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Manufacturing Technology: OPTIMIZATION OF MACHINING PERFORMANCE IN CONTOUR FINISH TURNING O_2

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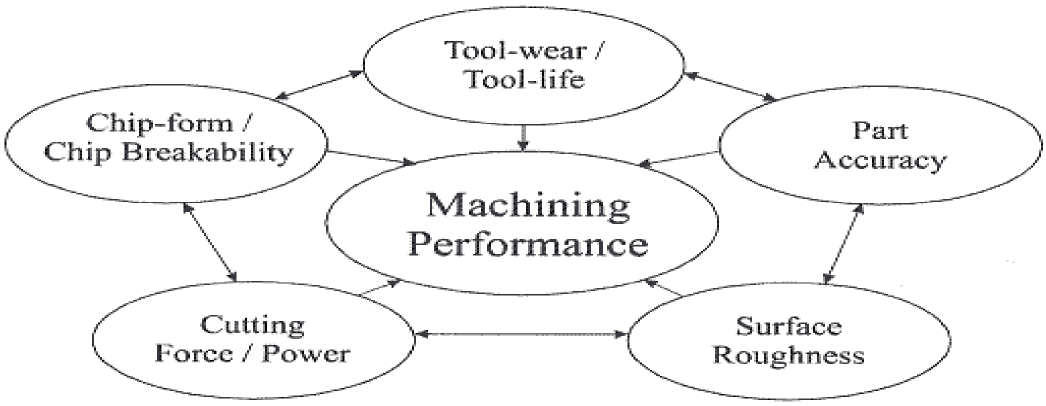
Abstract -*Unlike straight turning, the effective cutting conditions and tool geometry in contour turning operations are changing with changing workpiece profile. This causes a wide variation in machining performance such as chip flow and chip breakability during the operation. This thesis presents a new methodology for optimizing the machining performance, namely, chip breakability and surface roughness in contour finish turning operations. First, a computer program to calculate the effective cutting conditions and tool geometry along the contour workpiece profile is developed. Second, a methodology to predict the chip side-flow for complex grooved tool inserts is formulated and integrated in the current predictive model for contour turning operations. Third, experimental databases are established and numerical data interpolation is applied to predict the cutting forces, chip shape and size, and surface roughness for 1045 steel work material. Finally, based on the machining performance predictions, a new optimization program is developed to determine the optimum cutting conditions in contour finish turning operations.*

Key Words: **Optimization, Chip side-flow, Chip control, Contour turning, Finish turning operations**.

1. INTRODUCTION

In machining operations, chip control is one of the most important factors for achieving good surface finish and part quality, operator safety, machine productivity, cost efficiency, and tool sustainability. However, chip control tends to be overlooked because of the complexity of the process. However, chip control itself is not an independent factor in machinability assessments, as it relates to several other factors such as tool-life and surface finish diag. shows the most common



Machinability assessment criteria involving several interrelated machining performance measures. Several researchers have worked on developing chip flow predictive models since Colwell proposed the earliest model in 1954. However, most researchers focus on the straight turning process and these models cannot be simply applied to contour profiles of the workpiece. This is because the effective cutting conditions and tool geometry are changing with changing workpiece profile. Once the predictive model is established, the next step is the optimization. Since computer simulation programs of the predictive model can be developed as long as the model has a mathematical form, it is always possible to associate this program with an optimization program. The benefits of this connection between the simulation and optimization processes are not only to obtain the optimal machining performance, but also to make the process planning much easier With regards to the chip flow predictive model, it can lead to control chip flow in a more favorable direction by changing cutting parameters, such as cutting conditions and tool geometry Cutting conditions, especially feed and depth of cut, are among the major factors influencing the machining performance. In contour turning, the machining surface can be divided into small segments according to the shapes such as concave and convex. The optimal cutting condition would be different in each segment due to the various effective parameters.

1.1 Previous Work:

a) Chip Side-flow Model :

One of the earliest chip flow models was established by Colwell. Chip flow is substantially perpendicular to the side-cutting edge for the sharp-nosed tools but the direction swung progressively toward the tool axis as the nose radius is increased. He assumed that the chip-flow over the cutting face of the tool was perpendicular to the major axis of the projected area of cut. Cutting pattern was classified in terms of tool nose radius and depth of cut and derived the equations of chip-flow prediction based on the condition that the cutting was approximately orthogonal, i.e., both the rake and inclination angles were zero degrees.

b) Background of the Predictive Model for Contour Turning :

Due to the complex workpiece geometry in contour turning, most of the current theories are for straight bar turning. Changing workpiece profile causes varying effective cutting conditions, such as effective depth of cut and axial feed, and effective tool geometry, such as effective side-cutting edge angle and end-cutting edge angle. We conducted an experimental study of contour turning of aluminum alloys using PCD flat-faced and diamond coated grooved tools. This work focuses on attaining the best machining performance under dry conditions. In order to study the effects of contour geometry on machining performance in aluminum machining, a contour shape with sudden changes from convex to concave and concave to convex geometries was specially designed by the authors to include various combinations of features.

2. Program Results and Validation :

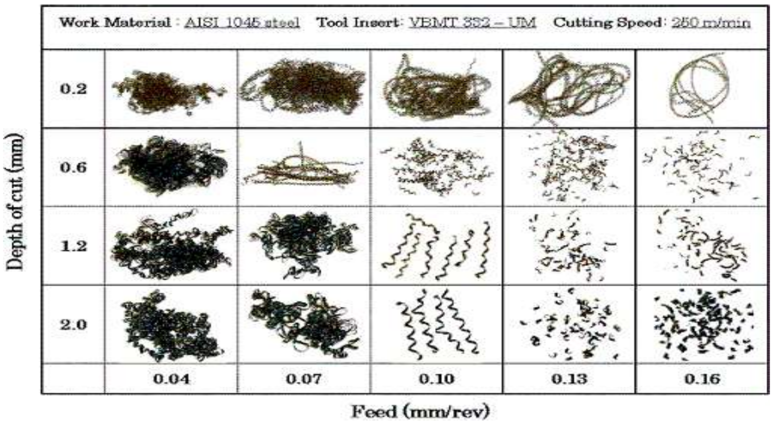
Once the databases for the radial and feed forces with grooved tool are created, the predictive program can be applied to contour turning operations. The details of the experimental conditions to create the databases and their results are shown in.Specific cutting tool, VBMT 332-UM, and work material, AISI 1045 steel are used and a sample workpiece with various geometric shapes is selected as the case study. In order to comprehensively study the effects of contour geometry, the sample workpiece includes convex, concave, and the straight line with positive, negative, and zero slope angles and it is divided by 8 segments according to the geometric shapes.

3. Experimental Database :

Two major technological machining performance measures, chip breakability, and surface roughness, are considered in the optimization criteria. The chip breakability takes into account the chip shape and size, and chip side-flow in this research work. Since currently available metal cutting theories are unable to predict chip shape and size, cutting forces in complex grooved tools, and surface roughness under the condition of finishing operation range, experimental databases have been created and cubic spline data interpolation method is used to obtain the functions of these measurements. By using as input the effective depth of cut and axial feed into these functions, predictions of chip shape and size, cutting forces, and surface roughness can be made.

4. Chip shape and size:

The definition of membership values according to the chip-form given as shown in Table was used to estimate the chip shape and size. Generally speaking, smaller cutting speeds tend to produce slightly better chip breakability. However, the effect of cutting speed on chip breakability is not as significant as the effects of feed and depth of cut. Therefore, the cutting speed was kept constant as 250 m/min. Figure shows the chip chart of the experimental results using the given tool insert (VBMT 332-UM) and work material (AISI 1045 steel) and shows the membership values of the chip shape and size. A cubic spline interpolation technique was used after creating the database to obtain chip shape and size.



Chip chart in terms of feed and depth of cut.

Test data for chip shape and size *CSS* (Cutting speed: 250 m/min, work material: AISI 1045 steel, cutting tool: VBMT 332-UM)

CSS		Feed (mm/rev)				
		0.04	0.07	0.1.0	0.13	0.16
Depth of cut (mm)	**0.2**	0.2	0.2	0.2	0.3	0.4
	0.6	0.2	0.3	0.6	0.9	0.9
	1.2	0.1	0.1	0.5	0.9	0.9
	2.0	0.1	0.1	0.5	0.8	0.85

The contour of chip shape and size.

5) Summary of Present Research Work :

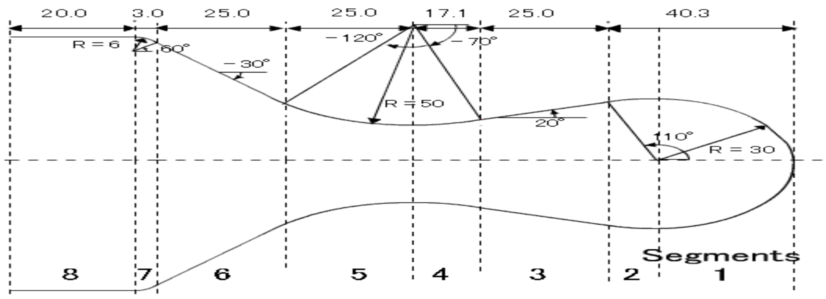
Industrial products have some curvatures to be machined and the cutting conditions are continuously changing along the workpiece profile. In this research work, two major accomplishments are made:

1) Chip side-flow prediction with complex grooved tool inserts in contour turning operations.

2) Optimization of machining performance in contour finish turning operations.

The hybrid models of Redetzky et al. and Ghosh et al. are applied, with calculated effective cutting parameters and tool geometries, to simulate the chip side-flow angles along the workpiece profile. Since this simulation model does not depend on the workpiece geometry, it can be applied to any workpiece geometry by changing the input parameters of the workpiece profile as long as the work material and cutting tool remain the same. Hence, it is also possible to modify or optimize the original product design features using this simulation program to make the chip flow in the most favorable direction.

The program was run under various cutting conditions in finish turning range. Cutting speed was kept constant at 250 m/min. It must be mentioned that the chip side-flow predictions and measurements are referenced with respect to the horizontal X-axis. Figure shows the calculated effective cutting conditions and the tool geometry according to the workpiece profile.



Once the simulation model is established, then the next step was to optimize the cutting conditions to improve the machining performance. Two major machining performance measures, chip breakability, and surface roughness are selected in this thesis work because of their relative importance to finishing operations. The goal of this optimization is determine the optimum cutting conditions according to the workpiece segments in order to improve the machining performance.

By configuring weighting factors and constraints for chip breakability and surface roughness, the best cutting conditions, fulfilling the required machining performance, can be obtained. The results of the validation experiments show that small constant feeds tend to give good surface roughness, but the chip breakability is so poor that surface is deteriorated. On the other hand, a larger. constant feed tends to give good chip breakability but surface roughness is poor as expected. Moreover, even a small difference in the depth of cut gives a larger difference in the chip breakability because of the effective depth of cut making the effect of the depth of cut larger in contour turning operations. The optimum cutting conditions give better chip breakability and surface roughness with the performance fulfilling requirements. In other word, it is maximizing the machining performance under the user-selected constraints.

6) Conclusion Suggestions for Future Work :

This research work focused on optimizing cutting conditions, namely the feeds and depth of cut. Since all simulation and optimization results are stored as data, it is possible to integrate this with other software. For example, by integrating suitable CAD software with this optimization program, the all required data could be automatically used as input for the optimization program from CAD. Also, the CNC-code to operate the CNC turning machine can be provided as the output of the optimization results since all workpiece configurations and cutting conditions are stored. In effect, this new optimization method can greatly help the machining process planners by providing the most-needed optimization module in the computer-aided process planning systems (CAPP).

It is also possible to determine the optimum cutting tool configurations and chip breaker from tool selections. By creating a database for each tool insert, an evaluation of which tool gives a larger utility function can be made, but this requires much more experimental work.Another possibility is to optimize a product design in order to make chip flow in a favorable direction. In most cases, the design of a product has some flexibility to change unless the change affects the product's function and concepts. By giving constraints for workpiece geometry, optimum product design can be determined.

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8) BIOGRAPHY OF CORRESPONDING AUTHOR:

Anirudh Atrish is a Young and Dynamic boy and has Completed Engineering and his Masters in Mechanical engineering. He has keen Interest in making things better with his new and creative ideas through his research and implementations. This research Paper is a Part of it.