PERFORMANCE IMPROVISATION AND MATHEMATICAL MODELLING OF HARDNESS OF TUBE TEX ROLLER USED IN TEXTILE INDUSTRY

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ABSTRACT

The textile industry is a rapidly growing industry and seen many innovations to date. One of the widely used machines in this industry is the Tube Tex compacting machine. It is used to remove the shrinkage in the fabric that is being used to manufacture different garments. The present work is on the rollers of the tube tex machine. Many parameters are involved in increasing the efficiency of the machine. It is a mechanical shrinkage control process. It also maintains the stability of the fabric; hence it is a vital process. The rollers are subject to wear and tear. The aim of the present work is to reduce the wear and tear of the rollers by coating the rollers with tungsten carbide using High - Velocity Oxygen Fuel (HVOF) coating technique. A mathematical model has also been developed to predict the hardness that can be obtained by varying some of the parameters like the standoff distance of the HVOG nozzle and coating thickness. The statistical analysis shows that the obtained models are very close to practicality and can be used to predict the hardness. By implementing the coating on the rollers the overall efficiency can be improved resulting in cost saving.

KEYWORDS: Textile, Compacting, HVOF, Mathematical Mode & Hardness

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INTRODUCTION

The open width tube tex machine is an important machine in the knit finishing industry. The machine is an output of continued engineering and research. It helps the industry to use new materials. It helps in the faster changeover of fabric, high quality, and reduced costs. The rollers of the machine are made of EN 8 material. The rollers are subject to continuous rubbing against the fabric, also oil of 60 degrees temperate is circulated within the rollers to give a pressing effect to the fabric. The residual shrinkage after passing through the rollers is less than 1%. Owing to the continuous rubbing and temperature the rollers wear out after the certain time. The replacement of the rollers is a very costly affair.

In order to avoid the replacement of the roller and also to enhance the efficiency of the rollers, coating the rollers with Tungsten Carbide (WC) is one of the options available. The High -Velocity Oxygen Fuel (HVOF) coating is one of the thermal spray coating processes (GULBRANSEN, 1963). It restores a component's surface properties or dimensions. It extends the life of the component by increasing the resistance to wear, erosion and corrosion (Zhang dan Li, 2003). In this process, molten metal is sprayed over the component which can be later ground to produce a very good finish. The HVOF method of coating allows the user to coat the parent metal with

different kinds of metals (Fernandes, Senos dan Vieira, 2007). Some of the benefits of HVOF coating include reduced costs, improved performance and electrical properties (Fischer, Dvorak dan Siegmann, 2001). It enables the components to operate at higher or lower temperatures. The coated specimen is shown in Figure 1.

Figure 1: Coated Specimen

The XRD analysis was done to ensure that the coating had the right constituents. The XRD analysis of one of the same is shown in Figure 2.

Figure 2: XRD Analysis

SEM analysis was done to ensure the uniform coating and to check whether there are any defect or major abnormalities. The SEM image is shown in Figure 3

Figure 3: SEM Analysis

Design of Experiments

The Design of experiments is a familiar tool used by researchers to systematically conduct experiments to capture the impact of the certain variable on a variable that is of interest. In this work microhardness is the output variable and the independent variables are the coating thickness and the standoff distance of the HVOF nozzle. By using Taguchi technique L9 orthogonal array was formed. Two factors were considered for the array and three levels of each of the factors are

considered. The different factors and the levels that were considered is given in Table 1.

Table 1: Factors and their Respective Levels

Factors	Level I	Level II	Level III
Coating thickness Microns)	100	150	200
Standoff distance(inches)	9	10	11

The L9 orthogonal array that was obtained using the Taguchi technique along with the responses is given in Table 2.

Table 2: Experimental Sequence and Corresponding Responses

Experiment No.	Standoff Distance (Inches)	Thickness (Micron)	Hardness (Hv)
1	9	100	560
2	9	150	619
3	9	200	678
4	10	100	585
5	10	150	655
6	10	200	519
7	11	100	616
8	11	150	576
9	11	200	436

Hardness Measurement

The experiments were conducted in the order as shown in Table. The coating hardness was checked using Vicker's microhardness testing machine. The equipment used was Matsuzawa, Japan/MMT-X7A. The specimen on which the hardness testing was done is shown in Figure 4.

Figure 4: Hardness Testing Specimen

Mathematical Modeling

The purpose of mathematical modeling in this work is to predict the microhardness that has resulted from the coating of the specimens using HVOF technique. The measurement of microhardness that results due to the coating as explained in the previous section is an expensive method and meticulous effort is needed to ensure that the results obtained are precise and accurate(Lee et al., 2015). Using the regressions analysis tool that is available in the commercially available software Microsoft Excel, the regression analysis was performed. The regression analysis details are shown in Table 3.

Table 3: Regression Analysis

Regression Statistics					
Multiple R	0.87663809				
R Square	0.76849433				

Adjusted R Square	0.62959093				
Standard Error	42.0564436				
Observations	9				
ANOVA					
	df	SS	MS	F	Significance F
Regression	3	29357.16667	9785.722	5.532581	0.047973075
Residual	5	8843.722222	1768.744		
Total	8	38200.88889			
	Coefficients	Standard Error	t Stat	P-value	
Intercept	-934.44444	655.9696776	-1.42452	0.213602	
stand off	158.333333	65.37939844	2.421762	0.059987	
thickness	12.62	4.219639883	2.990777	0.03042	
comb	-1.31	0.420564436	-3.11486	0.026405	

RESULTS AND DISCUSSIONS

A mathematical model has been developed using the statistical technique for predicting the microhardness after coating the specimen with tungsten carbide. It was observed that the percentage of error for 90% of the experiments was less than 15%. The measured values, the values predicted by the mathematical model developed and the error are shown in Table 4.

Table 4: Percentage Error between the Measured Value and Predicted Value

Measured Value	Predicted value	% error
560	574	-2%
619	615	1%
652	657	-1%
585	601	-3%
655	577	12%
519	553	-7%
606	628	-4%
560	539	4%
436	449	-3%

The normal probability plot is shown in Figure 5. The plot indicates that the measured values are normally distributed. From the statistical analysis, the R-square value and the Adjusted R-square value are high enough to conclude that the model is close to practicality. ANOVA shows that Significance F, the value is 0.04 which is below the recommended value of 0.05 indicating that the factors considered are actually affecting the dependent variable, that is microhardness.

Figure 5: Normal Probability Plot

CONCLUSIONS

As seen in Table 2. The P value for standoff distance is 0.05, the thickness is 0.03 and for the combination of

these parameters is 0.02 which indicates that these factors significantly affect the dependent variable in the range that is considered. The mathematical model that is developed is very close to the actuality. Using the mathematical model to predict the hardness is dependable way than conducting expensive experiments. The authors of the work are also working on optimizing the factors that affect the hardness. Since there are only a few types of research available in this area, developing a model is very relevant. Future works involve FEM simulations that can reduce the cost of analysis to a great extent (Marimuthu, Thirtha, and Chethan, 2017, 2018)

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