging norms for manufactured products as well.

- Process standards may extend so far as to specify bans against the use of certain substances during the manufacturing process.

- Resource consumption standards are another variation of process standards. Here, limits are placed on the consumption of water and / or energy. However, the former is more prominently targeted by most countries.

Figure 9: The Different Categories of Environmental Regulations



Thus, there are a fair number of conditionalities in a bid to control environmental pollution.

4.3.2 The Setting Process for Environmental Standards

In the past, environmental standards were regarded as Government notifications, wherein the Government and its advisors would take stock of conducted baseline research on the environmental status, new technology, newly available information on health impacts of pollutants, etc. and issue certain decrees mandating environmental compliance. Ensuring environmental compliance has had mixed reactions across the world – countries with weak regulatory control capacities typically experience low levels of environmental compliance.

Presently, there has been a changing trend in the process of setting environmental standards. Increasingly, environmental standards are prescribed by Government authorities over the world following consultations with the relevant stakeholders such as sector leaders in the industry, technology providers, etc. Such consultations give rise to what are known as negotiated standards, whereby the Government and the stakeholders participate in a series of discussions leading to the creation of a road map envisioning incremental advances towards higher standards of environmental quality. The time lines for such road maps may extend for 5 to 10 (and perhaps more) years. Thus, negotiated standards present the ways and means to envision environmental goals well into the future. Additionally, since the negotiated standards are mutually agreed to all concerned parties, it becomes easier to ensure compliance with the standards.

4.3.3 Associated or Allied Regulations

Generally, environmental standards do not exist as a standalone; rather, there are a number of allied regulations to be complied with as well. We have already seen a very valid example (i.e. particularly valid for MSMEs in the Egyptian secondary aluminium sector) of such allied regulations in Chapter 2 of this report – namely, the regulations concerning the purity content of aluminium in finished products – 99.7% in cookware products destined for export and 95% otherwise.

Other allied regulations which are applicable to the MSMEs in this sector include the Factories Act, licensing regulations, applicable taxes, worker health and safety, employee insurance, manpower regulations, and industrial regulations (industrial control authority).

Again, such allied regulations generally exist so as to protect the workers in the unit and / or the environmental resources being used during the manufacturing processes.

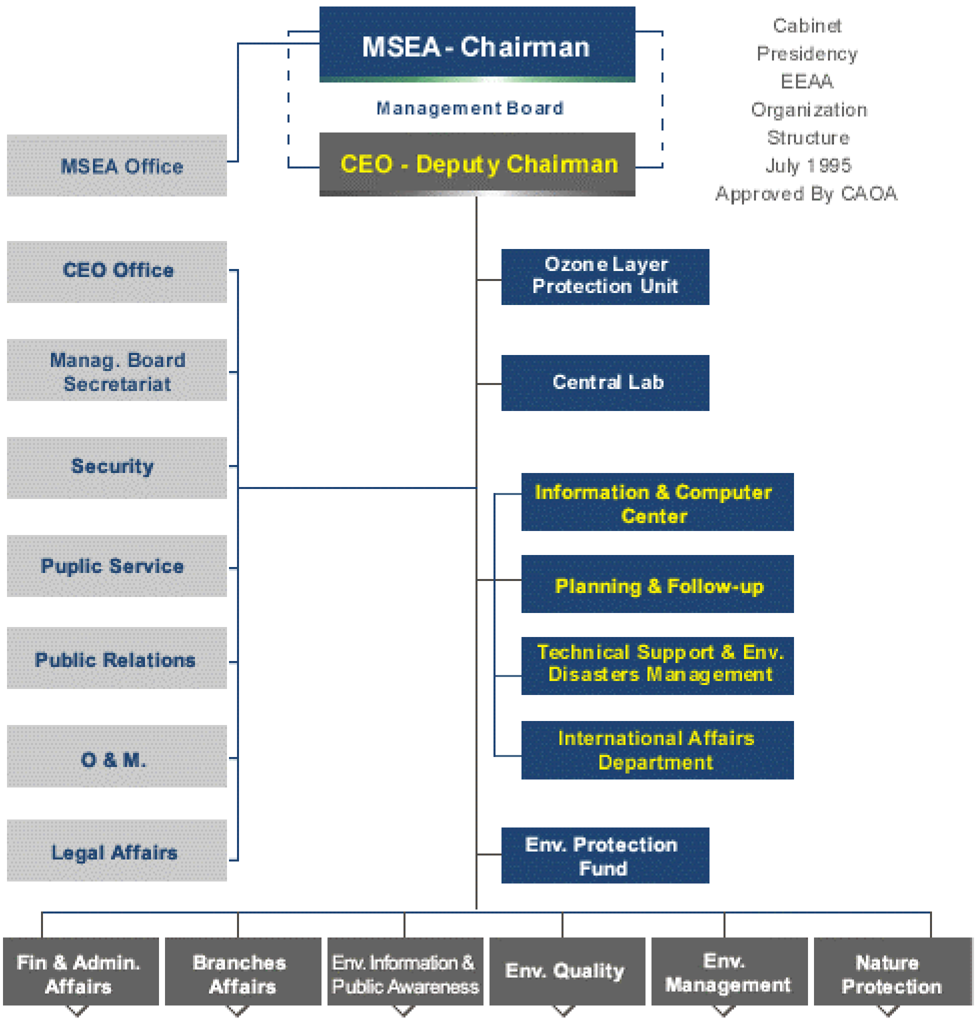
However, in many cases, MSMEs are not aware of the existence of these regulations, their intended purpose and how to comply with them.

4.3.4 Institutional Framework

In order to be effective as a tool for environmental pollution control, the standards must be in line with the implementation capabilities of each country. Implementation capabilities require the establishment of an adequate institutional framework generally consisting of an overseeing body (such as a management-cum-advisory board), an executive body, enforcement units, research and development functions, testing units, training units, etc.

In Egypt, all environmental regulations fall under the mandate of the Ministry of State for Environmental Affairs (MSEA). At the central level, the Egyptian Environmental Affairs Agency (EEAA) represents the executive arm of the Ministry. The EEAA is the highest authority in Egypt responsible for promoting and protecting the environment, and coordinating adequate responses to these issues. The EEAA is also responsible for establishing environmental standards for the country. Figure 10 provides an organization chart depicting the overall institutional set-up for the environmental regulatory framework in Egypt at the National level

Figure 10: Organization Chart Depicting the Institutional Set-up for Environmental Regulatory Framework in Egypt at the National Level



- At the Governorate level, the Environmental Management Units (EMUs) are the entities responsible for environmental management activities within each Governorate. The EMUs work in association with the Regional Branch Offices under the guidance of EEAA.

4.4 Waste Treatment Practices for the Secondary Aluminium Industry

It follows naturally, that with environmental standards in place, there is also a necessity to take corrective actions with the wastes generated. These corrective actions are taken by treating the wastes through the use of end-of-pipe (EOP) technologies. Thus, EOP measures involve treatment of the pollutants prior to their disposal to soil, water and / or air.

The following are the waste treatment practices adopted by the secondary aluminium industry the world over:

- For air emissions: Typical emission control devices include spray towers, floating-bed scrubbers, venturi- scrubbers, quench towers, electrostatic precipitators, multiple cyclones, and baghouses. Aluminium dust collection is desirable to reduce particulate emissions[38]. The maintenance and operation of these systems tends to present problems of its own and thus, would require experienced inputs from an environmental engineer. Such inputs are not readily available to MSMEs. Last but not the least, electricity / power for running effluent treatment systems in rural areas are not always as well-provided as their urban counterparts. The lack of uninterrupted power supply can serve as a major impediment in this regard.

The treated emissions are then let out through a chimney (i.e. stack) of a certain prescribed minimum height (refer to Annexes for more details).

- For wastewater: Wastewater pretreatment controls include conditioning, thickening, dewatering, conversion, and drying processes which should be designed with the consideration of the parameters of the sludge/effluent[39]. Often, the choice of the wastewater treatment process as well as the design parameters tend to differ on a case-by-case basis. Again, the operation and maintenance of such equipment involves some skill on the part of the unit where the device is installed.

Another strategy which has been reported as quite successful in the control of water pollution due to industrial operations in geographical clusters is the concept of "Common Treatment Facilities (CTFs)" or "Common Effluent Treatment Plants (CETPs)". This concept was conceived as a collective approach of achieving EOP treatment of combined industrial wastewaters by full-time professionally trained specialists at lower unit costs than could be achieved by individual industries, and to facilitate discharge monitoring and enforcement by environmental regulatory authorities. Applied to MSMEs in particular – one, because of the fact that MSMEs also concentrate in geographical clusters, and two, because the lack of finances and treatment plant operator skills are very much an issue for MSMEs also - the concept of CETPs can play a very useful role, since it can deal with most of the perceived gaps at the implementation level. A CETP equipped with a combined resource recovery unit40 and sludge treatment plant could provide an ideal solution to many of the environmental pollution problems posed by industries on a collective scale. However, while

[38] Source – "Reference Data Sheet for Aluminum" by William D. Sheridan. Available at: http://www.meridianeng.com/aluminum.html

[39] Source – "Reference Data Sheet for Aluminum" by William D. Sheridan. Available at: http://www.meridianeng.com/aluminum.html

[40] Resource recovery units are equipped to recover that part of the waste which would normally be discarded, and make it available for reuse as a resource, e.g. recovery of chromium by a resource recovery unit attached to a CETP serving a cluster of leather tanning units.

the concept of CETP appears to be a promising solution, there are also some concerns with operational and institutional aspects41, which require to be dealt with before CETPs can emerge as a holistic solution in water pollution control.

- For solid waste: Solid waste (i.e. slag) is disposed off to the landfill without any treatment.

4.5 Response from MSMEs in the Secondary Aluminium Sector to the Environmental and Allied Regulatory Framework

In general, the MSMEs in the sector are not as well-equipped as they should be in terms of complying with the environmental regulatory framework. While they may be aware as to the existence of some of the regulations associated with their line of work, there is nevertheless a lack of the following:

- Understanding as to the intended purpose of the regulation,
- Understanding as to how to comply with the regulation,
- Financing mechanisms (including capital and operating costs) for the MSME to enable them to equip itself with waste treatment equipment, and
- Skilled operators to run and maintain the waste treatment equipment.

In terms of allied regulations, the situation is not much different. The difficulties that MSMEs in the sector face when it comes to complying with worker health and safety considerations have already been noted in Chapter 2. It is significant to repeat here that most of the worker health and safety issues are closely tied in with environmental factors, which in turn are closely related to technological considerations.

Clearly then, while the environmental allied regulatory framework of Egypt is existent, there are still a number of gaps which exist within it, particularly from the perspective of MSMEs. It is important to address these gaps effectively so that the implementation of environmental and allied standards by the MSMEs is possible and serves the purpose the regulations were ultimately intended for.

4.6 The Status of Environmental Standards in Egypt from the Context of MSMEs and Strategies for Filling in the Gaps

Having gained an insight into the various aspects of environmental management and regulatory framework, it would be pertinent to review the status of environmental standards in Egypt from the context of MSMEs in the secondary aluminium sector. Currently, environmental standards in Egypt comprise of:

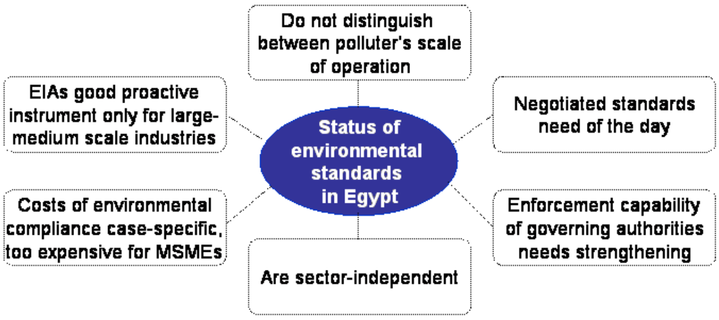
- Occupational health and safety standards,
- Concentration-based disposal standards, and
- Ambient standards.

[41] It is not within the scope of this report to expand on these features here.

The National Standards apply to all Governorates. They may be tightened only in the case of designated natural reserves within some Governorates.

A number of significant points need to be underlined at this stage (see also Figure 11):

Figure 11: The Status of Environmental Standards in Egypt



- It was noted earlier in this section that environmental standards may vary as per the age and size of the industry. However, in Egypt, environmental standards are uniform across all industrial sectors and do not vary as per the age and size of the industry. Therefore, the disposal standards in Egypt *do not distinguish between the polluter's scale of operation*. The same yardstick is applied to the large-scale enterprise as well as the micro-scale enterprise. Experience has shown that such an application is simply not tenable; it is rather like comparing an orange to an apple. While a large-scale unit may be adequately equipped in terms of finance, machinery and human expertise in addressing all the requirements set down by the standards, the MSME unit is likely to lack one or all of these to ensure that it meets the standards.
- The disposal standards in Egypt tend to be sector independent; i.e. the same laws apply to an industry engaged in secondary aluminium processing operations and an industry engaged in dairy processing. In contrast though, the nature or characteristics of wastes generated across diverse sectors is rather different, and many a time, attempting to employ the same disposal standard to wastes generated from different sectors is fairly difficult, if not impossible.
- In Egypt, Environmental Impact Assessments (EIAs) are a prerequisite for new industries, while the existing industries hold approvals for discharge permits towards meeting the standards. In the context of the secondary aluminium industry, new industries are required to undergo the grey category of the EIA. The EIA permits enquiry into the project design and investment aspects and is meant to ensure a reasonable level of certainty in compliance with the environmental standards. However, while the EIA has proved to be good proactive instrument for environmental management for medium to large-scale industries, the situation differs substantially in the case of small and micro-scale industries.
- Besides the ability of the industry to meet environmental standards, there is also the vital question of the enforcement capability of the Governing authorities. As stated in an earlier part of this section, countries with weak regulatory control capacities

typically experience low levels of environmental compliance. While certain countries have built their capacities towards enforcing the prescribed environmental standards, the situation in Egypt is quite different. The requirement of human resources and the costs of monitoring for compliance are also quite high, and tend to increase with time. While Egypt does not currently endorse negotiated standards, the increasing preference all over the world towards negotiated standards (as against prescribed environmental standards) should be viewed as a positive sign towards enabling environmental compliance and therefore, appears promising. Consequently, an enabling and well-aligned framework soliciting the co-operation of Egyptian Line Ministries, financial institutions, credit organizations, research and technical institutions, the industry, etc. becomes a crucial milestone in strengthening environmental compliance.

- Further, in attempting to meet the specifications laid down by the standards, the manufacturing units have to bear some costs. The extent of these costs will be case-specific and would depend on the type of industry, its location, its scale of operations, types of products the unit produces, manufacturing processes, age of the equipment the unit employs (i.e. old / new), maintenance of the equipment, etc. By and large, such costs tend to be highly prohibitive and hence, the MSME generally finds it very difficult, if not impossible, to comply with the required environmental standards / regulations. As environmental regulations are tightened, costs of compliance also increase, and at times, quite drastically.

In order to fill in these identified gaps, it would be worthwhile to think of long-term strategies as opposed to ad hoc short-term solutions. Instead of enforcing treatment or EOP solutions alone, it would be more prudent to test and develop several innovative approaches towards formulating a practical long-term strategy, such as aiming to generate as less pollution as possible in the first place, instead of treating large amounts of the pollution at the end of the production line. Thus, while some level of waste treatment is unavoidable, it would be prudent to explore, initiate and implement pollution prevention (as opposed to pollution control) practices in day-to-day MSME scale secondary aluminium sector operations.

We shall further explore such practices through the concept of Cleaner Production in greater detail in Chapter 5 of this report.

Chapter

5

5.0 The Concept of Cleaner Production

Chapter 5: The Concept of Cleaner Production

5.1 Introduction

In Chapter 2, it was observed that the concept of Cleaner Production can provide MSMEs in the secondary aluminium sector in Egypt with practical, cost-effective and sustainable solutions so as to address their concerns on environmental, worker health and safety, and productivity issues. In this chapter of the report, there will be an introduction to the formal definition of this concept, and how it can help an enterprise as well as the entire sector.

5.1.1 The Definition of Cleaner Production

The United Nations Environment Programme (UNEP) defines Cleaner Production formally as42:

"The continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency, and reduce risks to humans and the environment. Cleaner Production can be applied to the processes used in any industry, to products themselves and to various services provided in society."

Box 4 gives us the operational definition of Cleaner Production.

Box 4: The Operational Definition of Cleaner Production
The operational definition of Cleaner Production is as follows: ▪ *For production processes*, Cleaner Production results from one or a combination of conserving raw materials and energy, substituting toxic hazardous materials with more benign materials, and reducing the quantity and / or toxicity of all emissions and wastes before they leave the production process ▪ *For products*, Cleaner Production focuses on reducing environmental impacts along the entire life cycle of the product (from raw material extraction to its ultimate disposal) through appropriate design ▪ *For services*, Cleaner Production incorporates environmental concerns into the design and delivery aspects

This definition of Cleaner Production makes the following key points:

- Cleaner Production is a *continuous* application, not a one-time activity.

[42] Source: *Cleaner Production – Key Elements* by UNEP. Available at: http://www.uneptie.org/pc/cp/understanding_cp/home.htm.

- Cleaner Production addresses worker health and safety concerns and emphasizes risk reduction. In this perspective, Cleaner Production is a holistic environmental management strategy.
- Cleaner Production does not deny growth but insists that it be sustainable. It is a 'win-win-win' strategy protecting the environment, the health and safety of workers while improving efficiency, productivity, profitability, and competitiveness.
- Cleaner Production makes sound business sense to industries and service providers as it often results in cost reduction, improved productivity and enhanced competitiveness in wider markets.
- Cleaner Production assists regulators in developing proactive strategies for complementing enforcement, or command and control.
- Cleaner Production is a forward-looking, anticipatory and preventive philosophy.

5.2 Reasons to Adopt the Concept of Cleaner Production

Cleaner Production is a particularly strategic concept because it can take into consideration not just the interests of the enterprise, but also that of the sector as a whole. This is possible mainly due to the co-operation between different stakeholders – industry/business, government, academia (i.e. research, development and training institutions), financing institutions and communities (including workers as well as neighbourhoods affected by the industrial activity). The concept of Cleaner Production strongly promotes interaction between these stakeholders to the maximum extent possible thus solving environmental, social as well as economic issues together. Having viewed the requirements in the area of sector reform for the secondary aluminium sector in Egypt, it would be worthwhile to introduce and practice the concept of Cleaner Production amongst MSMEs in this sector.

5.3 Overview to Barriers Faced by MSMEs in Trying to Adopt Cleaner Production

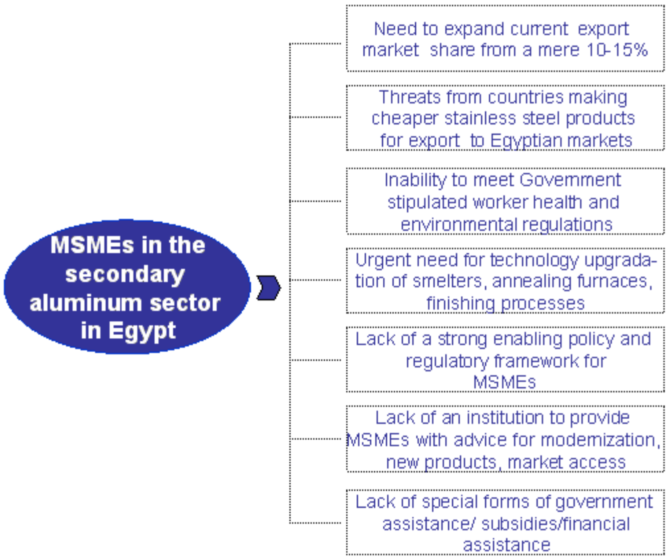
While adopting the concept of Cleaner Production makes good business sense, there are various factors which could restrict MSMEs from doing so (see Figure 12).

- MSMEs in this sector are vulnerable to the changing economic situation and competition from foreign markets/countries which export items such as stainless steel kitchen utensils to compete with Egyptian-made aluminium utensils. Additionally, competitors from countries like Korea and Dubai are threatening the traditional aluminium utensils market share in Egypt as well since they tend to have more sophisticated technologies and an increasingly better understanding of customer requirements. At the present time, only 10-15% of the export market share appears to have been tapped. Unfortunately, MSMEs lack the understanding of market forces and the financial capability to improve their knowledge of the market scenario and upgrade their technologies to compete. Such an economic scenario leads to uncertainties which compel MSMEs tend to produce below production capacity.
- MSMEs do not enjoy any government subsidies or financial incentives to aid them towards bettering their situation.
- Outdated smelter and annealing oven designs, lack of auxiliary control equipment, etc. make it difficult if not impossible for the units to meet environmental and worker

health and safety laws (refer to Chapter 2). Again, technology improvements and sustained on-the-job training become important points in this regard.

- The absence of a strong enabling policy, regulatory and institutional framework has been hampering MSMEs in the secondary aluminium sector.

Figure 12: Barriers Faced by MSMEs While Trying to Adopt Cleaner Production



5.4 Cleaner Production Options: Ways and Means to Implement Cleaner Production (with Specific Reference to MSMEs in the Secondary Aluminium Sector for Utensils in Egypt)

Having understood the need for MSMEs in the secondary aluminium sector to implement Cleaner Production, this sub-section will provide an explanation of how they may go about it. “Cleaner Production options” entail the various means to implement Cleaner Production. They are identified using a tool known the “Cleaner Production Opportunity Assessment” or CPOA. The options could fall under one of the following categories:

- <u>Housekeeping</u>: Improvements to work practices and methods, proper maintenance of equipment etc., fall within this category. Efficient housekeeping can provide significant benefits in terms of saving resources. These options tend to be low cost and provide low-to-moderate benefits[43].

A simple example of good housekeeping in a secondary aluminium production unit would be the re-organization of the smelting site layout in foundries. Such improvements have the potential to allow improved feeding of aluminium scrap to the smelter, reduced worker safety risks (from injures which may occur near the smelter) and also increased productivity (since more scrap material could be smelted in the same time period).

[43] Interested readers may like to refer to *Good Housekeeping Guide for Small and Medium-sized Enterprises* (available at: www.getf.org/file/toolmanager/O16F15343.pdf).

- Management and personnel practices: This option includes employee / staff training, enhancement of operator skills, effective supervision on the shop floor / unit. Depending on the number of staff / people to be trained, this option may involve low-medium costs and provides moderate-to-high benefits.

A simple but important example of instilling good management / personnel practices in secondary aluminium production unit would be training provided to staff for the correct operation of all machinery/equipment used for production activities - for instance, the operation and handling of the aluminium smelters, annealing ovens, caustic soda immersion baths, grinding and polishing machines, lathes, etc. Correct operation of the equipment not only ensures improvements in product quality and less product rework, but also better worker health and safety, and longer life of the equipment.

- Process rationalization: Experience has shown that very often, the machinery/equipment used in the process is not done so optimally; i.e. as per the equipment manufacturer's specifications/manual. When this is the case, the equipment cannot operate at its best efficiency and this reflects downstream in the quality of the product and/or the overall efficiency of the process. Manufacturer's specifications for the equipment could include warnings as to the types of raw materials not to use with the equipment, range of pressure/temperature combinations to be used, loading parameters and so on.

The reasons for sub-optimal operations involving machinery/equipment are many; for instance, the employee handling the machinery may be unaware of the manufacturer's specifications and thus requires awareness and training for the same, or the machinery may be bought second-hand and the manufacturer's specifications may be missing, or the business may not have a Preventive Maintenance Programme in place and thus, its equipment may have gone into a state on misuse/disrepair. Thus, rationalizing the process would involve checking that “things are working as they should be”. This option involves low costs and provides moderate benefits.

For MSMEs in the secondary aluminium sector, process rationalization could form a major avenue for Cleaner Production implementation. The lack of observance with a number of operating parameters, particularly in the caustic soda immersion process, provides crucial points for improvement. Many a time, the caustic soda bath process is operated with “worker experience” alone rather than the use of temperature control mechanisms or controls to clock the time of product immersion. The installation of controls to allow accurate setting/reading of the temperature of the bath as well as the requisite time period for product immersion in it, thus form one aspect of process rationalization for the secondary aluminium sector.

- Process optimisation: This option involves rationalization of the process sequence, combining or modifying process operations to save on resources and time, and thus improve the overall efficiency of the process. This option typically involves low-medium costs and provides moderate-high benefits.
- Raw material substitution: Primary / auxiliary raw materials can be substituted if better options exist in terms of costs, process efficiency, and reduced health and safety related hazards. Such an approach may be necessary if the materials already in use are difficult to source or become expensive, or come under the purview of new

environmental or health and safety regulations. In all cases of material substitution, it is crucial to test the suitability of the new material in terms of environmental and economic benefits, optimum concentration, product quality, productivity, and improved working conditions. This option generally involves low-medium costs and provides moderate-high benefits.

A simple example for raw material substitution for a secondary aluminium production unit is the substitution of mazout by liquefied petroleum gas (LPG). Egyptian environmental standards prohibit the use of mazout as fuel. Thus, raw material substitution becomes a necessity in the case of mazout since the material comes under the purview of environmental regulations. Further, LPG has proven benefits in terms of economy and improved working conditions (through reduced emissions), to make it a suitable choice for the new material.

- Onsite recycling and reuse: This Cleaner Production option involves the return of a waste material either to the originating process or to another process as a substitute for an input material. This option typically involves low-medium costs and provides moderate-high benefits.

An example of this option in a foundry would involve the recycling of trimmings/cutting residues left over from the cutting process44. All the MSME foundries in Egypt already practice this Cleaner Production option.

- Recovery of useful by-products and resources: This Cleaner Production option entails the recovery of wastes as by-products / resources, which may have useful applications within the industry itself or outside it. This type of options essentially leads to the reuse / recycle, and thus minimization, of waste as well as to cost savings. This option entails low-medium costs and provides moderate-high benefits.

An interesting example of this option for MSME forming workshops would be the recovery and reuse of sludge produced from the caustic soda immersion bath step. The sludge is mostly aluminium hydroxide that can be reused in paints, cement or ceramics45.

- New technology: Adopting and transferring new technologies can often reduce resource consumption, minimize wastes, as well as increase the throughput or the productivity. These options are often capital intensive, but can lead to potentially high benefits. Modifications in equipment design can be another option, which tends to be slightly less or equally capital intensive as the option for new technology, and can lead to potentially high benefits.

An example of new technology for an MSME scale secondary aluminium production unit would be redesign of the annealing furnace to include improved insulation towards preventing heat loss, and to ensure homogeneous distribution of heat inside the furnace by the circulation of the hot gases from the combustion chamber all the way up in the furnace and down into the product until they are expelled through the chimney/stack. The

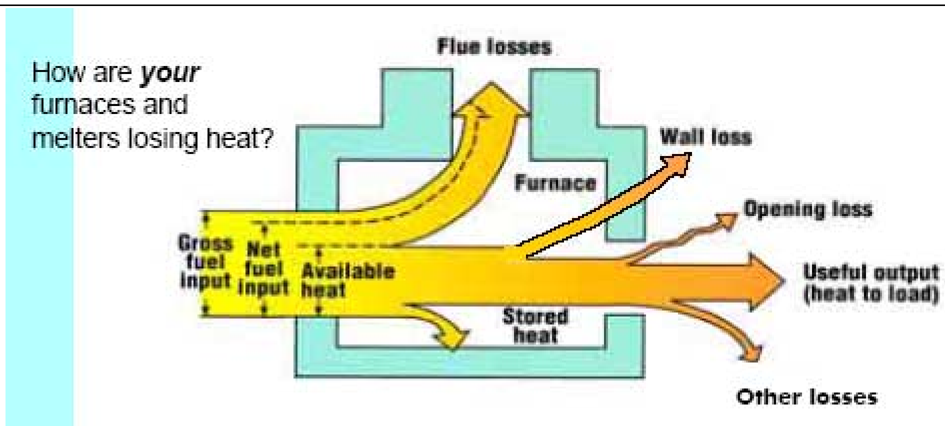
[44] Refer to **Chapter 3** for "Process Steps for Manufacturing Aluminum Discs in Foundries".
[45] Source: Chemical Fact Sheet – Aluminum. Available at: http://www.speclab.com/elements/aluminum.htm

improvements in annealing furnace technology have the potential to effect a number of improvements and are thus regarded as highly beneficial to the unit. These improvements take the form of:

- Significant reduction in fuel consumption (due to reduced heat losses)
- Decrease in material wastage or rejects from the rolling process by as much as 20% (as a result of the homogeneous temperature distribution within the aluminium sheets/discs)
- Drastic reduction of worker injuries in the rolling and forming areas due to disintegration of the improperly annealed sheets/discs

Another example of technology improvements in this sector involves the redesign of smelting furnaces, which are currently liable to incur large quantities of heat losses (see Figure 13). The magnitude of heat losses not only means more fuel consumption, but also loss of productivity and uncomfortable working conditions for the employees.

Figure 13: Problems in Heat Losses with Incorrect Smelter Furnace Design



- <u>New product design</u>: As the name implies, this option concerns designing a brand new product. In order to accomplish this, (often) considerable research, laboratory and pilot-scale testing would be required so as to ensure that the new product would meet expectations of taste, texture, ease of operations, pricing, market demand, etc. before it is introduced to the market. This particular Cleaner Production option is the most expensive of all options. However, if planned and implemented correctly, it could lead to very high benefits for the unit.

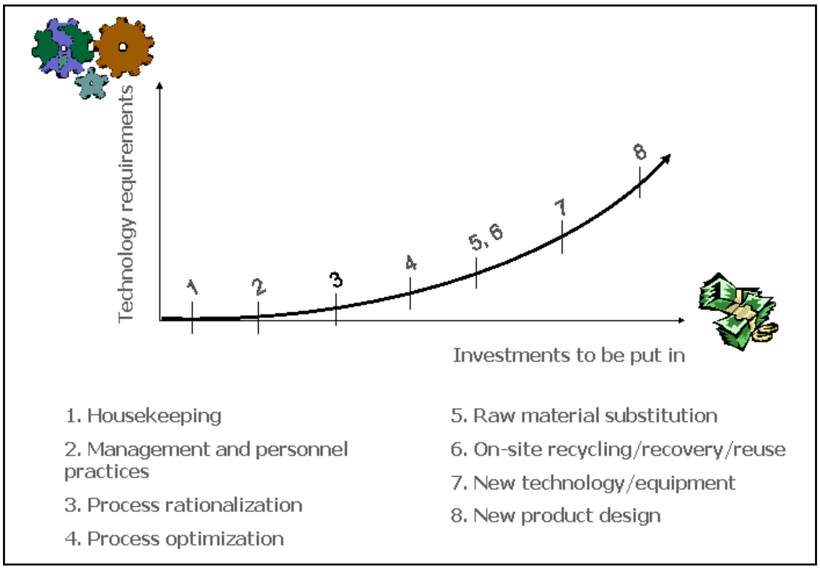
An example of new product design for an MSME scale secondary aluminium production unit could be the expansion of the product range to include aluminium foil, aluminium wires, corrugated aluminium sheets, castings for the car industry, etc. implementing this option for the secondary aluminium sector in Egypt could make a difference between survival and closure of the industry. As it stands today, the sector produces kitchen utensils and cooking pots as products. Expansion of the product range would add great value to this industry through the formation of new and more lucrative markets[46].

5.4.1 A Planned Approach in Implementing Cleaner Production Options

There are some important points which should be kept in mind while experimenting with / instituting Cleaner Production options. They are as follows:

- In general, it is better to not generate a waste in the first place, rather than generate it and later recycle or recover / reuse it. Therefore, one should only consider the latter type of options once all the others that could prevent waste generation have been examined. In general, therefore, the hierarchy of options available from the view points of technology and investment requirements may be recognized and practiced as shown in Figure 14.

Figure 14: Hierarchy of Cleaner Production Options from the View-point of Technology and Investment Requirements



- In reality, many of the options a team will identify result as a combination of the above categories so as to produce cost-effective and sustainable results. For instance, any option of new technology should be preceded and followed by improvements in management and training. In addition, many a time, the option of new technology also requires substitution of raw materials.
- It is important to bear in mind that some of the chosen options may require major changes in the processes or equipment or product. Often, these will dramatically

[46] Refer also to **Figure 2.1: Uses of Aluminum** (given in **Chapter 2** of this manual).

reduce waste generation or increase productivity, but they also often imply considerable investments.

- In the case of product re-design as a Cleaner Production option, one should remember that it is a major business strategy. It is likely to involve feasibility studies and market surveys, especially if the supply-chain around the product is already established and is complex.
- It is equally important to bear in mind that certain chosen options will require thorough laboratory / bench scale / pilot studies to ensure that the product quality does not degrade as a result of their application, and that it is acceptable to the market.

5.5 A Programmatic Approach to Introducing and Sustaining Cleaner Production in MSMEs

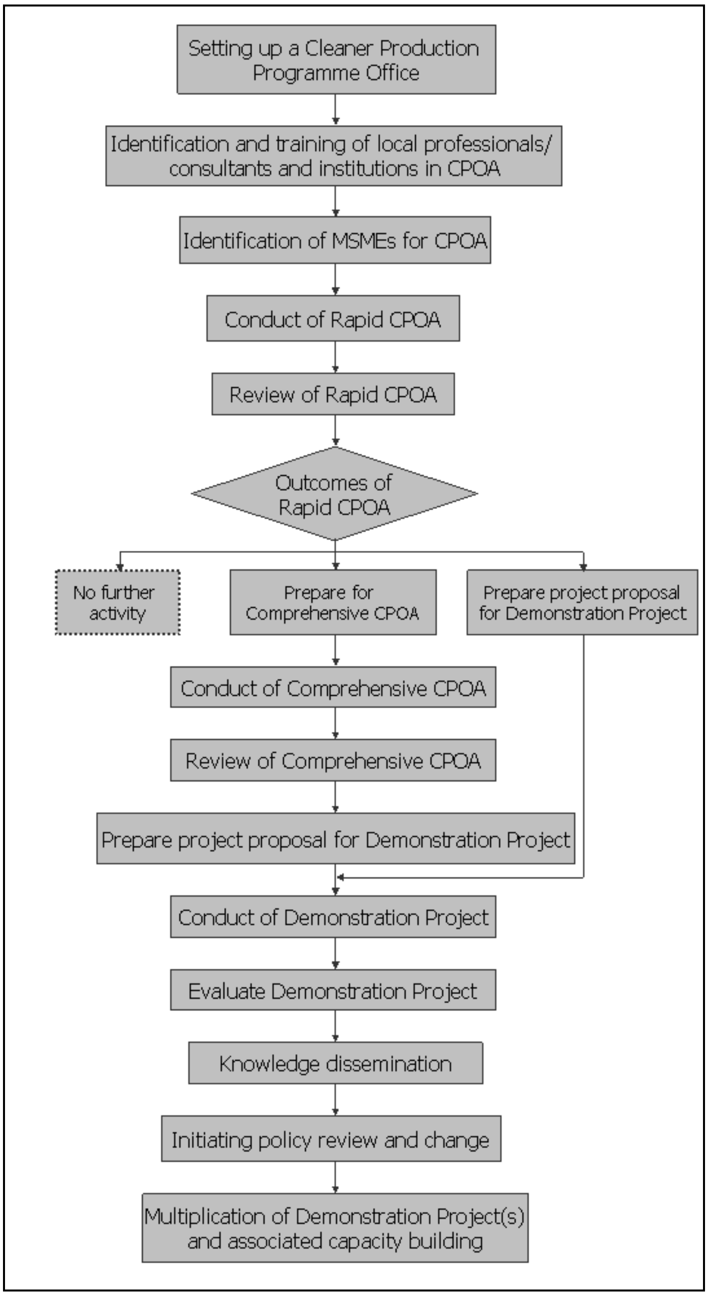
A programmatic approach encourages and enables the formulation of a broader overall outlook which addresses the environmental, social as well as economic concerns in a comprehensive and sustained manner, crucial aspects of Cleaner Production implementation. *Without this approach, standalone projects and / or programmes, however well-intentioned, cannot be sustained.* Through this approach, four vital things can be accomplished:

1. Building the capacity (i.e. awareness followed by in-depth understanding) of local consultants for Cleaner Production in the sector,
2. Identifying promising Cleaner Production options to be implemented at MSME units and their subsequent conversion into Demonstration Projects (so that the benefits of Cleaner Production become evident to the MSMEs),
3. Initiating appropriate policy change and review, obtaining support of the Line Ministry, and enabling financing mechanisms so as to ensure the support of Cleaner Production in the sector, and
4. Dissemination of the knowledge and experiences earned from the Demonstration Projects so as to achieve a multiplier effect through geographical clusters of MSMEs47.

The various steps involved in the programmatic approach are explained in Figure 15.

[47] **Figure 2.4** of **Chapter 2** shows that MSMEs in the secondary aluminum sector tend to operate in geographical clusters.

Figure 15: Steps Involved in the Programmatic Approach to Practicing Cleaner Production at the MSME Scale



Interested readers may like to refer to the SEAM Guidance Manual on "A Guide for Cleaner Production Opportunity Assessments in Small and Medium Enterprises"48. All the micro-steps have been thoroughly covered under the manual and it is not the intention of this report to reproduce an explanation of each step here. Nevertheless, there are some points that one must keep in mind and these are listed below.

[48] Available at: http:www.seamegypt.org

5.5.1 Building the Capacity (i.e. Awareness Followed by In-Depth Understanding) of Local Professionals for Cleaner Production in the Sector

Once the Programme Office has been set up, the identification and training of local professionals in CPOA should be undertaken. The local professionals should have had previous exposure to the sector(s) chosen for Cleaner Production interventions and ideally some working knowledge of the Cleaner Production concept. International consultants should also provide inputs as and when required, e.g. for the provision of overall methodologies to be followed, training of local consultants, review of outputs and advice, training on the preparation and implementation of new Demonstration Projects, etc. International consultants would be required mainly to enhance and build the capacity of national consultants, who in turn will be responsible for taking forward all the Cleaner Production activities normally entrusted to international consultants once their capacity has been adequately built. The national consultants would thus be responsible for conducting Cleaner Production activities at the national and regional levels, and would be involved in the development and training of local professionals / trainers through hands-on training. Thus, a simple but crucial framework for training and capacity-building activities must exist for any Cleaner Production Programme to be a success.

5.5.2 Identifying Cleaner Production Options through the "Cleaner Production Opportunity Assessment" Tool

Cleaner Production options are identified through the use of a management tool called the CPOA. It consists of a systematic and an objective review of manufacturing processes, products and services. It is designed to identify Cleaner Production opportunities for increasing productivity, profitability and sustainability of the enterprise, while reducing its environmental impacts and associated risks.

The Rapid CPOA is a quick appraisal of environmental and productivity related opportunities of the selected MSMEs. It is based predominantly on observations made during a walkthrough as well as discussions with the owner. The Rapid CPOA is generally conducted with the assistance of Cleaner Production practitioners or consultants with cooperation of the MSMEs. Based on the findings of the Rapid CPOA, decisions are taken in terms of the nature of assistance possible for each selected MSME. These decisions could be of either of the following forms:

- No further investigation is warranted; i.e. all further investigations stop at this point. This conclusion is reached if the Rapid CPOA shows that there are no innovative opportunities related to Cleaner Production at the MSME or the owner of the MSME is not interested or is supportive of the Demonstration Projects.
- Opportunities for demonstrating Cleaner Production exist. Some of these options may be readily implemented if a suitable proposal is prepared based on the results of the Rapid CPOA.
- Opportunities for demonstrating Cleaner Production exist, however their implementation will require more detailed assessment in the form of a Comprehensive CPOA.

If a detailed assessment is felt to be required for identifying the Demonstration Project, a comprehensive CPOA will have to be conducted. A Comprehensive CPOA includes a more detailed assessment of Cleaner Production options. This assessment is accompanied by cost-benefit analyses and an implementation plan. It is generally conducted with the assistance of Cleaner Production practitioners or consultants with cooperation of the MSMEs.

A strategy of deploying more number of Rapid CPOAs helps in scoping few Comprehensive CPOAs to implement "quality" Demonstration Projects. Implementation of Demonstration Projects through a two step sequence of Rapid and Comprehensive CPOAs is therefore a cost-effective strategy. Both Rapid and Comprehensive CPOA provide hands-on training to the Cleaner Production practitioner, and are therefore useful in building local capacities, especially to achieve a multiplier effect.

It has already been noted that Cleaner Production is not a one-time activity. Therefore, the CPOA should also not be treated as a one-time activity and should be conducted at least once a year, so as to ensure the long-term positive effects that it can offer to the enterprise.

5.5.3 Earmarking Demonstration Projects

The review of Comprehensive CPOA report should lead to the identification of Demonstration Projects at selected MSMEs. In order to finance and implement a Demonstration Project, it is necessary to prepare a project proposal. This project proposal is generally submitted for approval, to the programme office / agency funding the programme for financial / technical assistance. The proposal should address the need, implementation methodology, cost-benefit analysis, financing mechanisms required, responsibilities etc. of the project.

The Demonstration Project is then evaluated based on certain criteria. The evaluation helps to understand whether the Demonstration Project has been successful in achieving its aims and objectives, and whether it is appropriate for replication. Evaluation also assists in identification of policy-related triggers that may be useful to resolve some of the barriers.

Knowledge dissemination of a Demonstration Project is the next crucial step as it enables maximum replication of Cleaner Production options at other MSMEs also.

5.5.4 Initiating Policy Review and Change

Policy change is a necessary precursor to create an enabling environment for inducing the replication / multiplication of Demonstration Projects.

This step addresses policy makers, financial institutions, regulators as well as business / trade associations.

5.5.5 Multiplying Demonstration Projects and Enabling Associated Capacity Building

Multiplication of successful Demonstration Projects necessitates additional inputs from various sources, which may be missing and identified only once a Demonstration Project is targeted or underway. Such sources may include guidance to the new units / enterprises participating in the multiplication stage in the form of training workers, preparation of bankable financial proposals in cases where Cleaner Production options involve higher costs of implementation, training of new CPOA professionals, involvement of the private sector and academic institutions.

For instance, academic and research organizations have an interesting role to play in the promotion of Cleaner Production. They support the research necessary to bring about some of the Cleaner Production innovations. In many cases, they also provide a sound infrastructure for monitoring and analysis activities required in CPOAs. It is important to note that today's students in such institutions will be employed by the industry of tomorrow. Thus, an early exposure to Cleaner Production concepts can go a long way in mainstreaming Cleaner Production in the sector.

The SEAM Programme follows the programmatic approach for all its Cleaner Production interventions.

Having understood the holistic concept of Cleaner Production, Chapter 6 of the report will endeavour to provide an analysis of Cleaner Production opportunities for MSMEs in the secondary aluminium sector, in terms of Cleaner Production experiences in the sector throughout the world, lessons learnt from them, barriers specific to Egypt, and the strategies which may be employed for MSMEs in the sector in order to overcome these barriers.

Chapter

6

6.0 Cleaner Production Opportunities

Chapter 6: Cleaner Production Opportunities

6.1 Introduction

Chapter 5 of this report elaborated on the concept of Cleaner Production and its significance for the MSMEs in the secondary aluminium sector in Egypt. It also introduced the terms "Cleaner Production Opportunity Assessment" and the 4P approach advocated by the SEAM Programme towards introducing and sustaining Cleaner Production for MSMEs in Egypt. As a follow-up to Chapter 5, this chapter will provide an analysis of Cleaner Production opportunities for MSMEs in the secondary aluminium sector.

The secondary aluminium industry around the world has been well established since the early 1900s[49]. However, the scale of production and sophistication of technology used differs significantly from country-to-country. Basically, while the production process for any particular item (e.g. cookware, aluminium wires, aluminium parts to be used in the automotive industry, etc.) manufactured by the industry is more or less the same, some differences may remain. Thus, it may sound inappropriate to provide an assessment of prevailing or newly established practices in the sector between the secondary aluminium sectors in different countries, but such an analysis is nevertheless useful in gaining an understanding as to the strengths of the Egyptian MSMEs and the challenges facing them in terms of revamping their business operations.

6.2 Cleaner Production Opportunities in the Secondary Aluminium Sector

Chapter 3 of this report provided information on the process descriptions of MSME operations (foundries and forming workshops) in the sector. This chapter will follow the different steps in the process descriptions and where available, will outline possible Cleaner Production opportunities against each step. Accordingly, the process steps for manufacturing semi-final aluminium products in MSME foundries are provided as Figure 16 (i.e. cookware)[50].

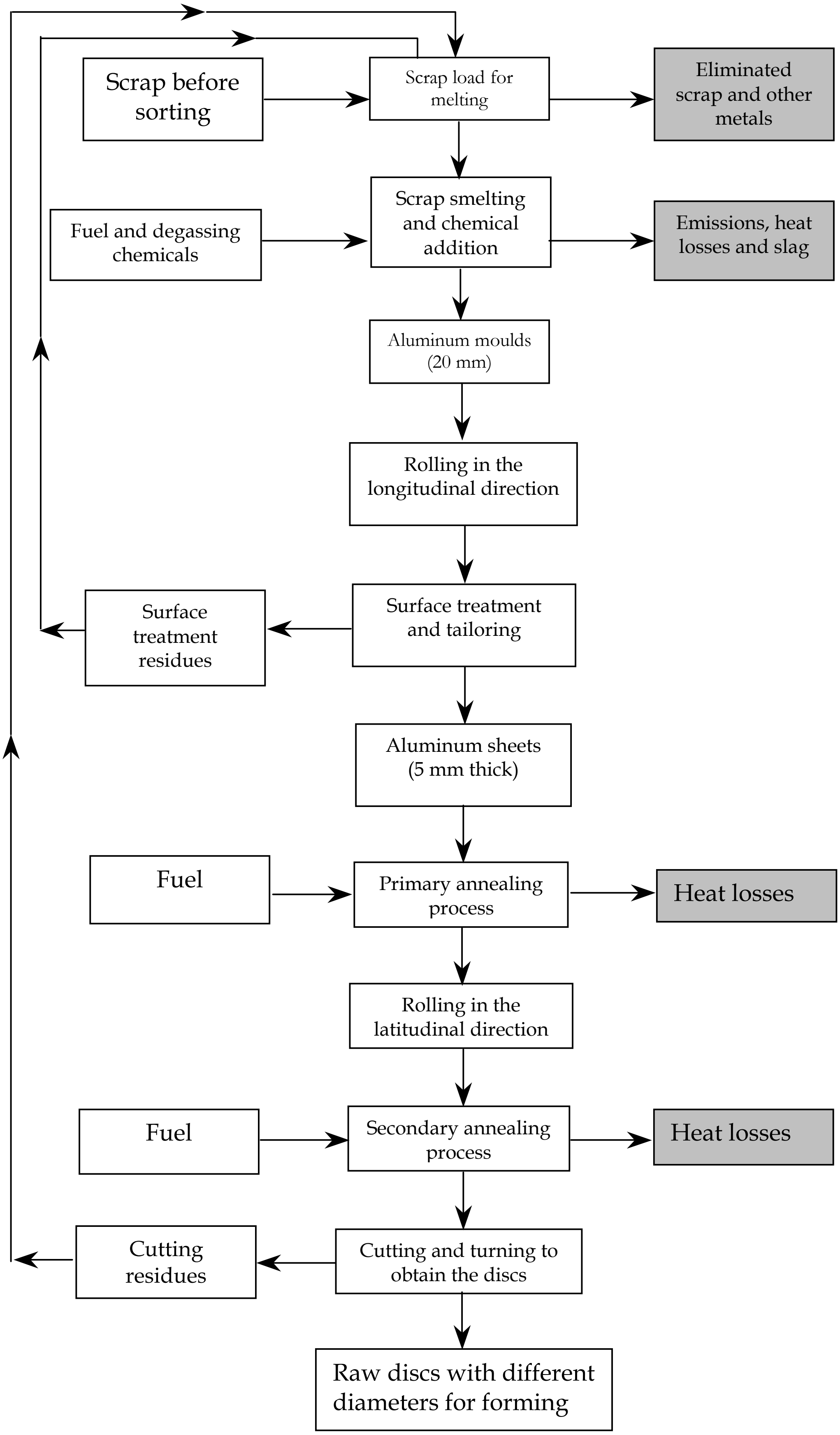
6.2.1 Cleaner Production Opportunities in Foundries

Cleaner Production opportunities for foundries will be discussed in this sub-section.

[49] Source: Definition of "Aluminum". Available at: www.webster-dictionary.org/definition/aluminum

[50] Reproduced from the corresponding figures given in **Chapter 3** of this report.

Figure 16: Process Steps for Manufacturing Semi-final Aluminium Products in Foundries



Each Cleaner Production opportunity for a step is outlined under the following bullets:

- Background
- An explanation of the Cleaner Production opportunity for that step/process
- Cleaner Production option category[51]
- Technology working/specifications
- Benefits gained from the Cleaner Production opportunity
- Calculated payback period for the demonstrating company
- Status of MSMEs in Egypt concerning decoating of aluminium scrap

Step 1: Sorting aluminium scrap

BACKGROUND: DECOATING AS PART OF THE SORTING OF ALUMINIUM SCRAP[56]

A critical part of the aluminium recycling process is the removal of organics such as oil, rubber, plastics, paint, etc. from the scrap aluminium material. Proper organics removal is called "decoating" and has a great impact both on the quality of the final recycled aluminium and on the energy use and emissions generated during the process. Since the scrap material is likely to come from a variety of sources (e.g. old aluminium wiring/cables, etc.) and is likely to have undergone some wear and tear, the decoating operation becomes significant. If unprocessed organics / improperly decoated scrap are fed into the furnace along with the scrap material, they tend to vapourize and contaminate the scrap. The contaminated portion of the melted aluminium must then be removed as waste. Additionally, once in the furnace, the burning of organics results in an undesirable increase in volatile organic compounds (VOC) and particulate emissions. Generally, conventional decoating technologies (gas kilns, typically with low thermal efficiencies) have difficulties in ensuring total organics removal52.

Dust is both an environmental and financial problem in the process, and arises as a result of the direct-fired nature of the conventional decoating kilns. Because the burner flames directly impinge on the scrap, the surface undergoes significant thermal shocking, which produces 6-7% dust which is harmful for worker health.

Overheating the scrap in the conventional decoating kiln is possible, and with the amount of oxygen present, an oxide coating is formed. After charging into the furnace, the oxidized scrap (along with the aluminium substrate) is removed and discarded as slag. Alternatively, the kilns can underheat the scrap, resulting in inadequate decoating, which leads to oxidation in the furnace and a subsequent increase in slag. As much as 8% of the furnace melt material could be lost as slag.

CLEANER PRODUCTION OPPORTUNITY IN THE DECOATING OPERATION

---

[51] Explained in more detail in **Chapter 5** of this report.

[52] Due to this fact, conventional decoating technologies will not be discussed in this report. They are being superseded by a better version of technology and it is the latter version which will be presented here.

The Energy Research Company (ERCo), teamed with Wabash Alloys (formerly Roth Brothers Smelting Corporation), the U.S. Department of Energy's National Industrial Competitiveness through Energy, Environment, and Economics (NICE3) Programme, and the New York State Energy Research and Development Authority (NYSERDA) to demonstrate a system to decoat aluminium using an indirect-fired, controlled atmosphere kiln called IDEX™. The IDEX decoater was installed at Roth Brothers, classified as a large-scale secondary aluminium processor in the United States, in January 1997.

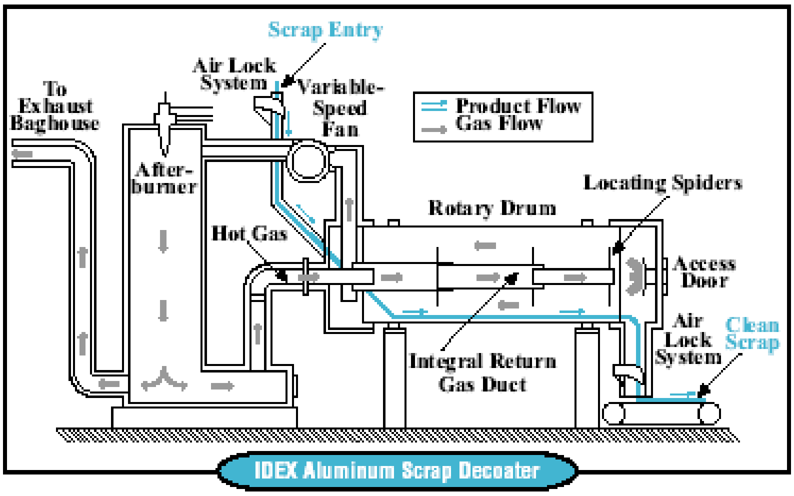
CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under the Cleaner Production option category of "new technology".

TECHNOLOGY WORKING/SPECIFICATIONS

To eliminate the introduction of the organics into the furnace, the IDEX first decoats the scrap in a low-oxygen, controlled atmosphere rotary kiln (see Figure 17). The scrap enters the kiln through an air lock. The combination of the kiln rotation and the internal baffles disperses the scrap throughout the kiln. The scrap stays in the kiln about 15 to 20 minutes. Gases at 800°C enter the kiln's centre tube, flow parallel to the scrap, then reverse direction after exiting the centre tube. The heat of the gases vaporizes the organics in the scrap in the kiln (instead of combusting them and adding to the emissions). Because the oxygen in the kiln is kept below the lower flammability limits of the organics, no combustion takes place in the kiln.

Figure 17: The IDEX™ Aluminium Scrap Decoater



After vaporization, the gases are passed from the kiln to an incinerator (afterburner) to elevate the temperature. In this environment, the organic vapours are allowed to combust - this process not only destroys the VOCs, but also releases a significant amount of heat. The fuel consumption continually decreases as the VOC content increases because the heating value of the VOCs is used in the process. With no VOCs, 2,600 kJ/kg are required, reducing to 800 kJ/kg at 4% VOC (2%

moisture). As the VOC content increases, a so-called autothermic53 point is reached at which no natural gas is needed. A portion of these gases is thus recirculated to the kiln to provide heat to drive the kiln vaporization process. The remainder is directed to the baghouse for final processing.

BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

Box 5: Benefits of Installing the IDEX™ Aluminium Scrap Decoater Technology

- Energy savings of 55% over conventional decoating technologies. For the years 1997-2000, the company calculated a cumulative cost savings of USD 1.8 million (or about LE 11 million) due to reduction in natural gas usage.
- Reduced air emissions from reduced energy use.
- Improved product quality, less waste generation and thus, greater productivity.
- Reduced solid waste disposal due to reduced waste generation. The company calculated reduced land fill costs of USD 260,000 (about LE 1.6 million) annually.
- Reduced VOC and particulate emissions; hence ease of meeting environmental compliance.
- Improved worker health due to reduction in emissions
- The scrap emerges from the IDEX clean and furnace-ready (at 330°C) for subsequent smelting and alloying. If this hot scrap is fed into the furnace, additional energy savings are possible to the tune of 850 KJ/kg.
- Reduction in metal loss from 8.2% to 7.5% with the IDEX taking up only 20% of the feedstock

  Ability to accept a wider range of aluminium scrap materials than previously possible

CALCULATED PAYBACK PERIOD FOR THE DEMONSTRATING COMPANY

With production valued at USD 1.32 per kg54 (USD 0.60 per lb), the total increase in gross revenue would be USD 3.1 million. Additionally, the landfill costs for disposal would be avoided, giving an additional USD 260,000 savings to the plant. Combining all these benefits results in a payback of much less than one year.

STATUS OF MSMES IN EGYPT CONCERNING DECOATING OF ALUMINIUM SCRAP

At the present time, Egyptian MSMEs do not follow decoating procedures before melting aluminium scrap. This is because the inputs to the secondary aluminium production process are generally "clean" – i.e. a mixture of pure aluminium ingots and aluminium scrap from material such as used kitchen utensils, etc. However, as stated earlier, since the scrap material is likely to come from a variety of sources (e.g. old aluminium wiring/cables, etc.) and is likely to have undergone some wear and tear, the decoating operation becomes significant. Moreover, if the

[53] When the energy release from the VOCs is equal to, or in excess of, what the process requires.

[54] At 1997 rates.

MSMEs decide to accept scrap aluminium from sources other than the ones currently in use (say, aluminium cans, etc.), the decoating operation becomes a necessity.

Although the scale of technology illustrated here is much larger than requirements of typical Egyptian MSMEs, it would be prudent to initiate some research towards adapting this technology indigenously55.

Step 2: Forming and preparing the scrap for melting according to product requirements

BACKGROUND: IMPROVEMENTS IN DEGASSING[60]

As seen in Chapter 3, bubbling inert gas such as inert argon or inert nitrogen through a melt of aluminium reduces the amount of undesirable hydrogen (also referred to as "degassing"), non-metallic inclusions and alkali metals in the aluminium metal, and increases the quality of the semi-final product. The inert gas bubbles bring about an excellent stirring that assists in homogenizing the temperature and chemical composition of the melt. The addition of a reactive substance like chlorine to the inert gas is normally practiced in larger secondary aluminium processing units to further improve the quality of the melt by reacting with and removing the unwanted hydrogen.

The improvements to the degassing process come in the form of substitution of chlorine with sulphur hexaflouride (SF6).

CLEANER PRODUCTION OPPORTUNITY IN DEGASSING56

SF6 is mixed with the gas at a 2.5% or 5% level. Unlike chlorine, SF6 is non-toxic, non-corrosive and not listed as a carcinogen. This overcomes the two major problems chlorine brings to the working environment - corrosion and worker health hazards.

CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under the Cleaner Production option category of "raw material substitution".

TECHNOLOGY WORKING/SPECIFICATIONS

This particular mixture of chemicals is referred to as "Linde Mix 14" and the application of this process is patented by Linde Gas LLC, a company based in the United States. More commercial information may be obtained from the company at http://www.us.lindegas.com/International/Web/LG/US/likelgus.nsf/DocByAlias/nav_industry_alum_stir.

---

[55] More information on decoating technologies may also be obtained from The Aluminum Decoating Handbook by Richard Evans and Graham Guest. Available at: www.gillespiepowers.com/brochures/aluminum%20decoating%20handbook(gpx-adhb-001-060900).pdf

[56] This particular mixture of chemicals is referred to as "Linde Mix 14" and the application of this process is patented by Linde Gas LLC, a company based in the United States.

In fact, most degassing technologies viewed on the World Wide Web are patented[57] and technical information is available to the interested company only once it becomes a client.

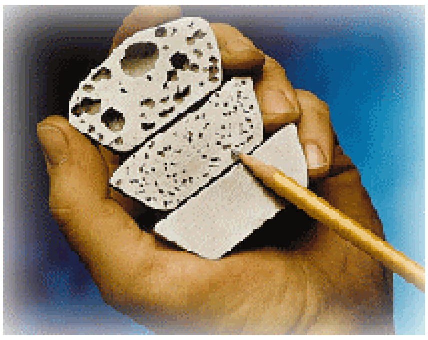
BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

Box 6 provides the benefits of this Cleaner Production opportunity.

Box 6: Benefits of Improvements in the Degassing Process
▪ Better removal of hydrogen leading to lower porosity in the semi-final product (see Figure 18) ▪ Removal of non-metallic impurities and unwanted alkali metals ▪ Improved quality and properties of the final product ▪ Non-toxic and non-corrosive compared to chlorine which is used conventionally ▪ Easy to use

[57] See also **Degassing Methods and Consumables** by © Refractech Pty Ltd. at http://www.refractech.com.au/foundry.htm

Figure 18: Gradations in Bubble Formation in the Semi-final Product due to Inadequate Removal of Hydrogen Gas and Impurities[58]



CALCULATED PAYBACK PERIOD

Information not available at this time.

STATUS OF MSMES IN EGYPT CONCERNING THE DEGASSING PROCEDURE

At the present time, the majority of the MSMEs do not use degassing chemicals. The main reason is that is too expensive relative to the products they manufacture. In some cases, the MSMEs use degassing chemicals when the client requires a product of high quality (e.g. products which will be exported).

Step 3: Melting scrap and pouring into moulds

BACKGROUND: IMPROVEMENTS IN THE DESIGN OF THE FOUNDRY SMELTER[59]

As noted in Chapter 2, the smelter ovens are generally inefficient due to poor (i.e. incomplete) fuel combustion, which causes the release of air pollutants such as particulate matter and hydrocarbons. The concentration of particulate matter near typical MSME smelters has been reported to be 15 parts per million (ppm) or higher, a number which is over the allowable limit of 10 ppm as per Egyptian Law 4/1994 and ER 338/1995.

Excessive slag is generated as a result of the formation of aluminium oxides from direct burning in smelters. Additionally, the current practice in handling of degassing chemicals to be added during the smelting phase has also been reported to be unsafe, particularly from the point of view of worker health. Frequent incidences of flying ash are also a problem for worker safety.

Another environmental problem is that of excessive heat emissions/heat stress from smelters, owing to poor heat insulation linings in the smelter. All this causes immense discomfort to workers and also create compliance problems for the industry in terms of the mandated worker health and safety laws. There have been reports of temperatures inside the immediate work space

[58] The more the number of bubbles, the worse the quality of the semi-final product.

[59] SEAM Programme case study "Closed Furnace to Improve Smelting of Aluminium Metan and Ingots"

reaching an extremely uncomfortable point of 36OC, far exceeding the allowable limit of 28OC mandated by Egyptian Law 4/1994.

CLEANER PRODUCTION OPPORTUNITY FOR SMELTING FURNACES

A new closed indirect flamed smelter of the same capacity could be designed to replace the open smelters currently in use. The design should be such that the new smelter can accommodate all types of aluminium scrap material. The smelter must be equipped with a burner, chimney, and hood. The burner should be located in the tangential position to the combustion chamber in order to allow the smelter flame to enter with a swirling motion away from the crucible. This will facilitate better combustion and heating, as well as generate less damage for the crucible and thus, require less maintenance.

The combustion chamber should be located between the crucible and outer casing. At the end of the combustion chamber, all exhaust gases should be through the chimney. The chimney must be designed to allow air entrainment through four rectangular slots at the entrance to dilute and control the exhaust gases before their release to the atmosphere.

The crucible should be covered with an insulated cover, to decrease the heat loss and emissions of particulate matter/exhaust gases.

Figures 19 to 21 provide the diagrams for the new smelter design.

CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under the Cleaner Production option category of "new technology".

TECHNOLOGY WORKING/SPECIFICATIONS

- Crucible size = 250 kg aluminium per charge
- Smelter height = 120 cm
- Smelter diameter = 125 cm
- Lid: insulated with ceramic fibres
  - Diameter = 80 cm
  - Thickness = 5 cm
- Air blower capacity = 2 Hp
- Chimney height = 180 cm
- Insulation
  - Ceramic fibres = 5 cm
  - Light bricks = 5cm
  - Fire bricks = 10 cm

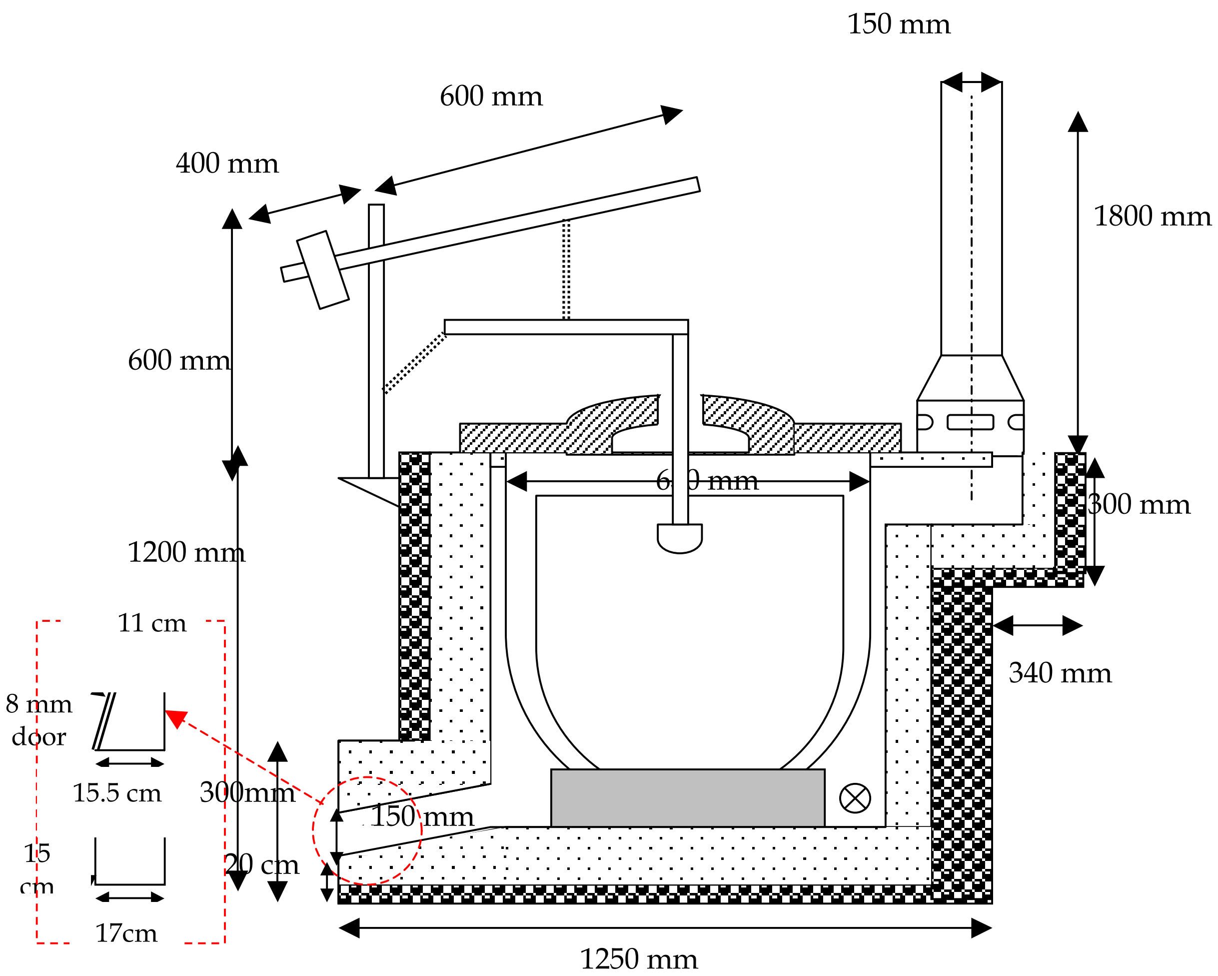


Figure 19: Smelter design

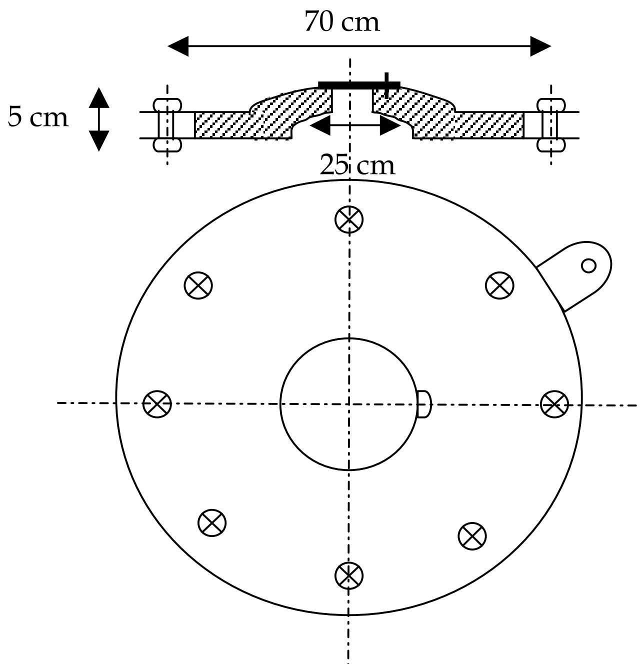


Figure 20: Furnace Cover with Insulation

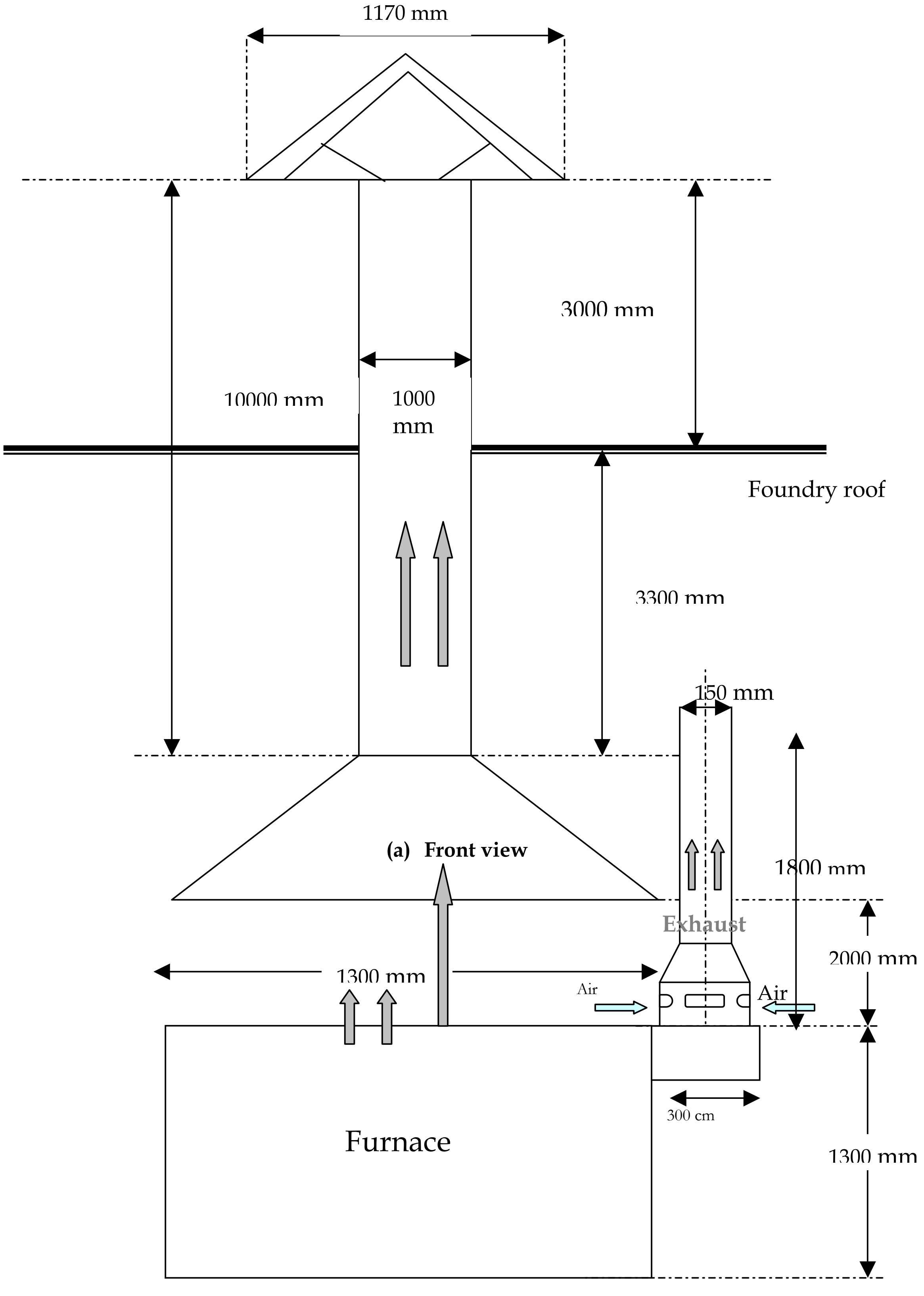


Figure 21: System design for the foundry

BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

Box 7 provides the benefits of this cleaner production opportunity.

Box 7: Benefits from Improved Smelter Design in Foundries

- Indirect burning can prevent metal oxidation and decrease slag formation by 3%, thereby increasing production by 3%. This translates to an increase in income by LE 108,000 /year (assuming average of two 2 tons of aluminium production each day).
- Production capacity can increase by more than 3% as a result of decreasing the amount of slag and the maintenance duration.
- Because of the improved material specifications and design, instead of the typical maintenance schedule of 15 days, the new smelter can enjoy a longer duration of maintenance free operation up to 45 days. This will lead to reduced maintenance, repairs and replacement costs, typically leading to a total savings of LE 8,000 /year.
- The lifetime of the crucible of the smelter increases by up to 50% more compared to the old smelter. This can reduce the costs of replacing the crucible and lead to savings of LE 25,000 /year.
- Other non-quantifiable benefits include:
    - Reduction in slag resulting in less release of waste to the environment.
    - Reduced risks to workers due to frequent incidences of flying ash.
    - Reduced emissions of total suspended particulates in both the working and surrounding environments, due to closed operation of the smelter and because of the stack provided for better pollutant dispersal.
    - Complying with relevant environmental standards.

CALCULATED PAYBACK PERIOD FOR THE CLEANER PRODUCTION OPPORTUNITY

These benefits can lead to net savings of at least LE 141,000 on an annual basis. The investment made can thus be paid back in less than 3 months.

STATUS OF MSMES IN EGYPT CONCERNING REDESIGNING FURNACE SMELTERS

At the present time, the new smelter design shown above is currently installed at the Technical Foundry for Melting and Rolling Aluminium, Meit Ghamr. The factory owner had modified the rest of his smelters to the new design. Three other factories in Meit Ghamr received assistance from SEAM to modify their smelters to the similar design.

The local design and manufacture of the smelter also helped in ensuring that any teething problems were solved easily and as less a time as possible, without the requirement of foreign consultants/agencies. The design was the outcome of a Cleaner Production demonstration project supported by the SEAM Programme, Egypt.

BACKGROUND: RECOVERING ALUMINIUM FROM SLAG[60]

Slag is a waste by-product generated at this stage of the production line. When molten aluminium is exposed to ambient air, part of the metallic aluminium is oxidized. The oxides which are formed freeze at a higher temperature than the freezing temperature of molten aluminium. The metallic aluminium and other impurities freeze on the oxides, generating aluminium slag. The slag may contain as much as 50% aluminium metal, thus leading to loss of productivity to the business and wastage of a valuable resource.

CLEANER PRODUCTION OPPORTUNITY FOR RECOVERING ALUMINIUM FROM SLAG

Extracting the unused aluminium from the waste slag presents a Cleaner Production opportunity. This separation has been a difficult process in the past. Traditionally, the process of separation of metallic aluminium from oxides has been very difficult. It was necessary to add various salts in order to lower the temperature at which aluminium separates from the oxides. The salt addition formed salt contaminated wastes, which complicated the disposal process61. A new technology has been introduced to counteract these problems, one that can extract nearly 100% of the trapped aluminium from the slag. The implementation of this technology thus presents a very viable Cleaner Production opportunity.

CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under the Cleaner Production option categories of "new technology" as well as “(raw material) recovery”.

TECHNOLOGY WORKING/SPECIFICATIONS

To eliminate the need for salt fluxes, a new plasma torch treatment has been developed to heat the rotary furnace. No salt/other additives are required to separate the metal from the slag. The unique ability of the plasma torch to heat the materials to the required temperature is utilized in this process. The furnace is rotated to tumble and expose the slag to the plasma flame. Air is used as the

[60] Technology Database for SMEs. Available at: http://www.techsmall.com/index.htm
[61] Secondary Aluminum Production. Available at: http://www.p2pays.org/ref/01/text/00778/chapter4.htm

process gas. The emissions generated from the furnace are exhausted to the open air via a particulate filter.

BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

The Cleaner Production opportunity makes possible the recovery of what was previously regarded as a waste material. Thus, the recovered aluminium can be added to the front of the process as a raw material. This would help the MSME generate a larger quantity of product and also save costs on the procurement of raw material (i.e. aluminium scrap).

CALCULATED PAYBACK PERIOD FOR THE CLEANER PRODUCTION OPPORTUNITY

While the calculated payback period is not available at this time, details are available for the economics of the Cleaner Production opportunity.

- Energy needed for 1 ton of slag input containing 50% by weight of free aluminium = 465 kWh
- Electrical capacity of the plasma torch = 300 kW
- Thermal input (at the rate of 60%) = 200 kW
- Required number of hours of heat = 3
- Required number of heat episodes per day = 2
- Plant and machinery equipment (capital) cost = LE 1.34 million
- Daily operating cost = LE 1,340
- Production capacity = 300 TPA

STATUS OF MSMES IN EGYPT CONCERNING REDESIGNING FURNACE SMELTERS

Currently, no specific aluminium slag recovery technologies exist in Egypt. The scale of technology illustrated here is about the same as the requirement of Egyptian MSMEs - the technology offer originates from India62 and has been designed specifically for Indian SMEs. Nevertheless, it would be prudent to initiate some research towards adapting this technology indigenously.

Step 4: Rolling in the longitudinal direction

No Cleaner Production opportunities to report

[62] Ref ID: TBS-1149-TO. Available at: http://www.techsmall.com/index.htm

Step 5: Surface treatment and tailoring

No Cleaner Production opportunities to report

Step 6: Primary annealing process

BACKGROUND: IMPROVEMENTS IN THE DESIGN OF THE ANNEALING OVEN[63]

As stated in Chapter 2 of this report, the MSMEs also face a lot of productivity related problems, which require urgent attention. Primary productivity concerns in foundries centre around energy consumption issues in the annealing process and direct burning practiced in smelters. The annealing process is normally carried out using inadequately insulated ovens leading to very large heat losses and hence, excessive energy consumption. Heat losses of up to 80% have been recorded, with related wastage in fuel consumption amounting to LE 24,000 per year.

In addition to increasing the production costs, the quality of the final product also suffers due to improper annealing. Typical annealing ovens do not have proper temperature control. The aluminium sheets/discs do not undergo annealing to the required extent, thus making the shaping of semi-final products very difficult. Due to this, the volume of aluminium returned to the annealing oven often increases.

On the downstream side (i.e. once the semi-final product has been passed on to the forming workshops), the volume of rejects from the forming process also increases due to the non-homogeneous distribution of hardness in the annealed metal. This causes disintegration of the metal and contributes to worker injuries in about 50% of the cases. Material wastages and rejects of about LE 40,000 per year have been recorded. Thus, production capacity cannot be met.

The direct burning practiced in smelters leads to the generation of excessive amounts of slag, as a result of the formation of aluminium oxides. More aluminium scrap material is lost in the slag as a consequence, thus indirectly leading to loss of production. This undesirable practice could cost the unit a loss of up to LE 108,000 per year[64].

Additionally, due to their inherent inefficiency, both the smelter and annealing ovens require frequent maintenance, repairs and replacements of working parts, which could come up to LE 2,000 to 8,000 per year. This adds to the downtime of the unit and increases production costs.

[63] SEAM II Programme case study “Energy Conservation in Aluminium Foundries – Annealing Furnaces”
[64] Assuming an average production capacity of two tons of semi-final aluminum each day.

CLEANER PRODUCTION OPPORTUNITY IN THE ANNEALING PROCESS

In principle, Cleaner Production also addresses productivity concerns. Therefore, the redesign on the annealing oven presents a good Cleaner Production opportunity. The new design should ideally allow extension of the annealing time (from 1.25 hours to 1.75 hours) for better annealing – i.e. it should have a higher capacity. The hot gases of the new furnace should rise all the way up from both sides of the oven wall, move down through the aluminium melt and then exit through the chimney. This will enable better temperature control and distribution of heat.

The furnace would consist of two burners, a control unit, carriage, the main oven body and a door. The burner would consist of: two high pressure 2 Hp fuel pumps, 0.75 inch gas filter (250 mesh size), 0.75 inch safety valve 10 bar pressure, 0.75 inch solenoid valve, two 4 HP 60 cm blowers, 4 gallons per hour diesel fuel atomizers, and air-fuel mixing chamber. A control unit with on/off signals to fuel pumps can be provided to maintain the temperature at an optimum point. The main body of the furnace must be well insulated with light bricks, ceramic fibres, and clay hollow bricks.

The oven door as well as the carriage should be heat insulated to reduce the amount of heat loss. The oven door could be insulated with ceramic fibres and light bricks, while the carriage could be insulated only with light bricks.

CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under the Cleaner Production option category of "new technology".

TECHNOLOGY WORKING/SPECIFICATIONS

- Length = 5 m
- Width = 3.75 m
- Height = 4 m
- Carriage
  - Length = 3.6 m
  - Width = 1.2 m
  - Height = 1.7 m
- Chimney: clay bricks 25 cm thickness followed by 25 cm firebricks. Additional sheet metal chimney is added at the top to move the exhaust gases outside the factory
  - Internal cross-section = 40 cm x 40 cm
  - Height = 5.5 m
- Furnace insulation
  - 5 cm fibre ceramics
  - Light bricks of thickness 6 cm for floor and 12.5 cm for all walls

    - Clay hollow bricks of thickness 40 cm
    - Fire bricks of thickness 15 cm for floor and 25 cm for all walls
- Door
    - Width = 1.2 m
    - Height = 2.2 m
    - Thickness = 22 cm
- Combustion chamber
    - Length = 4.2 m
    - Width = 25 cm
    - Height = 25 cm
    - Two blowers (4 Hp each, 60 cm diameter)
    - 4 gallon/hr diesel fuel atomizer
    - Two fuel pumps (2 Hp each)
    - Temperature control
    - 0.75 inch fuel filter (250 mesh size)

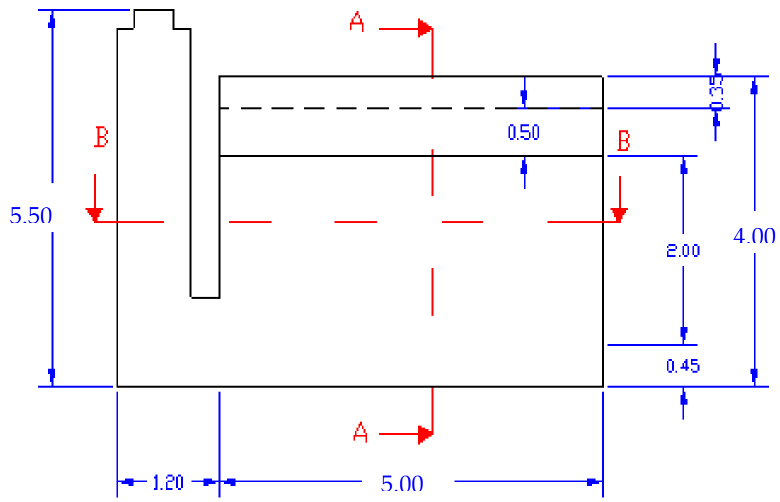


Figure 22: Annealing Furnace - Side view

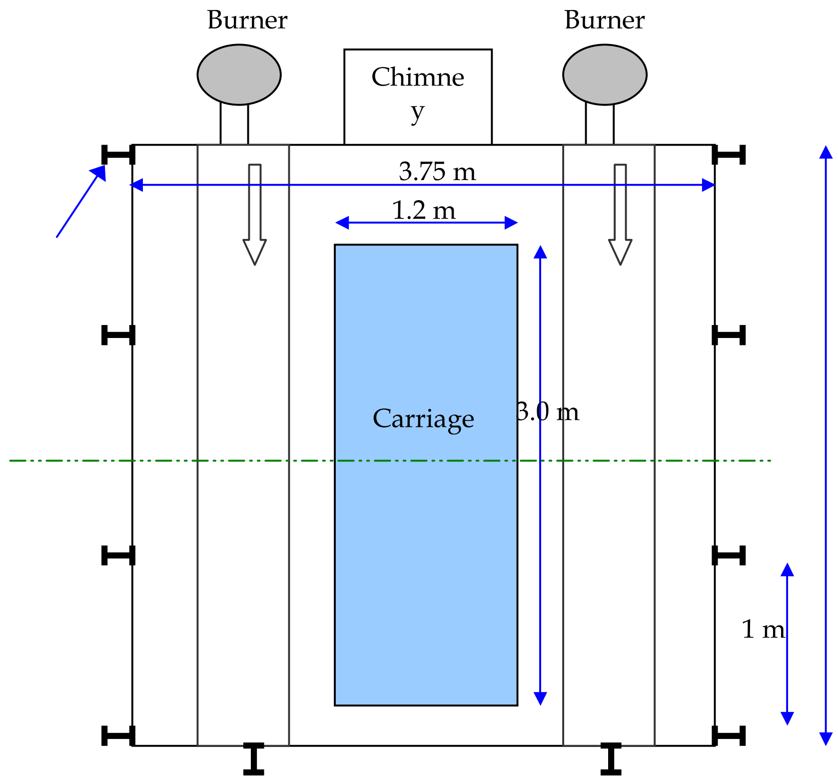


Figure 23: Top view of annealing furnace

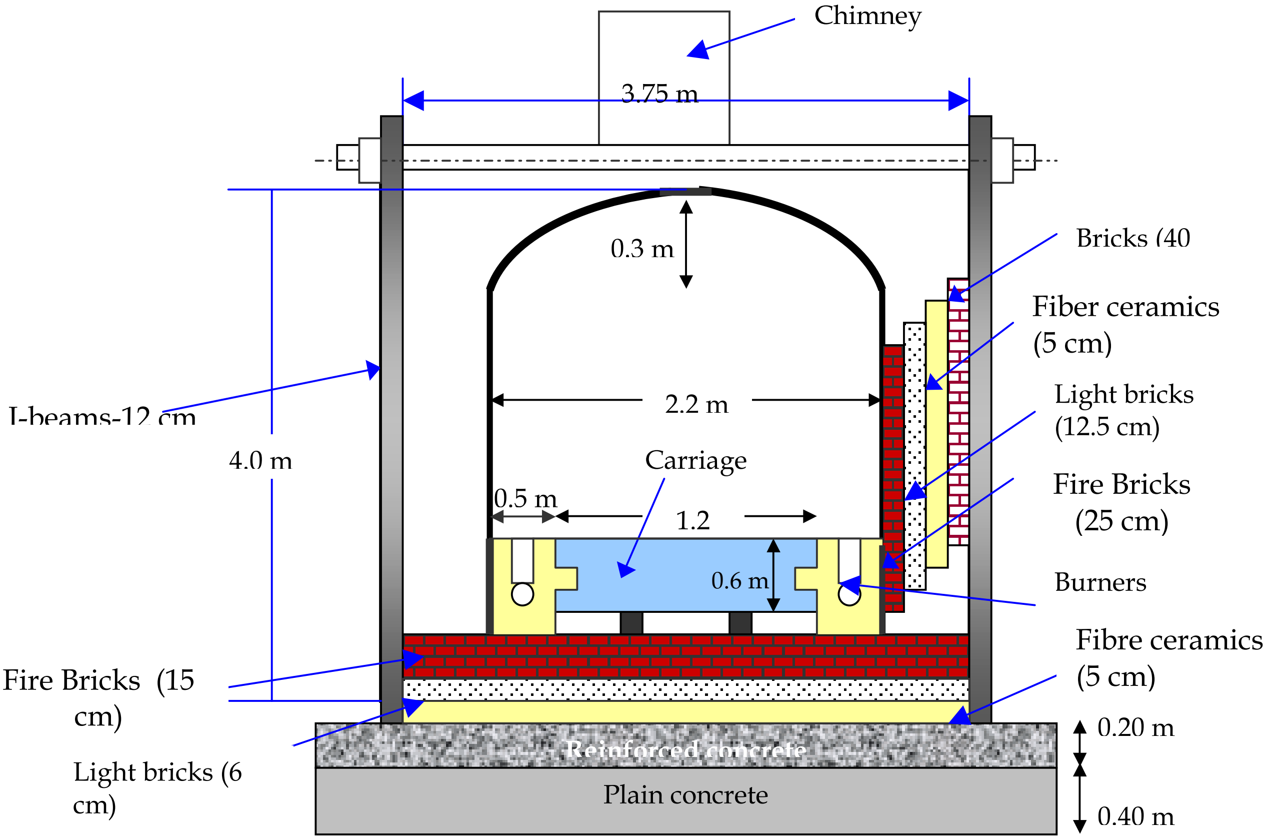


Figure 24: Annealing furnace - Sectional front

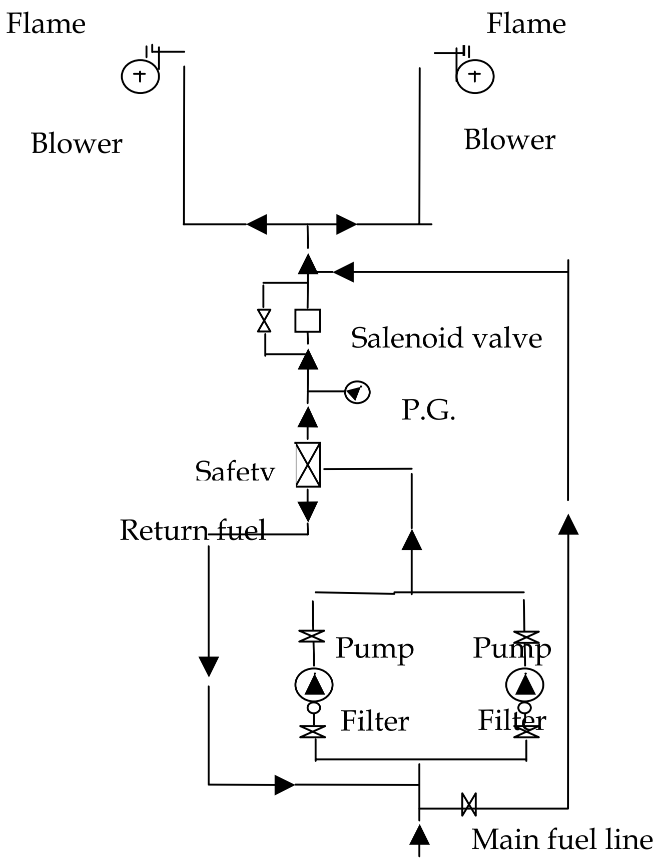


Figure 25: Combustion system and control

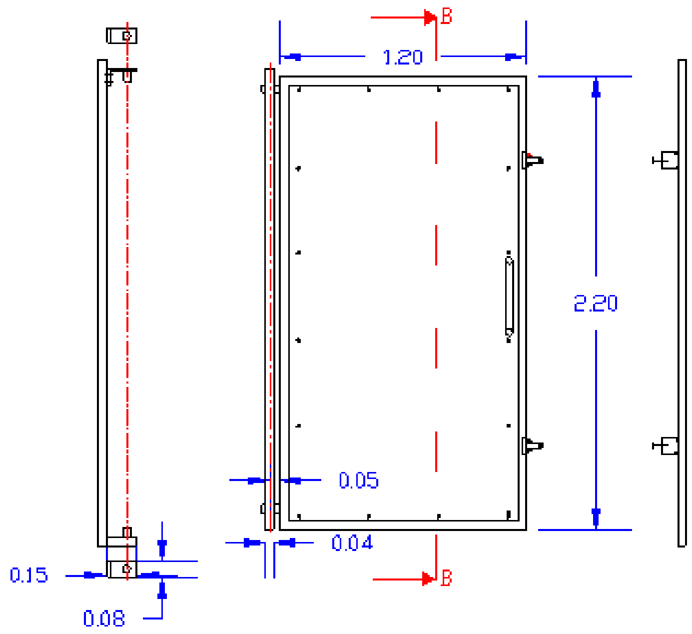
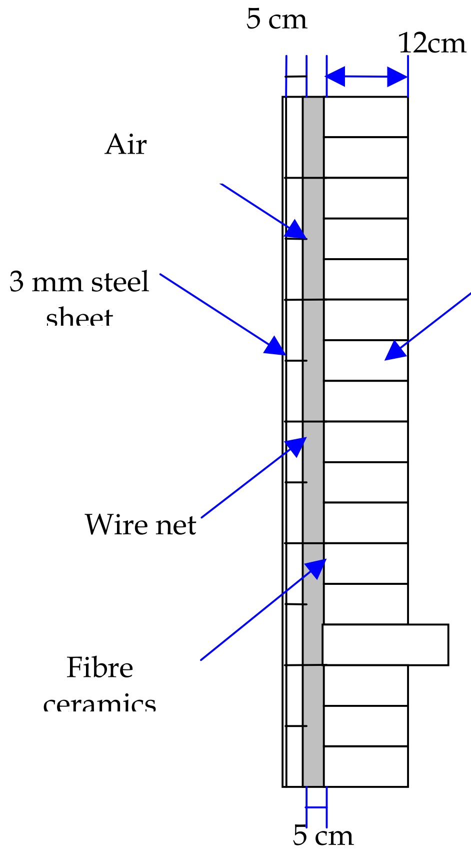


Figure 26: Annealing furnace door



BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

Box 8: Benefits from Improved Annealing Oven Design in Foundries

- Heat losses from the oven can be reduced by up to 80%. This reduction coupled with better temperature control, would lead to a drop in fuel consumption, with a potential total savings of LE 24,000 /year[65].
- Material wastage or rejects after the rolling process would reduce as a result of the homogeneous temperature distribution within the aluminium sheets. Potential savings of up to LE 40,000 /year are anticipated as more finished aluminium items will be available for sale.
- Due to the homogeneous temperature distribution within the annealed discs, the trimming losses of the forming process in the products will be reduced by up to 20% with a potential savings of about LE 16,000 /year.
- The new furnace is likely to require maintenance only once every four months, compared to the old furnace. The maintenance costs of the annealing furnace will

[65] However, electricity consumption can increase by a nominal amount due to the usage of the fuel pump for fuel atomization and better combustion performance.

Figure 6.5 (d): Combustion system and control

therefore decreased leading to further savings.

- Other non-quantifiable benefits include:
  - Increased lifetime of the annealing furnace. It is expected that the lifetime of the new annealing furnace would be double that of the old furnace.
  - Because of the homogenous distribution of hardness in the annealing process, the instances of disintegration of metal will reduce significantly, preventing injuries to workers in the rolling and forming areas.
  - Heat and air emissions in the workspace and neighbourhood will be considerably reduced due to improved operation of the annealing process and the stack provided for better pollutant dispersal. The temperature at the immediate work-space should reduce to comfortable levels, thus meeting worker health and safety standards.

CALCULATED PAYBACK PERIOD FOR THE DEMONSTRATING COMPANY

These benefits can lead to a net savings of LE 80,000 on an annual basis. The investment made can thus be paid back is less than 14 months. Further, since the capacity of the furnace will be increased by 25%, the production can also increase by the same proportion; this could lead to a potential benefit of another LE 50,000 /year.

Status of MSMEs in Egypt concerning the redesign of annealing ovens

At the present time, the new annealing oven design shown above is currently installed in Tiba Company for Aluminium Meit, Ghamr. Two other factories received assistance from SEAM to modify their existing annealing ovens. The local design and manufacture of the annealing oven also helped in ensuring that any teething problems were solved easily and as less a time as possible. The design was the outcome of a Cleaner Production demonstration project supported by the SEAM Programme, Egypt.

<u>Step 7: Rolling in the latitudinal direction</u>

No Cleaner Production opportunities to report

<u>Step 8: Final or secondary annealing</u>

The Cleaner Production opportunity reported in Step 6 (for primary annealing) applies to this step as well.

Step 9: Cutting and turning

No Cleaner Production opportunities to report

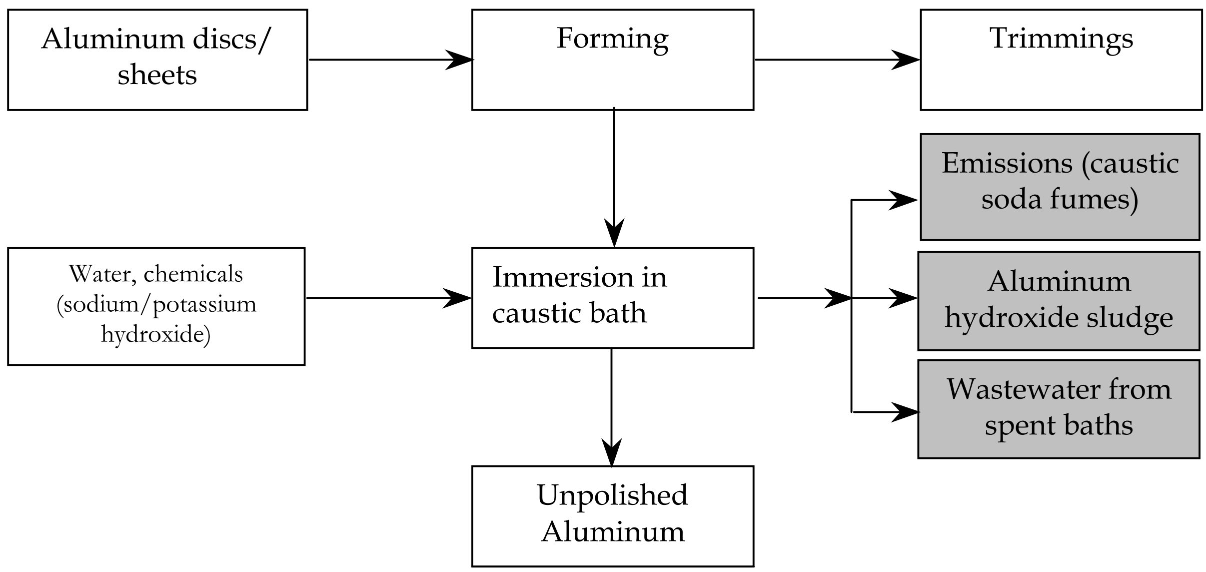
Step 10: Collecting the generated wastes / residues

In practice, the generated wastes of aluminium trimmings are returned to the process as scarp material. As such, this is a Cleaner Production opportunity in itself (i.e. material reuse), which is already being implemented at MSMEs in Egypt.

6.2.2 *Cleaner Production Opportunities in Forming Workshops*

Cleaner Production opportunities for forming workshops will be discussed in this sub-section.

Figure 27: Process Steps for Manufacturing Unpolished Aluminium Products in Forming Workshops



1: Forming the aluminium discs/sheets

No Cleaner Production opportunities to report

2: Immersion in the caustic bath

BACKGROUND: IMPROVEMENTS IN THE CAUSTIC SODA BATH IMMERSION PROCESS

During the finishing process, caustic soda (also called "sodium hydroxide", although potassium hydroxide may also be used for the process), a toxic and hazardous chemical is used as the primary material. The caustic soda baths are inefficient and poorly controlled, often generating noise, fumes, aerosols, and other nuisance emissions. Generally, the spent baths are discharged without further treatment into the sewers and the sludge from the bath is dumped into the street and collected for dumping at the landfill. This adds to instances of non-compliance with Egyptian environmental regulations.

CLEANER PRODUCTION OPPORTUNITY IN THE CAUSTIC BATH IMMERSION PROCESS

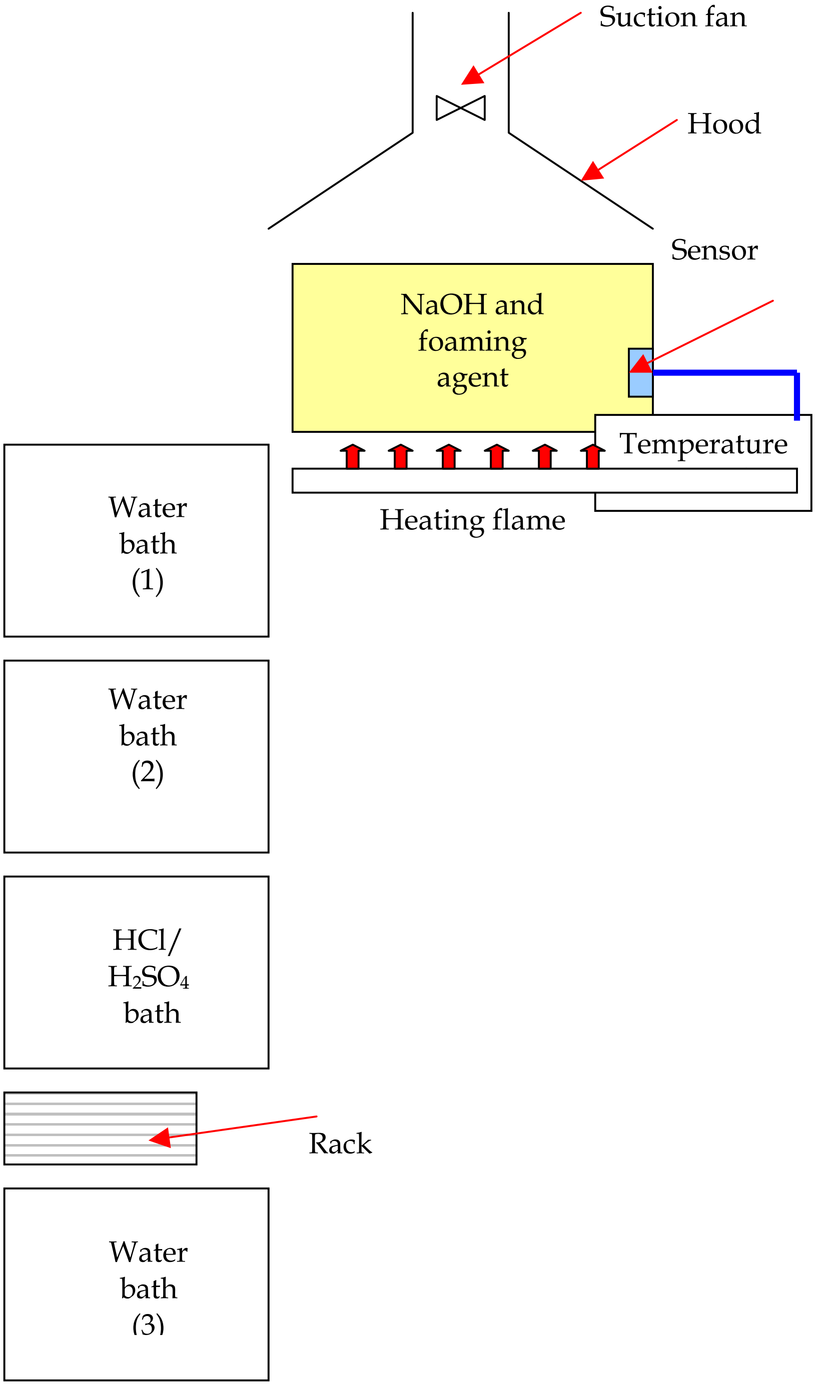
A number of optimal conditions must be established to ensure optimal working conditions. These include adjusting the activity of the bath (i.e. the concentration of the active chemicals), the time of product immersion and bath temperature. New handling procedures for the process and the products should be developed to further improve the process. This also includes an element of awareness-raising and training for the supervisory management and the workers.

Specific points of attention will include:

- The use of improved raw materials (soap, surfactants and foam-breakers).
- The use of efficient heaters for the caustic soda bath.
- The installation of temperature and activity controls.
- The implementation of counter-current rinse baths: At least two rinsing baths are required for the operation - the first rinsing bath to remove the residuals and also to substitute the water loss in caustic soda bath. The second rinsing bath can be used to substitute the water loss in the first rinsing bath.
- The improvement of the handling of products (racks, etc.) so as to allow proper dripping in order to reduce the drag out.
- The recovery and reuse of the sludge produced from the caustic soda process: The sludge is mostly aluminium hydroxide which can be reused in the manufacture of paints, cement or ceramics.

Figure 28: New caustic soda bath system

Figure 28 shows the new caustic soda bath system[66].



[66] SEAM Programme case study "Improving the Aluminium Finishing Processes and Reducing Noise and Particulate Mattar".

CLEANER PRODUCTION OPTION CATEGORY

This particular Cleaner Production opportunity falls under multiple Cleaner Production option categories-good housekeeping, management and personnel practices, process rationalization, raw material substitution and recovery and reuse of material previously deemed as waste.

BENEFITS GAINED FROM THE CLEANER PRODUCTION OPPORTUNITY

Box 9 provides information on the benefits gained from improving the caustic soda immersion bath process.

Box 9: Benefits gained from improving the caustic soda immersion bath process
▪ The caustic soda consumption will be reduced by 60%, giving an annual benefit of LE 4,300.
▪ Water consumption will be reduced by 50%, giving an annual benefit of LE 900.
▪ Fewer nuisance emissions will help make the workplace safer for the employees (not quantified at this time).
▪ The Cleaner Production measures will no doubt help the company towards meeting environmental and worker health and safety standards.
▪ Additional income from the sale of the aluminium hydroxide sludge can be realized by the implementing company (not quantified at this time).

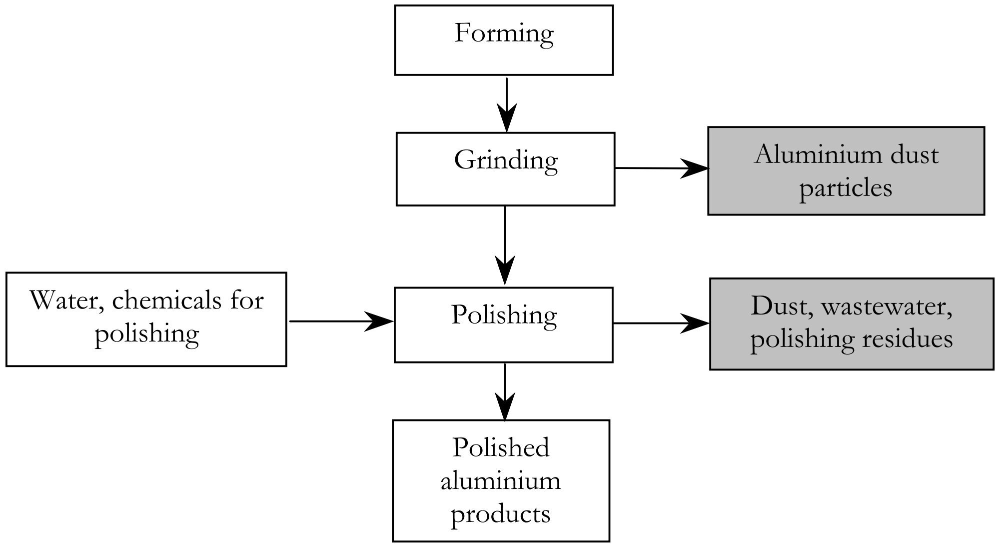
CALCULATED PAYBACK PERIOD FOR THE DEMONSTRATING COMPANY

It is anticipated that the improvements in the caustic soda bath immersion process would require an investment of LE 19,500. Assuming a production capacity of 30 to 50 ton/month and combining the information available from Box 6.5, the calculated payback period for this Cleaner Production opportunity works out to be somewhere in the range of 1-2 years.

Status of MSMEs in Egypt concerning the improvements in the caustic soda bath immersion process

At the present time, the improved caustic soda immersion bath process shown above is currently installed in Tiba Company for Aluminium and Mattar for Aluminium Forming, Meit Ghamr The implementation was the outcome of a Cleaner Production demonstration project supported by the SEAM Programme, Egypt.

Figure 29: Process Steps for Manufacturing Polished Aluminium Products in Forming Workshops



<u>1: Forming</u>

No Cleaner Production opportunities to report

<u>2: Grinding</u>

The grinding process is undertaken with machines that do not have any suction systems to collect the particulates generated. The dust affects the life-span of the machines and in addition to that the dust is harmful to the workers.

<u>3: Polishing</u>

BACKGROUND: IMPROVEMENTS IN THE POLISHING PROCESS

The finishing department consists of different polishing and sanding machines that are used for high quality products. The working environment is full with aluminium dust and other particulates and emissions. No ventilation system exists; which increases concentrations of indoor contaminants and reducing the life span of the machines.

CLEANER PRODUCTION OPPORTUNITY IN THE POLISHING PROCESS

The most problematic environmental aspect of the polishing system is the particulate emission. A good polishing design should be based on dust collection and ventilation concepts. All particulates generated from the polishing processes will be collected through a hood, blower and duct system shown in figure (1) to ensure good working environment. Water scrubbing mechanism shown in figure (3) will be installed to collect all dust before going to the surrounding and guarantee a good surrounding environment.

Attention should be given to the working environment as well as the surrounding environment. Providing a good working environment can guarantee a long life span for machines and good occupational health for the workers in order to increase their productivities and reduces the sick leaves.

Design of polishing machines

A semi closed suction hood will be provided to the cloth brushes connected with 4-inch flexible piping at the lower part of the hood as shown in figure (6.8); in order to collect all particulate emission from the polishing process. The 4-inch flexible hose will be connected to 2 HP blower to accelerate the collection of particulates. The particulates exhausted from the blower will then be sucked to a 25 cm square collection duct; in order to collect the particulates from all machines within the polishing department.

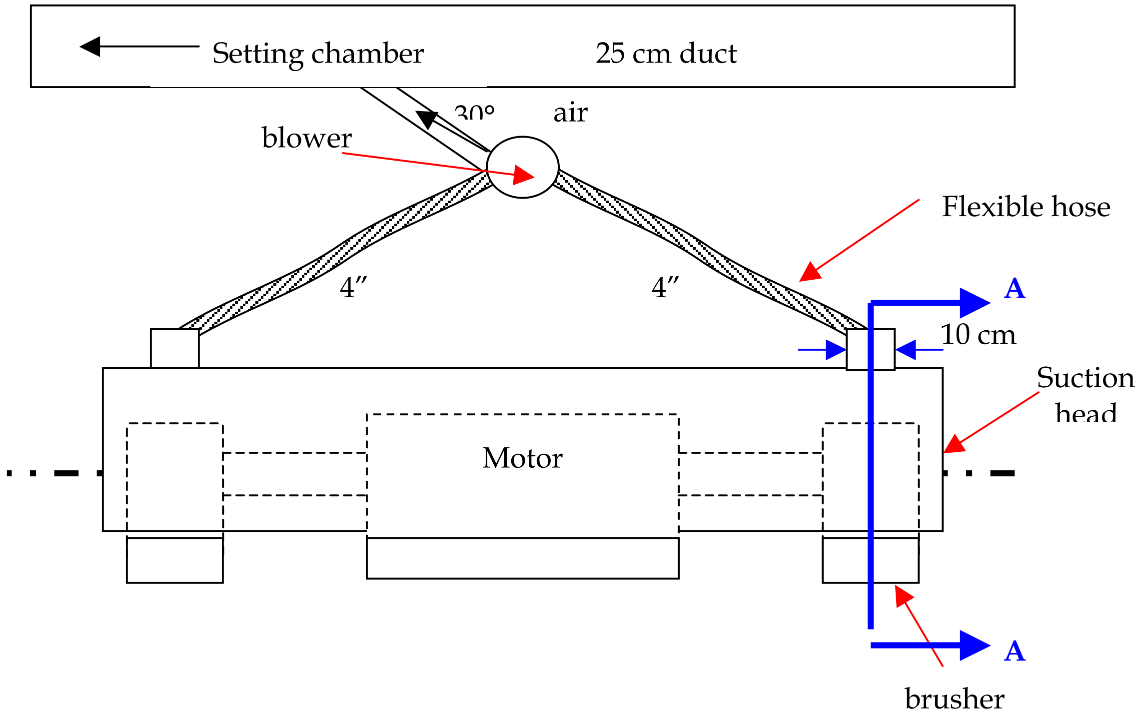


Figure 30: Polishing

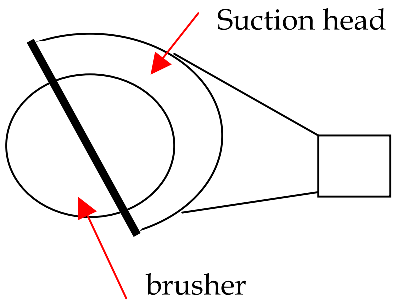


Figure 31: Brusher – sectional view A-A

To guarantee a good surrounding environment water scrubbing system will be installed to collect all particulates from the 25 cm square collection duct. The water scrubbing system (Figure 32) consists of water walls in the near chamber and water spry in the second chamber. This system can guarantee an excellent dust collection system.

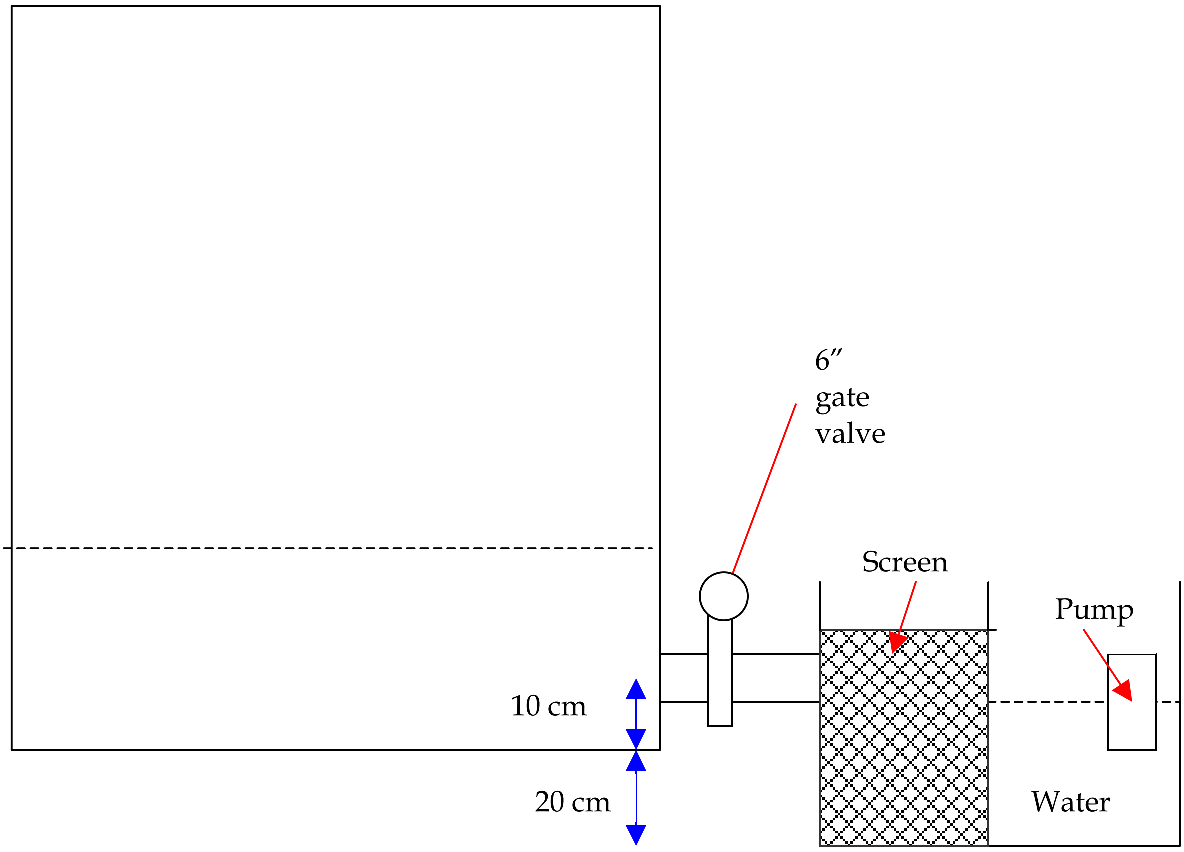


Figure 32: Drainage system – side view

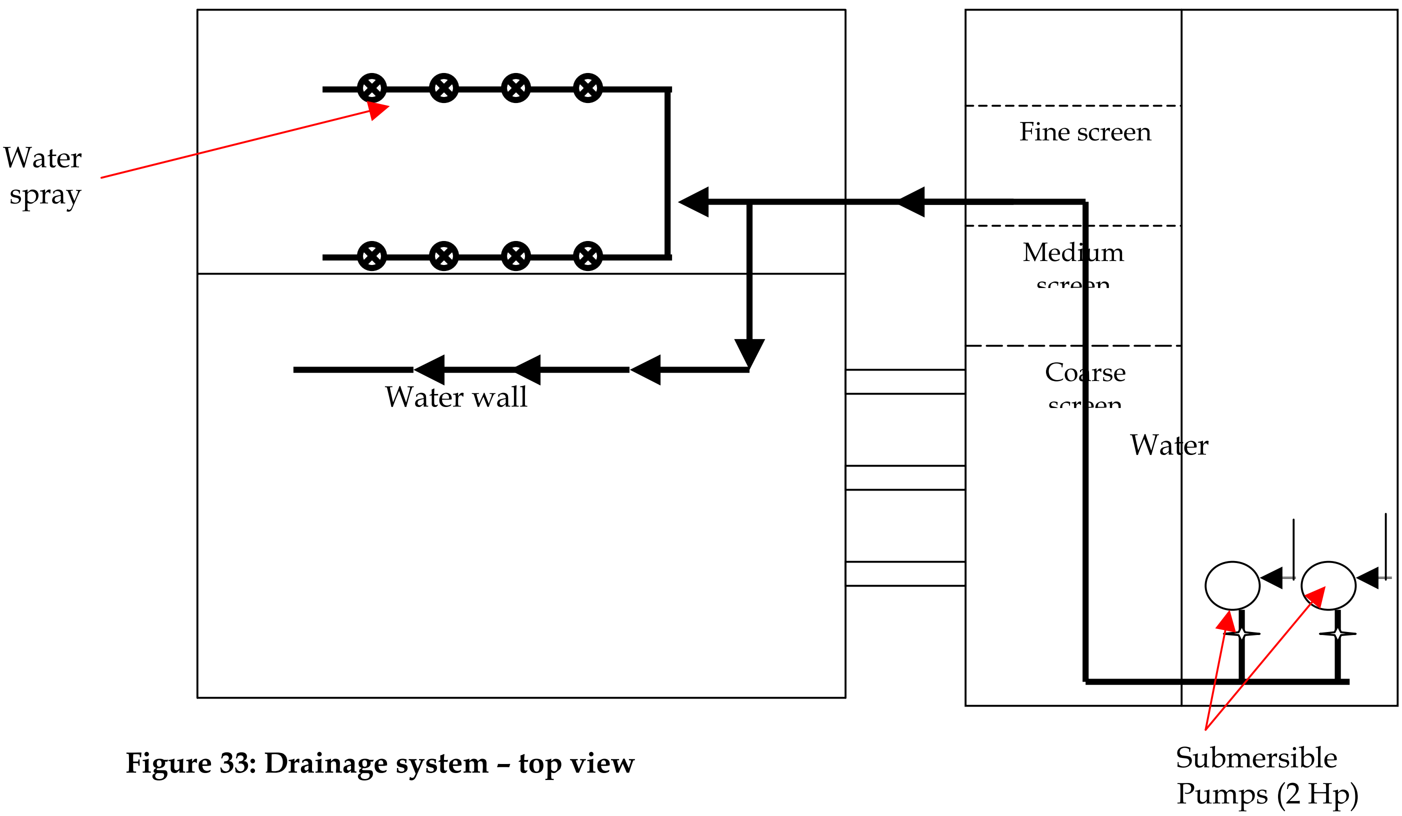


Figure 33: Drainage system – top view

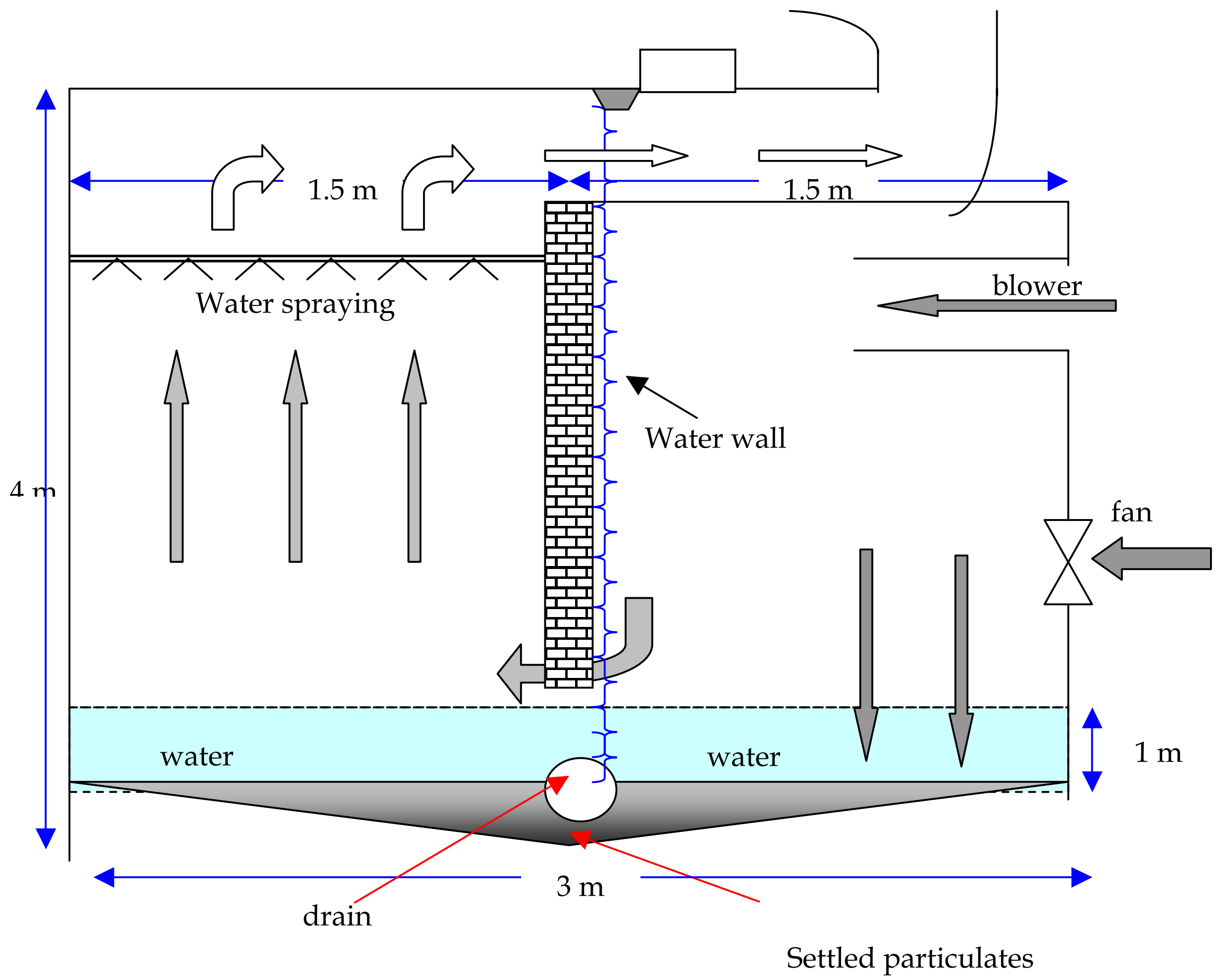


Figure 34: Settling tank

Specifications of polishing machines

- 50-cm diameter cloth brushes
- A 30 HP motor is used to run two cloth brushes simultaneously with 3,000 rpm.
- 60-cm diameter conical suction hood
- 4-HP blower to accelerate the suction of the particulates from the hood.
- 4-inch (10 cm) flexible piping to connect suction hood with the blower
- 25-cm dust collection duct equipped with air cleaning doors.
- 2 HP submersible pump to provide water to both the water wall and water spraying systems.
- Three sets of screens: coarse, medium, and fine.

BENEFITS OF IMPROVED POLISHING MACHINES DESIGN

In the case of the factory where an improved design of polishing was introduced, a better working environment will be provided as well as a better surrounding environment.

In the same company, a new design could afford a longer duration of maintenance and free operation up to 30 days instead of earlier maintenance schedule of 15 days, because of the improved working conditions.

There were several other non-quantifiable benefits including:

- Reduced emissions of total suspended particulates in both the working environment and surrounding environment due to installing a particulate collection system.
- Reduced risk to workers due to the decrease of the flying particulates inhaled by the workers lungs and causing other occupational health problems

STATUS OF MSMES IN EGYPT CONCERNING THE IMPROVEMENTS IN THE POLISHING PROCESS

At the present time, the improved polishing process shown above is currently installed in Tiba Company for Aluminium, Meit Ghamr The implementation was the outcome of a Cleaner Production demonstration project supported by the SEAM Programme, Egypt.

Annexes

Annex 1: Environmental Regulatory Framework for the Secondary Aluminium Sector in Egypt Concerning the Workplace

In Egypt, the Ministry of Manpower is responsible for issues pertaining to labour safety and health in workplaces (Law 137/1981). A number of laws exist to ensure that there are no violations to the environment of the workplace. These laws and possible locations where violations to the workplace may occur are listed below:

- Gas emissions from the boiler house are regulated by Article 43 of Law 4/1994, Article 45 of the Executive Regulations and Annex 8. The limits for the relevant pollutants are listed in **Table A**.
- In locations where any heating activity is conducted, the temperature and humidity are regulated by Article 44 of Law 4/1994, Article 46 of the Executive Regulations and Annex 9.
- Near heavy machinery, noise is regulated by Article 42 of Law 4/1994, Article 44 of the Executive Regulations and Table 1, Annex 7.
- Ventilation is regulated by Article 45 of Law 4/1994 and Article 47 of the Executive Regulations.
- Smoking is regulated by Article 46 of Law 4/1994 and Article 48 of the Executive Regulations and Law 52/1981.
- Work and environment conditions are addressed in Law 137/1981 for labour, Ministry of Housing Decree 380/1983, Ministry of Industry Decree 380/1982.

Table A: Maximum Limits of Emissions in the Work Place from Sources of Fuel Combustion

Material	Threshold values			
	Time average		Exposure limits for short periods	
	PPM	mg/cu.m.	PPM	mg/cu.m.
Carbon dioxide	5,000	9,000	15,000	27,000
Carbon monoxide	50	55	400	440
Sulphur dioxide	2	5	5	10

Concerning Effluent / Wastewater

Limits for pollutants in wastewater vary depending on the type of receiving water body. The parameters which should be monitored and / or inspected are:

- Biochemical oxygen demand (BOD)
- Chemical Oxygen Demand (COD)
- pH
- Oil and grease
- Temperature
- Total suspended solids (TSS)
- Settleable solids (SS)
- Residual chlorine

Table B represents the permissible limits of discharge to the different types of receiving water bodies (i.e. the sea, the Nile river, canals, agricultural drains and public sewers), according to the different relevant laws.

Table B: Egyptian Environmental Legal Requirements for Discharge of Industrial Wastewater to

Parameter (mg/L, unless mentioned otherwise)	Coastal environment [67]	Sewer systems [68]	Underground reservoir and Nile river branches / canals[69]	Nile river (mainstream)	Drains (municipal)	Drains (industrial)
BOD_5 (20°C)	60	< 600	20	30	60	60
COD	100	< 1,100	30	40	80	100
pH	6-9	6 – 9.5	6-9	6-9	6-9	6-9
Oil and grease	15	< 100	5	5	10	10
Temperature (°C)	10°C > average temperature of receiving water body	< 43	35	35	35	35
TSS	60	< 800	30	30	50	50
SS	-	< 10	-	20	-	-
Chlorine	-	< 10	1	1	-	-

[67] As per Law 9/94.
[68] As per Law 93/62 (as Decree 44/2000).
[69] As per Law 48/82 applies to discharge of industrial wastewater to this category of water body as well as to the Nile river (mainstream), and municipal and industrial drains.

Spent lube oil has a negative impact on water and soil, and therefore, its disposal requires monitoring. A record should be kept for this purpose.

Concerning Solid Waste

A number of laws address solid waste management. The following laws apply to sludge from a wastewater treatment plant (WWTP).

- Law 38/1967 addressing public cleanliness regulates the collection and disposal of solid wastes from houses, public places, commercial and industry establishments.
- Ministry of Housing, Utilities and Urban Communities (MHUUC) Decree no. 134 of 1968, providing guidelines from domestic and industrial sources, including specifications for collection, transportation, composting, incineration and land disposal.
- Law 31/1976 which amended Law 38/1967.
- Law 43/1979, the Law of Local Administration, which states that city councils are responsible for 'physical and social infrastructure', effectively delegating responsibility for infrastructure functions.
- Law 4/1994 regulating incineration of solid waste.

Concerning Hazardous Material and Waste

- Law 4/1994 introduced the control of hazardous material and wastes70.
- Articles 25, 31 and 32 of the Executive Regulations (Decree no. 338/1995) specify the necessary precautions for handling hazardous materials.
- Articles 29 and 33 of the Law make it mandatory for those who produce or handle dangerous materials in gaseous, liquid and / or solid form(s) to take precautions to ensure that no environmental damage shall occur.
- Activities concerning the usage and storage of fuel for boiler usage (i.e. hazardous material) are covered by Law 4/1994.
- Materials classified as hazardous for the dairy industry include hydrochloric acid and nitric acid.
- Note that there are no explicit articles in Law 4/1994 or in Decree 338/1995 (Executive Regulations), regarding holding a register for hazardous materials. However, maintaining a register for hazardous materials is implicit in Article 25 of the Executive Regulations, which addresses the matter of application for a license.

The Environmental Register Article 22 of Law 4/1994 states that the owner of the establishment shall keep a register showing the impact of the establishment activity on the environment. Article 17 and Annex 3 of the Executive Regulations specify the type of data recorded in the register.

[70] Note that hazardous "material" differs from hazardous "wastes", in that wastes are generated *after* the material has been used in a process.

The emergency response plan and the hazardous materials register are also part of the Environmental Register.

Concerning Emissions

Article 40 of Law 4/1994, Article 42 of the executive regulations and Annex 6 deal with gaseous emissions from combustion of fuel. The statutes relevant to the combustion of fuel are:

- The use of solar oil and other heavy oil products, as well as crude oil shall be prohibited in dwelling zones.
- The sulphur percentage in fuel used in urban zones and near dwelling zones shall not exceed 1.5%.
- The design of the burner and fire-house shall allow for complete mixing of fuel with the required amount of air and for uniform temperature distribution, so as to ensure complete combustion and minimize gas emissions caused by incomplete combustion.
- Gases containing sulphur dioxide shall be emitted through chimneys rising sufficiently high, in order that these gases become lighter before reaching the ground surface. Also, fuel using high content of sulphur in power generating stations, industry and other regions lying away from inhabited urban areas, providing that atmospheric factors and adequate distances to prevent these gases from reaching the dwelling and agricultural zones and regions, as well as the water courses shall be observed.
- Chimneys from which a total emission of gaseous wastes reaches 7,000–15,000 kg/hr shall have heights ranging between 18–36 m.
- Chimneys from which a total emission of gaseous wastes reaches more than 15,000 kg/hr, shall have heights exceeding at least two and half times the height of the surrounding buildings, including the building served by the chimney.

The permissible limits of emissions from sources of fuel combustion are given in Table C71.

[71] As per Ministerial Decree no. 495, 2001.

Table C: Maximum Limits For Emissions from Sources of Fuel Combustion

Pollution	Maximum limit (mg/cu. m. of exhaust)
Sulphur dioxide	3,400
Carbon monoxide	250
Smoke	50

Concerning Allied Standards

- The Ministry of Industry requires that these industries maintain an Industrial Register. The Ministry is also responsible for setting the standards for required purity levels in the finished secondary aluminum products - finished cooking pots should be of an extremely high level of purity (at least 99.7%), and it is mandated that the proportion of impurities and lead should not exceed 0.3% and 0.10% respectively.

- The Ministry of Trade mandates the maintenance of a routine Trade Register.
- The Ministry of Finance acts as the tax authority for the industries in this sectorThe following rules are applicable for calculation of sales tax:

- The consumption of 300 kilowatt of power is equivalent to production of 1 ton low grade matt kitchenware.
- The consumption of 400 kilowatt of power is equivalent to production of 1 ton high grade (polished) kitchenware.
- The consumption of 450 kilowatt of power is equivalent to production of 1 ton kitchenware produced in “modern” factories using electric finishing.

The general tax is calculated as 20% of the overall profit. There are currently efforts underway to reduce this figure as well.

Annex 2: Melting Aluminium and its Alloys

1) Properties of Pure Aluminium

Aluminium and its alloys are used in industry since they possess suitable properties. They are highly resistant to most forms of corrosion. A key property is low density and its low melting point.

The density of pure aluminium (99.75%) varies with temperature as shown in Table 1.

Table 1: Density of pure aluminium (99.7 1

Temp., °C	Density, gm/cm³	Temp., °C	Density, gm/cm³
20	2.703	658 (liquid)	2.382
100	2.690	700	2.371
400	2.620	900	2.316
658 (solid)	2.550	1100	2.262

The melting point of pure aluminium (99.996%) is 660 °C and its boiling point is 2200 °C.

Following is the viscosity of aluminium at different temperatures:

Temp., °C	720	765	800
Viscosity, Poise	0.0125	0.01175	0.01102

The surface tension for pure aluminium at 700 °C is 900 dyn/cm and at 800 °C is 865 dyn/cm.

The amount of heat content for melting aluminium is 96 kilocalorie/gm and the heat content for aluminium evaporation is 2500 kilocalorie/gm.

Tables 2, 3 and 4 shows the values of the specific heat, the coefficient of heat conductivity, and the coefficient of heat expansion at various temperatures.

Table 2: Specific Heat for Aluminium at Different Temperatures

Temp., °C	Specific Heat, kilocalories/gm °C	Temp., °C	Specific Heat, kilocalories/gm °C
-253.9	0.0024	200	0.2374
-184.7	0.0967	400	0.2529
-114.3	0.1709	658 (solid)	0.2727
-81.5	0.1867	658 (liquid)	0.2502
0	0.2220	800	0.2571
100	0.2297	1000	0.2667

Table 3: Coefficient of Heat Conductivity at Different Temperatures

Temp., °C	Specific Heat, kilocalories/gm °C	Temp., °C	Specific Heat, kilocalories/gm °C
-200	1.17	100	0.52
-150	0.63	200	0.52
-100	0.61	400	0.46
20	0.55		

Table 4: Coefficient of Heat Expansion at Different Temperatures

Temp., °C	Coefficient of Heat Expansion, 10^{-6} mm/ °C	Temp., °C	Coefficient of Heat Expansion, 10^{-6} mm/ °C
20-100	23.86	20-400	26.50
20-200	24.58	20-500	27.68
20-300	25.50		

Aluminium is a chemically active element. It reduces most of the elements from their oxides. Aluminium readily oxidises and when oxidized, a thin layer is formed (with a high density) which protects it from oxidation.

Several gases dissolve in aluminium (H_2, CH_4, CO, etc.). Hydrogen dissolves largely in aluminium as shown on Table 5.

Table 5: Hydrogen Gas Dissolution in Aluminium at Different Temperatures

Temp., °C	Hydrogen Dissolution cm^3/100 gm	Temp., °C	Hydrogen Dissolution cm^3/100 gm
300	0.001	658 (liquid)	0.69
400	0.005	700	0.92
500	0.012	800	1.67
600	0.026	850	2.10
658 (solid)			

Table 6: Chemical Composition for Aluminium Products Based on Specifications

Aluminium	Percentage of Allowable Impurities					
	Iron	Silicon	Copper	Zinc	Titanium	Total
High Quality						
99.995	0.0015	0.0015	0.0010	0.0010	0.0010	0.005
99.990	0.003	0.003	0.003	0.003	0.002	0.01
99.970	0.015	0.015	0.005	0.005	0.002	0.03
99.950	0.030	0.010	0.010	0.010	0.002	0.05
Commercial Grade (purity)						
99.850	0.08	0.06	0.01	0.02	0.01	0.15
99.800	0.12	0.10	0.01	0.04	0.02	0.20
99.700	0.16	0.16	0.01	0.05	0.02	0.30
99.600	0.25	0.25	0.01	0.06	0.03	0.40
99.500	0.30	0.30	0.02	0.06	0.03	0.50
99.000	0.50	0.50	0.02	0.08	0.03	1.00

2) Aluminium Alloys

The chemical composition, the structure of the aluminium alloys and the products' properties depends on the manufacturing method. Aluminium alloys can be divided to two types based in the method each is manufactured.

a) Aluminium alloys ingots used in foundries.
b) Ductile aluminium alloys used for forming. This is used to manufacture products formed by pressure.

Aluminium alloys used in foundries

The following alloys are divided into five groups depending in their chemical composition:

1. Aluminium and Silicon alloy
2. Aluminium and Copper alloy
3. Aluminium and Magnesium alloy
4. Aluminium and Silicon and Copper alloy
5. Other alloys

Table 7 shows the chemical composition of aluminium alloys used in foundries based in the Russian specifications.

Table 7: Chemical composition of aluminium alloys used in foundries.

Alloy	Percentage of Elements in Alloy (% weight)				
	Silicon	Copper	Magnesium	Molybdenum	Other
Al1	-	3.75-4.5	1.75-1.25	-	-
Al2	10.0-13.0	-	-	-	-
Al3	4.0-6.0	1.5-3.5	0.2-0.8	0.2-0.8	-
Al3-B	4.0-6.0	1.5-3.5	0.2-0.8	0.2-0.8	-
Al4	8.0-10.5	-	0.17-0.3	0.25-0.5	-
Al4-B	8.0-11.0	-	0.2-0.4	0.2-0.5	-
Al5	4.5-5.5	1.1-1.5	0.35-0.6	-	-
Al6	4.5-6.0	2.0-3.0	-	-	-
Al7	-	4.0-5.0	-	-	-
Al7-B	-	3.0-5.0	-	-	-
Al8	-	-	9.5-11.5	-	-
Al9	6.0-8.0	-	0.2-0.4	-	-
Al9-B	6.0-8.0	-	0.2-0.5	-	-
Al10	4.0-6.0	5.0-8.0	0.2-0.5	-	-
Al11	6.0-8.0	-	0.3-1.0	-	0.10-0.14
Al12	-	9.0-11.0	-	-	-
Al13	0.8-1.3	-	4.5-5.5	0.1-0.4	-
Al14-B	6.0-8.0	1.-3.0	0.2-0.6	0.2-0.6	-
A115-B	3.0-5.0	3.5-5.0	-	0.2-0.6	-
Al16-B	3.0-5.0	2.0-4.0	-	0.2-0.5	0.2-0.4
Al17-B	3.0-5.0	1.5-2.5	-	0.2-0.6	0.4-0.7
Al18-B	1.0-2.5	1.5-3.5	-	6.0-1.0	1.0-1.8
Al19	-	4.5-5.3	-	6.0-1.0	0.25-0.45
Al20	1.5-3	3.5-4.5	0.7-1.2	0.15-0.3	0.2-0.6
Al21	-	4.0-6.0	0.8-1.3	0.15-0.25	0.6-1.2
Al22	0.8-1.2	-	10.5-13.0	-	0.5-0.8
Al23	-	-	6.0-7.0	-	0.05-0.4
Al24	-	-	1.5-2.0	0.2-0.5	3.5-4.5
Al25	11.0-13.0	1.5-3.0	0.8-1.3	0.3-0.6	0.8-1.3
Al26	27-30	1.5-2.5	0.4-0.7	0.4-0.8	1.0-2.0
Al27	-	-	9.5-11.5	-	0.05-0.15
Al28	-	-	4.8-6.3	0.4-1.0	0.05-0.15
Al29	0.5-1.0	-	6.0-8.0	0.25-0.6	-
Al30	11.0-12.0	0.8-1.5	0.8-1.3	-	0.8-1.3
BAlA	-	-	1.5-2.0	0.2-0.5	0.1-0.2

Aluminium alloys give the ingots good mechanical properties at normal temperatures and has high resistance for corrosion.

Aluminium – Copper Alloy

This alloy is highly resistant to corrosion, but has low ductility properties. It is easy to work this alloy with different cutting machines. This alloy is highly resistant to temperature. The properties of this alloy can be improved by thermal treatment, adding Manganese and Titanium (e.g. alloy Al19).

Aluminium – Copper – Silicon Alloy

This alloy is used to manufacture hard products which require keeping their shape and dimensions during servicing. These products require having a high quality and smooth surface. This alloy is used for die casting for auto (automobile, automotive, car, vehicle) parts. The alloy AL7 has the best properties in this alloy group.

Aluminium – Magnesium Alloy

This alloy is known for its light weight and its high resistance to corrosion. It is used to produce ingots which is exposed to vibrations (e.g. AL8 and AL22).

These alloys tend to oxidize and tends to form shrinkage porosity, gaseous porosity, cracks and to react with humidity. In addition to that, the liquidity is low, thus problems arise when pouring the alloys into moulds.

Other alloys:

The other alloys used usually have a complicated composition. These alloys are used for manufacturing ingots that will be exposed high temperatures and pressure (AL1, AL10) or parts that will be welded (BAL4), products which are workable on cutting machines (AL21, AL11).