CHAPTER - 6

SUMMARY, CONCLUSIONS, LIMITATIONS AND FUTURE SCOPE

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6.1 Summary

Manufacturers around the world constantly strive for lower cost solutions in order to maintain their competitiveness on machined components and manufactured goods. Globally, part quality has been found to be at acceptable levels and it is continuous to improve while the pressure for part piece cost is enormous and is constantly being influenced down word by competition and customer strategies. The trend is towards high quality, low cost and small batch size. Hence, it is necessary to seek appropriate new technological solutions that can help the manufacture to select the appropriate tools for a particular material.

The surface roughness, metal removal rate and power consumption is measured in hard turning process for machining of hardened alloy steel AISI 4340 under dry cutting conditions. The PVD (PR1125) and CVD (CA5515) coated tools used in experimental and analysis. The design of Experiments is implemented based on the Taguchi Method of selection of Orthogonal Array.

6.2 Conclusions

The conclusions arrived on the research work in machining AISI 4340 steel using PVD and CVD coated tools under dry conditions in hard turning are presented in the following.
1. The experimental results in turning AISI 4340 steel using PVD and CVD coated tools on surface roughness shows that, the depth of cut is most influencing parameter.

2. The influencing parameter of metal removal rate on AISI 4340 steel for both PVD and CVD tools is on speed. Similarly of power consumption the most influence parameter is speed for PVD tool whereas for CVD tool is depth of cut.

3. It is also observed from the ANOVA that there is no coincidence of levels of operating cutting conditions for better surface, Surface Roughness and maximum Metal Removal Rate and minimum Power Consumption.

   The adopted technique for better cutting conditions is simulated by ANN. The results are shows for the 75% of train data and 25% of the test data which is considered from the Orthogonal array of $L_{27}$ and $L_{36}$ design of experiments for three parameter analysis and four parameter analysis respectively. The results show that overall of 25 neuron layers shown the minimum deviation with experimental results for prediction of output parameters.

4. For prediction of Ra, MRR and PC linear logarithmic equations are developed and deviation is observed to be minimum and hence, these equations are considered as objectives in GA.

5. For optimal cutting conditions multi objective function along with weights are considered. These weight functions are selected randomly such that the summation of weights is equal to 1.
6. From the results of GA on PVD shows that for the weights W1 = 20.7%; W2 = 55.5%; W3 = 23.8%; i.e. Minimization of power consumption is the highest priority, shows the optimum conditions of 732 RPM of speed; Feed 0.09mm/min and 0.15mm of Depth of cut for which the predicted surface roughness is 4.835μm; 0.621 mm³/min of MRR; and 10.06 kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 5%, 4% from the actual GA value for Ra, MRR and 5 % deviation for Power consumption. (Refer tables 5.33 to 5.36).

7. From the another set of results of GA on PVD shows that for the weights W1 = 55.5%; W2 = 23.8%; W3 = 20.7%; i.e. Maximization of MRR is the highest priority, shows the optimum conditions of 730 RPM of speed; Feed 0.09mm/min and 0.15mm of Depth of cut for which the predicted surface roughness is 4.835μm; 0.619 mm³/min of MRR; and 10.04kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 5.5%, 3% and 5 from the actual GA value of Ra, MRR and PC. (Refer tables 5.33 to 5.36).

8. From the another set of results of GA on PVD shows that for the weights W1 = 23.8; W2 = 20.7%; W3 = 55.5%; i.e. Minimization of surface roughness is the highest priority, shows the optimum conditions of 710 RPM of speed; Feed 0.09 mm/min and 0.15mm of Depth of cut for which the predicted surface roughness is 4.803μm; 0.594 mm³/min of MRR; and 9.7 kw of power
consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 1.8%, 5.4% and 2.68% from the actual GA value of Ra, MRR and PC. The large deviation of 5.5 in Ra is due to one of the experimental data is observed to be large surface roughness for that particular trial. And also for another set of data similar results are observed and the results of GA and ANN are in acceptable range which is presented graphically. (Refer tables 5.33 to 5.36).

9. From the results of GA on CVD shows that for the weights W1 = 15.5%; W2 = 66.6%; W3 = 17.9%; i.e. Minimization of power consumption is the highest priority, shows the optimum conditions of 480 RPM of speed; Feed 0.05mm/min and 0.05mm of Depth of cut for which the predicted surface roughness is 3.299 μm; 0.2385 mm³/min of MRR; and 4.6 kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 1%, 11.78% and 5.3% from the actual GA value for Ra, MRR and PC. (Refer tables 5.41 to 5.44)

10. From the another set of results of GA on CVD shows that for the weights W1 = 66.6%; W2 = 17.9%; W3 = 15.5%; i.e. Maximization of MRR is the highest priority, shows the optimum conditions of 675 RPM of speed; Feed 0.05mm/min and 0.06mm of Depth of cut for which the predicted surface roughness is 4.293μm; 0.4176 mm³/min of MRR; and 6.485kw of power consumption. The optimum values of GA results for this level is simulated in
ANN, shows an approximate deviation of 2.3%, 2.6% and 5.6% from the actual GA value of Ra, MRR and PC. (Refer tables 5.41 to 5.44).

11. From the another set of results of GA on CVD shows that for the weights W1 = 17.9%; W2 = 15.5%; W3 = 66.6%; i.e. Minimization of surface roughness is the highest priority, shows the optimum conditions of 736 RPM of speed; Feed 0.09 mm/min and 0.05mm of Depth of cut for which the predicted surface roughness is 3.262μm; 0.3833 mm³/min of MRR; and 9.072kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 2%, 7.5% and 21.4% from the actual GA value of Ra, MRR and PC. The large deviation of 21% in PC is observed for other set of data. And also similar results are observed and the results of GA and ANN are in acceptable ranges which are presented graphically. (Refer tables 5.41 to 5.44).

12. Power consumption is observed to be deviating for the following significant reasons

   1. Fluctuations in supply of voltage
   2. Variation in cutting forces
   3. Friction between tool and work-piece.
   4. Uncontrollable factors beyond operators control.

13. The reason for considering additional input parameter is one of the following reasons
a. Most of the authors considered for comparing two tools by considering TOOL - A & TOOL – B for design of experiments. By considering this same set of operating conditions, better of the two tools are recommended for better operating cutting conditions.

b. If the tool and work piece hardness ratios are considered, for similar operating conditions as said above, additional parameter exists for selection of one of the tool.

14. Based on the above reason an additional parameter “Hardness ratio between work-piece and tool” is considered and analyzed. From the results of GA on four factors shows that for the weights W1 = 12.3%; W2 = 71.7%; W3 = 16.0%; i.e. Minimization of power consumption is the highest priority, shows the optimum conditions of 515 RPM of speed; Feed 0.09mm/min; 0.12mm of Depth of cut and 0.666 of Hardness fraction (SF) for which the predicted surface roughness is 3.974μm; 0.395 mm³/min of MRR; and 6.570kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 9.3%, 1% and 0.1% from the actual GA value for Ra, MRR and PC. (Refer tables 5.60 to 5.63).

15. From the another set of results of GA on four factors shows that for the weights W1=71.7%; W2 = 16.0%; W3 = 12.3%; i.e. Maximization of MRR is the highest priority, shows the optimum
conditions of 450 RPM of speed; Feed 0.09mm/min; 0.06mm of Depth of cut and hardness fraction 0.666 for which the predicted surface roughness is 3.519μm; 0.254 mm³/min of MRR; and 5.398kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 1.2%, 14.2% and 6.8% from the actual GA value of Ra, MRR and PC. (Refer tables 5.60 to 5.63).

16. From the another set of results of GA on four factors shows that for the W1 = 16.0%; W2 = 12.3%; W3 = 71.7%; i.e. Minimization of surface roughness is the highest priority, shows the optimum conditions of 450 RPM of speed; Feed 0.09 mm/min; 0.15mm of Depth of cut and hardness fraction 0.666 for which the predicted surface roughness is 3.99μm; 0.35 mm³/min of MRR; and 5.7kw of power consumption. The optimum values of GA results for this level is simulated in ANN, shows an approximate deviation of 3.1%, 10.25% and 21.4% from the actual GA value of Ra, MRR and PC. The large deviation in PC is observed for other set of data by considering the additional factor (Hardness ratio). And also similar results are observed and the results of GA and ANN are in acceptable ranges which are presented graphically. (Refer tables 5.60 to 5.63).

17. To conclude the better machining conditions on AISI 4340 by using the two tools is summarized in the follows.
a. The better cutting conditions for PVD tool are 710 rpm of speed; 0.09mm/rev feed; 0.15mm of depth of cut.
b. The better cutting conditions for CVD tool are 675 rpm of speed; 0.05mm/rev feed; 0.06 mm of depth of cut.
c. It is observed that from the analysis the better cutting conditions when Hardness fraction is considered are 515 rpm of speed; 0.09mm/rev feed; 0.12 mm of depth of cut of CVD tool.
d. The adopted procedure has given better optimal condition with minimum number of experiments. In view of the above factor this method can adopted for industrial purpose.

6.3 Limitation of the Present Research

The present work is carried out on TURNMASTER- 350 Lathe Machine. The range of feeds is 0.040 -063 mm/rev in longitudinal and 0.015-0.21 mm/rev for transverse feeds which is very low. And also depth of cut is 0.05-0.15 mm. Usually it must be more than this.

6.4 Scope for further Research work

1. The work can be extended for multi objective optimization like surface roughness, tool life and production cost and production time.

2. The effect of tool vibration, cutting fluid, nose radius, tool material and acoustic emission can be considered as they have great
influence on surface roughness, power consumption and cutting forces. So, including all those along with speed, feed rate and depth of cut studies.

3. Hybrid system for prediction like adoptive Neuro – Fuzzy Inference System (ANFIS).