

Process-integrated resource management – an efficient instrument for environmentally friendly textile finishing

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Environmental awareness has long ceased to be the preserve of production plants in Europe. In the so-called developing countries, authorities are focussing increasingly on big polluters. Unfortunately, in this context textile wet finishing has an extremely bad reputation all around the world. However, there is some hope that a new, integrated environmental concept from Swiss textile machinery manufacturer Benninger, which can run without producing any waste water at all, may well make this bad reputation a thing of the past in the next few years render this negative reputation a thing of the past

Worldwide, only around 10% of total water consumption is accounted for by direct human needs. The lion's share of 70% is used in agriculture, and the remaining 20% is used in industry. Regional variations give an indication of the degree of industrialisation of the different national economies. For example, China uses 80% of its water to irrigate fields, whereas in Europe half of the water is pumped into factories. All this is in stark contrast to the geographical distribution of the resource "water". While China is home to around 20% of the world's population, it only has access to around 5% of world's freshwater supplies. Conflicts in this area are already (pre-)programmed.

A large amount of our drinking water is already used during the production of food. For example, it takes 5,000 litres of water to produce just one kilogram of meat for human consumption. But also vegetarians have an impact: The production of both one kilogram of bread or one litre of orange juice entails the use of 1000 litres of water. In the light of this, the remaining consumption of an average household in Switzerland seems to be rather modest, which adds up in a daily water consumption of approximately 162 litres per head (a Swiss household needs for example: showers/washing 32 l, toilet flushing 48 l, washing machine 30 l, cooking, drinking, washing up etc. 20 l).

Water and energy always have been the two main components in the production of textile fabrics. The majority of it goes into the production of the natural fibres: Regardless of whether cotton, wool or linen is concerned, the plants need to be watered throughout their entire lifecycle, and the sheep need to be fed and watered. In the case of cotton, this can sum up to as much as 20,000 litres of water per kilogram (in Sudan as much as 29,000 l). Against the background of increasing shortages of global resources, these are alarming figures, albeit ones which can be dramatically reduced with the aid of innovative irrigation techniques (plantation cultivation / "drip irrigation"). With these new techniques, the production of one kilogram of cotton still requires between 7,000 and 9,000 litres of water, but the downward trend at least gives some cause for hope.

Water is an elixir which has long been a political issue in the Middle East. The intensive water consumption of the cotton growing industry has strained relations between Turkey, Iraq, Israel and Syria. By contrast, sophisticated irrigation of cotton fields is up to now uncommon in West African countries.

The consequences of irrigation lead worldwide to salinisation, erosion of the soils, the depletion of water reserves and contamination of groundwater. In view of the expected shortages of the increasingly valuable resource "water", it seems inevitable that the amount of water used to grow cotton will have to be reduced rather in the short term than long term, especially as more and more fields will have to be irrigated as a consequence of the climatic change.

Besides irrigation of cotton fields, the wet finishing is the undisputed number two in the list of resource waste. Starting with sizing and desizing, washing, bleaching, mercerising, then dyeing and printing, perhaps even coating, all along in these processes there is always also a washing cycle involved, which may require as much as 20 litre of water per each cycle per kilogram of material. As a result water consumption may add to as much as 200 litre of water during the wet finishing processes for just one kilogram of grey cotton. By the time a standard men's shirt is tailored and displayed in a shop, more than 2,000 litres of water have gone into its production and processing (basis: 100% CO, 125 g/m²).

Minimising resources

The scenario described above clearly shows that quick measures are absolutely essential. Measures which are needed to be implemented only necessary in industrial nations, but on a worldwide basis. Easy to comprehend and simple to implement. Benninger has developed a new concept which will address the problem on two levels:

1. Minimisation
2. Recycling

The minimisation of resources consumed is based on the optimisation of processes and machinery. Improved processes modified recipes - this leads to improved quality and reproducibility and as a result leads to lower consumption. The change from exhaust dyeing to a continuous process illustrates a good example.

Based on the optimised consumption, water, energy and other resources then can be recycled. The result is a form of textile production which is both commercially and environmentally sustainable.

"Even the longest journey starts with a first step". In the case of resource management, - a first step may also be a small one. An effective way to save energy in textile finishing is to enclose steam valves in a housing (fig. 1). The costs are minimal which results in a short payback period of less than 8 months.

A step further would be to enclose an entire cylinder drier in a housing. The insulation not only reduces dissipation, but at the same time the drying efficiency is increased. .

As a result, the same performance can be achieved with less heating cylinders and thus reduces the total investment outlays for the cylinder dryer. The steam savings add up to more than 15%, therefore the total costs can be recovered in less than two years.

Cost savings of 15% through counter-flow optimisation

Further cost savings can be achieved with the liquor path. The magic word here is "counter-flow": The grey fabric runs through the washing compartments from the entry to the exit, the clean water is passed through the plant from the rear to the front. This means that the cleanest fabric comes into contact with the cleanest washing liquor. By rigorously applying this counter-flow principle, it is possible to save both water and energy.

Example: CPB dye washing. During dyeing with the CPB method (cold pad batch method), a padder with nip-controlled rollers (so-called "swimming") rollers are used to apply dyestuff to the fabric in a defined manner. After a dwelling time (which varies depending on the dyestuff) the excess dyestuff needs to be washed out. Here, a distinction is made between the following processes:

1. Rinsing out dyestuff from the surface
2. Soaping (here, the dyes are moved from the core of the fibres to the surface)
3. Neutralization
4. Washing out of the salts produced during neutralization

This process normally requires 20 litres of water and 1.6 kg of steam per kg of fabric (refer to fig. 2).

In a first step the counter-flow principle can be rigorously applied to the individual processes. The water used to wash out the salts in the rear compartment is directed around the soaping compartments and is then used again when the surface dyestuffs are rinsed out. As the level of soil is low in the rear part of the washing range, this liquor can be used effectively to wash in the front. In addition, less heating of the water is required for the soaping process, which saves energy in the form of steam (fig. 3).

The consumption of resources in this process amounts to 9 litres of water and 0.95 kg of steam for one kilo of fabric. In addition, less energy is required in the downstream drying process, as the temperature is already 40°C higher than in conventional processes.

By calculating the savings on the basis of average costs, the following values can be achieved.

- Water savings 55%
- Steam savings 41%
- Overall cost savings 15%

Here is a clear possibility, to improve the internal cost without new investment, structure considerably. The key to these improvements are process know-how and modern open width plant concepts.

Innovative concepts in handling knitted goods

The choice of the correct plant concept also plays an important role in the next example. In the past, knitwear finishing was largely performed in rope form. The fabric tension and curling of the edges made a continuous handling of these goods impossible and therefore an efficient handling impossible. New drive concepts and adapted fabric guidance systems permit companies for new investments to revert to an open width fabric guidance system based on the TRIKOFLEX principle from Benninger.

The quality benefits of open width treatment are felt in texture and consistency of the surface of the fabric. While Jet treatment is a mechanical process, continuous treatment in the TRIKOFLEX washing modules is a much gentler method. Therefore no creasing or abrasive surface damage (pilling) is expected. In addition, the individual processes are clearly separated from each other, and with the modern plant controls a clear overview is maintained at all times. Apart from an improved user guidance, this results in an excellent reproducibility, improved quality and reduced subsequent costs.

However, the main savings of continuous treatment are found in the variable costs. While the exhaustion dyeing process requires between 70 - 90 litres on average to dye and wash one kilogram of knitwear, a modern TRIKOFLEX plant only uses 18 litres for the same process, which corresponds to a saving of nearly 75%. Even more impressive is the improvement in terms of energy consumption: instead of the previous 19,100 kJ, continuous treatment only uses 4500 kJ per kilo of dyed knit goods.

However, it would be wrong to imagine that the resource savings outlined above have already reached their limits. Having achieved these savings a further optimisation lies in water recovery and recirculation. As long as the optimisation of processes is not fully exploited, the use of process water would still be unnecessarily vast.

The water flow in textile finishing plants

A waste water treatment and a recovery system for selected types of waste water from textile processes consists of the following components:

1. Ultrafiltration
2. Reverse osmosis

The difference between the two systems is largely in the pore size of the filter systems used. While ultrafiltration retains particles of less than 10 to 100 nm (this corresponds to 0.00001 to 0.0001 mm) reverse osmosis filters out particles less than

1 nm in size. In comparison: cigarette smoke particles are in the order of magnitude of around 1000 nm, and a human hair is 100,000 nm thick.

The layout of this type of system is shown in fig. 4. The waste water from the washing process is directed to the ultrafiltration stage. This cleaning stage is made up of tiny, self-cleaning ceramic tubes which are highly resistant to chemicals and have a service life of around 10 years. High temperatures are also no problem for this module. This process leads to a reduction of the chemical oxygen demand (COD) - which acts as an indicator of organic substances in the bath - of 63% during desizing, 80% during bleaching and still 48% during reactive dyeing. In the illustration, this effect corresponds to the difference between sample 1 (original waste water) and sample 2 in fig. 5.

After the ultrafiltration stage, the waste water passes through the reverse osmosis stage. Here, the remaining dyes and dissolved salts are separated from the remaining liquor. This effect is the result of a spirally rolled-up polymer which operates at a pressure of 25 bar. The service life here is three years, and the component is cleaned according to the "Cleaning in Place" method (CIP). In this method, the surfaces of the system which are in contact with products are cleaned without major disassembly work. The effect of reverse osmosis can be seen in the difference between sample 2 and sample 3 in fig. 5 (sample 4 shows normal tap water as a direct comparison).

In order to protect the reverse osmosis process, the hot water from the washing baths is cooled in a heat exchanger after the ultrafiltration stage. After the reverse osmosis, the water can then be heated using this energy. As a result, 70% of the employed energy can be reused. Depending on the level of soil, up to 85% of the water can be recovered. Restrictions only apply to substances which would cause the filters to block up. These include silicates if the pH value is less than 7, printing paste, silicone oil, fluorocarbons and a few other particular specialities which can vary from manufacturer to manufacturer and need to be verified for each individual chemical.

"Zero Discharge"

Given the current pricing pressure in the textile industry, regional and national environmental regulations can often make all the difference between commercial success and failure. Every step towards independence in terms of waste disposal requirements is also a step towards financial independence. By combining ultrafiltration and reverse osmosis, plants can even operate without any waste water altogether - a concept known as "Zero Discharge". The highly concentrated contaminants which have accumulated from both filtration stages are collected and transferred to a solidification process. The resulting solids usually have an organic basis and often have an excellent calorific value. Without doubt, this is an opportunity to improve the image of textile finishing and, at the same time, reduce the potential conflict between a company's own production and the requirements of the community.

So how does this filtration impact on the cost calculations we looked at above? In the example of a washing process as mentioned earlier on, the amount of freshwater is reduced to just 1.5 litres per treated kilogram of fabric. This corresponds to a saving of nearly 92%. Even more impressive are the potential savings which can be achieved with the investment in a modern open width installation for knitted goods in combination with ultrafiltration and reverse osmosis. Instead of the 70 - 90 litres consumption in a discontinued process, a modern and more efficient TRIKOFLEX plant uses just 4 litres, which represents a saving of 94%.

Fostering sustained environmental awareness and a responsible approach to nature

There is no doubt that the increased environmental awareness all around the world has its roots purely in commercial considerations: Polluted rivers keep tourists away, dried out fields hardly attract investors, over salted lakes do not help to accelerate development aid. However, even if the main motivating factor is commercial by nature - the time for action has long arrived. For the reasons described above, textile finishing has a special responsibility as a "water consuming industry". It is now time to meet this responsibility. In the past, Europe has always taken on a leading role when it came to innovations or general, fundamental changes. For this reason it is important today, more than ever, to set the standard.

The technology is available, and its use is lucrative and makes good commercial sense, even if it results in competing objectives in terms of the composition of the chemicals and additives which are used - and a lot of obstacles can be overcome through dialogue with customers and suppliers. Particularly when the issue at stake is the preservation of the world we live in for generations to come.

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