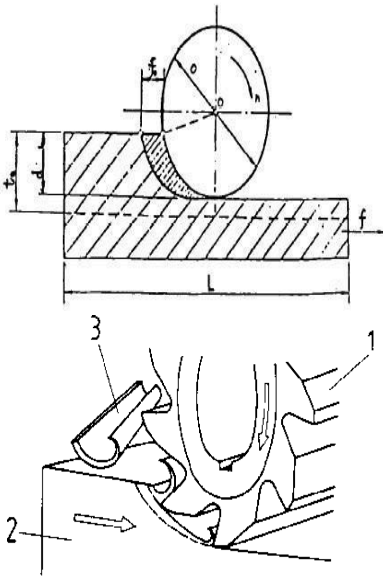
"DEMONSTRATING AND FATIGUE STUDY OF MILLING CUTTER"

B. SANDHYA RANI, V.SARITHA, KELLI RAGHURAM, 4.P.SRIKANTH
5.S.SANGEETHA
Assistant Professor, Department of Mechanical Engineering, Ellenki college of Engineering and Technonlogy, patelguda (vi)' near BHEL ameenpur (m), Sangareddy Dist. Telangana 502319.

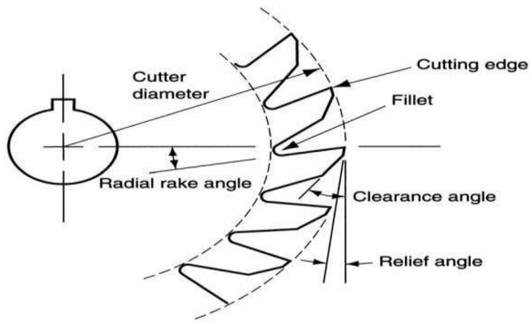
Abstract
Milling machine is one of the important machining operations. In this operation the work piece is fed against a rotating cylindrical tool. The rotating tool consists of multiple cutting edges (multipoint cutting tool). The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine. Milling is an interrupted cutting operation: the teeth of the milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to withstand these conditions. Cutting fluids are essential for most milling operations. In this Paper the design aspects of milling cutter is analyzed. The objective considered is the design and modeling of milling cutter and to analyze various stress components acting on it. By taking two different materials i.e. HSS and Silicon Carbide to check stress and deformation. The design and analysis is carried out using the software like Catia-V5 and ANSYS.

I. INTRODUCTION

Milling machine is one of the important machining operations. In this operation the work piece is fed against a rotating cylindrical tool. The rotating tool consists of multiple cutting edges (multipoint cutting tool). The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is a milling machine. Milling has its own particularities, such as variation on the unreformed chip thickness (h), interrupted cuts, etc. Models developed for turning and adapted to milling, working with average chip thickness, can yield reasonable results in terms of force. There are operations, however, where a more accurate result is needed and then, the discrepancies may become unacceptable. That is the case with high speed milling, which uses very low chip thickness. In this case, the cutting edge radius almost equals the unreformed chip thickness and the rake angle tends to be highly negative. The material seems to be removed like in abrasive processes. Additionally, the main parameters describing the models are a function of other ones related to the tool (material,geometry, coating, etc.) and the machine (rigidity, speed, position control, etc.). In order to investigate the end milling process in some cutting conditions, at any particular combination tool-machine-work piece, a simple and fast method is needed to find the main parameters of the classical existing models and study some new ones.



WORKING MOTIONS OF PLAIN MILLING OPERATION



CUTTING CONDITIONS IN MILLING

II. LITERATURE REVIEW

ChittibommaTirumalaneelam and TippaBhimasankaraRao(2013)developed geometric design model of a end milling cutter in terms of three-dimensional (3D) parameters. For analysis they took a single teeth of cutter. By taking different load condition analyze the stress and strain.

Mohammed and Tandon (2013) proposed a shape design methodology in order to develop the geometry of a generic special shaped milling cutter. The proposed three- dimensional parametric definition of the cutter with varying the rake angle of the insert and insert seat was analyzed using FEM

III. KINDS OF MILLING CUTTER

- Plain Milling Cutter: The most common type of milling cutter is known as a plain milling cutter. It is merely a metal cylinder having teeth cut on its periphery for producing a flat horizontal surface.
- T-Slot Milling Cutter: The T-slot milling cutter is used to machine T-slot grooves in worktables, fixtures, and other holding devices. The cutter has a plain or side milling cutter mounted to the end of a narrow shank. The throat of the T-slot is first milled with a side or end milling cutter and the headspace is then milled with the T-slot milling cutter.
- Concave and Convex Milling Cutters: Concave and convex milling cutters are formed tooth cutters shaped to produce concave and convex contours of one-half circle or less. The size of the cutter is specified by the diameter of the circular form the cutter produces.
- Metal Slitting Saw Milling Cutter: The metal slitting saw milling cutter is essentially a very thin, it is ground slightly thinner toward the center to provide side clearance. It is used for metal sawing and for cutting narrow slots in metal.
- End Milling Cutters: End milling cutters, also called end mills, have teeth on the end as well as the periphery. The smaller end milling cutters have shanks for chuck mounting or direct spindle mounting. Larger end milling cutters are called shell end milling cutters and are mounted on arbors like plain milling cutters. End milling cutters are employed in the production of slots, keyways, recesses, and

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tangs. They are also used for milling angles, shoulders, and the edges of work pieces.

• Corner-rounding Milling Cutter: The corner-rounding milling cutter is a formed tooth cutter used for milling rounded corners on work pieces up to and including one-quarter of a circle. The size of a cutter is specified by the radius of the circular form the cutter produces, as with concave and convex cutters.

• Special Shaped-formed Filing Cutter: Formed milling cutters have the advantage of being adaptable to any specific shape for special operations. The cutter is made for each specific job. In the field, a fly cutter is made to machine a specific shape.

IV. TYPES OF MILLING CUTTER

Milling is best defined as a cutting process where we use a cutter, with multiple rotating cutting surfaces, to remove the material from the surface of a work piece or metal. Available in many shapes and sizes, these milling cutters used in several milling machines, play a vital role in the process. It is the most commonly used process in industry and machine shops today. It’s not an easy deal in choosing a milling cutter. You have to think of their diameter, the material from which they are made, etc for selecting a milling cutter.

• Roughing End Mill: This type of cutter is used when you have. to remove more amount of material from the work piece. By using roughing end mills, we obtain a rough surface finishing.

• Slab Mill: This type of cutter is used when you have to remove more amount of material from the work piece

• End Mill: These types of milling cutters have the cutting teeth on the both sides. We use end mill more in the vertical milling processes. High speed steel or the cemented carbide are used to create end mills

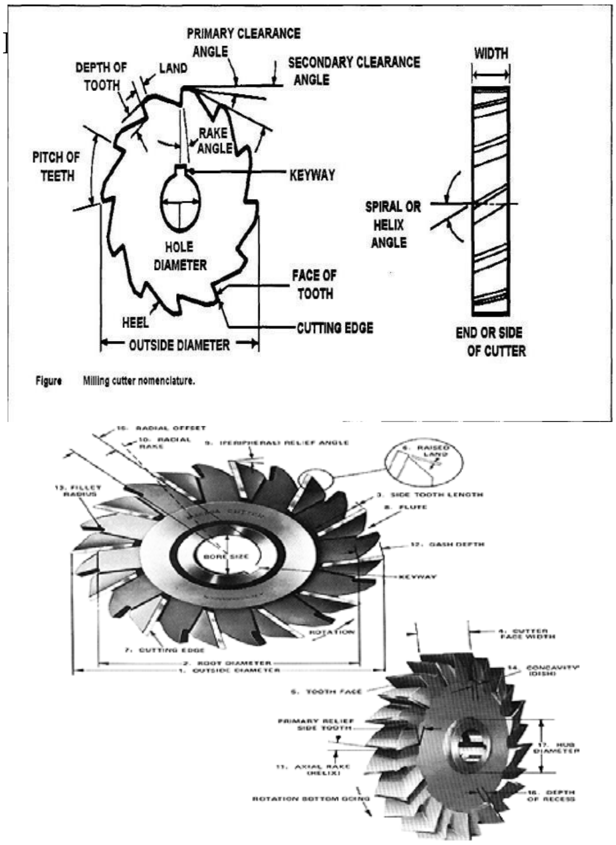
• Hollow Mill: They are also referred as hollow milling cutters. They look like a pipe having thicker walls. You will find the cutting teeth of the hollow mills on the inside surfaces. Hollow milling cutters are used in the screw machines.

• Ball Mill Cutter: Ball cutters are also famous as ball nosed cutters. You can be easily identify as ball cutters as their end is hemispherical in shape. Ball cutters are used to decrease the stress concentration and are also known as ball end mills. Whenever there is need of cutting three dimensional shapes then, there is a use of ball cutters to perfectly cut those three-dimensional shapes.

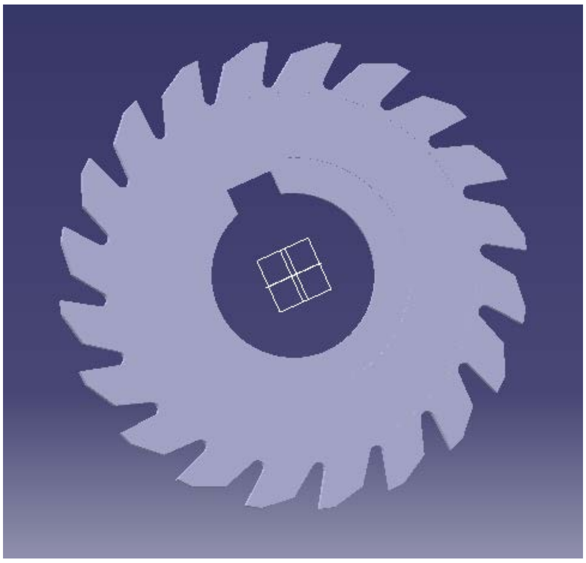
• Face Mill Cutter: With this type of mill cutter, machining is done by the teeth on the flat surface of the cutter. The finished surface is usually perpendicular to the axis of the cutter. The cutting teeth are present on its sides. Another interesting feature of this cutter is that it has got carbide inserts which are gold in color and these tips can be exchanged. You can also replace it with a newer one, whenever one of the tips get damaged. The cemented carbide in it also refers as indexable carbide insert.

V. GEOMETRY OF MILLING CUTTER

The milling cutter is a multiple point cutting tool. The cutting edge may be straight or in the form of various contours that are to be reproduced upon the work piece. The relative motion between the work piece and the cutter may be either axial or normal to the tool axis. In some cases a combination of the two motions is used. For example, form-generating milling cutters involve a combination of linear travel and rotary motion. The figure below shows the plain milling cutter nomenclature and model created using Catia software.



NOMENCLATURE OF PLAIN MILLINGCUTTER



CATIA MODEL OF MILLING CUTTER

VI. ANALYSIS OF PLAIN MILLING CUTTER

The fatigue analysis on the cutting tool can be performed through an integrated Finite Element (FE) based analysis providing appropriate tool material by using Marrow correction.

Finite element method able to predict the deformation, stresses and strain in the work-piece as well as the load on the tool under the specified cutting parameter.

The teeth of Milling cutter Enter and Exit the work during each revolution. This interrupted cutting action subjected the teeth to a cycle of Impact Force and Thermal Shock on each revolution.

The Tool Material and Cutter Geometry must be designed to with stand this conditions.

The basic steps for performing analysis are listed below:

•Create the model geometry and mesh using Catia

•Selecting The Analysis System In Ansy's Workbench

•Engineering Data Source Selecting The Types Of Materials (HSS and Silicon Carbide).

•Exporting the modelling part from Catia(Saved in.igs format) to Ansy's.

•Selecting the Type of Solutions Required

☐ Total Deformation

☐ Directional Deformation

☐ Equivalent Elastic Strain

☐ Equivalent Stress

☐ Structural Error

☐ Strain Energy

• Review the results

VII. RESULTS AND DISCUSSION

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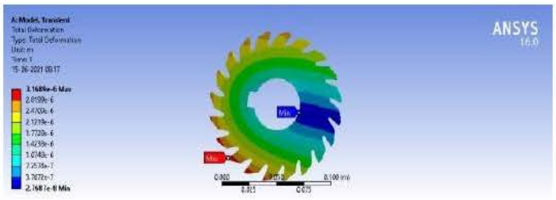
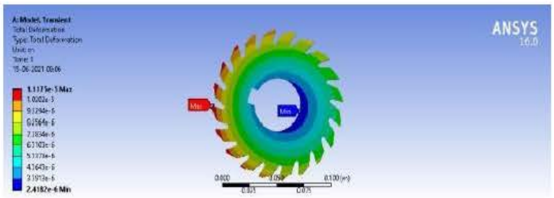
The teeth of Milling cutter Enter and Exit the work during each revolution. This interrupted cutting action subjected the teeth to a cycle of Impact Force and Thermal Shock on each revolution

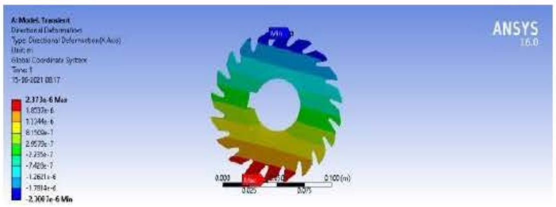
TAKING HSS AND SILICON CARBIDE

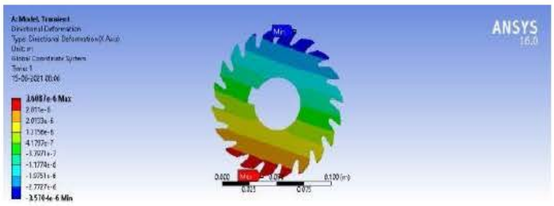
- Total Deformation



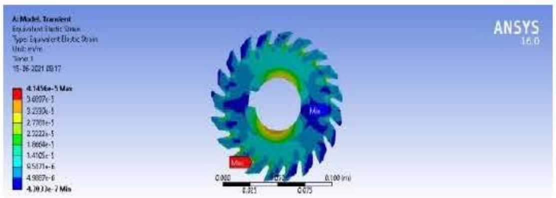


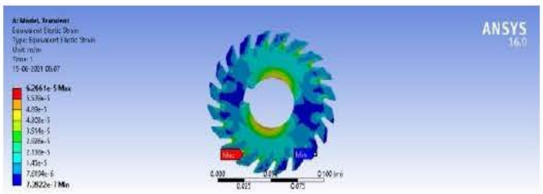
- Directional Deformation



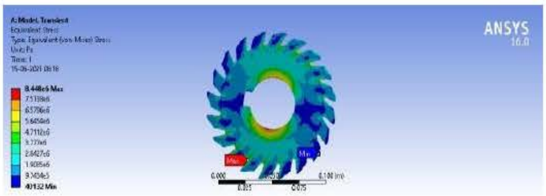


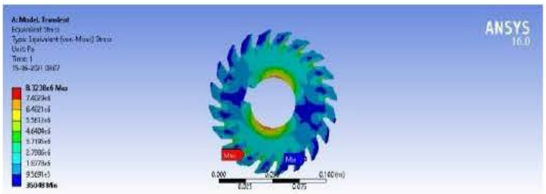
- Equivalent Elastic Strain



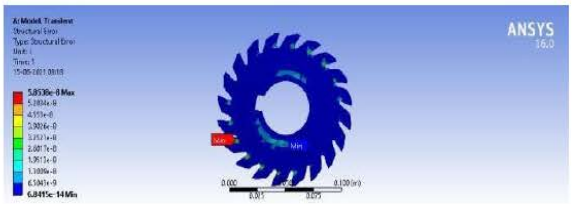


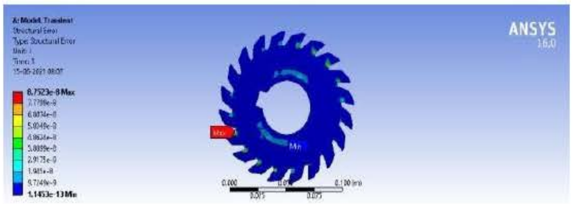
- Equivalent Stress



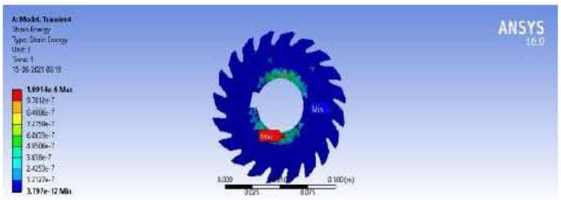


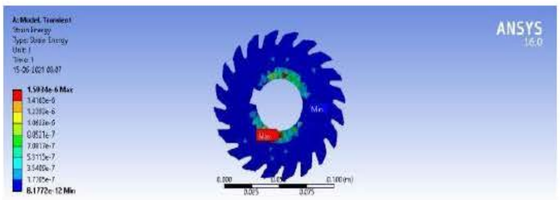
- Structural Error





- Strain Energy





Solutions for HSS (High Speed Steel)				
Object Name	State		Minimum	Maximum
Total Deformation	SOLVED	RESULTS	2.7687e-008 m	3.1689e-006 m
Directional Deformation			-2.3007e-006 m	2.373e-006 m
Equivalent Elastic Strain			4.3033e-007 m/m	4.1456e-005 m/m
Equivalent Stress			40132 Pa	8.448e+006 Pa
Structural Error			6.8415e-014 J	5.8538e-008 J
Strain Energy			3.797e-012 J	1.0914e-006 J
Solutions for SiC (Silicon Carbide)				
Object Name	State		Minimum	Maximum
Total Deformation	SOLVED	RESULTS	2.4182e-006 m	1.1175e-005 m
Directional Deformation			-3.5704e-006 m	3.6087e-006 m
Equivalent Elastic Strain			7.3922e-007 m/m	6.2661e-005 m/m
Equivalent Stress			36048 Pa	8.3238e+006 Pa
Structural Error			1.1453e-013 J	8.7523e-008 J
Strain Energy			8.1772e-012 J	1.5934e-006 J

VIII. CONCLUSION

This work illustrates an advanced modeling paradigm that can be used to accurately model a special shaped milling cutter and thus, opens up paths to define conveniently various customized cutters. Here, different design activities, such as geometric modeling, finite element analysis and design improvements have been integrated. As is evident, the approach illustrated in this paper is flexible and easy to use.

This approach can also be used to design any complex mechanical component, specifically for the cutter design, it produced the cutting variables that yield the minimum cost of manufacturing. The different design activities, such as design solid modeling, and finite element analysis, have been integrated.

From the results table, it is observed that the stress and deformation of the cutter are decreasing with increase in the speed i.e. they are inversely proportional to each other. The optimum rotating speed is 2000 rpm at which the stress and deformation are 1.1175e-005 m and 0.005015mm respectively for a load of 8.3238e+006 Pa.

The values obtained are compared with the model and theoretical stress values of the special shaped milling cutter. It was observed from the results, both stresses and deformation values were reduced for Silicon carbide than the tool material HSS.