IOSR Journal of Mechanical & Civil Engineering (IOSRJMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X
PP 56-60
www.iosrjournals.org

A Review of Package Dyeing System in Textile Industries

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Abstract: *This paper reviews the detailed study of package dyeing system used in textile industry. The literature review is carried on design and analysis of pressure vessel and pump incorporated in a package dyeing machine. In this paper the recent and past developments, theories on design of pressure vessel using ASME codes are presented, analysis of pressure vessel using PV-Elite and FEM software's are reviewed.*

Keywords - *ASME code, Analysis, Design, Package Dyeing System and Pressure Vessel*

I. INTRODUCTION

The textile industry holds significant status in the India. Textile industry provides one of the most fundamental necessities of the people. It is the second largest employment generator after agriculture [1]. About 35 million people are already engaged with this sector. That is why the Indian textile industry occupies a very important place in the economy of India. Its importance is underlined by the fact that it accounts for around 4 % of Gross Domestic Product, 14 % of industrial production, 9 % of excise collections, 18 % of E in the industrial sector, and 16 % of the country's total exports (Ex) earnings.

The textile sector comprises clothing, apparel, garments, chaddars and bed-sheets, terry towels and allied products. Amongst these products, Solapur (Maharashtra-India) is well known for manufacturing of terry towels and allied products. In fact, terry towels from Solapur have a market share of approximately 70-80% of the total international demand (for yarn dyed terry towel on Jacquard power loom).

Solapur is known for its textile products. It has a good base for its industries for logistical reasons, with approximately 98 medium and 8986 smaller industries [1]. Solapur is one of the leading centers for power looms and cotton mills. Chaddars (Solapur Bed sheets) and Towels have earned Solapur a name and fame for their durability and novel designs. In any textile product quality mainly depends on color. And colors have some importance in Indian tradition. Dyeing yarn adds beauty to textile products like towels. Now a day's dyeing has become a most integral part of textile process. Process flow diagram of terry towel manufacturing in Textile Industries

The process of manufacturing of terry towels in textile industries is shown in Fig.1.

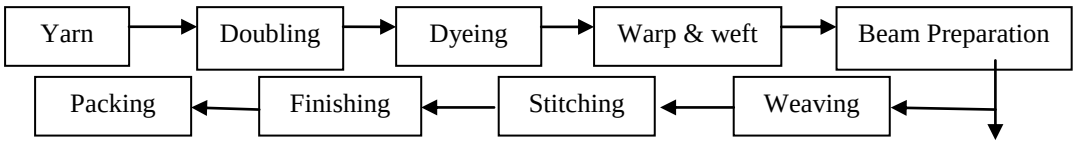

Fig. 1: Process flow diagram of terry towel in textile industries [2].

1.1 Dyeing

Dyeing is a method which imparts beauty to the textile by applying various colors and their shades on to a fabric. Dyeing can be done at any stage of the manufacturing of textile- fiber, yarn, fabric or a finished textile product including garments and apparels. The property of color fastness depends upon two factors- selection of proper dye according to the textile material to be dyed and selection of the method for dyeing the fiber, yarn or fabric.

1.2 Yarn Dyeing

Yarn Dyeing is the process by which colored yarn is obtained. There are many forms of yarn dyeing. Common forms are the package form and the hanks form.

1.3 Package Dyeing Process

The term package dyeing usually denotes for dyeing of any type yarn wound on the compressible dye springs/perforated solid dyeing tubes or cones [3]. Yarn dyeing in package form is done at under high pressure,

with the packages mounted on hollow spindles .These spindles are fixed on the dyeing carriers, which is inserted into the dyeing vessel after closing the lid of the machine, the dyeing liquor is forced through the packages in two way pattern (inside to out and outside to in) and goes on circulating throughout the vessel and yarn. With the start of dyeing cycle, the dye liquor goes on circulating throughout the vessel and tank. This happens till all the dye is used up or fully exhausted. Once full exhaustion is brought about, the carrier of colored yarn is consequently removed from the vessel. Finally the yarn is dried using an infra-red drying oven. The package dyeing process with a single cone yarn is shown in Fig. 2.

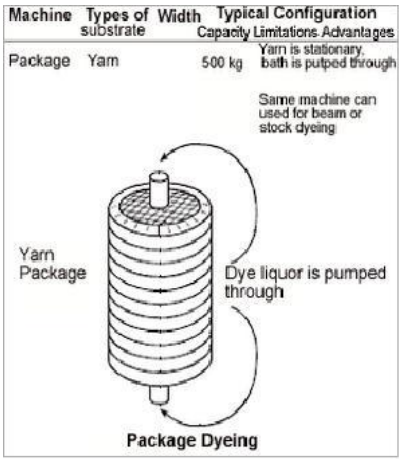

Fig. 2: Package Dyeing Process [3]

II. LITERATURE REVIEW

The literature survey has been carried out on various components used in package dyeing system. The pressure vessel and pump are two major components used in package dyeing system. The detailed study of existing package dyeing system is studied. The Design and analysis of pressure vessel are discussed. Design of pressure vessel is governed by the ASME pressure vessel code. Detailed study has been done on the pump used in package dyeing system, which can be helpful for designing a package dyeing system for small capacity. Tsui Tak Ming William [4] had invented the Sample package dyeing machine. A dyeing machine used for dyeing a sample yarn package comprises a kier, a spindle mounted in the kier for supporting a sample yarn package, and a dye liquor circulation system operable to circulate dye liquor through the sample yarn package with inside-to-out and outside-to-in flow directions, the kier and the spindle configured to accommodate a single sample yarn package with a weight less than 1.2 kg, and the machine having an operating volume such that a single sample yarn package weighing less than 1.2 kg can be dyed using a liquor ratio of substantially 1:6. Tsui, Tak Ming William [5] has invented the method and apparatus for controlling the flow of treatment fluid in a package dyeing machine. The invention is directed to a method of controlling fluid flow rate during operation of a textile package fluid treatment machine, comprising, measuring the differential pressure across a unidirectional pump in a fluid circulation system connected to vessel of the machine. Fig.3 shows a schematic representation of a textile package treatment machine having a fluid circulation system with a pump and a reversal device and apparatus for controlling the fluid flow according to an embodiment of the invention.

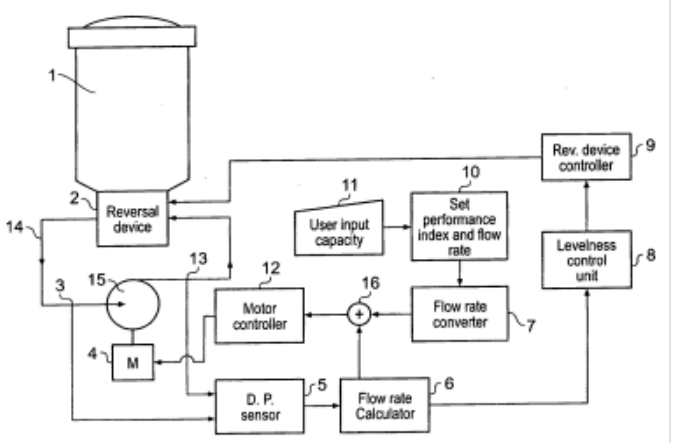

Fig.3: flow diagram for controlling the fluid flow in package dyeing

Tsui, Tak Ming William and Clifford, frank Graham [6] their invention relates to a pump incorporated in a textile package dyeing machine. According to the invention there is provided a pump comprising an axial flow impeller rotating in a concentric cylindrical housing to pump treatment liquor through the machine, the pump having an axial nozzle at one end and centrifugal nozzle at the other end whereby a flow and pressure performance characteristic typical for a centrifugal pump can be obtained when the impeller is rotated in one direction and a flow and pressure performance typical for an axial flow pump can be obtained when the impeller is rotated in the opposite direction.

Fig. 4 (a) and 4(b) shows use of the pump for inside-out treatment of textile yarns and for outside-in treatment of textile yarns, by treatment liquor.

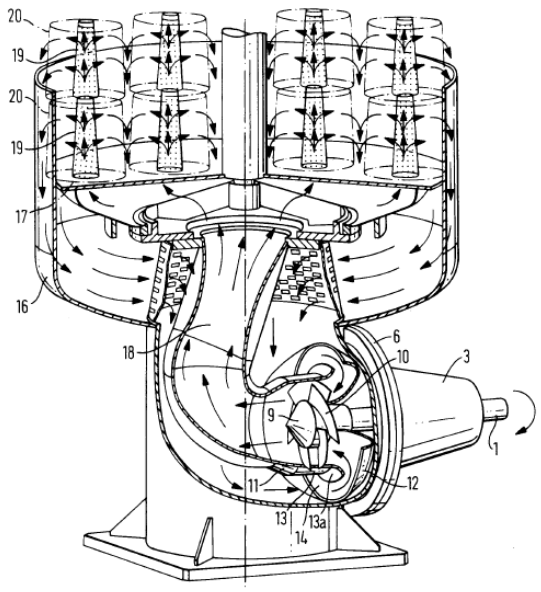

Fig. 4(a): Inside-out treatment

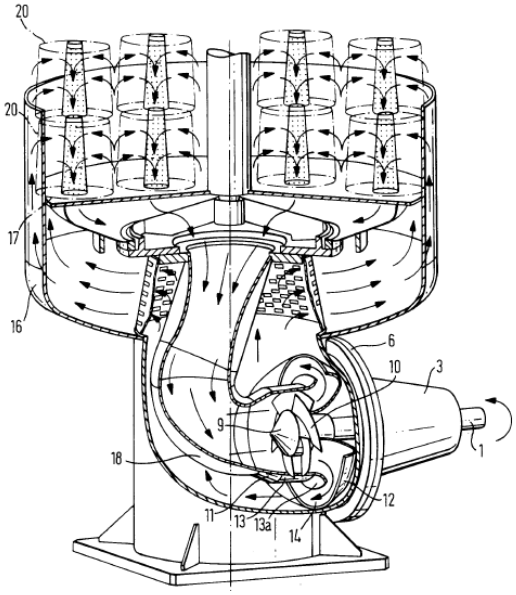

Fig. 4(b): Outside-in treatment

B.S.Thakkar and S.A.Thakkar [7] did a case study and put efforts to design the pressure vessel using ASME codes & standards to legalize the design. The performance of a pressure vessel under pressure can be determined by conducting a series of tests to the relevant ASME standard in future scope they have mentioned Design of pressure vessel in PVELITE software can be accrue. Further FEA analysis can be done to verify the above design procedure, they concluded that the design of pressure vessel is more of a selection procedure, selection of its components to be more precise rather designing of every components, pressure vessel components are selected on the basis of available ASME standard and the manufactures also follow the ASME standard while manufacturing the components so that leaves designer free from designing the components. This aspect of design greatly reduce the development time of new pressure vessel, it also allows the designer to keep free from multiple prototype for pressure vessel before finalizing the design, here standard part are used so it reduce time for replacement so less overall cost. Shamey and Nobbs [8] reviewed various factors that influence the outcome of the dyeing process, the history of automation and the use of computer control in the dyeing industry. Due to use of controlled dyeing system it results in high levels of production and lower costs while maintaining or increasing production standards. Ahmed Ibrahim et al. [9] presented their work on detailed stress analysis and stressed developed in thin walled pressure vessel. Equations of static equilibrium along with the free body diagram has be used to determine the normal stressed $\sigma 1$ in the circumferential or hoop direction and $\sigma 2$ in the longitudinal or axial direction. They had performed a case study on a soda can that was analyzed as a thin wall pressure vessel. Shyam R Gupta and Chetan P. Vora [10] had presented work on a review on pressure vessel design and analysis, this paper deals with developments in the determination of stress concentration factor in pressure vessels at opening, stress analysis of different types of end connections. Design of pressure vessel is governed by the ASME pressure vessel code. From this paper it is seen that ASME and other code are providing solutions for more general cases and required higher factor of safety, also limit load and stress concentration formulae are not available for non standard shape and intersection and geometrical discontinuity. The study of effect of change in size, position, location of the opening in pressure vessel to study the stress concentration is essential, the position and location of the opening on cylinder is not studied in past by

researcher and there is no code provision for such design, here PV Elite software is used for designing of pressure vessel. SAIS program also used for reducing time for calculation, FEA is an extremely powerful tool for pressure vessel. Vijay Kumar and Pardeep Kumar [11] has discussed the safety factor of a pressure vessel is related to both the tensile stress and yield strength for material allowance. ASME code section VIII has fully covered these two on the construction code for pressure vessel. This code section addressed mandatory and non-mandatory appendixes requirement, specific prohibition, vessel materials, design, fabrication, examination, inspection, testing, certification, and pressure relief. Mechanical design of a horizontal pressure vessel based on this standard had been done incorporating PV ELITE software. Analyses were carried out on head, shell, nozzle and saddle. Kuldip A Rade et al [12] conducted a detailed study for small scale textile industry in depth for various processes involved, chemicals required, raw material and equipment details, operating parameters, energy requirements during processes including different losses etc. and to optimize thermal energy requirements in order to achieve acceptable good quality of cotton colored products. The objective was to optimize the process parameters and experiments were conducted by varying different parameters such as temperature, time etc. A mathematical calculation has been carried out for heat consumption. It is found that process parameters have the significant influence on the heat consumption. P. C. Tewari et al [13] discussed the performance modelling and availability analysis of Yarn Dyeing System of a Textile Industry. The Textile Industry is a complex and repairable engineering system. For performance modelling and analysis of availability, a performance evaluating model has been developed with the help of mathematical formulation based on Markov-Birth-Death Process. The differential equations have been developed on the basis of Probabilistic Approach using a Transition Diagram. Abu Shaid et al [14] mentioned that Package to Package and within package shade variation problem are the major technical difficulty for all the yarn dyeing factories engaged in dyeing of double ply yarn packages in cheese form. In most cases the density variation results in unevenness of dyed package. Reverse tension mechanism on cheese dyeing can ensure uniform density which is the basic rock for the foundation of level dyeing. Nobutaka Ono [15] describes the method of dyeing yarn cheeses which comprises winding up laments or yarns on press bobbins, mounting and stacking the resulting yarn cheeses one upon another on a spindle, pressing the yarn cheeses and dyeing them. In a method of dyeing yarn cheeses stacked on a spindle and pressed to a definite compression degree by flowing a dye liquor through the yarn layers, the dye liquor is flowed while undergo pulsation in a minimized flow rate and a minimized flow pressure, thereby enabling even permeation of the dye liquor into yarn layers and accordingly, even dyeing.

2.1 Summary of Literature Review

From the above literature review, the system of package dyeing for textile industries of small capacity can be designed and analyzed. The pressure vessel and pump are the major components of package dyeing system. The design of pressure vessel is governed by ASME codes and analysis of pressure vessel is carried out in FEM and PV Elite software's.

2.2 Findings of Literature Review

1. Researchers have focused on the existing dyeing package system for large capacity of 300-500 kg.
2. Many researchers have solved the problems on shade variation, un-level dyeing of package dyeing system for large capacity.
3. Researchers have optimized the process of package dyeing by using controlled parameters.
4. For performance modelling and analysis of availability, a performance evaluating model has been developed with the help of mathematical formulation.

2.3 Literature Gap

The current literature is available on package dyeing system of large capacity (300-500 kg) and sample dyeing machine of (1kg). Extensive Research is not carried out on small capacity (5- 10 kg) of package dyeing system.

III. CONCLUSION

From this review of research on study of package dyeing system we can conclude that

1. The design of a pressure vessel used for package dyeing is more of a selection procedure, selection of its components to be more precise rather designing each and every component. It is observed that all the pressure vessel components are selected on basis of available ASME standards and the manufactures also follow the ASME standards while manufacturing the components.
2. PV Elite software is used for designing of pressure vessel; Finite element analysis is an extremely powerful tool for analysis of pressure vessel.
3. The pump is particularly suitable for treating textile yarns since said one direction of rotation can be used for out-to-in treatment liquor flow where relatively high resistance is encountered and said

opposite direction of rotation can be used for in-to-out treatment liquor flow where resistance is relatively lower.

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