CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

This chapter presents the summary of the present research work. The salient features of the present research work are summarized in the first section. The major conclusions drawn from the results of the experimental studies are given in the following section. The scope for future work is given in the final section.

7.2 SUMMARY OF THE PRESENT RESEARCH WORK

Experiments were conducted on a CNC vertical machining center to investigate the effect of the proposed “Progressive Feed Rate” method while machining AISI 1045 steel. Cutting speed, feed rate and depth of cut were considered as the major cutting parameters that would affect the output response. Output responses viz., surface roughness, tool flank wear and cutting force were considered for the study. Machining was done using PVD coated, CVD coated and Uncoated carbide inserts.

Machining was done for both the existing ‘Constant Feed Rate’ method and the proposed ‘Progressive Feed rate’ method. While $L_9$ (9 trials) OA was used for the existing method, $L_{27}$ (27 trials) was used for the proposed method. The output characteristics of the existing method were compared with the equivalent trials of the proposed method.
In order to predict the output characteristics, a second order statistical model using Response Surface Methodology (RSM) was developed. Analysis of Variance (ANOVA) was used to check for the adequacy of the model developed using RSM. The models were found to be adequate at 95% confidence level. This showed that the developed model could be reliably used to predict the output characteristics for the given input machining parameters.

To further strengthen the developed regression model, Artificial Neural Network (ANN) was used to validate the model and thereby use it for predicting the output responses. Comparison of the experimental data with the outcome of the models, RSM and ANN, proved that the models were adequate enough to predict the machining output characteristics accurately. Accurate prediction helps in avoiding catastrophic failures during actual machining.

With three input and three output characteristics it is essential to optimize the input parameters for an overall improved output. An orthogonal grey relational analysis was used to optimize the machining process with multiple performance characteristics.

7.3 MAJOR CONCLUSIONS

With the existing constant feed rate method, anticipating a sudden increase in the cutting force at the start of the cut, a programmer is likely to incorporate a conservative feed rate which will not be optimal. With the new concept of progressive feed rate the programmer can confidently incorporate the maximum feed rate that is permitted for the given machining conditions like the work material-cutting tool combination, cutting speed and depth of cut.
In CAM software there is an option to reduce the feed rate while machining an arc or a curved profile. This is to retain the geometry of the profile. The programmer at his discretion either enables it or disables it. Instead, if the Progressive Feed Rate concept is built into the CAM software it will lead to efficient machining.

The major conclusions drawn from the present research work are given below:

- After using progressive feed rate concept a reduction in surface roughness was found. For PVD coated inserts, the amount of reduction varied from a minimum of 7.8% to a maximum of 12.1%. For CVD coated inserts, the range was 8.0 – 18.9%. For uncoated carbide inserts, the range was 7.5 – 16.1%.

- Compared to the existing constant feed rate method, under progressive feed rate a reduction in tool flank wear was observed. For PVD coated inserts, the amount of reduction varied from a minimum of 4.5% to a maximum of 15.8%. For CVD coated inserts, the range was 4.0 – 11.8%. For uncoated carbide inserts, the range was 5.0 – 18.5%.

- In constant feed rate method a high starting cutting force was seen, whereas with progressive feed rate the cutting force increased gradually.

- In addition to the gradual increase in the cutting force, as mentioned above, a reduction in the maximum cutting force was also found. For PVD coated inserts, the amount of reduction varied from a minimum of 2.2% to a maximum of
37.4%. For CVD coated inserts, the range was 7.6 – 52.7%. For uncoated carbide inserts, the range was 0.8 – 42.1%.

- Response Surface Methodology (RSM) was used to develop a regression mathematical model which could be used for predicting the output characteristics even before the actual machining is performed.
- ANOVA tool was used to validate the regression model. It was found to be significant.
- ANOVA was used to find the most significant factor among the input parameters, on the output parameter.
- Artificial Neural Network (ANN) model was developed to validate the regression model and was found to be in close agreement.
- ANN model was also used to predict the output characteristics for the given input characteristics.
- Experimental data, values obtained from regression equation and ANN models were compared and were found to be in close agreement with each other.
- Grey relational analysis was used to optimize the machining parameters. It was found that high cutting speed, low feed rate and less depth of cut gave the optimum output characteristics.

7.4 BENEFITS TO THE MANUFACTURING INDUSTRY

- Reduced surface roughness leads to an improved surface finish which in turn will reduce or eliminate the secondary finishing operations. This will reduce the cycle time and also the machining cost.
• Reduced tool wear means infrequent tool change. This reduces the setup time and thereby the cycle time.

• Reduced tool wear leads to reduced tooling cost which in turn will reduce the production cost.

• Reduced cutting force enables the safety of the CNC machine and thereby increases the life of the machine. In addition, reduced cutting force also ensures the safety of the cutting tool and the workpiece material.

7.5 SCOPE FOR FUTURE WORK

This research focuses on the new concept of Progressive Feed Rate and its effect on the output parameters, surface roughness, cutting force and tool wear. However the following works can be taken as an extension of this research work.

• Metallurgical aspects can be taken up for study.

• A combined equation to address all the three types of cutting tools and all the input machining parameters, cutting speed, depth of cut and feed rate can be developed.

• Machining can be tried with different work materials and tool materials to check the effectiveness of the progressive feed rate concept and thereby establish a wider database.