Optimization of Surface Roughness & Cutting Force during Turning of AISI 1020 Steel with Edge Honed Carbide Tool

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Abstract— Machining is highly recommended operation to produce desired shape & size products. In turning operation, tool must be harder than the workpiece. To carry out machining operations by single point cutting tool, it must be provided with proper angles & nose radius. Rough turning with large amount of process parameters creates more wear on tools. Due to that it increases the cutting force. So, to reduce the cutting force, there are some different methods & technologies are developed in modern era. Edge honing is considered as one of the techniques to optimise cutting force for the cutting tools. It can be used to provide proper edge radius on the tools & hence to improve surface finish of machined parts. Influence of various types & dimensions of tool edge radius on tool life is studied & optimisation of cutting force & surface roughness for particular tool-workpiece combination is found out. Cutting speed and depth of cut has the main impact on the surface finish and cutting force respectively.

Key words: Edge Honing, Surface Finish, Cutting Force, Edge Radius, Depth of Cut, Feed, Cutting Speed

I. INTRODUCTION

Machining by single point cutting tool is the fundamental process to understand the phenomena of metal removal process. For the machining process, tool must be harder than the workpiece & proper angles should be provided to the tool so that machining is carried out very effectively. By providing tool angles & radius to the tool less forces are generated on tool during machining and desires surface finish can be achieved on the final product. The primary purpose of edge honing is to establish the interface between the tool and the workpiece. Chip flow, cutting speed, in-feed pressure and other machining variables are strongly impacted by the characteristics of this interface. The size and shape of the hone determine the amount of tool pressure required for a machining operation to be successful.

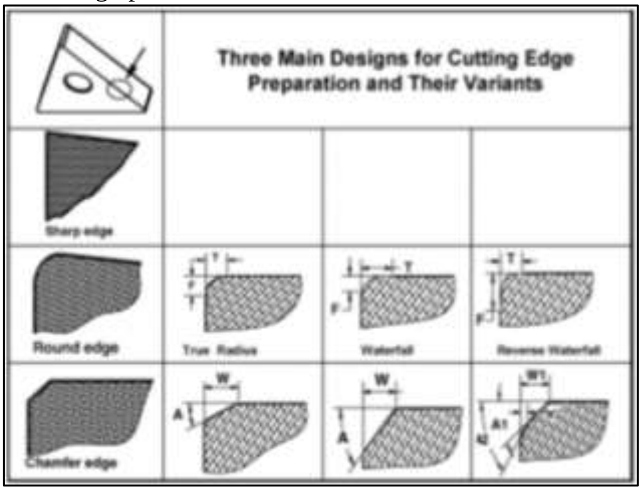

Fig. 1: Types of Edge Honing on Cutting Tools

II. LITERATURE REVIEW

Jaroslava Fulemova, Jan Rehor (2015): Influence of form factor of the cutting edge on tool life during finishing milling, Procedia engineering 100 (682-688) studies When K<1 it shows better tool life & good surface finish with increase in K up to 1 tool wear & notch wear increase. After K>1 surface roughness value deteriorates. In this case, K is the form factor, which is the ratio of length of cutting edge on rake face to the flank face.

Moises Izaias de Santanq, Milton Luiz Polli (2015): The influence of twist drill main cutting-edge preparation in drilling process, Materials research 2015; 18 (suppl 2): 148-153 mentions the tool edge protected by chamfering & honing presented a lifetime 8 times greater than the sharpened tool without edge preparation, wherein the honed tool presented no wear on its cutting edge.

N.Z.Yussefian, P.Koshy (2013): Parametric characterization of the geometry of honed cutting edges, Precision engineering 37 (746-752) The B-splines considered comprise 3 piecewise segments corresponding to the cutting edge profile & two tool faces. This case is valid to understand the phenomena of machining by 3D modelling and analysis of the same.

Ceren Celebi, E. Ozlu, Erhsn Budak (2013): Modelling & experimental investigation of edge hone & flank contact effects in metal cutting, Procedia CIRP 8 (194-199) says that total cutting force increases with the edge hone radius.

N.Z.Yussefian, P.Koshy (2013) : Application of foil electrodes for electro-erosion edge honing of complex shaped carbide inserts, Journal of material processing technology 213(434-443) concludes by using foil counter face, simultaneous processing of a batch of complex-shaped inserts, with no particular alignment requirements. This condition is applicable for the mass production or machining with larger process paramteters.

Berend Denkena, Jens Koehler, Michael Rehe (2012) : Influence of the honed cutting edge on tool wear & surface integrity in slot milling of 42CrMo4 steel, Procedia CIRP 1 (190-195) says that the wear behavior of honed cutting edges show a strong connection to the form factor K. Shifting the hone to the rake face, face wear occur due to the negative effective rake angle in the hone. Changing the hone design to a form factor of K<1 flank wear dominates due to an increase of friction between the tool & workpiece.

After studying above mentioned research papers, we have found out some of the areas, which are left for the research work. And also, some of the machining methods & future scopes led us to some research gaps.

– Among all those research papers, we found that by increasing the edge radius surface finish increases, but after the extreme limit they show chattering effect. So, it is needed to be optimised for the increase in tool life employing edge honing.

- Most of the researches have gone for the different tool and workpiece combination, while no one has done for the AISI 1020 steel and carbide tools
- For the increase in cutting force, no one has done optimisation to consider its effect on the edge honed tool.

The final outcome or you can say objective of the work is mentioned below. These are the points are kept in the consideration throughout the work.

1) To have optimisation of cutting force and surface roughness for particular tool workpiece combination
2) To study the effects of cutting force on edge honed radius on single point cutting tool
3) To have optimum surface finish on machined part by employing edge honing on tool

A. Main Effects Plot Analysis

The analysis is made with the help of a software package MINITAB 17. The main effect plots are shown in Figures. These show the variation of individual response with the three parameters i.e. cutting speed, feed, and depth of cut separately. In the plots, the x-axis indicates the value of each process parameter at three level and y-axis the response value. Horizontal line indicates the mean value of the response. The main effects plots are used to determine the optimal design conditions to obtain the optimum surface finish.

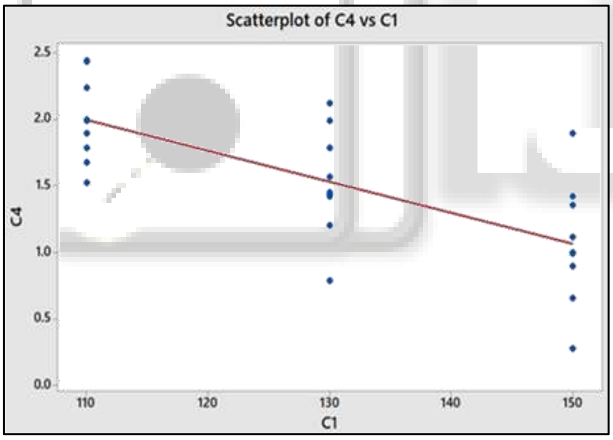

Fig. 1: Plot for cutting speed Vs surface roughness

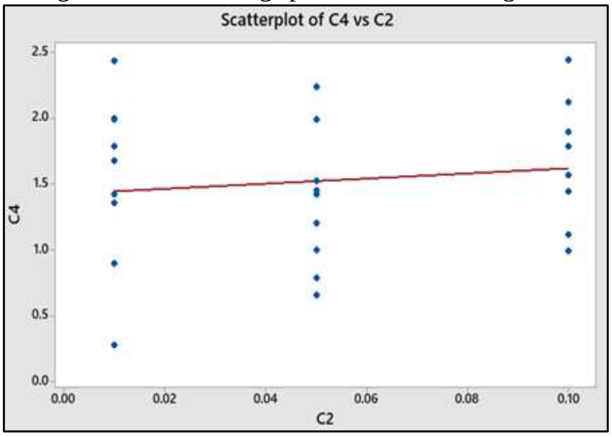

Fig. 2: Plot for feed Vs surface roughness

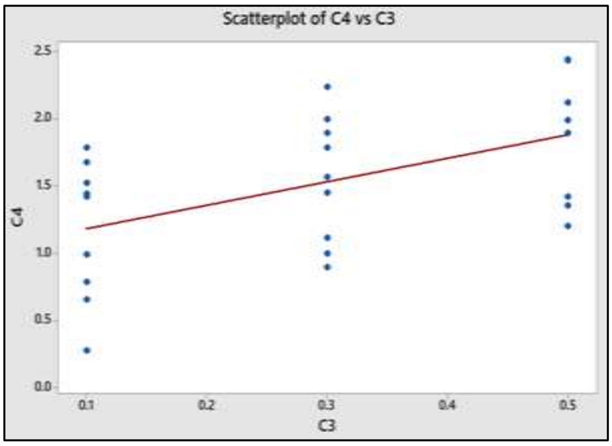

Fig. 3: Plot for depth of cut Vs surface roughness

According to this main effect plot in figure, the optimal conditions for minimum surface roughness are:

- Cutting speed at level 1 (150 m/ min)
- Feed rate at level 2 (0.05 mm/ min)
- Depth of cut at level 1 (0.1 mm)

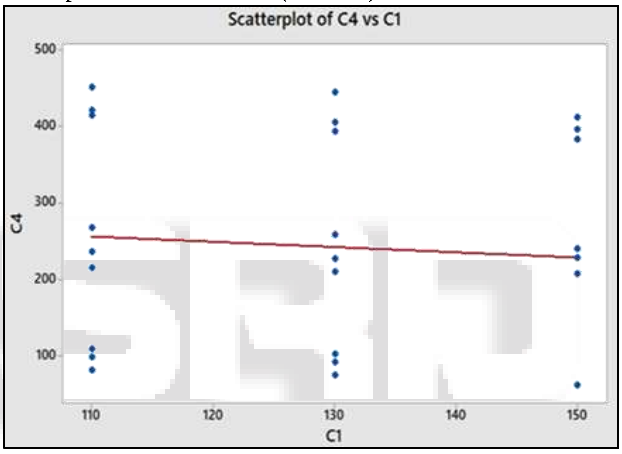

Fig. 4: Plot for cutting speed Vs cutting force

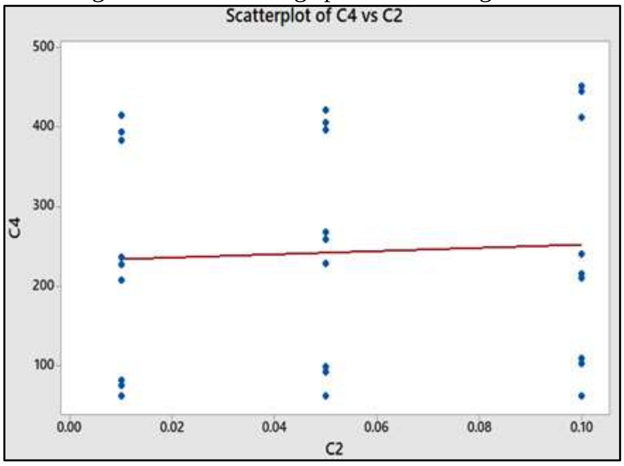

Fig. 5: Plot for feed Vs cutting force

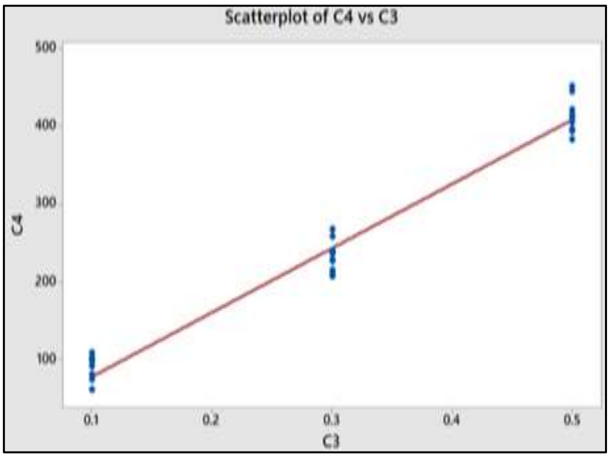

Fig. 6: Plot for depth of cut Vs cutting force

Figure shows the main effect plot for material removal rate. According to this main effect plot, the optimal conditions for minimum cutting force are:

- Cutting speed at level 1 (150 m/ min)
- Feed rate at level 2 (0.05 mm/ min)
- Depth of cut at level 1 (0.1 mm)

III. CONCLUSION

A. *Surface Roughness*

- Cutting speed, feed rate and depth of cut significantly effects on surface roughness.
- Feed rate is found to have maximum effect on surface roughness. Increase in feed rate, value of surface roughness is increase.
- Cutting speed is found the most significant effect on surface roughness. Increase in cutting speed, value of surface roughness is decrease.
- Depth of cut is found to have little effect on surface roughness. Increase in the value of depth of cut increases value of surface roughness.
- The percentage contribution of cutting speed is 50.20%, feed of 6.44% and depth of cut of 28.29% on surface roughness for edge honed single point cutting tool.
- From the ANOVA it is concluded that the cutting speed is most significant parameter which contributes more to surface roughness.

B. *Cutting Force*

- Cutting force increases for every value when the tool is edge honed.
- Depth of cut has the main impact on the cutting force, when the tool is worked with the edge honing process.
- Unarguably, change in the values of the cutting speed and feed have lesser effect on the cutting force.
- Increase in the cutting force is observed due to rounding of the edges of the single point cutting tool by edge honing process.
- Ultimately, by the use of edge honing on the cutting tool, its life increases.

IV. FUTURE SCOPE

The following suggestions may prove useful for future work:

- Similar work can be carried out by changing the process parameters or by changing value of process parameters as well as by changing the material for experimental purpose.
- Investigation of different cooling environment like gas, vapour, liquid, etc. on Surface Roughness and cutting force in CNC turning centre of AISI 1020.
- Influence of process parameters on tool wear and cutting force in CNC turning centre of AISI 1020 with the help of edge honed cutting tool.
- Chip formation analysis in machining of AISI 1020 by edge honed tool.
- Machining performance of various cutting tool (Coated and Uncoated) in machining of AISI 1020 with edge honed cutting tool.

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