PROMOTION OF ENERGY AND WATER CONSERVATION CONCEPTS IN THE TURKISH TEXTILE INDUSTRY

*Nilgun Kiran and Ahmet Baban

TUBITAK-MRC Energy Systems and Environmental Research Institute
Gebze 41470 Kocaeli - TURKEY

Summary

The Turkish textile industry is one of the country's most important and is comprised of several sub-sectors, among which cotton is of major importance. Best Available Technology options were assessed for the industry and feasibility studies undertaken, most of which were related to water conservation. One of them is based on reduction of water consumption in the regeneration process. Concerned with energy conservation; heat recovery from the effluents is investigated. Special emphasis was given to recover the heat of blowdown, which was discharged into the wastewater treatment plant. The results of the calculations made during the feasibility stage demonstrated that identified Cleaner Production (CP) options were worth implementing. The technologies which were concluded to be feasible were unique for the textile company investigated during this research. Moreover, wastewater treatment methodology for another selected cotton textile plant was described.

Key words
cleaner production, cotton, energy, textile, water, wastewater

INTRODUCTION

The textile, leather and clothing industry are one of the most important industrial sectors in Turkey. In 1997, 20% of the total industrial establishments operating in the textile sector employed 30% of all industrial workers. The textile sector has steadily increased its importance within Turkish industry, primarily due to its very high export potential. At present, the textile industry accounts for about 35% of the overall Turkish export capacity [1].

The qualitative and quantitative patterns of both the production process and the associated resource utilisation are of utmost importance within the framework of Cleaner Production (CP). Recently introduced regulations impose several limitations on the overall production chain of the textile industry regarding CP methods.

For the identification of suitable CP options, a thorough analysis of all material, water and energy balances is essential There exists a strong heterogeneity among different industrial sectors as well as sub-sectors in terms of the utilised raw materials, employed processes, water use and energy production/supply options [2]. Therefore, this CP assessment has to be industry-specific. In this study, CP assessment in the textile sector is investigated with a special emphasis on cotton based operations. Water consumption in the cotton textile industry is high and can be up to 110 l/kg and is, therefore, an important area to consider. With respect to energy consumption, the proportion of energy cost within the total production cost is generally around 5-10%. In general, however, process heat requirements are mainly in the low temperature range and are satisfied predominately by steam. About 42% of the process heat requirements are at temperatures below 120°C while about 75% are below 150°C [3]. Waste heat utilisation options are also discussed in order to help reduce the quantity of energy requirements in the Turkish textile industry.

In addition, another cotton based textile enterprise is taken into account as an example of a wastewater treatability study and subsequent plant design conceptualization.

CLEANER PRODUCTION APPLICATION IN THE TEXTILE INDUSTRY

The CP program for the textile industry in Turkey has to comprise of a set of organisational, administrative and planning activities that aim at enhancing the CP approach throughout the production of textiles.

The cotton sub-sector is very important within the Turkish textile industry. In the 1995/1996 production season, the amount of cotton production in Turkey was 851 487 tons and 780 000 tons of this amount were consumed [1]. For this study, a cotton enterprise, which is working under 100% commission, was selected. The applied cotton processes for this enterprise are summarised in Figure 1. From the point of CP the processes were grouped as dry or wet processes. Dry processes basically included processing of fibres into yarn and construction of a usable fabric were not applied in the selected enterprise [4]. Wet processes were found in the production of all fabrics.

The involvement of the individual enterprise is a must at all stages of CP. Since, CP is a very new concept in Turkey, the commitment of the enterprise is of great importance at the outset in the Planning and Organisation Phase. For our work, in order to adapt and finalise the CP audit in this initial phase, an audit team of one textile expert and one environmentalist was established. The economical situation and the market were taken into account in specifying the goals. Depending on the organisational, internal and external barriers of the enterprise specific appropriate solutions have to be sought at this phase [2].

In the Pre-Assessment Phase, during a walk through in the plant, obvious losses, which included low/no cost options, were identified and remedial solutions sought. Also included was flowchart development for the process for integration into an Assessment Phase. The common problem faced at this stage, however, was obtaining reliable current data. Depending on the inputs and outputs, focus points for subsequent CP assessment were realised. This was always carried out in correlation with the established goals of the Planning and Organisation Phase, otherwise it would have been impossible to get the support of the enterprise for further studies.

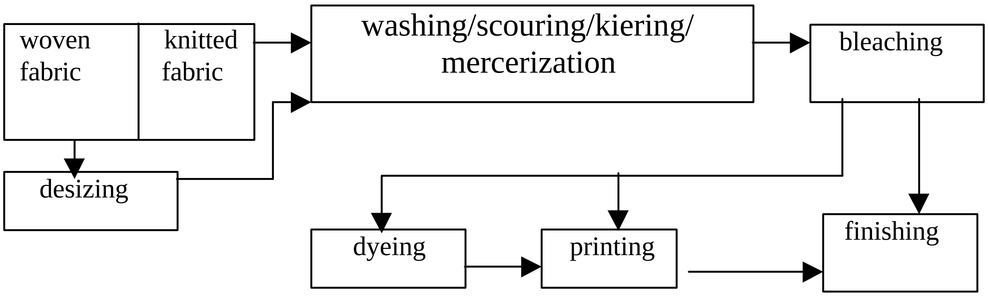

Figure 1: Main processes of the cotton textile industry [4]

Wet processing stages were taken into account from the point of resource(s) conservation. In general, wet treatment processes such as bleaching, dyeing and finishing are very important in terms of the environmental aspects of textile production, not only because of the vast quantity of water and variety of chemicals used, but also because of a high thermal energy requirement [4,5]. Water and energy are, therefore, also significant cost elements for most production units [2].

Since, CP is a comprehensive approach, water, energy and material balances were integrated. Figure 2 illustrates the different components of the material and energy balances for a unit operation/process.

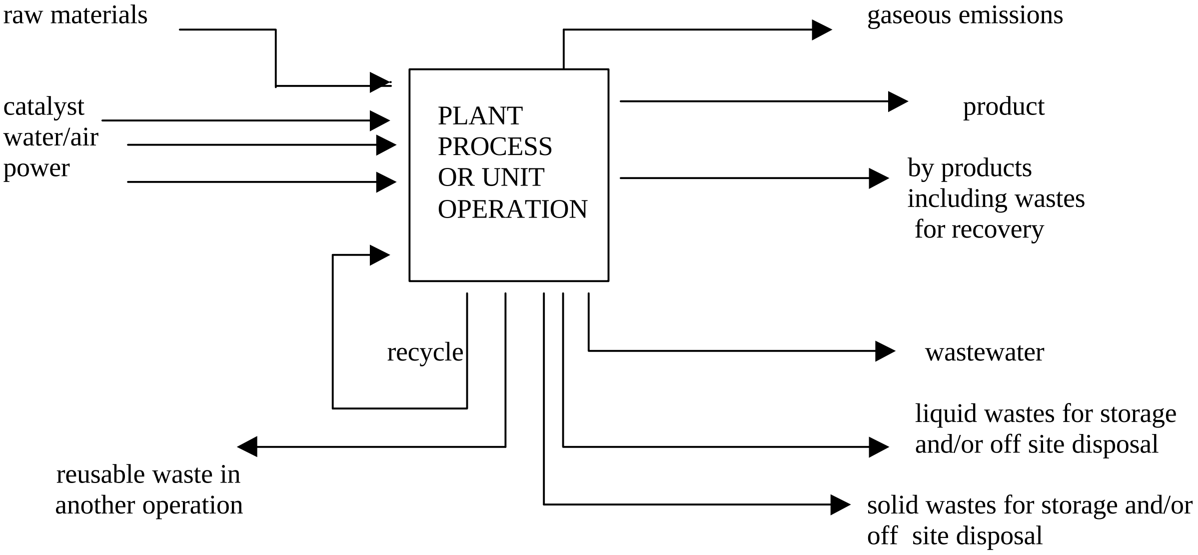

Figure 2: Components of material balance for cotton textile industry [2]

The costs associated with the material and energy in and outflows were investigated. During the evaluation of water costs, both industrial water preparation and wastewater treatment were considered. Furthermore, discharge costs for treated wastewater were also included. With a clear insight into these costs, management can be usually convinced to agree to rapid implementation of CP, particularly with respect to chemical substitution. Within this framework, extensive CP options were subsequently developed.

Before the Feasibility Stage, the generated set of CP options were prioritised. The prioritised options which seemed to be most promising were then submitted to a feasibility study. The feasible options could subsequently be recommended to the enterprise, with implementation carried out under a regime of continuous monitoring and evaluation.

The discharge values of wastewater parameters at the enterprise investigated were well below the legislation limits, so that no additional attempt was made to upgrade the wastewater treatment plant. Due to this, implemented wastewater methodology for another cotton textile plant is also presented in this paper. The scope of the work started with a comprehensive investigation of wastewater sources regarding their discharge rates as well as pollutant characteristics. Accordingly, three consecutive composite or grab type samples were taken and analysed. The results were evaluated and wastewater lines which should be segregated, determined. For example, in the presented case wastes generated from the lublication unit were separated since it provided very high pollutant levels (e.g. COD of 74000 mg/l) with a relatively low flow rate.

EVALUATION OF POSSIBLE CP OPTIONS

In the Pre-Assessment Phase, due to the impressions gained from the “walk through” avoidable, poor housekeeping practices were noticed. Leaving wastes in the wrong place or careless storage of harmful materials could be eliminated as they were inconsistent with the commitment to the pollution prevention. Furthermore, machines which had high energy losses due to poor or deteriorated insulation were identified. The calculated losses were up to 10% and this also led to production of additional emissions and wastes.

Depending on a CP Audit Focus of the Pre-Assessment Phase, CP opportunities were identified and explained. However, it should be noted that the variety of operations carried out, as well as the quality and quantities of energy used, make it difficult to develop a global energy target for the entire industry. This is illustrated by considering the various cotton treatment processes used and calculated associated average energy consumptions (Table 1). The overall energy consumption at the enterprise described in this paper was calculated to be between 1.5-1.7 kWh/kg finished textile.

Since, technology changes tend to be capital intensive, modification of the existing process streams without the application of new machinery was preferred. For this reason, waste heat utilisation with the use of heat exchangers was established [6]. The calculated energy saving targets for cotton knit wet processes were calculated and are summarised in Table 2.

Cotton treatment options	Consumption of energy (kWh/kg finished textile)
Scouring/washing	1.4-3.6
Bleaching/washing/drying	2.2-9.2
Bleaching/dyeing/washing/drying	2.8-9.8
Dyeing/washing/drying	2.2-5.0
Finishing	1.7-3.4

Table 1: Some cotton fabric processes for the selected plant

Description	Net energy savings (kWh/kg finished textile)
Utilisation of water to water heat exchanger for process wastewater.	0.3-0.4
Utilisation of air to air heat exchanger	0.03
Total	0.33-0.43

Table 2: Energy efficient technologies [5]

Flue gas effluents from the hot-air dryer and heat-set stenders contain only a relatively minor amount of pollutants. The emissions emitted from the stack of the dryer could be used to preheat the air which was introduced into the dryer. The heat recovery from bleach and dye wastewater was up to 0.4 kWh/kg finished textile. In addition to this, a heat exchanger could be installed to recover the heat of blowdown, which was clean process water discharged from the boiler directly to the wastewater treatment plant. The heat of blowdown could be used to heat the washing pool of printing screens (5 m x 5 m x 0.5 m). The blowdown had a temperature of approximately 98°C and a flowrate of 7-8 m^3/day. A storage tank would easily supply the necessary hot water for the pool since the blowdown and the pool were installed close to each other. The pipes that have a length of 40 m would transfer the stored blowdown from the storage tank to the pool. Pipes of 10 m length would heat the pool water up to 50°C for screen washing.

The water consumption of the factory is 80 l/kg for the production of 57% cotton, 7% man-made fibres and 36% cotton-polyester mix products. The classification of water consumption per process in the dye house can be seen in Table 3.

The material balances were carefully checked to determine gaps, inaccuracies and inconsistencies by using data obtained. During the evaluation of inputs and outputs, loss of 20% water was an assumption due to absorbance by the textile and evaporation. As it can be seen, bleaching is the process that led to the highest water consumption.

Since, there was a problem of water shortage in the location of the textile plant in question, most of the CP options were related to this factor. The prioritizing of selected options for water conservation was made mostly taking into account availability and suitability. The Feasibility Phase was then realised for the screened CP options and priority was given to the option for decreasing the liquor ratio of dyeing machines for water conservation. Later on, reuse of treated wastewater in certain processes, such as prewashing of printing screens was investigated and optimisation in the regeneration process for backwashing of the resins with sodium chloride solution for the softening of raw water carried out. During the latter process, water hardness was almost zero after 43 min from starting from the back-wash operation. However, it was found that the process was terminated at 62 min. Therefore, not only a process time of 19 min could be saved, but also a reduction in 3 m^3/process could be attained for each regeneration process (2 regenerations were carried out per day). The net income will be about 11 DM/day, plus a labour reduction of 0.7 DM/day. The results are presented in Table 4.

Type of machine/process	Water consumption (l/kg)	Water consumption (%)
Bleaching (overflow machine)	40-52	40-40
Polyester, nylon textiles dye machines (jet type machine)	28-35.2	28-27
Polyester, nylon textiles dye machines (high temperature machine)	2.5-3	2-2
Reactive washing of cotton, polyester and nylon textiles (continuous machine)	9-10.5	9-8
Mercerisation (continuous machine)	3.8-3.8	4-2
Washing for cotton, polyester, nylon textiles (continuous machine)	4-12	4-8
Printing	1-1.5	1-1
Other facilities	12-12	12-12

Table 3: Water consumption for each process in the dye house

		Before implementation	After implementation	Saving	Environmental evaluation
Inputs					
Electricity	(Kwh/d)	880.2	877.2	3.0	energy conservation
Chemicals	(kg/day)	1924.0	1916.0	8.0	reduction of chemicals in wastewater treatment.
	(DM/day)	291.4	290.0	1.4	
Water	(m^3/day)	1800.0	1794.0	6.0	water conservation
	(DM/day)	1818.0	1810.0	8.0	
Outputs					
Chemicals	(kg/day)	1163.0	1156.0	7.0	reduction of chemicals in wastewater treatment.
	(DM/day)	161.0	159.0	2.0	
Wastewater	(DM/day)	1177.7	1171.7	6.0	reduction in wastewater

Table 4: Feasibility study for optimisation in the regeneration process

The wastewater treatability study of other textile enterprise commenced with determination of the necessity for the application of physicochemical treatment options before biological treatment. In this case, taking into consideration the adverse effects of raw textile wastewater on microbial flocs, it was decided to carry-out jar test treatability studies prior to the activated sludge biological treatment. The types of chemicals that could be used for neutralisation, flocculation and coagulation purposes along with their optimum concentrations, workable pH range, optimum mixing rates and retention times and coagulation aids (polyelectrolides) were all studied in the laboratory. Target pollutant concentrations were also determined at each step of the application. Once the chemicals, optimum concentrations and other conditions for physicochemical treatment had been obtained, biological treatability study were started. At this stage, kinetic considerations, organic loading, parameters related so sludge settling characteristics and overall design parameters were determined.

The wastewater treatment facilities (flow equalisation, coagulation, flocculation, neutralisation, extended aerated activated sludge, sludge thickening and dewatering) were designed by making use of the data obtained from the laboratory work. The treatment plant was constructed and is currently in operation. The operational data of the plant revealed that it can treat wastewater at 360 m^3/day with an average COD of 2950 mg/l (other operational parameters of the plant are listed in Table 5). It should be emphasised that typically in the textile industry, 80-84% organic matter removal is attained by physicochemical and biological purification processes. A further step would be application of tertiary treatment such as ozone oxidation or activated carbon adsorption to the biologically treated wastewater to remove refractory organics. In this case, reuse of treated wastewater within the plant would also be considered. Consequently, application of the methodology to the textile industrial wastewater resulted in the successful construction and running of the plant within the predicted discharge limits without encountering operational problems.

Parameter	Raw wastewater	Treated wastewater (physicochemical and biological	Treatment efficiency %	Discharge limit to the sewage system
BOD_5, mg/l	1100	180	84	250
COD, mg/l	2950	560	80	800
Suspended solids, mg/l	230	65	72	350
Oil and grease, mg/l	85	5	94	100
Phenol, mg/l	0.90	0.018	98	10
pH	4.10	7.2	-	6-10

Table 5: Treatment efficiency and discharge criteria for textile wastewater treatment

CONCLUSIONS

A textile industrial plant has been investigated thoroughly by means of a step-wise CP assessment. The calculations for the implementation of the options revealed that it was worth applying CP options from the point of both energy recovery and cost effectiveness. Along these lines, it was predicted that approximately 20% annual cost savings would be achievable. The benefits obtained were not only attributed to cost savings, but better environmental awareness as well. It was also verified that applied methodologies resulted in considerable water conservation, which is vitally important for the textile industry investigated. Furthermore, the industrial wastewater treatability, design and implementation methodology for a cotton plant indicated that 80-95% reduction in pollutant concentrations can be realised.

It is concluded that the successful application of CP methodology in the Turkish textile sector will encourage other industrial sectors to take similar actions. It should also be noted that the managerial commitment of any enterprise is of utmost importance in CP, since without their commitment and financial support, there will be no real actions and no real results.

REFERENCES

[1] Electrical Works Research Office. National Energy Conservation Centre. (1997). Principles of Energy Management in Industrial Sectors, Vol.1, Annex 2.

[2] DTI International, Cleaner Technology Assessment. (1995). Danish Technological Institute. Taastrup, Denmark.

[3] Unlu G. Arikol M. and Kaptanoglu D. (1985). Survey of Industrial Energy Requirements: Findings for Turkish Textile Industry. TUBITAK-Marmara Research Centre. Rep. No:40., Kocaeli, Turkey.

[4] Laursen S. E. Hansen J. Bagh J. Jensen O. K. and Werther I. (1977). Environmental Assessment of Textiles. Miljoproject No.20, pp. 132-174.

[5] Koran N. and Ozdogan S. (1998). Integration of Process Energy Supply Options into Cleaner Production in Textile Industry. Proc. of the Kriton Curi International Symp. On Environmental Management in the Mediterranean Region. June 18-20. Antalya, Turkey, pp 947-955.

[6] Cooper S. G. (1978). *The Textile Industry Environmental Control and Energy Conservation*, ndc Press, pp. 104-117, 151-180.