

LOW WASTE TECHNOLOGY IN TEXTILE INDUSTRIES

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Abstract -- Processing of textile materials involves fibers from vegetable and animal origin and man-made polymers, together with process chemicals of different nature. These ingredients are processed along a variety of process schemes, which are dependent on the fiber or fiber blends used and the desired product quality. A lot of water and energy is consumed during these operations.

With the steadily increasing cost of energy, chemicals fibers and treatment of water and waste water, technologies have been introduced and are under development aimed to save as much as possible of the resources.

This paper will give a survey over the measures performed within the areas of water reduction, reuse of water and chemicals and substitution of chemicals and will finally discuss further possibilities for the future.

INTRODUCTION

The textile industry is characterized as a dynamic industry with constantly changing manufacturing processes. This is to a great deal dependent on the customers demand but also on new fibres, process chemicals or technology introduced.

Figure 1 describes the different fibre materials utilized in the textile industry. Out of those wool, cotton and man-made fibres are presently the basic fibres used.

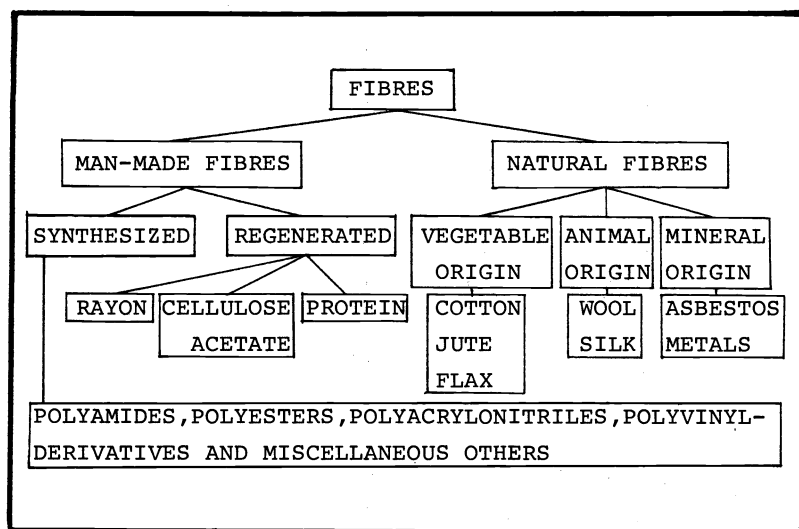


Fig. 1. Fibre materials used in the textile industries.

To process these fibres into textile products, lots of chemicals are needed. The chemicals are used, either to improve the process, or to add a certain

quality to the product. The process chemicals can be divided into six groups, which are shown in Tab 1. Some examples of subgroups are given, but the total number of products amounts to several thousands.

A survey, made in 1975 (1), revealed 2.600 commercial products apart from individual dyestuffs, used in the Swedish textile industries.

TABLE 1. Chemicals used in textile processing.

CHEMICALS USED IN TEXTILE PROCESSING	
1.	BASIC CHEMICALS: ALKALI, ACIDS, SALTS, SOLVENTS ETC.
2.	DETERGENTS: CATIONIC, ANIONIC, NONIONIC AND BLENDS.
3.	DYESTUFFS, PIGMENTS, OPTICAL BRIGHTENERS.
4.	AID CHEMICALS (DYEING): CARRIERS, DETERGENTS, COMPLEXING AGENTS.
5.	AID CHEMICALS (PRINTING): THICKENERS, BINDERS ETC.
6.	FINISHING AGENTS: STARCH- AND CELLULOSE DERIVATIVES, SYNTHETIC POLYMERS, RESINS ETC.

The process scheme is somewhat different depending upon the fibre or fibre-blends used. Fig. 2, apart from being simplified, describes the complex nature of processes to get a finished woven product from stockfibres.

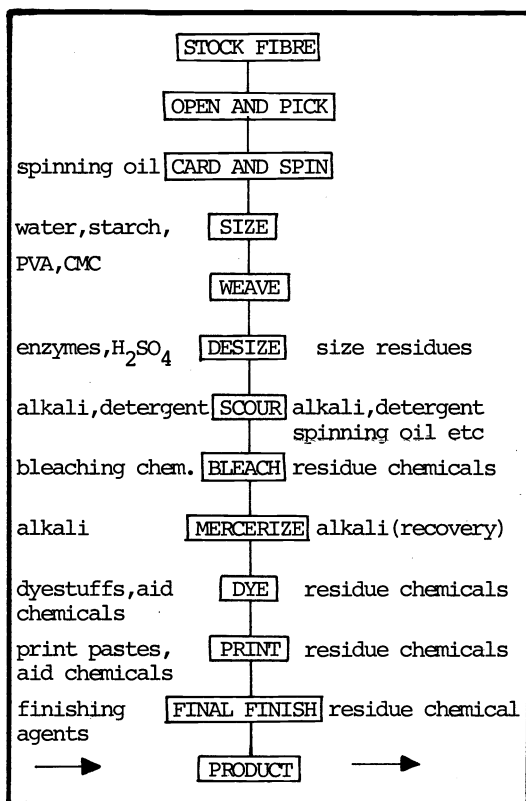


Fig. 2. Textile process scheme.

The content and character of the waste effluent depend partly on the fibre used, partly on the choice of process scheme. Tab. 2 shows the median water consumption and raw waste values obtained from a survey over the American textile industries (2).

TABLE 2. Median raw waste values in the American textile industries (2).

MEDIAN RAW WASTE VALUES				
Subcategory	Water usage l/kg	BOD ₅	COD kg/kg	TSS
1.WOOL SCOURING	11.7	41.8	128.9	43.1
2.WOOL FINISHING	287.8	59.8	204.8	17.2
3.WOVEN FABRIC FINISHING	78.4-113.4	22.6-45.1	92.4-122.6	8-14.8
4.KNIT FABRIC FINISHING	122.4	23.4	81.1-115.4	6.6
5.CARPET FINISHING	46.7	25.6	82.3	4.7
6.STOCK & YARN FINISHING	100.1	20.7	62.7	4.6

As can be seen from this brief introduction, textile processing is a complex technology involving a lot of different fibres, chemicals and processes, generating different types of waste waters.

LOW WASTE TECHNOLOGY

Low waste technology can be defined purely as process technology aimed to utilize as much as possible of the resources, in order to generate as little waste as possible. The term could be extended to involve the whole range, from raw materials and production to treatment of waste compounds. Fig. 3 illustrate the material flow scheme through a textile industry, and points out the different environmental areas, which have to be considered.

The incentive to modify the processes to low waste technology, is mainly depending on cost and availability of resources. This is true for water, chemicals and certainly for energy. An increased cost of energy will affect both production and treatment of water, and production of fibers and process chemicals. In the past most low waste technology installed, was concerned with water- and chemical savings, which as a secondary benefit also resulted in an energy reduction. During the last years, the technology focused on energy savings has been improved, and with the increasing cost of energy, such technology development will rapidly increase.

In this paper I will try to summarize the low waste technology used in the textile industry, and the new developments, which seem to have a potential for the future. Finally, I will briefly comment on a Scandinavian project, which is dealing with in-plant control, toxic chemicals and waste water treatment and reuse.

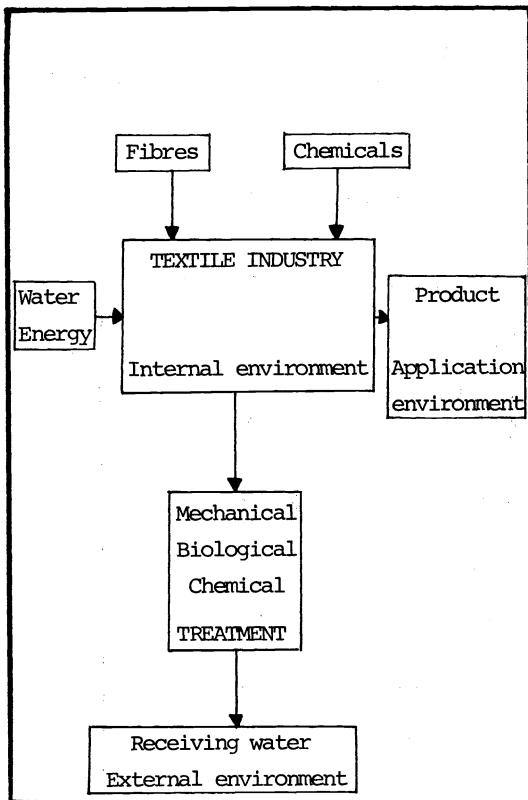


Fig. 3. Material flow through the textile industry.

IN-PLANT CONTROL

It is convenient to divide in-plant control into four types, as follows: 1) water reduction-reuse, 2) reuse of process chemicals, 3) chemical substitution, and 4) process modification-new process technology.

Water reduction-reuse

Water reduction and water reuse measures, simply lower the hydraulic load on treatment facilities, which in turn may yield improved effluent quality and smaller treatment units, involving less capital and operating costs. The interest in watersaving measures is steadily growing, especially in the field of rinsing operations. Presently this is under investigation in the above mentioned Scandinavian project. The use of automatic shut-offs, level- and flow control valves and meters, and similar modifications to existing equipment are important for the reduction of both water and energy. Good housekeeping, has frequently been cited as a valuable in-plant control. This consists of close control over the wet processes to avoid accidental losses of water or process chemicals and play a most important role in the over all saving program. The most common water reduction measure is counter current flow of water during wet processing operations. This system is considered standard procedure in wool scouring, and is common practice at textile mills that scour, bleach, mercerize, or dye on continuous ranges. Water reductions of up to 75 %, compared to conventional operations have been reported (3). The most frequently utilized source for water reuse without any treatment, is the cooling water. Cooling water, that does not come in contact with the cloth, or have excess added chemicals can be reused directly. Examples include condenser cooling water, water from water-cooled bearings, heat-exchange water and the like. This water can be stored for reuse in operations where heated water is needed, such as dye makeup, bleaching, rinsing and cleaning. Substantial savings in energy and water can be obtained. The American Survey (2) reported energy savings between 0.3 and 30 MWh per year and water savings between 10 and 400 m³ per day, depending upon the size of the mill.

streams, one containing chemicals which can be effectively degraded by biological methods, and another which would go directly to a hyperfiltration unit. (Fig. 4). By this type of application, together with direct hyperfiltration of some textile processes, a 90 % recovery of water including specific chemicals and energy, may be obtained (28). Naturally, a lot of work has to be done in each textile mill, prior to reuse of chemicals and water, to analyze the feasibility and the influence on product quality.

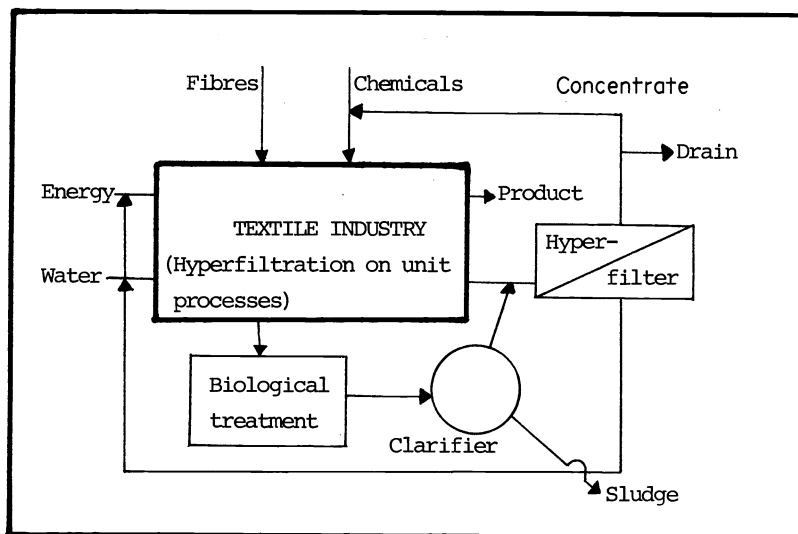


Fig. 4. Proposed design for minimum discharge using hyperfiltration.

The Scandinavian textile project

The waste water segregation and specific treatment is also the theme for the Scandinavian textile project. The project, which involves textile industries and research organisations in Denmark, Finland, Norway and Sweden, is divided into three subprojects: inplant measures, chemical characterization and waste treatment, and water recovery-reuse. (Fig. 5). The project is aimed to reduce the water consumption, reduce or eliminate pollution priority chemicals and to treat and reuse less contaminated process-streams. The results will be published in late 1980.

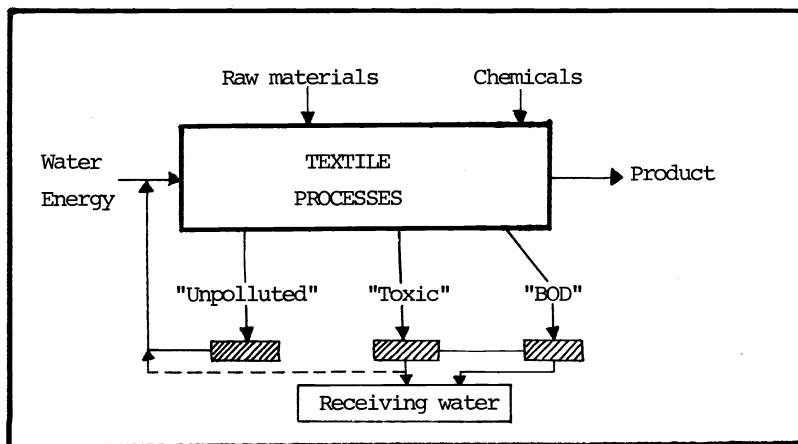


Fig. 5. The Scandinavian textile project.

Finally, I would like to stress the importance of good house-keeping. Any capital investment in low waste technology should be preceded by a survey, covering water, manufacturing operations, raw-materials and energy, to define the major sources of waste resources.

Significant reductions can also be achieved by reusing certain process water elsewhere in the operations. Wash water from bleaching can be reused in caustic washing, scour make up or as rinse water, scouring rinse water can be reused in desizing or washing printing equipment. Treatment of process waste water for reuse is not actually an "inplant control". Treatment of total waste water (4) and of certain process waste streams (5) for reuse has recently been reported. The latter treatment objective is one part of the Scandinavian project and the present results will be discussed in the second next paper at this conference. The costs and advantages of these types of treatment for water reuse, will have to be compared with costs and advantages of conventionally treated water. All types of water reduction and reuse incentives have to be carefully analyzed for the feasibility in each case, prior to introduction, in order not to spoil the quality of the product.

Reuse of process chemicals

The reuse of process chemicals is mainly performed to reduce processing costs, with the reduction of organic waste loadings being a secondary benefit. One of the most common measures undertaken is recovery and reuse of caustic after mercerizing. This is mainly used within large finishing mills, and has been for a long time.

Another area of process chemical recovery and reuse is in the sizing-desizing operations. After the introduction of synthetic fiber materials, new sizing agents, like polyvinylalcohol (PVA), polyacrylic acid (PAA) and carboxy methyl cellulose (CMC), have been introduced, besides the traditional starch compounds. Since only the latter is easily biodegradable, the formers will highly contribute to the organic load of the waste water. Several systems have been investigated to recover these sizing compounds. One promising technique is the membrane separation, which has been reported to reclaim 96 % of PVA at one mill, or about 2.000 tons per year (6). A similar type of technique has been tested for recovery of indigo, the dyestuff used for dyeing blue jeans, with a 80-90 % recovery (6). The membrane technology will be further outlined below.

Several attempts have been made to reuse spent dyeing baths by reconstituting to the proper formulation of dyes and process chemicals. Possible savings of 33 % in chemicals, 58 % in water and 67 % in energy requirements have been obtained (7,8).

Chemical savings can also be achieved by utilizing the chemicals in continuous operations, such as scouring and dyeing or in printing pastes, for longer periods without dumping.

It is highly probable that the costs of process chemicals and waste water treatment will make chemical recovery and reuse more important in the future.

Chemical substitution

As has been mentioned above a great number of chemicals have been developed for the textile industry, and the continuous development of more efficient textile chemicals and possible chemical substitution, will play an important role in the future waste load reduction. The purpose of chemical substitution is to replace chemicals having high pollutant potential, with chemicals that are less polluting or more easily treatable. A substitution should not be made in the way, that one pollution problem is replaced by another.

During the 1950's it was commonly advised to replace high BOD-compound with low BOD-ones, in order to reduce the polluttional load (9). One example is the replacement of starch by PVA; PAA or CMC. As long as the main waste treatment technology is biological, the low BOD-chemicals will probably not be accepted, but as physical-chemical methods or closed-loop systems are adopted, they will have a certain significance.

One of the most accepted substitution is the replacement of so called "hard" detergents with "soft" or biodegradable, low foaming detergents, thereby reducing the problems with foaming in treatment facilities and receiving waters. In certain dyeing processes, in order to eliminate chromium, chromate oxidizers have been replaced by hydrogen peroxide or iodates. In other dyeing processes acetic acid has been replaced by mineral acids, and soap in wool fulling operations with sulfuric acid. The latter substitutions will reduce the organic load, but they will at the same time increase the salt concentration (10).

Several chemical products can be chosen for a specific textile application. By performing an investigation of the different chemicals, according to their technical, economical and polluttional properties, an optimized application system can be obtained (11,12). The basic knowledge on polluttional properties

is, however, very meagre and available biological-ecological data are often obtained from different test species or procedures, and thus not comparable. An improvement in this field is a must for future reduction, or eliminations of specific, or priority pollutants. In the Scandinavian textile project, a chemical and biological characterization is presently under way, on carrier compounds, detergents and finishing chemicals. The project will result in recommendations of chemical substitutions, according to polluttional properties.

Process modifications and new process technology

The process modifications and the new process technology are very important for low waste technology. During the last years new equipments and processes have been developed and new process chemicals have been introduced, which are aimed to improve the utilization of the resources (13).

Process modifications are a group of measures, which more or less will result in reductions of hydraulic and pollutant loadings to treatment systems. By changing processes and material flow procedures, savings can be achieved. For example, the continuous operations generally require less space, water, and process chemicals, than do conventional batch operations (14).

Additional improvement of the continuous operations have been made by the introduction of instrumental monitoring equipment, including the use of mini-computers (15,16). By combining separate processes, such as scouring and dyeing in the finishing of synthetic fibres, and desizing and scouring of cotton, a substantial water reduction can be obtained.

The newer textile processes and processing equipment have been developed with focus on energy conservation. As secondary benefits, savings in chemicals and water are often achieved.

About 60 % of the total energy consumed in textile operations is consumed in the wet processes, and there mainly to evaporate water (17). A substantial energy conservation can be achieved by reduction in wet pick-up. A lot of methods have been introduced based either on saturation and removing of surplus, or on applying a limited amount of liquor (18,19). The latter group includes foam processing, which has been reported to save energy of up to 70 %, and water by at least 50 % in dyeing, printing and finishing. Another advantage is the low capital expenditure, which further increase the potential for foam processing in the future. The main problem today, is to make stabile foams for different applications.

Transfer printing, which is a process, where a colored pattern is transferred, through sublimation, from a predyed paper to the textile fabric, is another process involving low capital investment. Since transfer printing is a dry process, it needs no evaporation and fixation steps, produces no waste effluent and the fabric wastage is less than 1 % compared to 5-12 % for wet printing. Today, the process can only be used with dispersed dyes for printing polyester and nylon, but research is going on to develop other dyestuff systems, applicable to other fibres (20). By monitoring speed and sublimation temperature, it is possible to obtain three prints out of one roll of transfer paper (21).

Much interest has been shown during the past decade to solvent processes. In general it has not yet fulfilled its early promise, except for certain processes. The main drawbacks are that the solvent recovery system will not meet with economical feasibility, and that only a limited number of dyestuffs and chemicals are available, which directly can be transferred to solvent systems. Successful applications have, however, been reported for continuous scouring of polyester knit goods with a solvent loss of only 0.5 %, based on fabric weight (22), and for sizing-desizing including size recovery (23).

Energy conservation through heat reclamation is a field, where a lot still can be done. In a recent published survey over the energy consumption in the Swedish textile industries, it was revealed, that at least 25 % could be saved (24). Similar energy saving figures have also been reported elsewhere as a result of good housekeeping and heat reclamation (25,26).

The most ideal situation of low waste technology, would be if it was possible to close up the total textile process and reuse water, chemicals and energy. To some extent, this could be realized according to the potential of hyperfiltration. High temperature hyperfiltration and ultrafiltration for recycle of water, chemicals and energy have successfully been demonstrated for different textile processes. The potential economic payout is reported to be good, with recovery of specific chemicals and energy being paramount factors (27). The fully use of hyperfiltration has been proposed as a treatment design, most likely to give minimal discharge. The textile plant will have two waste

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