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WASTE MINIMISATION IN HOSIERY TEXTILE DYEING – A CASE STUDY

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ABSTRACT

This paper deals with the evaluation of waste minimisation options that are implemented in hosiery dyeing units at Tirupur. The evaluation was carried out on technical, environmental and economic aspects in which the production capacity, space requirement and equipment requirement were considered as the criterion for technical aspects, payback period was the criterion for economic aspect and the change in effluent characteristics, reduction in water and power consumption, reusability of waste was the criterion for environmental evaluation. The implementation of several options led to increase in production by 2% to 10%, reduction in water consumption by 2% to 50% and the power consumption by 2% to 67%. The TDS in the effluent was reduced by 35% to 56%. Most of the options do not require any space and investment and the payback calculated for the options are only few months.

INTRODUCTION

Tirupur, an important industrial town of South India accounts for a major share of India's hosiery and knitwear exports. The annual production is about 1, 45,000 tonnes of fabric in the form of T-shirts and sweaters (Narayanaswamy and Scott, 2001). Though it invariably attributes to the infrastructural development on one hand, it is a source of some of the environmental problems on the other. There are about 850 bleaching and dyeing industries located in and

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around Tirupur generating about 90 - 100 million litres of effluent per day.

Any manufacturing processes generate some form of waste which requires a significant investment for its management. Waste reduction is not only very often economically beneficial for an industry, but also improves the quality of the environment. This paper deals with the evaluation of waste minimisation options that are implemented in hosiery dyeing units at Tirupur.

Waste minimisation can be a bonanza for small and medium scale industry in the present times when many of these industries are facing tough global competition. In addition to the direct savings like chemical and dyestuff reduction, reduction in water consumption, optimisation of fuel consumption and electrical energy conservation, waste minimisation would also result in indirect cost benefits in reduced treatment costs of raw water and waste water, reduced rejection/reprocessing costs and improved quality of product (Kalathiyappan, 2001).

Waste minimisation concept

Initially the industries focused their environment protection efforts on controlling the effluent at the point where they enter the environment. This concept is appropriately known as "End of Pipe (EOP)" treatment (Chiu and Peters, 1994).

While this EOP approach has to some extent been effective for protecting the environment, it had the following disadvantages (Chiu and Peters, 1994):

· Transfer of pollutants from one medium to another, thereby effecting no net environmental benefits.

· Need for huge investments and recurring expenses which makes this con cept highly unsustainable and at times for most the Small and Medium scale Enterprises (SMEs) this is just not feasible on account of poor profit ability, space constraints etc.

Waste minimisation can be defined as A new and creative way of thinking about products and the processes which make them. It is achieved by the continuous application of strategies to minimise the generation of wastes and emissions (NPC, 1994). For processes, waste minimisation involves conserving raw materials and energy, eliminating the use of toxic substances as much as possible, reducing quantity and toxicity of emissions and wastes before they leave the process etc. For products, it means reducing their environmental impact during its entire life cycle from raw material extraction till ultimate disposal.

Waste minimisation in textile industries

The wet process part of the textile industry is a large consumer of process water, energy, chemicals, textile auxiliary agents and dyes. It produces a lot of effluents, which are mostly released to the environment. The quantity and toxicity of wastewater produced in textile wet processing depend on the type of textile processed, dyes used, type of equipment, etc. (Petek and Glavic, 1996).

The textile industry is also a large consumer of energy, especially for heating. Heat in the form of steam is most frequently used in textile wet processing. Waste treatment costs increase with increasing toxicity and volume of effluents. Therefore, it is necessary to reduce waste flows and toxicity of effluents within the process via several measures.

Waste minimisation options

Some successful waste minimization options which can be applied in textile wet processing are as follows (CPCB, 2000).

· Conservation of water by using low liquor to cloth ratio machines.

· Conservation of fuel by optimizing combustion process in low efficiency boiler.

- Optimization of auxiliary chemicals and dyestuff usage, optimizing the operating practices, dosing procedure, process control, avoiding unnecessary process steps and substituting chemicals.

· Good housekeeping and regular maintenance should be of primary con cern in seeking waste prevention because some trivial steps can contribute considerabley to the reduction of the waste generated. God house keeping involves proper vigilance and maintenance of the equipment and the process utilities, Wastages of raw material as well as finished products during handling, storage and transportation can be avoided through good house keeping.

During the plant walkthrough, the waste minimisation options implemented in all the study units were identified and categorised as depicted in Figure 1 (Shantha and Joseph, 2005).

A case study from hosiery textile dyeing units
Methodology

Table 1
Unit prices for evaluated items

S.No	Items	Unit	Rate (Rs.)
1.	Water	m^3	40
2.	Electricity	kW.h	5
3.	Firewood	kg	1
4.	Steam	kg	0.62
5.	Crystallized common salt	kg	0.80
6	Vacuum evaporated common salt	kg	2.25
7.	HCl	L	5
8.	Acetic acid	L	31
9.	Hypochlorite	L	1.5
10.	Peroxide	L	27
11.	Wastewater Treatment	m^3	7.5

Table 2
Effect of chemical substitution on cost and consumption

Materials	Consumption (kg)	Cost (Rs.)
Hydrochloric acid	15.6	78
Acetic acid	2.6	80.6

Table 3
Characteristics of effluents from neutralization with acetic acid and HCl

S.No.	Parameters	Acetic acid	Hydrochloric acid	Change in effluent load
1.	pH	8.1 – 8.4	1.85 – 2.20	+6.2 to 6.25
2.	TDS (kg/day)	69.2 – 71.0	150.7 – 169.5	-56.2%
3.	BOD (kg/day)	4.1 – 5.3	1.2 – 2.3	+62.8%
4.	COD (kg/day)	20.3 – 29	17.2 - 32	Nil

Table 4
Consumption and cost comparison on chemical substitution

S.No.	Materials	Consumption (kg)	Cost (Rs.)
1.	Common salt		
	- Dark shade	104	83.2
	- Medium shade	52	41.6
	- Light shade	26	20.8
2.	Vacuum evaporated salt		
	- Dark shade	78	175.5
	- Medium shade	39	87.75
	- Light shade	19.5	44

Table 5
Characteristics of effluents from enzyme based and conventional reducing agent

Sl.No.	Parameters	Enzyme based reducing agent	Conventional reducing agent	Change in effluent load
1.	pH	8.3-8.5	9.0-9.9	+4.1 to5
2.	TDS (kg/day)	40.1 - 56	71.9 – 75.8	-34.9%
3.	BOD (kg/day)	10.3 – 12.1	2.6 – 3.1	+75.6%
4.	COD (kg/day)	47.4 – 54.3	10.6 – 16.8	+73.1%

Table 6
Characteristics of effluents from peroxide and hypochlorite process

Sl.No.	Parameters	Peroxide	Hypochlorite	Change in effluent load
1.	pH	10.7 – 11.9	6.6 – 6.9	+0.7 to 1.40
2.	TDS (kg/day)	148.8 – 155.8	138.8 - 147	+6.2%
3.	BOD (kg/day)	19.9 – 23.4	6.3 – 7.6	+67.9%
4.	COD (kg/day)	71 – 85.8	22.6 – 32.8	+64.7%

Table 7
Consumption and cost comparison for hypochlorite and peroxide

S.No.	Chemical	Consumption (L)	Cost (Rs.)
1.	Hypochlorite	130	156
	Anti-chlorine	1.3	26
2.	Peroxide	2.6	70.2
	Acetic acid	2.6	80.6

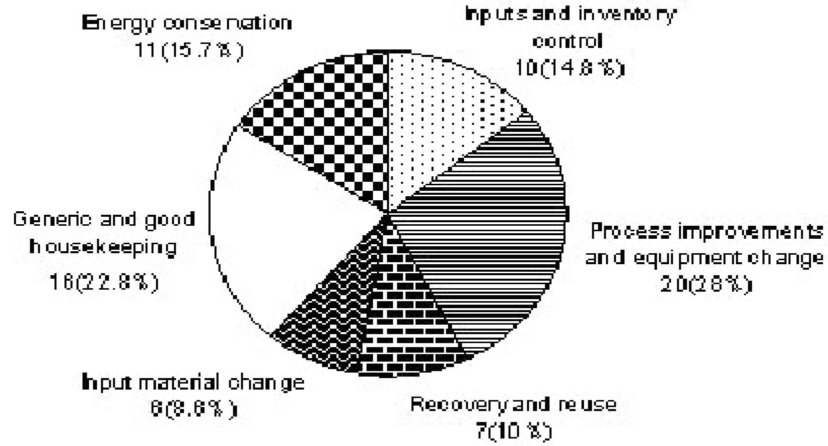

Fig. 1 Classification of waste minimisation options

The studies were carried out in hosiery textile dyeing units that are all the members of Waste Minimisation Circle at Tirupur. The industries chosen for the study were of different production capacities and operate throughout the year.

Initially, a plant walkthrough was done to understand the process carried out in the dyeing units. The main operations in the dyeing process were pre-treatment and dyeing. The pre-treatment process was carried out to purify the fabric by removing the oily substances and natural colouring material. After fabric purification, the dyeing was carried out to obtain the required depth of shade. The methodology adopted for the study involved collection of all the relevant data from the industry and analysis of the data to evaluate the waste minimisation options on technical, economic and environmental basis.

Technical evaluation

The criteria considered for technical evaluation includes Impact on production capacity, Equipment requirement and Space requirement.

An assessment of impact on production capacity was done based on the capacity of equipments and time requirement for the process. By equipment modification, the production capacity increased by reduction in overall process time. Chemical substitution reduced the total number of baths and thereby minimising the overall process time. The time saved were utilised for processing the additional quantity of fabric resulted in increased the production.

The assessment of space requirement was done based on the space required for implementation of the option in the dyeing units. The space requirement differs for various options because of equipment size and its auxiliaries.
The assessment of equipment requirement was done based on the requirement of equipment for implementation of the options. It differs from option to option.

Environmental evaluation

The criteria considered for environmental evaluation were Reduction in water consumption, Reduction in power consumption, Reusability of waste and Change in effluent characteristics.

The reduction in water consumption was determined by calculating the difference in consumption of water before and after implementation of the options. Reuse of water from the process led to reduction in water consumption in many cases. The reduction in power consumption was estimated by calculating the difference in consumption of power before and after implementation of the options. The reusability of waste was estimated by quantifying the waste recycled and reused in the process. It differs from option to option.

The change in effluent characteristics was assessed for the options related to chemical substitution. The effluent samples were analysed for the parameters such as pH, TDS, BOD and COD. A calomel electrode type pH meter of ELICO LI 120 make was used for measurement of pH. TDS, BOD and COD were determined by following the standard methods (Clesceri *et al.* 1998) .

Economic evaluation

The Economic evaluation was carried out to establish the economic feasibility and benefits of the waste minimisation options. The criteria considered for economic evaluation was payback period calculated based on capital cost, operation and maintenance cost and cost savings.

Payback period = Capital investment / Net savings per annum

The capital cost includes direct cost and indirect investment cost. The operation cost and savings include the changes in cost of raw materials, labour and changes in the cost of utilities including water, steam and electricity. The unit prices adopted in the cost estimation are listed in Table 1.

RESULTS AND DISCUSSION

The evaluated waste minimisation options are as follows:

1. Substitution of HCl by acetic acid for neutralisation

In dyeing process, alkalies were used, which increases the pH. To neutralize this, HCl was used. After neutralizing, the fabric was subjected to washings. While using HCl, three washings were required in the neutralizing bath where as by using acetic acid, only a single bath was required by which two washings were avoided. The effect of substituting HCl by Acetic acid in the neutralising step for 100 kg of fabric is shown in Table 2.

It saved 2, 600 litres of water, which costs Rs.104. Reduction in power consumption of 2 kWh, was achieved with a saving of Rs.10. The savings in treatment cost was Rs.19.50. Additional cost for acetic acid was Rs.2.60. The total savings was estimated to be Rs.130.90.

By implementing this option, the production capacity was increased by 7%. Also, no additional space and equipment was required. The impact of chemical substitution on effluent characteristics in a unit of 1500 kg per day production capacity is given in Table 3. By avoid two washings, the water used for the process was reduced and also, the processing time of the machine was reduced by which the power consumption was minimised. The implementation of this option reduces the water consumption by 13% and the power consumption by 9%. Also, using Acetic acid reduces the TDS in the neutralisation bath.

2. Water and power conservation during mixing of chemicals

Water and power was conserved during mixing of chemicals by avoiding spillage of water and frequent operation of pumps. This was achieved by constructing a separate tank with a capacity of 900L to store water required in a day for mixing chemicals. About 5m^2 was required to implement this option.

This option reduces the water consumption by 13% and power consumption by 67%. The details are given below:

No. of times pump operated per day	=	12@1 min each time
Power consumption (kWh)	=	0.914
Quantity of water wasted by spillage per day	=	60 L
Investment cost for constructing a 900 L tank	=	Rs.1, 200
Pump operating time to fill the tank	=	4 min
Power consumption (kWh)	=	0.30
Savings in water per year	=	18,000 L
Cost of water saved	=	Rs.720
Savings in power consumption per year	=	Rs. 900
Total savings per year	=	Rs.1, 620
Pay back period		= 1,200/1,620
	=	9 months

3. Substitution of crystallised common salt by vacuum evaporated common salt

The impurities present in the common salt reduced the dye uptake and caused reprocessing of fabric. The substitution of vacuum evaporated common salt for crystallised common salt reduced reprocessing of fabric by 2%, which led to increase the production of equal quantity. By minimising the reprocessing process, the water and power consumption was reduced by 2%.

The effect of substitution of vacuum evaporated salt in the dye bath instead of common salt for 100 kg of fabric is shown in Table 4.

Monthly production of dyed fabric	=	36,000 kg
Increase in cost for vacuum evaporated salt	=	Rs.20, 780
Reduction in redyeing process of fabric	=	720 kg
Cost for redyeing per kg of fabric		= Rs.30
Savings per month	=	Rs.21, 600
Net savings per month	=	Rs.820

4. Use of enzyme based reducing agent for peroxide removal in pretreatment process

By using conventional reducing agent (peroxide killer), six numbers of baths were required to complete the pretreatment. By using enzyme based reducing agent, this was reduced to three and increases the production was increased by 10%.

The impact of chemical substitution on effluent characteristics in a unit of 1200 kg per day production capacity is given in Table 5.

The minimisation in number of baths led to reduction in water consumption by 50% and also the power consumption reduced by 50%. In processing 100kg of fabric, this option saved 3, 900 litres of water costing Rs.156. Reduction in power consumption of 5 kWh, was achieved with a saving of Rs.25. The savings in treatment cost was Rs.30. The reduction in consumption of acetic acid of 1200 ml was achieved with a saving of Rs.37.20. The total savings was estimated to be Rs.248.

5. Substitution of hypochlorite by peroxide in pretreatment

In pretreatment process (scouring and bleaching) using hypochlorite, six numbers of baths were required and the time required to complete the process was 285 minutes. By using peroxide, the number of baths was reduced to four and the time taken was 160 minutes, increasing the production by 7%.

The impact of chemical substitution on effluent characteristics in unit of 1500 kg per day of production capacity is given in Table 6. The option leads to water conservation by 33% and power savings by 36%. The effect of this option for dyeing 100 kg of fabric is presented in Table 7.

It saved 2, 600 litres of water costing Rs.104. Reduction in power consumption of 6.4 kWh was achieved with a saving of Rs.32. The savings by cost of chemical was Rs.31.20 and by treatment cost was Rs.19.50. the total savings was estimated to be Rs.187.

CONCLUSION

It was seen that, the Waste Minimisation options implemented in the hosiery dyeing units increased the production by 2% to 10%. The water consumption was reduced by 2% to 50% and the power consumption was reduced by 2% to 67%. The TDS in the effluent was reduced by 35% to 56%. Most of the options do not require any space and investment and the payback calculated for the options are only few months.

REFERENCES

Clesceri, S. Lenore, Greegerg E. Arnold and Eaton D. Andrew 1998. *Standard Methods for the Examination of Water and Wastewater*. A PHA, Washington.

Chiu, S. and Peters, S. 1994. *Industrial Pollution Prevention*. Asian Development Bank, Philippines.

CPCB, 2000. *Textile industry*. Comprehensive Industry Document Series, COINDS/59/1999-2000, Central Pollution Control Board, New Delhi.

Kalathiyappan, .S. 2001. Results of WMC in cotton hosiery processing cluster, Ludhiana. *Waste Minimisation Circle News*. 2 (6) : 2-6.

Narayanaswamy, V, and Scott .S.J, 2001, Lessons from Cleaner Production experiences in Indian hosiery clusters. *Journal of Cleaner Production*. 9 : 325-340.

NPC, 1994. *From waste to profits –Guidelines for waste minimisation*.N.P.C.,N.Delhi,India.

Petek, J. and Glavic, P. 1996. An integral approach to waste minimisation in process industries. *Resources, Conservation and Recycling*. 17 : 169 - 188.

Shantha Kumar, S. and Kurian Joseph 2005. Evaluation of waste minimization options in hosiery dyeing units. *Journal of IAEM*. 32 (2) : 122 - 130.