CHAPTER 8

RESULTS AND DISCUSSIONS

The aim of this thesis is to investigate the influence of different coated tools on AISI316 and AISI410 in CNC turning under dry conditions. AISI316 and AISI410 materials were taken as the work piece materials for all trials with a diameter of 32 mm and machined length of 60 mm. TiCN/Al₂O₃ coated insert was used for case-I, TiAlN coated insert was used for case-II, Ti(C, N, B) coated insert was used for case-III, B-TiC coated insert was used for case-IV and B-Al₂O₃ coated insert was used for case-V. The experiments were conducted in Fanuc CNC lathe. Three factors, three levels were taken for this research work. Cutting speed (110, 160 and 210 m/min), feed (0.1, 0.2 and 0.3 mm/rev) and depth of cut (0.7, 1.4, 2.1 mm) were considered as parameters. The SR and TW were the important turning characteristics in turning operation and hence minimization of SR and TW were taken as objective of this research work. SR was measured for all the case by the SURF TEST 211 and it was denoted by Rₐ. Measurements were taken by the proper setting of work pieces and instrument. TW was measured by an optical tool maker’s microscope with image optic plus version 2.0 software designed to run under Microsoft widow’s 32 bit system, which could be captured by the area of the tool wear.
8.1 COMPARISON OF DIFFERENT COATED TOOLS FOR TURNING AISI316

Stainless steels are used for many commercial and industrial applications owing to its high resistance to corrosion. It is too hard to machine due to its high strength and high work hardening property. The coated cutting tool is mainly affect the quality of the product. Different coated cutting tools such as TiCN/Al₂O₃, TiAlN, Ti(C,N,B), B-TiC and B-Al₂O₃ are used to turning AISI316 under dry conditions. Figure 8.1 shows comparison of different coated tools with SR at cutting speed of 110 m/min, feed of 0.1 mm/rev, depth of cut of 1.4 mm. Figure 8.2 shows the comparison of different coated tools with TW at cutting speed of 110m/min, feed of 0.1 mm/rev, depth of cut of 1.4 mm. The TiAlN coatings is superior to the other selected in terms of higher harness, resistance against the wear and lower coefficient of friction. Hence better surface finish and reduce tool wear could be obtained from machining TiAlN coated tool than the other coated tools (Kaladhar et al 2011).

Figure 8.1 Comparison of different coated tools with SR for turning AISI316
Figure 8.2  Comparison of different coated tools with TW for turning AISI316

8.2  SINGLE RESPONSE OPTIMIZATION FOR TURNING AISI316 USING TiAlN COATED TOOL

Optimization of the single response problem using Taguchi method provides an effective methodology for optimization of turning parameters. The single response optimization of the S/N ratio for SR and TW on AISI316 with TiAlN was obtained by Taguchi analysis. Based on delta value the rank showed that feed had stronger effects on SR with delta 5.62 followed by depth of cut with delta 2.45. The minimization of SR on AISI316 was possible at cutting speed set at 110 m/min, feed set at 0.1 mm/rev, depth of cut set at 2.1 mm. Based on delta value the rank showed feed had stronger effects on TW with delta 4.80 followed by depth of cut with delta 3.48. The minimization of TW on AISI316 was achieve at cutting speed set at 110 m/min, feed set at 0.2 mm/rev, depth of cut set at 1.4 mm.
8.3 MULTI RESPONSE OPTIMIZATION FOR TURNING AISI316 USING TiAIN COATED TOOL

Multi-response optimization was performed using the grey relational analysis. Optimum setting for minimization of SR and TW was based on the grey relational grade value with a cutting speed set at 110 m/min, feed set to at 0.1 mm/rev, depth of cut set at 1.4 mm.

8.4 MODELING AND PREDICTION FOR TURNING AISI316 USING TiAIN COATED TOOL

The response surface model for AISI316 was developed from the observed data and the predicted values were fairly close, indicating that the developed model could be effectively used to predict the response. The major effect on SR was the linear effect of feed and it was followed by linear depth of cut having a P-value of 0.035 and 0.045. The major effect on TW was the quadratic depth of cut which was followed by linear feed rate having a P-value of 0.035 and 0.081. The normal probability plots departure from this straight line would indicate a departure from a normal distribution, which was used to check the normality distribution of the residuals for different coated tools.

8.5 WEAR BEHAVIOR OF TiAIN COATED TOOL FOR TURNING AISI316

The TiAlN coated cutting tool performed better than the other coated cutting tools for minimization of SR and TW. Figure 8.3 shows scanning electron microscope image for TiAlN coated tool at cutting speed 110 m/min, feed 0.1 mm/rev and depth of cut 2.1 mm during turning AISI316. It showed that cavities and grooves occurred on the edge of the cutting tool (Samir et al 2007).
Figure 8.3 Wear behavior of TiAlN coated tool for turning AISI316

Figure 8.4 shows scanning electron microscope image of TiAlN coated cutting tool at cutting speed 110 m/min, feed 0.1 mm/rev and depth of cut 0.7 mm during turning AISI316. It showed that the sliding wear occurred on the edge of the cutting tool (Davi 2013).

Figure 8.4 Wear behavior of TiAlN coated tool for turning AISI316
Comparisons of TiCN/Al$_2$O$_3$, Ti(C, N, B), TiAlN, B-TiC and B-Al$_2$O$_3$ coated tools in CNC turning AISI410 is presented in Figure 8.5. It clearly showed the minimum surface roughness was obtained from the TiAlN coated cutting tool rather than other coated tools. Figure 8.6 shows the comparison of different coated tools at cutting speed of 110 m/mn, feed of 0.1 mm/rev and depth of cut of 1.4mm. It clearly showed the minimum tool wear obtained from the TiAlN coated tool than the other coated tools.

**Figure 8.5** Comparison of different coated tools with SR for turning AISI410
Figure 8.6  Comparison of different coated tools with TW for turning AISI410

8.7 SINGLE RESPONSE OPTIMIZATION FOR TURNING AISI410 USING TiAlN COATED TOOL

The single response optimization of the S/N ratio for SR and TW on AISI410 with TiAlN was obtained by Taguchi analysis. Based on delta value the rank showed feed had stronger effect on SR with delta 11.94 followed by cutting speed with delta 2.99. The minimization of SR on AISI410 was at cutting speed set at 110 m/min, feed set to at 0.1 mm/rev, depth of cut set at 0.7 mm. Based on delta value the rank showed cutting speed had stronger effects on TW with delta 6.20 followed by depth of cut with delta 4.06. The minimization of TW on AISI410 was at a cutting speed set at 160 m/min, feed set at 0.2 mm/rev, depth of cut set at 0.7 mm.
8.8 MULTI RESPONSE OPTIMIZATION FOR TURNING AISI410 USING TiAlN COATED TOOL

Multi-response optimization was performed using the grey relational analysis. Optimum setting for minimization of SR and TW was based on the grey relational grade value cutting speed set at 110 m/min, feed is set at 0.1 mm/rev, depth of cut set at 0.7 mm for turning AISI410 using TiAlN coated tool.

8.9 MODELING AND PREDICTION FOR TUNING AISI410 USING TiAlN COATED TOOL

The major effect on SR was the linear effect of feed which is followed by cutting speed having a P-value of 0.000 and 0.069. The major effect on TW was the linear effect of cutting speed which is followed by interaction effect of cutting speed and depth of cut having a P-value of 0.012 and 0.045 for turning AISI410 using TiAlN coated tool.

8.10 WEAR BEHAVIOR OF TiAlN COATED TOOL FOR TURNING AISI410

Figure 8.7 shows scanning electron microscope image of TiAlN coated tool at cutting speed 110 m/min, feed 0.1 mm/rev and depth of cut 0.7 mm during turning AISI410. It showed the plastic deformation with attrition wear on the cutting tool. Abrasive wear affected by hardness of the work material and was controlled by content of the cutting material. It was found that the temperature rise during cutting could significantly reduced the strength of the tool and hence the wear resistance of the tool. Figure 8.8 shows TiAlN coated cutting tool at cutting speed 160 m/min, feed 0.2 mm/rev and depth of cut 0.7 mm during turning AISI410. It showed the plastic deformation occurred in
downward direction on cutting tool. It was found that reduced the wear resistance of the tool (Samir et al 2007 & Davi 2013).

Figure 8.7 Wear behavior of TiAlN coated tool for turning AISI410

Figure 8.8 Wear behavior of TiAlN coated tool for turning AISI410
8.11 COMPARISON OF AISI316 AND AISI410

The TiAlN composition coated cutting tool performed better than the other composition coated cutting tool for all the level of cutting speed and minimum level of feed for minimization of responses. Figure 8.9 and Figure 8.10 shows the comparison charts for turning of AISI316 and AISI410 for SR and TW by different coated tools. Figure 8.9 and Figure 8.10 shows cutting speed 110 m/min, feed of 0.1 mm/rev and depth of cut 0.7 mm. It clearly shows the minimum SR and TW were obtained from AISI316 than AISI410 for all coated tools.

![COMPARISON OF SR](image)

Figure 8.9 Comparisons of AISI316 and AISI410 with SR using different coated tools
Figure 8.10  Comparisons of AISI316 and AISI410 with TW using different coated tools