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RESEARCH ARTICLE

INVESTIGATION OF EFFECT ON LOSS OF STRENGTH AND ELASTICITY OF DIFFERENT PUMP RPM IN WOOL FIBER DYEING

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ABSTRACT

After dyeing, the fiber undergoes some strength and elasticity loss due to pressure, temperature and chemical exposure. This leads to difficult progress of the fiber along the production line and decrease in yarn quality in the yarn production stages. In this study; The loss of strength and elasticity after dyeing, the penetration of the dyebath into the fiber at the desired level and the unevenness of dyeing were investigated depending on the pump cycles in the dyeing machine during dyeing of the wool fiber. In addition, the change in dyebath pressures and velocities were investigated in the dyeing machine according to the pump cycles in the fiber dyeing machine by performing dyebath flow analysis with the ANSYS program using CFD (Calculated Fluid Dynamics) method. It was seen that the increase of the pump revolution increased the loss of strength and elasticity of the fiber but did not affect the homogeneity due to the pressure difference in the inner tank of the dyeing machine.

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INTRODUCTION

Fiber dyeing is the process of dyeing textile fibers in bulk in a dispersed state without any physical treatment. Fiber dyeing process is more common in wool, polyamide and acrylic fibers. Irregular dyeing in the form of fibers can easily be removed during the blending process. In fiber dyeing process, the dye penetratios perfectly into the fibers and provides good color uniformity. This method is the easiest dyeing method and fastness to friction is high. Dyed fibers lose strength and elasticity, partly. This results in difficulties during spinning of the fibers (Ozcan, 1978). uneveness in the dyeing process depends on parameters such as pH, duration, temperature, fiber mixture used, dye used, dyeing conditions. These parameters have been determined by developing a two-step approach with the structure of artificial neural networks. With this approach, they have achieved satisfactory results by estimating how much dye will be used in the prescription (Hench and Al-Ghanim, 1995). The dyeability of anti-mite acrylic fibers and conventional acrylic fibers in their study. The dyeing ratios of both fibers were compared during the dyeing process according to the parameters such as pH, used agents, dyeing temperatures, dyeing times.

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It has been found that the dye-absorbing ability of the anti-mite acrylic fibers is higher than that of conventional acrylic fibers (Yu and Chen, 2006). The dye-absorbing ability of acrylic fibers in his theoretical work. In the dyeing process of acrylic fibers, they investigated the effect of different carriers at different temperatures. According to the result of the study, it was determined that the effect of the carriers decreased in the amorphous regions of the acrylic fibers when the temperature exceeded the transition temperature, and accordingly, the dye absorption decreased (Wang, 2009). The study in a similar environment to fiber staining was done to model the oil circulation in the compressor. A high-speed camera monitored the path of a sealed piston compressor while the crankshaft in the lubrication system was rotating. Two-phase flow of air-oil was analyzed using various models. The rise of oil in the compressor case was modeled by CFD. The methods used in this work also apply to the fiber dyeing process (Kerpicci, Yağcı, Onbasıoğlu, 2013). A better quality product after dyeing as a result of some improvements in his work. For this purpose, different dyeing experiments has been made by improving process conditions, maximizing fiber strength and minimizing the amount of dye used. Taguchi method is used for parameter design in experiments. Control parameters; Ph, dyeing temperature, retarder, being antistatic, amount of material, dyeing time, softener and amount of despergator. As a result of the experimental design; it is stated that the quality of acrylic fiber will be increased and the amount of faulty products will be reduced and cost will be saved (Yazici, 2010).In this study; The loss of strength and elasticity and dyeing efficiency of wool fiber lost after dyeing depending on pump cycle were investigated. In addition, according to pump cycles in fiber dye boilers, flotte flow analysis was performed in the boiler with ansys program to investigate the variation between the float pressures and velocities.

MATERIALS AND METHODS

Material

For fiber dyeing experiments, Dilmenler DMS EN 13445 model fiber dyeing machine with 10 kg capacity was used (Fig. 1). Dye used in fiber dyeing Lanaset Black B.The raw material used is 100% wool in 21 micron and taken from Tianyu, Australia. Prowhite fiber strength tester was used to measure fiber strength and elasticity. Unevenness tests made on the used fiber were made using Uster Tester 5 device.Ansys CFX is used for modeling of inner of fiber dyeing machine and for dyeing bath flow analysis.

Method

The fiber dyeing process was carried out at a temperature of 98 ^{0} C in the fiber dyeing machine. The difference in pressure in the fiber dyeing machine is set at 0.5 bar. Three different dyeing processes were carried out in three different pump cycles. In the dyeing processes, Dyeing was carried out using the same recipe and in black colour. The properties of the wool fiber used in the fiber dyeing are shown in Table 1.Fiber dyeing machine was modeled in the Ansys CFX program at 20%, 40% and 80% pump cycles using the CFD method to investigate the velocity and pressure distribution of the dye bath. It was seen that the speed and pressure distributions did not show a change with respect to the pump cycle, and there was no change in the dyeing efficiency. The unevenness values of the wool fibers used in Table 2 are shown. The tensile strength and elongation % values of the fibers taken from the three fiber samples after dyeing process were checked. For each fiber sample, the test was repeated 50 times with fibers taken from different spots and averaged. Table 3 shows the tensile strength and elongation values of the fiber samples before and after dyeing.

RESULTS AND DISCUSSION

Considering the difficulty of conveying the fiber on the yarn preparation line after dyeing, it is determined that there is a loss of up to 10% in elasticity by performing% strength test and elongation% tests at different ratios of pump RPM before and after dyeing process. Results of these tests validate the CFD analyzes that these losses are caused by applied pressure and temperature. It has been observed that as ratio of pump RPM is increased during dyeing in the fiber dyeing machine, the force applied to the fiber also increases considerably. Fig. 2, the analysis by the CFD method in the Ansys program shows the forces acting on the fiber depending on the operating conditions of the pump. The working force on the fiber when working with a 20% pump RPM ratio in the fiber dyeing machine was 3.5 N, the working force on the fiber when working with the pump RPM ratio of 40% was 7 N, the working force on the fiber increased to 14 N when working with a pump RPM ratio of 80%.

Fig. 1. Dyeing Machine

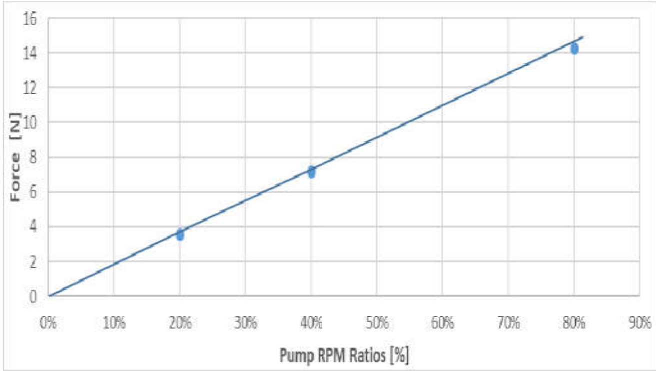

Fig 2. Effective force values on the fiber depending on the pump RPM ratio

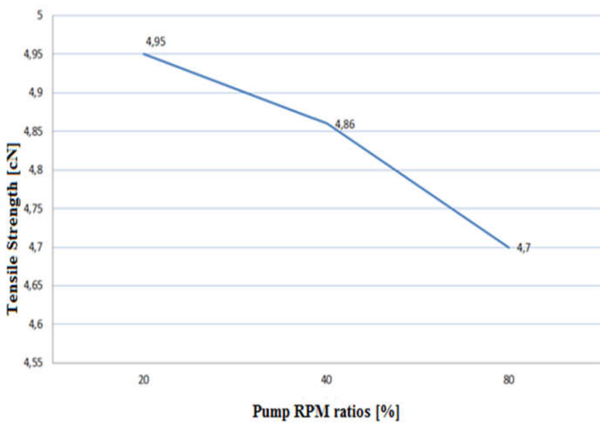

Fig. 3. The change in fiber tensile strength depending on the pump RPM ratio

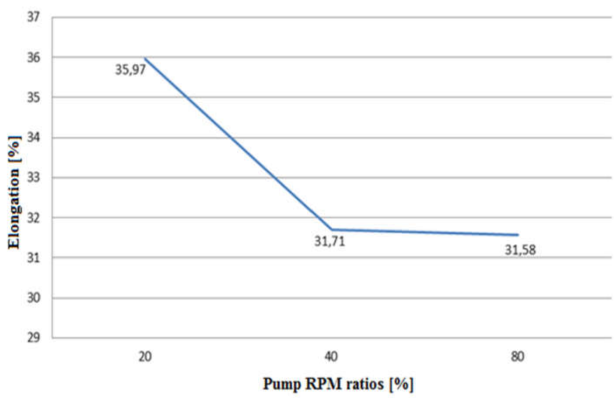

Fig. 4. The change in fiber elongation values depending on the pump RPM ratio

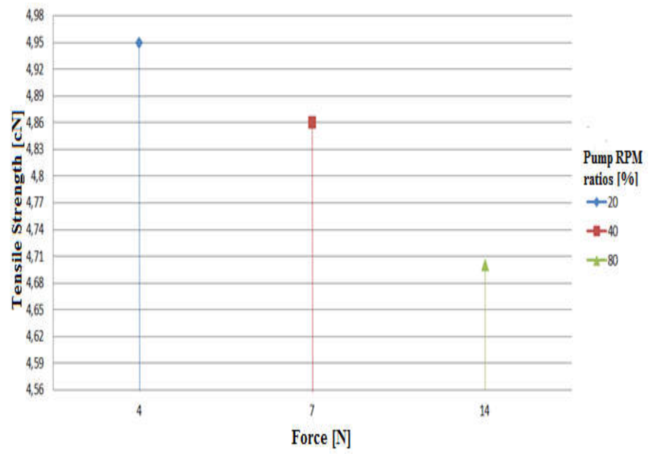

Fig. 5. Comparison of the force applied to the fiber and the change in the tensile strength of the fiber depending on the pump RPM ratio

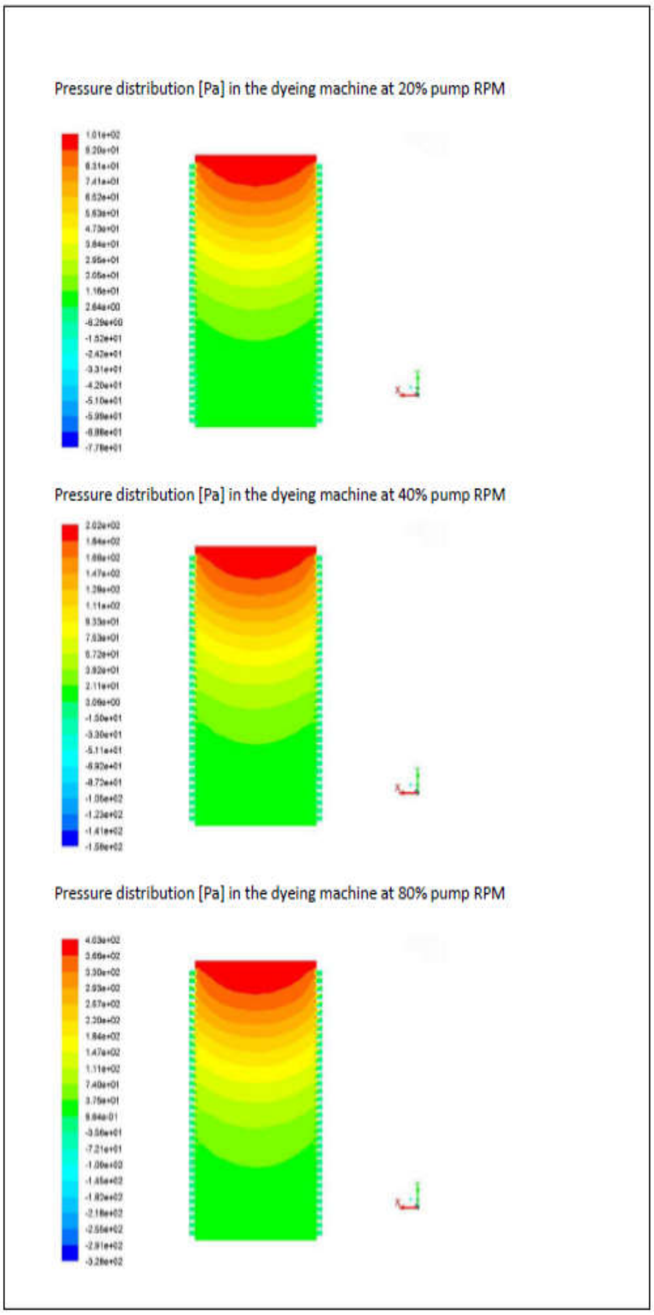

Fig.6. Comparison of pressure distribution [Pa] in the dyeing machine

Table 1. The properties of wool fiber used

Form of fibre	Tops
Colour	Ecru
Avarage of fibre length	75 mm
Fiber Thinness	21 micron

Table 2. The unevenness values of the wool fibers used

Fibre blend	%100 wool
Avarage U values (%)	2,76
Avarage CVm values (%)	3,40
Avarage CVm values (1 meter) (%)	1,32
Avarage CVm values (3 meter) (%)	1,14
Index Values (I)	7,14

Table 3. The tensile strength and elongation values of the fiber samples before and after dyeing

Colour	Ratio of Pump RPM (%)	Avarage Tensile Strength (cN)	Avarage Elongation %
Ecru (Before dyeing)	-	5	41,76
Black	20	4,95	35,97
Black	40	4,86	31,71
Black	80	4,70	31,58

In the fiber dyeing machine, as the pump RPM ratio increased, the effect on the fiber increased. Fig. 3 shows the change in fiber tensile strength depending on the pump RPM ratio in the fiber dyeing machine. When the fiber dyeing machine is operatiod with 20% ,40% and 80%, the average of the tensile strength of the fibers is 4.95 cN,4.86 cN and 4.70 cN, respectively. It was observed that as the pump RPM ratio is increased, there was a decrease in the tensile strength due to the increase in the force applied to the fibers. Fig. 4 shows the change in fiber elongation values depending on the pump RPM ratio in the fiber dyeing machine. The elongation % values decreased from 35.97% to 31.58% depending on the decrease in the tensile strength. In Fig. 5, the force applied to the fiber and the change in the tensile strength of the fiber are compared with respect to the pump RPM ratio.

The higher the applied force, the lower the tensile strength of the fiber is. In Fig. 6, the change in the pressure of dyebath is modeled by the CFD method depending on variation of the pump RPM ratio in the fiber dyeing machine. Variation of the dyebath pressure at 20%, 40% and 80% pump RPM ratios rates was analyzed. Pump inlet pressure; It is determined that the forces acting on the fiber are influenced by this parameter even though the pressure distribution and thus the homogeneity are not affected. As there are no large changes in the pressure difference ratios above and below the dyeing machine according to the pressure distributions of the dyebath in Fig. 6, all dyeing trials were also carried out succesfully . However, as determined in the strength and elasticity tests after dyeing, due to strength and elasticity losses, frequent machine stoppages due to breakage of sliver occurred while passing through drawing machines in the fiber preparation line. These stoppages were reported more oftenly in dyed fiber samples with 80% pump RPM ratio.

Conclusion

In this study, three different fiber samples, all 100% wool, were dyed at three different pump RPM values.

Depending on the pump RPM ratio, the pressure distribution in the dyebath in the fibre dyeing machine, loss of strength and elasticity of the fiber have been investigated.CFD method is used to compare the amount of force acting on the fiber according to the pump RPM ratio, by means of ANSYS®. In the case of fiber dyeing machine, as the pump RPM ratio increased, the ratio of the force acting on the fiber increased. When working at 80% pump RPM ratio, the amount of force acting on the fiber was found to increase to 14 N. After dyeing, tensile strength and elongation % tests were performed on the fiber samples. As a result of the tests made, it was seen that the fiber loses its strength and elasticity as the pump cycle ratio increases. Therefore, it has been determined that the loss of strength and elasticity is increased as the active force on the fiber increases. It has been determined that tensile strength and elongation % tests are carried out at different pump RPM's before and after dyeing on the fiber, and the losses are up to 10% especially in elasticity. In addition, the fiber dyeing machine was modeled by Ansys program and the pressure distribution of the dyebath in the dyeing machine was examined according to three different pump RPM ratios. It was seen that the change in the pump RPM did not affect the distribution of the dyebath pressure in the dyeing machine nor did it disturb the homogeneity. According to these results; It has been found that the change in pump RPM does not affect the pressure distribution of the dyebath in the dyeing machine but increases the amount of force acting on the fiber and therefore the strength and elasticity of the fiber are lost. It has been found that the end result of the friction and mechanical forces in the fiber drawing machines with the loss of strength and elasticity makes it difficult to finish, and the result of breakage causes frequent machine stoppages. It has been observed that these stoppages are seen more often in the dyed fiber samples with 80% pump RPM ratio.

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