AIJREAS VOLUME 2, ISSUE 8 (2017, AUG) (ISSN-2455-6300)ONLINE
ANVESHANA'S INTERNATIONAL JOURNAL OF RESEARCHIN ENGINEERING AND APPLIED SCIENCES

DESIGN AND STATIC ANALYSIS OF A TOOL FOR FOUR AXIS MILLING MACHINE

MOHD IBRAHIM
Branch:-Machine design
AL-HABEEB College of Engineering And Technology
searchforibrahim@gmail.com

Guide-Mr. Ch. ASHOK
M.Tech, Asst. Prof.
AL-HABEEB College of Engineering And Technology
Chashok027@gmail.com

HOD-Mr. UDAY BHASKER
M.Tech, Asso. Prof (Ph.D)
AL-HABEEB College of Engineering And Technology
hodmech@alhabeebcollege.ac.in

ABSTRACT:

This thesis aims to explore the theories and techniques behind procedures of developing a high precision cost-effective mini CNC milling machine tool. This newly designed machine tool can be widely used in electrical and medical industry for making small parts and engraving small features. Various structures were explored and compared during the design stage. Different commercial products were carefully selected and purchased from the Chinese market. PMAC from Delta Tau was used as the motion controller. Different setup and configuration issues using PMAC were explored. A newly designed motion controller using Arduino was also tested and implemented as a replacement of PMAC to reduce cost. Fabricated prototype machine tool was calibrated and tested under various self-testing procedures to meet industrial standard.

1.0 INTRODUCTION

The fabrication of a wide variety of parts and products in various fields, like aeronautics, automotives, biomedical, medical and electronics requires proper finishing for proper mating and functioning of products. A variety of operations like milling, drilling, turning, grinding, EDM and water jet cutting are utilized to fabricate and finish parts. One of the most common and important form of machining is the milling operation, in which material is cut away from the work piece in the form of small chips by feeding it into a rotating cutter to create the desired shape. Milling is typically used to produce parts that are not axially symmetric and have multiple features, such as holes, slots, pockets, and even three dimensional surface contours. Contoured surfaces, which include rack and circular gears, spheres, helical, ratchets, sprockets, cams, and other shapes, can be readily cut by using milling operation. Recently, micro milling process has gained immense popularity due to market requirements and technological advancements which has lead to fabrication and use of micro structures. It possesses several advantages like ease of use, capability to produce complex three dimensional geometries, process flexibility, low set-up cost, wide range of machinable materials and high material removal rates.

This chapter develops the background for the present work and discusses the need to take up this work. It presents a review of available relevant literature. Objectives of the present work along with methodology adopted to accomplish them are also discussed here.

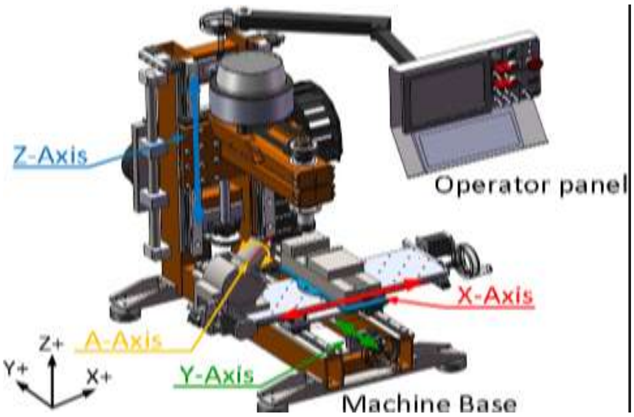


Figure 1.1 schematic view of milling machine

1.1 PROBLEM DEFINITION:

This work is an attempt to optimize micro milling tool parameters for minimization of micro tools formed during micro machining. The objectives of this work are stated as follows:

- To develop three-dimensional solid models of two flute and four flute flat-end micro milling cutters.

- To perform the static finite element analysis of the tools during micro milling.
- To perform the finite element detailed analysis of the tool and work piece combination during micro milling.
- To perform tool formation simulation in micro milling.

1.2 SCOPE OF THE PRESENT WORK

The outcome of the research will be a static finite element analysis of micro tools formed during micro-milling which can help in determining tool life and detailed dynamic analysis of micro tools formed during micro-milling operation in Al6061T6 which can benefit the aerospace industry, which utilises this alloy for fabrication of a large number of components. The results obtained during the analysis may be used for further research for tool minimization through tool optimization and process control.

2.0 LITERATURE SURVEY

Min and Dornfeld [2004], tool formation has eight basic stages. The process starts with the continuous cutting stage in which tool formation is unaffected by the deformation and stress distribution, as long as the work piece edge does not affect it. In the pre-initiation stage, the work piece edge bends due to elastic deformation and a plastic deformation zone is formed around the primary shear zone. This is followed by tool initiation in which the plastic deformation zone and the primary shear zone both extend. A pivoting point appears on the work piece edge in the pivoting stage, and cutting forces decrease, leading to a large deformation. As the tool develops, it enters the negative shear zone development stage in which the large deformation in the pivoting point expands and connects with the primary shear zone. The tool size increases as the tool approaches the work piece edge. Following this stage, there are three more stages – crack initiation

Hinds et al. [2000] presented the finite element method (FEM) features accurate predictions on a user friendly graphical interface and is employed widely for modeling, simulation and optimization of cutting processes. Thus, the cutting process potentially allows designers and engineers to reduce need for costly shop-floor trials, optimizes process conditions, improves cutting tool design, and shortens the lead time. The analysis of stresses in micro-drills is done by using the finite element method.

Lekkala et al. [2006] deduced that the depth of cut and the tool diameter are the main parameters, which influence the tool height and thickness significantly whereas the speed and the feed rate have small to negligible effect on the tool thickness and height.

Min and Dornfeld [2004], tool formation has eight basic stages. The process starts with the continuous cutting stage in which tool formation is unaffected by the deformation and stress distribution, as long as the work piece edge does not affect it. In the pre-initiation stage, the work piece edge bends due to elastic deformation and a plastic deformation zone is formed around the primary shear zone.

Chern [1993] found that tools formed in milling are dependent on the in-plane exit angle and classified tools formed into five categories - the knife-type tool, the wave type tool, the curl-type tool, the edge breakout, and the secondary tool.

3.0 METHODOLOGY

3.1 METHODS USED:

Lagrangian method:

Lagrangian formulation is used mainly in problems on solid mechanics. In this, the mesh moves and distorts with the material being modeled as a result of forces from neighboring elements. It is highly preffered when flow of material involved is unconstrained. Boundaries and chip shape need not be known beforehand. Simulation of discontinuous chips or material fracture can be done by using chip separation criteria in metal cutting models based on Lagrangian formulation. However, metal being suffers severe plastic deformation and distortion occurs. Mesh regeneration is therefore needed. Chip separation criteria also must be provided.

Eulerian method

In Eulerian formulation, the FE mesh is fixed spatially, which allows materials to flowfrom one element to the next. Besides, fewer elements are required for the analysis, whichreduces the computation time. However, determination of the boundaries and the chip shape needs to be done prior to the simulation. Also during the analysis, the tool-chip contact length, the contact conditions between tool-chip and the chip thickness, have to be kept constant.

3.2 DEVELOPMENT OF THREE DIMENSIONAL CAD MODEL:

Mill cutters used in this work are a two flute and a four flute flat micro end mill cutter. Method involved in the design of a micro end mill cutter includes:

- Creation of cross-sectional profile of the tool and helix generation
- Flute creation using slot operation
- Creation of back surface of the tool
- Cutting edge generation

Parameters involved in generating the cross sectional profile are:

- Rake angle of the tool
- Relief angle of the tool
- Tool diameter
- Number of flutes

The three dimensional CAD models of both the flat end mills was produced by performing solid modeling in CATIA V6 environment.

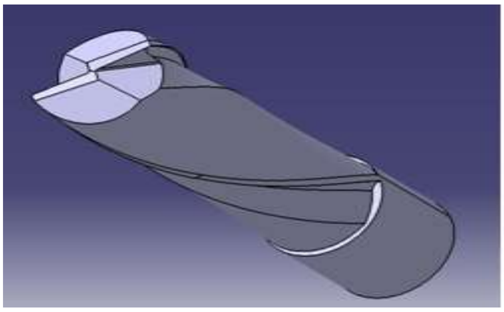


Figure 3.1 CATIA model of tool with one tip in milling machine

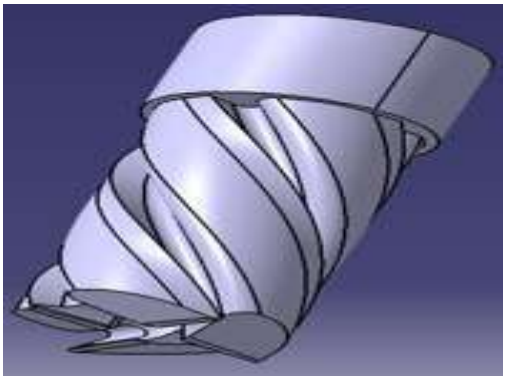


Figure 3.2 schematic view of tool with multi tip in milling operation

MESHING

The Figure shown is the meshed model of rigid flange coupling in the ANSYS analysis for the static structural process. To analyse, the FEM triangular type of mesh is used for the rigid flange coupling in the ANSYS environment

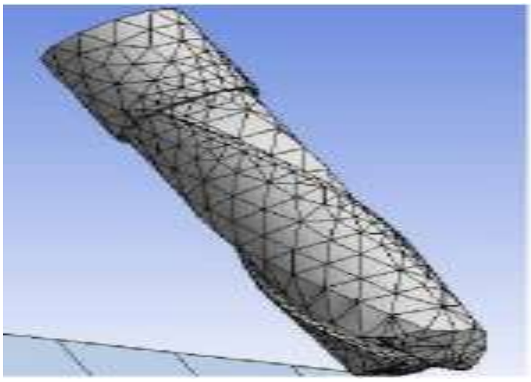


Figure 3.3 meshing model of tool with one tip in milling machine

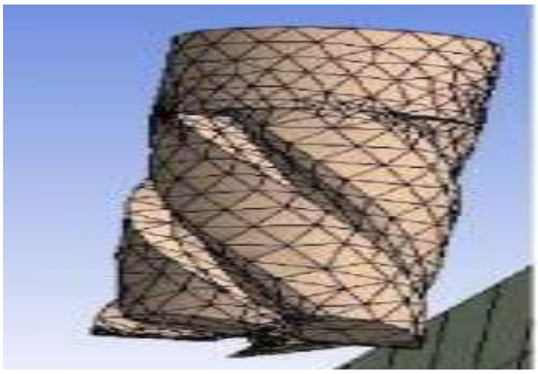


Figure 3.4 meshing view of tool with multi tip in milling operation

4.0 ANALYSIS AND RESULTS

Once a three dimensional CAD model of micro end mill cutter is developed, a no. of downstream applications can be performed, one of which is detailed finite element analysis and simulation of micro end mill during micro machining.

Table 4.1 Aluminum Alloy composition

Elements	Minimum (% by weight)	Maximum (% by weight)
Silicon	0.4	0.8
Iron	0	0.7
Copper	0.15	0.4
Manganese	0	0.15
Magnesium	0.8	1.2
Chromium	0.04	0.35
Zinc	0	0.25
Titanium	0	0.15
Aluminium	95.85	98.56
Others	0.05	0.15

ANALYSIS OF TOOL WITH ONE TIP:

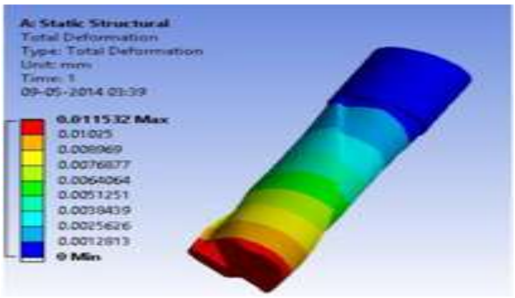


Figure 4.1 total deformation of tool with rank angle of 0^0c and relief angle of 10^0c

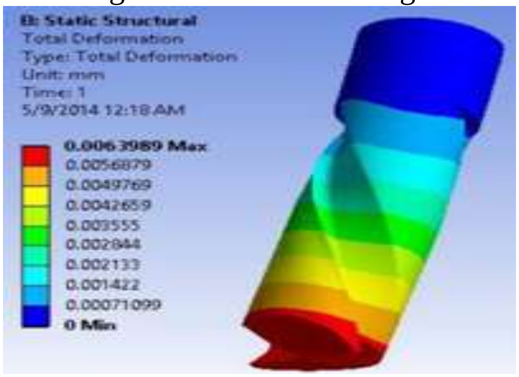


Figure 4.2 total deformation of tool with rank angle of 2^0c and relief angle of 6^0c

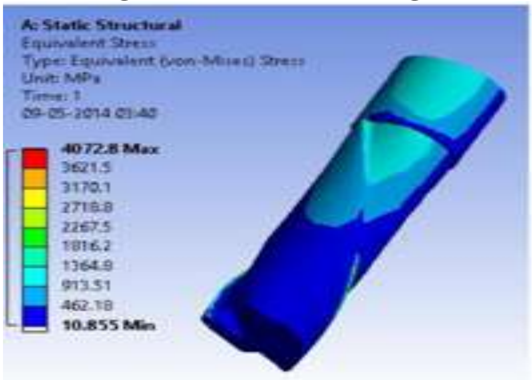


Figure 4.5 equivalent von mises stress of tool with rank angle of 0^0c and relief angle of 0^0c

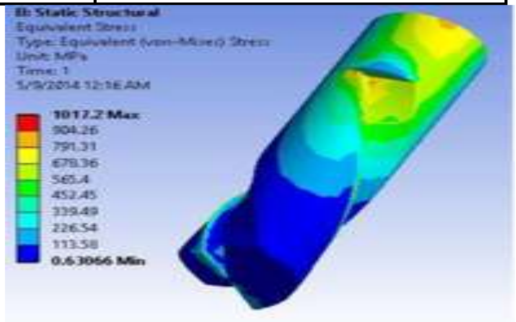


Figure 4.6 equivalent von mises stress of tool with rank angle of 2^0c and relief angle of 6^0c

ANALYSIS OF TOOL WITH MULTI TIP:

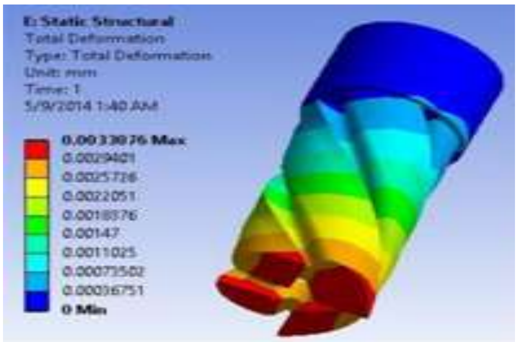


Figure 4.9 total deformation of tool with rank angle of 0^0c and relief angle of 10^0c

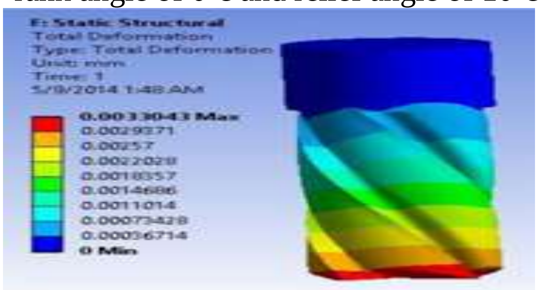


Figure 4.10 total deformation of tool with rank angle of 2^0c and relief angle of 6^0c

ANALYSIS OF TOOL PASSING INTO WORKPIECE:

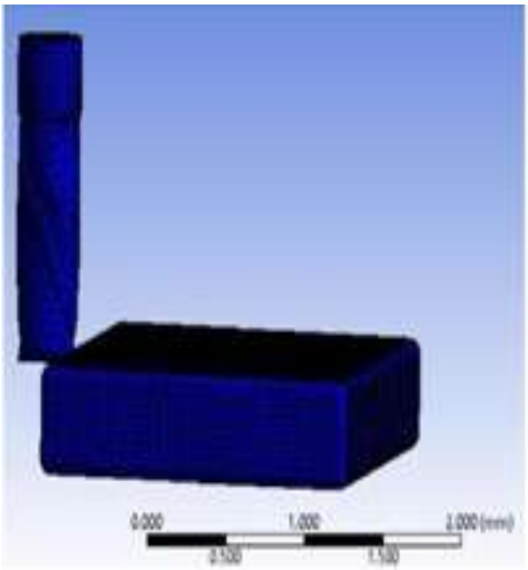


Figure 4.17 Entry of tool into the work piece

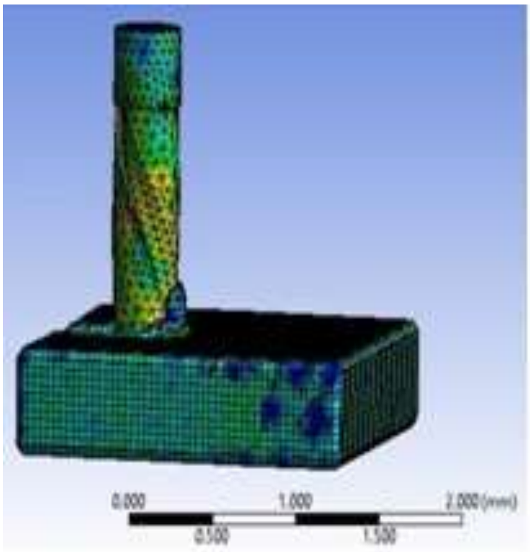
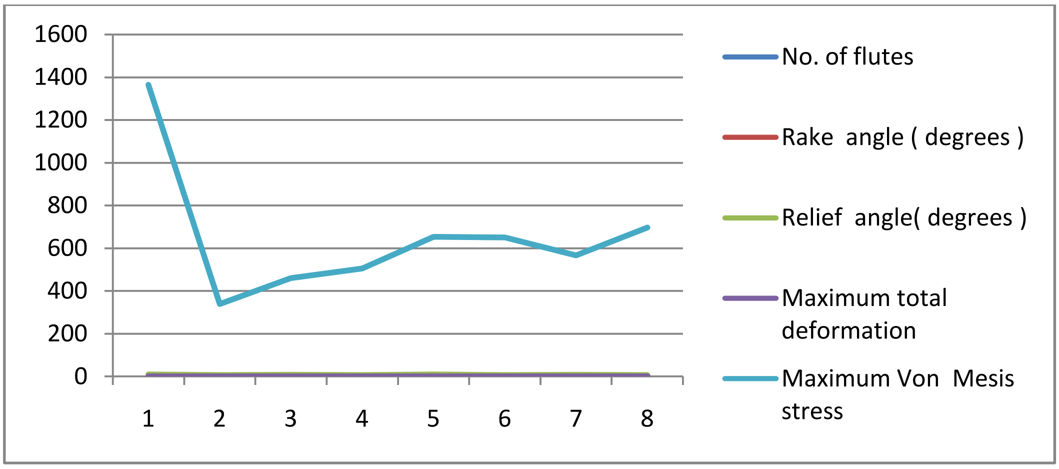


Figure 4.18 Chip formation initiations

Table 4.6 Results of static finite element analysis of tool with single and multi tip

No. of flutes	Rake angle (degrees)	Relief angle(degrees)	Maximum total deformation	Maximum Von Mesis stress
2	0	10	**0. 011532**	**1364.8**
	2	6	**0.063989**	**339.49**
	3	8	**0.006736**	**461.28**
	5	6	**0.0072553**	**505.52**
4	0	10	**0.0033076**	**654.41**
	2	6	**0.0033043**	**650.31**
	3	8	**0.0034248**	**567.43**
	5	6	**0.0034607**	**697.28**



Graph 4.1 Results of static finite element analysis of tool with single and multi tip

5.0 CONCLUSIONS

This chapter concludes the technical sum-up of the thesis work on three-dimensional geometric modeling and analysis of micro end milling cutters and simulation of micro tools formed during micro milling of aluminium alloy by using a tungsten carbide two flute micro end mill cutter. This is followed by directions for future work.Tool formation is a major hindrance to good surface finish in case of both macro and micro milling. However, tool formation in case of micro milling is of greater importance than in case of conventional milling as tools formed in the former case are of sub-micrometer size and detooling processes are expensive, and sometimes impossible. Hence, tool minimization is the only way of obtaining good surface finish in microstructures.

5.1 Future scope:

The results obtained from static FE analysis of micro end mills can be used in future to predict tool life and to choose the correct cutter geometry from available options for performing various micro milling operations.

REFERENCES

1. *Afazov, S.M., Ratchev, S.M. and Segal, J., Modelling and simulation of micro-milling cutting forces, Journal of Materials Processing Technology, Vol.210, pp. 2154-2162 (2010).*

2. *Alrabii SA, An experimental study of tool formation in drilling and slot-end milling operations, Journal of Engineering, 15(4) (2009) 4219- 4240.*

3. *Ávila M, Gardner J, Reich-Weiser C, Tripathi S, Vijayaraghavan A, Dornfeld D. Strategies for Tool Minimization and Cleanability in Aerospace and Automotive Manufacturing. SAE Transactions Journal of Aerospace, 114 (1), pp. 1073-1082 (2006).*

4. *Aziz M, Ohnishi O, Onikura H, Innovative micro hole machining with minimum tool formation by the use of newly developed micro compound tool, Journal of Manufacturing Processes, 14 (2012) 224–232.*

5. *Bao WY, Tansel IN, Modeling micro-end-milling operations. Part I: analytical cutting force model, International Journal of Machine Tools & Manufacture, 40 (2000) 2155-2173.*

6. *Bao WY, Tansel IN, Modeling micro-end-milling operations. Part II: tool run-out, International Journal of Machine Tools & Manufacture, 40 (2000) 2175–2192.*

7. *Campos F, Mougo A, Araujo A, 22nd International Congress of Mechanical Engineering (COBEM 2013) November 3-7, 2013, RibeirãoPreto, SP, Brazil*