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Project

Industrial Pollution Prevention

Case Study: Textile Sector

Bleach Clean-Up in Cotton Textile Processing using Enzymes

Dakahleya Spinning and Weaving Co., Mansoura, Egypt and AmirTex Co. for Dyeing and Finishing, Sadat City, Egypt

THE BLEACHING PROCESS

Bleaching is carried out after scouring to whiten fabrics and yarns. It can also dissolve substances not removed by scouring and prepares the fibres for further finishing processes, particularly dyeing. It is normally carried out

peroxide.

Once bleaching has been completed, the bleaching chemical must be completely removed from the fabric, so that it will not interfere with subsequent dyeing and finishing processes. This is normally done by either repeatedly rinsing the bleached fabric in water, or by neutralising the bleach with a mild reducing agent. Chemical agents are commonly used, such as sodium thiosulphate or hydrosulphite.

This case study describes an alternative clean-up option for hydrogen peroxide based bleaching. This option uses enzymes instead of chemical reducing agents and saves water, energy and processing time.

FACTORIES WHERE IMPLEMENTED

Under the SEAM Project, the use of enzymes in cotton textile processing has been demonstrated at Dakahleya Spinning and Weaving and AmirTex. A description of these two factories is provided below.

Dakahleya Spinning and Weaving, a public sector factory with annual production of 11,400 tons of spun yarns, knitted fabrics and ready made garments. The factory was built in 1965 and employs 4,000 workers. It comprises three spinning departments, an open end spinning unit and a tricot plant with a weaving unit, a dyehouse and a tailoring hall. The main products are cotton yarns, cotton knitted fabrics, polyester blended fabrics, and ready made knitted cotton garments. In 1997, average monthly production was 39.4 ton of full bleached fabric and 10.3 ton of half bleached fabric.

AmirTex, a privately owned company with around 100 employees. The factory was built in 1984 and comprises a weaving and knitting department, a printing unit and a dyehouse. The main products are cotton yarns, cotton knitted fabrics, polyester blended fabrics, and ready made knitted cotton garments. Average annual production is 720 tons of cotton, polyester and blended fabrics. In 1997, average monthly production was 29.4 ton of half bleached fabric.

IDENTIFICATION OF PROBLEMS

Conventional bleach clean-up methods have the following drawbacks:

- Higher levels of energy consumption.
- Higher levels of water consumption.
- Longer processing time.
- Release of toxic substances (sodium hydrosulphite, a toxic and hazardous chemical).
- Lower bleach clean up efficiency (bleach may not be completely removed).

ENZYMETIC BLEACH CLEAN UP

Catalase enzymes can be used in bleach clean-up as an alternative to multiple rinses or use of chemical reducing agents. In the SEAM Project, the *Terminox* 10L and *Terminox Ultra* 50L enzymes produced by Novo Nordisk were used, *Terminox Ultra* 50L being the more effective of the two. Both products break down residual hydrogen peroxide into non-active oxygen and water. This process is most efficient at pH 6.5-7; beyond this range, larger amounts of the enzyme are needed to achieve complete decomposition of hydrogen peroxide.

A comparison between conventional and enzyme-based bleach clean-up methods is highlighted below:

Rinsing with water:

Bleach → Rinse → Rinse → Rinse → Dye

Reduction with chemical reducing agents:

Bleach → Reduc e → Rinse → Dye

Using catalase enzyme:

Bleach → (Rinse) → Enzyme → Dye

Under industrial conditions, *Terminox* takes 10-20 minutes to completely break down residual hydrogen peroxide and has no adverse effect on either the fibres or the subsequent dyeing process. Once bleach removal is completed, dyeing can be carried out in the same liquor, without any need for further heating.

CLEANER PRODUCTION APPLICATION

Pilot scale trials were carried out using both *Terminox* 10L and *Terminox Ultra* 50L. These trials were carried out to identify optimum conditions for enzyme use, such that residual hydrogen peroxide was completely eliminated from the liquor.

Application of enzymetic bleach clean up is very straightforward. A summary of the methodology used at both factories follows.

General Methodology
1. Drain the spent bleaching liquor. 2. Fill with fresh cold water. 3. Check that pH is in the range 6.5-7 and the temperature 45- 4. Add enzyme. 5. Check after 10-20 min minutes that residual H_2O_2 has been removed by using Merck peroxide test strips. 6. Start the optical brightening procedure without changing the liquor. 7. Assess results and optimise enzyme concentration.
Note: If the fabric is very dirty, then it is recommended that an extra overflow rinsing step is carried out once bleaching has been completed and before the enzyme is added.

The results of the pilot trials carried out at Dakahleya Spinning and Weaving, using Terminox 10L are summarised as follows:

Trial No.	Enzyme conc. (g/l)	Liquor Characteristics		
		Before Clean-up	After Clean-up	
		Residual H_2O_2	pH	Residual H_2O_2
1	1.6	25	6	0
2	0.8	5	6	0
3	0.8	10	7	0
4	0.5	25	8	5
5	0.5	25	7	0
Note: Enzyme performance is reduced where H_2O_2 concentrations exceed 1,000 ppm.				

In Dakahleya Spinning and Weaving, when 0.5g/l enzyme was used and pH was 8, some hydrogen peroxide was still present. When pH was corrected to 7, no residual hydrogen peroxide was detected. This demonstrates that pH is critical in fine-tuning pilot scale experiments.

Checking for optimum pH conditions

Once an acceptable recipe had been developed, the pilot scale results and to check that dyeing would be of an acceptable quality. A summary of the results obtained at both factories at the production scale follows (note: in Dakahleya Spinning and Weaving, Terminox 50L was substituted for Terminox 10L at the production scale):

Dakahleya Production Trials - Optimising Enzyme Concentrations for Full Bleaching		
Trial No.	**Enzyme conc. (mg/l)**	**Whiteness Index**
1	0.18	96.45
2	0.16	100.78
3	0.14	98.69
4	0.12	99.94
Note: No residual hydrogen peroxide was detected once bleach clean-up had been completed.		

The recipe from Trial 4 was adopted for full-scale production, as it used the minimum amount of enzymes, whilst giving an acceptable whiteness index.

In the case of half bleaching, a lower level of whiteness is acceptable as the fabric is subsequently dyed. The requirements of hydrogen peroxide are also less and therefore the residual levels of hydrogen peroxide are low. The following table is a

summary of the results obtained at AmirTex for the half bleaching of cotton and cotton / polyester blend.

AmirTex - Half Bleaching and Dyeing		
Recipe: Terminox 50L, 137.5mg / l; acetic acid, 93.75mg / l.		
	BEFORE (Conventional Process)	**AFTER (Modified Process)**
a) Half bleached and dyed cotton; single jersey		
Bursting strength (kg / cm^3)	31	35.3
Washing fastness	4-5	4-5
b) Half bleached and dyed polyester/ cotton; interlock		
Bursting strength (kg / cm^3)	77.3	79.2
Washing fastness	4-5	4-5

At AmirTex, a slight improvement in the bursting strength was observed for both the 100% cotton and the cotton / polyester blend fabrics.

Adding Terminox enzyme to jet machines

PROCESS OPTIMISATION

Use of the enzymes meant that a number of stages could be combined or eliminated entirely. A summary of the optimisation achieved at the two factories follows.

Dakahleya Spinning and Weaving

- Elimination of 2 hot water washes.
- Elimination of 3 cold water rinses.
- step in full bleaching process.
- Reuse of enzyme bath as the dye bath in the bleaching / dyeing process.

AmirTex

- Elimination of 1 hot wash.
- Elimination of 1 cold rinse.

COSTS AND BENEFITS

Enzyme Bleach and Process Optimisation

No capital expenditure was necessary for implementation, as the benefits have been achieved mainly through substitution and process optimisation.

Dakahleya Spinning and Weaving

No increase in costs was recorded, as great care was taken to identify the lowest cost recipe (whilst maintaining an acceptable fabric quality) and to optimise the process in terms of water and energy consumption. As a result, steam, water and electricity costs were reduced by 24-50%.

Annual savings on current production: LE112,971.
Payback period: Immediate.

AmirTex

The biggest savings at AmirTex were made with regard to energy consumption, mainly resulting from the elimination of the hot water wash.

Annual savings on existing production: LE36,359.
Payback period: Immediate.

Savings in LE per ton of Fabric Processed			
	Dakahleya		**AmirTex**
Savings in:	**Half Bleach and Dye**	**Full Bleach**	**Half Bleach and Dye**
Chemical costs	30	5	(40)
Water use	25	29	23
Energy	158	149	120
Total savings (LE / ton)	213	183	103
Annual prod. (tons)	124	473	353
ANNUAL SAVINGS (LE)	**26,412**	**86,559**	**36,359**

Note: Figures in brackets indicate an increase in cost.

Increased Production Capacity

Dakahleya Spinning and Weaving

Processing time was reduced by 13% per ton of half bleached fabric and 33% per ton of full bleached fabric. This corresponds to a potential increase of 1.3 tons of half bleached fabric and 13 tons of full bleached fabric per month that could be achieved.

AmirTex

Processing time was reduced from 7 hours to 5 hours per ton of fabric, thereby increasing production capacity by 29%. As the average monthly production of half bleached fabric is 29.4 tons, a potential increase of 8.5 tons of half bleached fabric per month could be achieved. These benefits are not presently quantified.

Checking peroxide concentration with tester after enzyme bleach clean up

Environmental Benefits

- Effluent volume at both factories reduced, due to the elimination of unnecessary washing steps.
- The concentration Total Dissolved Solids (TDS) in the effluent was decreased.
- Most of the chemical agents for bleach clean up are hazardous to handle and difficult to degrade. In contrast, enzymes are safe to handle and completely biodegradable.

BENEFITS AND ACHIEVEMENTS

	Dakahleya Co.		AmirTex
	Half Bleach	Full Bleach	Half Bleach
Energy consumption reduced by:	48%	24%	45%
Chemical costs reduced by:	40%	83%	-
Water consumption reduced by:	36%	50%	43%
Processing time reduced by:	13%	33%	29%
▪ Improved productivity ▪ Improved working conditions			

CONTACTS

More information on this project and the SEAM Project, are available from:

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February 1999

The SEAM Project

Support for Environmental Assessment and Management (SEAM), is a multi-disciplinary

Department for International Development (DFID). This project is being implemented by the Egyptian Environmental Affairs Agency (EEAA) through the Technical Co-operation Office for the Environment (TCOE) and *En*tec, a UK engineering and environmental consultancy.

SEAM: Pollution Prevention

This is being implemented under the National Industrial Pollution Prevention Programme (NIPPP). NIPPP focuses on the introduction and promotion of low-cost improvement measures, which can be easily and quickly implemented by factories. It also emphasises the importance of economic benefits of any such intervention, particularly those with short pay-back periods.

Methodology - A Description

Pollution prevention opportunities can be identified through an industrial audit[1]. This

and processes, focusing on reducing waste, improving efficiency and alleviating pollution. This aims to identify and prevent losses from occurring in the first place, rather than resorting immediately to a treatment facility.

The SEAM Project has carried out audits in 32 factories in the food, textile and oil and soap sectors, which identified a wide range of low-cost pollution prevention opportunities, including water and energy conservation, the importance of good housekeeping, in-process modification and hazardous materials substitution. The SEAM Project is presently implementing 23 of these opportunities as demonstration projects.

Benefits of Pollution Prevention

It can ***REDUCE :***

- production costs;
- losses of valuable raw materials;
- on site treatment costs;
- energy and water costs;
- the volume of solid and liquid wastes generated;
- the risk of spills and accidents.

. . . and ***IMPROVE :***

- overall operating efficiency;
- generation of income through reuse and recycling of wastes;
- this approach can be easily replicated in sister factories to achieve similar savings;
- safety of employees;
- legislative compliance;
- company image.

1 Guidelines for Industrial Audits have been prepared by the SEAM Project.