Developments in textile machinery for ecofriendly chemical processing

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Textile machinery play an important role in indirectly controlling the pollution load for environment protection. Energy saving, reduced liquor-to-material ratio, counter current liquor flow for washing and use of microprocessor controls are some of the features incorporated in the present generation machines. These features help in reducing the generation of flue gases in boiler, allow to use reduced quantities of chemicals, produce reduced volumes of effluents and give better performance of machinery, resulting in reduced re-processing. Some of the developments in textile machinery covering these aspects are briefly highlighted.

Keywords: Ecofriendly chemical processing, Textile machinery

1 Introduction

Textile manufacturing activities such as production of synthetic fibres, regeneration of fibres, spinning, weaving, knitting, chemical processing, garment manufacturing are witnessing several developments. The main focus of all these developments is to make each manufacturing process environment friendly. This has become essential due to the impact of environment regulations. In the present paper, the developments in textile machinery for minimizing the adverse impact on environment are briefly discussed.

2 Machinery for Fibre Recovery

The manufacturing of synthetic fibres consists of extruding the molten mass of the polymer through spinnerets in the form of filaments, stretching/drawing to desired extension and cooling the drawn filaments. The staple fibre is obtained by cutting the drawn filaments to the required staple length. During this process, considerable quantities of polymer and fibre waste are generated, causing environment pollution. Machinery has been designed and fabricated to convert the polymer and fibre waste into polymer granules so that they can be recycled for the manufacture of filaments. This enables to reduce the polymer waste and in environment protection.

Machinery has been developed to recover fibres from diverse textile materials such as torn fabrics pieces, old textiles, non-wovens and carpets.

3 Machinery for Chemical Processing

3.1 Fibre

Both natural and synthetic fibres are subjected to various chemical processes such as scouring, bleaching and dyeing. For small lots, batch package type processing machines are used. For wool fibres, continuous flat-web processing systems have been developed. Drying of the processed fibres by hot air is time consuming and laborious. The development of the radio frequency drying system for the drying of fibres has considerably overcome many problems faced in fibre drying. Fibre lots thus dried are easier for opening than those dried by thermal drying. The radio frequency drying is also very useful for package drying of yarns and fabrics.

3.2 Yarn

Yarn processing in packages is carried out in the form of cheese, cone or beam. The machine essentially consists of a vessel of stainless steel carrying the yarn container. There is also a liquor circulating pump with a facility for reversing the liquor flow from inside to outside and outside to inside. The notable features of developments from ecological considerations are as follows:

- The liquor-to-material ratio can be varied from 20:1 to 4:1. This is achieved by using dummy container which reduces the volume of the liquor to be used.
- Very low liquor-to-material ratio is possible when the liquor flow is maintained from inside to out-
side only. In this case, however, the yarn package diameter has to be reduced to ensure the least variations in the depth of shade from the outer layer to the innermost layers of yarn.

- A recently introduced vacuum extraction facility for removal of water from the yarn package dispenses with the separate hydro-extraction procedure.
- In case of vat dyed yarn, after the dyestuff has been exhausted, the vacuum extraction step simultaneously oxidizes the reduced dye on the yarn package, thereby requiring minimal quantities of oxidizing agent. This is, therefore, an eco-friendly technique.
- For the yarn in beam form, a horizontal beam dyeing machine has been introduced which facilitates the mounting and dis-mounting of large width beam by the use of trolley type beam carrier. This overcomes the conventional laborious procedure of mounting the beam by the use of pulleys and crane for the lifting and lowering of beam in vertical type beam dyeing machine.

### 3.3 Hank

Hank mercerization machines have become popular, particularly in decentralized sector in India. Usually, the horizontal hank mercerizing machines are used but lately, the vertical hank mercerizing machines have also entered in the decentralized sector with the facility for manual operation. The advantages of the manual hank mercerization machine are:

- Simplicity of construction.
- Savings in electrical power.
- Suitability of the machine for mercerizing small lots and for carrying out other processing operations like scouring, bleaching and dyeing.

Recently, Jaeggli Machine Works has developed a single yarn mercerizing machine which is claimed to have the following operational features:

- Cone to cone yarn passage.
- Multiple passage through mercerizing liquor with the choice of variable tension and treatment time.
- Continuous hydro-extraction.
- Can be used for scouring, bleaching or dyeing.

The machine is available with microprocessor controls and, therefore, has better operational efficiency.

### 3.4 Fabric

#### 3.4.1 Singeing

Gas singeing machines have been modernized from the point of view of formation of minimum carbon dioxide and nitrogen dioxide, by using following techniques:

- Correct mixture of air and gas, thereby preventing escape of unburnt gas and carbon monoxide.
- Flame scanning by the use of ultraviolet detecting system for reducing soot formation to avoid pollution and deposition of soot on fabric surface.

In addition, attempts are being made to effect indirect singeing in place of direct singeing to avoid surface damage and bead formation in case of polyester and polyester blended fabrics. At the ITMA-99 exhibition, there were more than twelve singeing machines exhibiting one or more of the above functions. In the latest versions, electrical energy has been used to effect indirect singeing which is not only safe for thermally-sensitive fabrics but is also an eco-friendly technique.

#### 3.4.2 Scouring and Bleaching

The most noticeable feature has been the renaissance of the multi-use jigger machine used for scouring, bleaching and dyeing. The jigger has come back in a bigger size than before and the new form is commonly known as the "Jumbo jigger". In India, Jumbo Jiggers are now being manufactured by Harish Engineering Company and by Calico Machinery Company. These indigenous machines are now being exported and also exhibited in textile machinery exhibitions all over the world.

The basic advantages of Jumbo jiggers are:

- Liquor-to-material ratio can be kept very low (about 2:1) and, therefore, the effluent volume is reduced.
- Reduced consumption of water, steam and electrical energy.
- Since the fabric is processed in the open-width form, there are minimal chances of any permanent crease formation. Therefore, the jiggers are ideally suited for closely woven fabrics.
- Visual monitoring and inspection of the fabric during processing is possible.

#### 3.4.3 Mercerizing

Developments in mercerizing machines have taken place keeping into consideration the impact of environmental regulations. These machines achieve the following objectives efficiently:

- Minimum use of caustic soda.
• Maximum recovery of caustic soda on the machine itself by efficient use.
• Reduction of mangles and counter-current washing, and the efficient use of recuperators for caustic soda removal from fabric.
• Minimum outlet of objectionable effluents like hot alkaline washes, neutralizing solutions of acids, etc.
• Optimum utilization of water, steam and electricity.

A necessary requirement of all types of mercerizing machines is the use of caustic soda recovery plant. It is now an essential requirement for ecological considerations. These recovery plants are now being made by several machinery manufacturers.

3.4.4 Excess Water Removal

When the processed fabric containing excess quantity of water is to be dried, it is necessary to remove as much water as possible before drying. For ecological considerations, this would reduce steam consumption and minimize flue gases from boiler. For this purpose, mechanical means of reducing the water contents in the fabric have to be used. Mather & Platt has developed a special type of squeeze roller known as Robro Roll which can reduce the water content in the squeezed fabric to a level as low as 45-50% w/w.

Another useful technique to reduce water content in fabric is that of vacuum extraction. This system is used immediately after mangleing and before the fabric enters the drying system. It reduces the water content in fabric to as low as 45-50%.

3.4.5 Drying

After mangleing or vacuum extraction, the remaining water in the fabric is then removed by evaporation using heat energy during cylinder or stenter drying operations.

No further developments have been noticed in either of these machines, except that the concept of counter-current use of hot air from the last chamber of the stenter to the preceding chambers has been introduced in many new models. In the case of cylinder drying machines, it is now an established practice to recover the high pressure steam condensate for better heat recovery.

3.4.6 Dyeing

One of the most important development in jigger, winch and jet dyeing machines is the reduction of liquor ratio to a level of 3-5, 2-3 and 5-8 respectively.

3.4.7 Printing

Various developments have taken place in rotary, screen and jet printing but from the point of environmental considerations, the following developments are worthy of mention:
• Use of CAD systems to produce designs on flatbed screens and rotary.
• Agers have been developed (Minivap), which are capable of using saturated/superheated steam or hot air. The Stark HS II multi-purpose steamer enables the fixation of a variety of dyestuffs using saturated/superheated steam or hot air, using a two-phase steaming technique. The steam and/or air is effectively reconditioned and recirculated, thereby saving large quantities of steam and hot air.

4 Washing Machines

Washing machines play very important role in minimizing pollution loads of effluents emerging from scouring, bleaching, dyeing and printing. The developments in this field are numerous and noteworthy. A few examples are as follows:
• Use of vacuum simultaneously with a water spray leaving only about 65-70% water on the washed fabric (TVE Shark 2000 Washer and TVE Shark Spray/Vacuum Washer of Textile Vacuum Extractor Co.).
• Aquatex machine of Mather Machiney Co.
• Benninger's Injecta and Extracta washing machines with injection and turbulence system which ensure high efficiency of washing and use of direct steam, enabling complete removal of all types of sizing and soluble finishing chemicals. The other advantages include:
  - minimal water usage,
  - use of counter current system to reduce water flow and thereby excessive effluents,
  - high concentration gradient due to effective bath segregation,
  - spray washing with suction to remove dust and fibre particles, and
  - wash liquor circulation with filtration.

Similar machines with high efficiency of washing have also been brought out by Babcock, Mezzer and Arioli.

5 Environmental Control

Any textile chemical processing operation has to be carefully carried out and controlled to meet statutory...
requirements. Today, various systems have been
developed to test and control the following parameters:
  Volume of various processing effluents
  Colour
  C O D and B O D
  Suspended and dissolved solids in the incoming
  fresh water and in the outgoing effluents
  pH

Temperature
  Presence of objectionable heavy metals and other
  chemicals.

Similarly, there are instrumentation as well as
control system which have been developed for
controlled fuel combustion and efficient generation of
steam.