Process Optimization – A Six Sigma DMAIC Approach

Abstract

Nap fabrics used in paint roller covers are required to meet nap height specifications measured as the overall fabric thickness from its backside to meet substate paint application standards. Consistency in heat setting process is key to achieving customer specifications for nap fabrics. Therefore, a total design of experiments (DOE) was adopted to provide for comparative process performance across fabric styles. ANOVA was defined as the ratio of Kansas heat setting pile height (KPH) to weaving pile height (VIP) and PR is defined as ratio of finish pile height (PPH) to heat setting pile height (VIP). PR is a measure of change in fabric loft or pile height (VIP) leading to finishing action. PR was then adopted as a primary metric for gauging heat setting process performance while VIP will be used in DOE) improvement for determination of suitable process levels to meet finished product specifications. Figure 4 demonstrates pile height measurement equipment.

Measure (continued)

An MSA shown in figure 4 was done and at 15.4% variation, the system was found suitable for use in this study. Current data were grouped into heat set (HS) and control (CD) and PR values determined. A box plot shown in figure 3 suggested that even styles from the same yarns were at different PR levels. Minitab Demystified

Analyze (Continued)

Residual plots for PR confirmed normality assumptions were not violated. By using a target PR value and PR of 1.3 (determined from coasted Precision estimate gross annual savings of US $621,850) will accrue as a result of reduced full length as shown in Table 1. Figure 13 Minitab Optimizer Solution

Control

As shown in table 1 above, each group will be sampled and both PR and FR values determined using equations 1 and 2. The appropriate control for this study will be X-bar – R charts. Selected styles falling under the scope of this study will be sampled on daily basis for xph, yph, kph, and fph. A total of 58 styles will be included in the analysis. After optimizations are run, a variation solution of the solution is used to run a prediction of PR as shown in Figure 11.

Conclusions

DOE factorial ANOVA in Figure 8 revealed that there was main effect of TEMPERATURE type on PR (F [1, 38] = 973.09 p < .05), significant main effect of PPH on PR (F [1, 38] = 12.88 p < .05), indicating that Temperature and picks per inch has significant impact on pile ratio (PR). However, Tuft effect (F [1, 38] =503 p<0.05) and Speed (F [1, 38] =505 p<0.05) had significant influence on PR without interactions. 2-way interactions of temperature and Speed (F [1, 38] =505 p<0.05) and total process PR was significant. 3-way interactions of Temperature and Speed and PPH (F [1, 38] =14.84 p<0.05) was also significant. A significant model was found (F [3, 38] =114.10 p<0.05) with an R2 of 0.956. These results are further supported by an estimated annual cost savings on yarn consumption of US $621,850.

Acknowledgments


Figure 5: Minitab Prediction

Figure 6: Measurement System Analysis using Gauge R&R test: Fabric weight and grassing length. There were no statistical PR, data or specifications for determining the prevailing Kempin 2 zone. A well established product

Figure 7: tap plot: Pile height transition to final nap (PR)

Figure 8: Partial regression pr vs. temp (deg F), Speed (rpm), Tuft (rnm), FF;

Figure 9: Capability assessment of heat setting process

Figure 10: Comparison of PR and FR between vendor

Figure 11: Six Sigma DMAIC Tools in Practice: A Project Report

Figure 12: Minitab X bar – R Chart dialog box

Figure 13: Minitab Optimizer Solution

Figure 14: Sampling Finishing Process

Figure 15: X-bar and R chart for target PR and FR values with Range data from Measure phase will be used to create control chart limits as shown in Figure 16.

Figure 16: Control Chart for target PR and FR values with Range data from Measure phase will be used to create control chart limits.