Design For Manufacturing Micro Geometry Cutting Tools

Rashmi Mate[1], Prof. Vipin Khangar[2]
Department of Mechanical Engineering
[1]Research Scholar,G H Raisoni college of engineering Nagpur
[2]Assistant Professor, G H Raisoni college of engineering Nagpur

Abstract-*Machining techniques such as hard turning, hard milling and micro-mechanical machining, set high standards for tooling. These techniques, where the uncut chip thickness and the tool edge dimension are in the same order of magnitude, require cutting edges, which can withstand high mechanical and thermal induced stresses during machining. Machine tool vibration, tool life and workpiece surface integrity are all influenced by cutting edge size/shape. To optimize the machining process, variable micro geometry (VMG) cutting tools, in which the edge micro geometry varies along the edge line with respect to specific variables (such as machining parameters or expected tool wear), are manufactured.*

Keywords: Machining Variable Micro geometry, Cutting Edge, Design.

I. INTRODUCTION

Importance of cutting edge micro geometry in machining performance is well-acknowledged within the international machining community. Micro geometry of cutting edge can influence almost every aspect of the machining process namely the integrity of machined work piece [1], tool wear [2], the machining force [3] and the temperature distribution [4] in the machining zone .

Edge preparation should be carefully selected for a given application because it affects the surface properties of the work piece in terms of surface integrity. In a recent study, Liu and Shih (2006) compared the predictions of a 3-D FEA model with experimental measurements turning of titanium.

What Is Cutting Tool

In the context of machining, a cutting tool or cutter is any tool that is used to remove material from the work piece by means of shear deformation. Cutting may be accomplished by single-point or multipoint tools

II. METHODS OF MACHINING

- Milling.
  - Turning. Facing. Boring (also Single pass bore finishing)
  - Spinning (flow turning) Knurling. Hard turning. Cutoff (parting)
  - Drilling. Friction drilling.
  - Reaming.
  - Countersinking.
  - Tapping.
  - Sawing. Filing

In Conventional Machining processes, machine tools, such as lathes, milling machines, drill presses, or others, are used with a sharp cutting tool to remove material to achieve a desired geometry. It is a traditional process.

- Tools Used In Machining
- Broaching machine.
- Drill press.
- Gear shaper.
- Hobbing machine.
- Hone.
- Lathe.
- Screw machines.
- Milling machine
- CNC

Advantages of CNC Machining Over Convensional Machining

- You Don't Need Extensive Experience or Skills
- Products Can Be Easily Replicated Thousands of Times
- Machinery lets you program your machines to make the same cut over and over.
- Conventional machinery needs help from an experience operator to make similar pieces.
- Less Labor is required to Operate CNC Machinery
- CNC Software Increases Your Production Options
- No Prototypes are Necessary with CNC Machines
- CNC Machines Fit the Skills of Modern Workers

Proof-of-Concept

$\alpha 1$, $\alpha 2$ and γ are angles

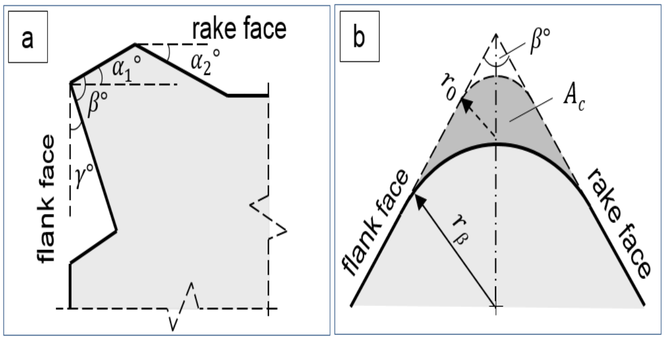
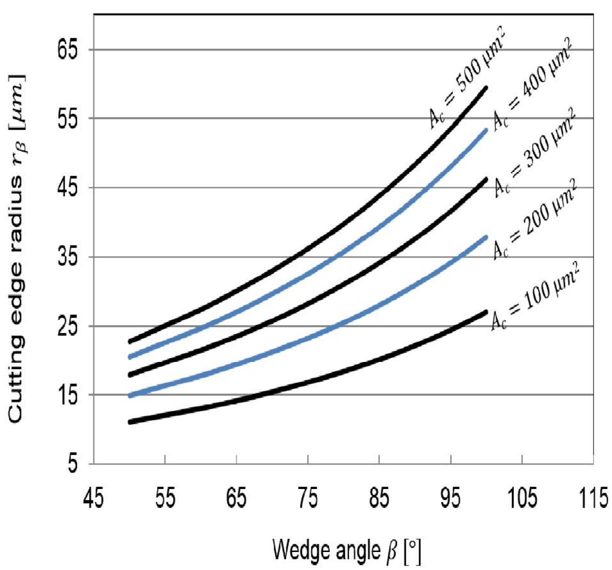


Fig. 1 (a) General macro geometry of a cutting tool wedge, (b) cutting edge micro geometry by removing Ac from the sharp edge

Fig. 2 explains the cutting edge radius (r) as a function of wedge angle and material removal. It is shown that under a constant removal, a smaller wedge angle leads to a smaller edge radius. It is further noticeable that for the same wedge angle difference ($\Delta\beta$), variation of edge radius (Δr) is elevated under a larger amount of material removal (Ac).



Cutting edge radius under various material removal from the edges as a function of wedge angle ($r0$ = 5 μm) Manufacturing of VMG Tools With regard to required macrogeometric modifications for the

III. MANUFACTURING OF VMG TOOLS

The proposed method should be integrated into the geometric design of a cutting tool as yet another design constraint among many. However, in the context of the concept evaluation of the proposed method in this research, the feasibility of VMG manufacturing is examined by macro geometric modifications applied to a regular cutting tool. Applying the wedge angle variations to a predesigned cutting tool should be done in a way to minimize any implication of macro geometric alterations. Any modification of $\alpha 1$, see Fig.1a, will directly alter the machining rake angle and in return substantially influence the machining performance. In this view, variable β is accomplished by only changing γ by means of peripheral grinding the flank face of the edge.

Machining Performance

Although the objective to manufacture VMG cutting tools by conventional edge preparation processes is accomplished in Sec. 3, it is imperative to examine the implications that required macro- and resultant micro-variations bring about for tool machining performance. To address this, the potential performance enhancement that VMG tools fabricated by this method can offer, compared to the original uniform honed geometry, are investigated by machining tests.

Advanced Cutting Tool Micro-Geometry Design

Edge preparation enhances tool life but at the same time makes cutting less efficient especially when the ratio of uncut chip thickness to tool radius decreases. This is especially true when friction factor increases with decreasing uncut chip thickness to edge radius ratio. The work material is trapped near end of the uncut chip geometry along the corner radius. Inefficient cutting results in increased strains in the work piece which in turn increases mechanical and thermal loads and results in high temperatures. This phenomenon becomes extremely important in hard turning. In order to explain this in detail, let us consider Fig. 3 which demonstrates the chip load of a uniform edge insert during cutting. As shown, the thickness of the chip varies from a maximum equal to the feed rate to a minimum on the tool's corner radius. If a uniform edge radius applied to the tip of the cutting tool, around that area cutting efficiency will be low due to small ratio of uncut chip thickness to tool edge radius. Three critical sections A-A, B-B and C-C are indicated in Fig.3. In Section A-A, uncut chip thickness is greater than the edge radius. In Section B-B, the uncut chip thickness is equal to the edge radius where the rubbing action becomes more dominant than shearing. In Section C-C the edge radius is larger than the thickness of the uncut chip and work material is rubbed against the workpiece. This rubbing action will result in increased temperatures on the tool and work piece surfaces and hinder the performance of the tool.

IV. CONCLUSION

A methodology for variable cutting tool micro-geometry design is explained. Cutting experiments and 3-D finite element analysis are performed to compare uniform and variable edge preparations. These results revealed that the variable edge preparation inserts perform better than uniform edge preparation utilized for more detailed investigations in predicting tool wear and work piece integrity. An experimental performance assessment of edge preparations in terms of tool life, work piece surface roughness and integrity is left for future studies. FE modeling can explain tool catastrophic breakage in the VMG3 variant by min principal stress analysis. Moreover, temperature distribution at the edge justified plastic deformation of the VMG2 tool. Experimental tests and finite element modelling revealed that for VMG fabrication by this method, it is imperative to identify the optimized macro/micro geometry for VMG fabrication.

REFERENCES

[1] Nasr, M. N. A., Ng, E. G., Elbestawi, M. A., 2007, Modeling the effects of tool edge radius on residual stresses when orthogonal cutting AISI 316L, International Journal of Machine Tools & Manufacture, 47, 401-411.

[2] Ventura, C.H.H., Köhler, J., Denkena, B., 2015, Influence of cutting edge geometry on tool wear performance in interrupted hard turning, Journal of Manufacturing Processes, 19, 129–134

[3] Denkena, B., Lucas, A., Bassett, E., 2011, Effects of the cutting edge micro geometry on tool wear and its thermo mechanical load, CIRP Annals -Manufacturing Technology, 60, 73-76.

[4] Denkena, B., Köhler, J., Bergmann, B., 2015, Development of cutting edge geometries for hard milling operations, CIRP Journal of Manufacturing Science and Technology, 8, 43–52,