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DESIGN MODIFICATION OF MILLING CUTTER AND ANALYSIS OF WORKING PERFORMANCE STRENGTH

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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). Normally axis of rotation of feed given to the work piece. Milling operation is distinguished from other machining operations on the basis of orientation between the tool axis and the feed direction; however, in other operations like drilling, turning, etc. the tool is fed in the direction parallel to axis of rotation. The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The machine tool that performs the milling operations by producing required relative motion between work piece and tool is called milling machine. It provides the required relative motion under very controlled conditions. These conditions will be discussed later in this unit as milling speed, feed rate and depth of cut. Normally, the milling operation creates plane surfaces. Other geometries can also be created by milling machine. Milling operation is considered an interrupted cutting operation teeth of 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 bear the above stated conditions. In this project work the changing the design aspects of plain milling cutter is analyzed. The objective considered is the design and meshing of modification plain milling cutter and to analyze strength and withstanding values weight redaction improve strength and various stress components acting on it. Various designing strategies are considered to design the effective plain milling cutter like blade inclinational angle, diameter, thickness, and face width. The design modification and analysis is

carried out using software's like CATIA V5 and ANSYS. In this study the design and analysis is carried out for two different cutter materials and they are existing material High Speed Steel and advanced composite material aluminum silicon Carbide, advanced reinforced material boron nitride. In this analysis the loads acting on the cutter and speed is varied and the results obtained are compared.

Keywords: design modification Plain Milling cutter, catia v5, weight redaction, strength improve, ansys.

Chapter 1:

1. INTRODUCTION:

Machining is undoubtedly the most important of the basic manufacturing processes, since industries around the world spend billions of dollars per year to perform metal removal (DeGarmo et al. 1997). That is so, because the vast majority of manufactured products require machining at some stage in their production, ranging from relatively rough operations to high-precise ones, involving tolerances of 0.001 mm, or less, associated with high quality surface finish. It is estimated that today, in industrialized countries, the cost of machining accounts to more than 15% of the total value of all products by their entire manufacturing industry, whether or not these products are mechanical (Merchant 1998).

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). Normally axis of rotation of feed given to the work piece. Milling operation is distinguished from other machining operations on the basis of orientation between the tool axis and the feed direction; however, in other operations like drilling, turning, etc. the tool is fed in the direction parallel to axis of rotation. The cutting tool used in milling operation is called milling cutter, which consists of multiple edges called teeth. The machine tool that performs the milling operations by producing required relative motion between work piece and tool is called milling machine. It provides the required relative motion under very controlled conditions. These conditions will be discussed later in this unit as milling speed, feed rate and depth of cut. Normally, the milling operation creates plane surfaces. Other geometries can also be created by milling machine. Milling operation is considered an interrupted cutting operation teeth of 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 bear the above stated conditions.

Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are 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. The cutter is lifted to show the chips, and the work, transient, and machined surfaces.

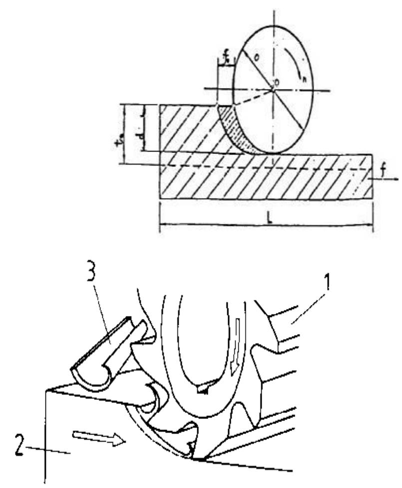

Fig1. Working motions of plain milling operation

1 plain milling cutter, 2 work piece, 3 direction of rotation,

The cutter design being presented in this paper is useful for single point as well as for multi-point cutters such as those used for turning and milling. In fact, the design principles for both single and multi-point cutters are similar. The design parameters such as rake angle, clearance angle of tooth, and height of tooth are common in both single point and multi-point cutters. Additionally, parameters such as speed of rotation, feed, and depth of cut are also similar. However, parameters such as diameter of the cutter, number of teeth on the cutter, and angular spacing of teeth are exclusively associated with milling cutters.

In the family of milling operations such as plain milling, slot milling, side milling, end milling, face milling, and form milling, design parameters differ only in their numerical values. In every case, the teeth of milling cutters have cutting edges and angles related to edges. In effect each tool acts like single point tool mounted on a cylindrical hub. The teeth on the milling cutters are mostly evenly spaced.

Chapter 2

Literature review:

Milling is the machining process in which the metal is removed by a rotating multiple tooth cutter. Fig. 1 shows the milling operation. As the cutter rotates, each tooth removes a small amount of material from the advancing work for each spindle revolution. The relative motion between cutter and the work piece can be in any direction and hence surfaces having any orientation can be machined in milling. Milling operation can be performed in a single pass or in multiple passes. Multi-pass operations are often preferred to single pass operations for economic reasons and are generally used to machine stocks that cannot be removed in a single pass. Various investigators have presented optimization techniques, both traditional and non-traditional, for optimization of multi-pass milling operation.

Hornik [1] describes the International Standards Organization (ISO) standards for milling cutter geometry. Indexable milling cutters are classified as double positive if both the axial and radial rakes are positive, double negatives if both are negative and positive/negative if the axial rake is positive and the radial rake is negative. However, these geometric descriptions make the mathematical formulation for design fairly complex.

Mohan[2] describes profile relieve cutters in milling contour surfaces. Profiles of these relieving tools are similar to the profile of the contour to be milled by the milling cutter, if the milling cutter is designed with a zero degree rake angle and straight flutes/gashes. In milling helical surfaces, the geometrical and dimensional accuracy of the profile cutter and its tool-life behavior is very important.

Davie[3] describes bonding of carbide inserts to such tools as Plain-mills instead of

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brazing them. He outlines development of such a technique and optimization of the tool design for bonding, selection of adhesives, cutting tests (using 0.14% carbon steel work piece), and an assessment of temperature developed in the tool.

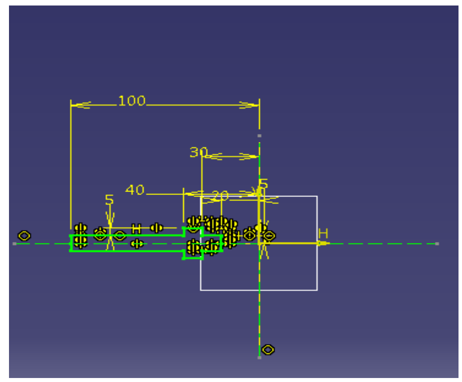
Milling plays a central role as a shape generating technique in the machining of hollow forms. Such hollow shapes are used in tools for presses, forges, and foundry work. Granger[4] describes the selection of a milling cutter in terms of average chip thickness rather than in feed/tooth. This approach depends on a combination of factors including material, component design, and strength, rigidity of fixturing, and type and age of machine.

Chapter-3

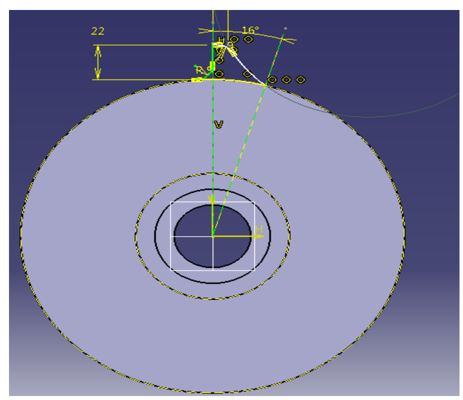
3.1 DESIGN:

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse.

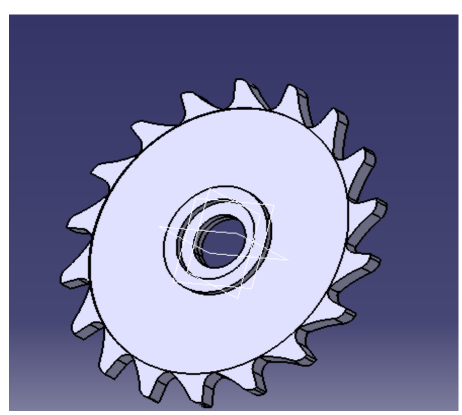
Milling sketch:



Teeth sketching:



Solid model:



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4 Ansys:

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

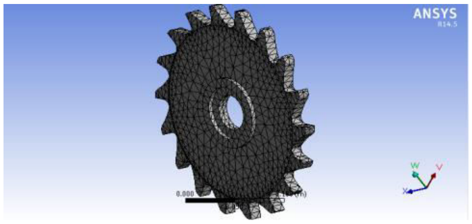
1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.
5. A typical ANSYS analysis has three distinct steps.
6. Pre Processor (Build the Model).

Material data:

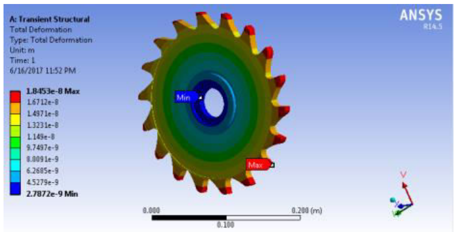
- **high speed steel:**

Density	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
8160 kg m^-3	1.9e+014	0.27	1.3768e+014	7.4803e+013

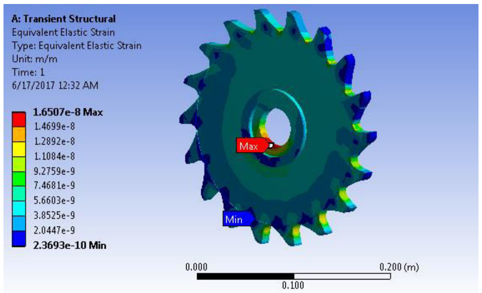
MESH:



Total Deformation



Equivalent Elastic Strain



Object Name	Total Deformation	Directional Deformation	Total Velocity	Equivalent Elastic Strain	Maximum Principal Elastic Strain
Minimum	2.7872e-009 m	-1.8166e-008 m	5.5284e-009 m/s	2.3693e-010 m/m	3.4568e-012 m/m
Maximum	1.8453e-008 m	1.7236e-008 m	3.66e-008 m/s	1.6507e-008 m/m	1.6267e-008 m/m

Aluminium silicon carbide:

Density	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa

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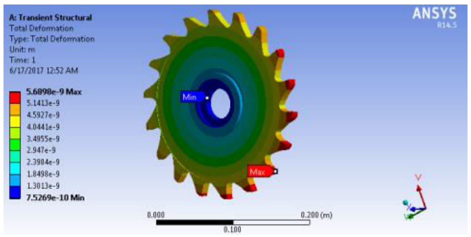
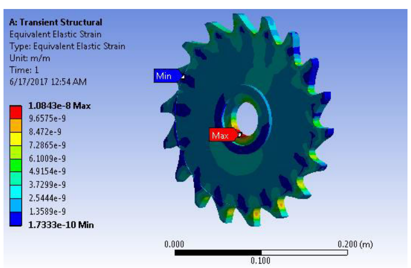
2950 kg m^-3	2.3e+014	0.154	1.1079e+014	9.9653e+013

Total Deformation



Equivalent Elastic Strain

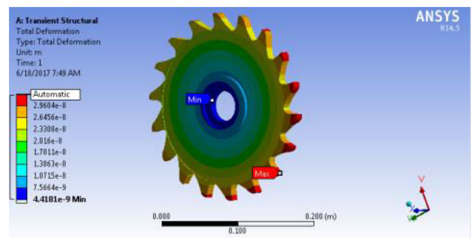


Object Name	*Total Deformation*	*Directional Deformation*	*Total Velocity*	*Equivalent Elastic Strain*	*Maximum Principal Elastic Strain*
Results					
Minimum	7.5269e-010 m	-5.4559e-009 m	1.4929e-009 m/s	1.7333e-010 m/m	-1.5832e-011 m/m
Maximum	5.6898e-009 m	4.7433e-009 m	1.1286e-008 m/s	1.0843e-008 m/m	9.7148e-009 m/m

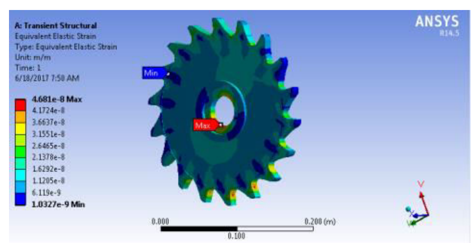
- Boron nitride.

Density	Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa
1922.2 kg m^-3	4.69e+013	0.3	3.9083e+013	1.8038e+013

Total Deformation



Equivalent Elastic Strain



Object Name	*Total Deformation*	*Directional Deformation*	*Total Velocity*	*Equivalent Elastic Strain*	*Maximum Principal Elastic Strain*
Minimum	4.4181e-009 m	-3.1593e-008	8.7631e-009	1.0327e-009	2.4704e-010

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		m	m/s	m/m	m/m
Maximum	3.2753e-008 m	2.776e-008 m	6.4964e-008 m/s	4.681e-008 m/m	4.6038e-008 m/m

CONCLUSION:

The model of the cutter is designed in CATIA and analysis is carried out using ANSYS. The results obtained are tabulated in the result table. The inputs taken for the analysis are diameter of cutter, speed, power and load in which diameter and power are kept constant and the speed and load are varied. The outputs obtained are W1, W2, stress and deformation. 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 1500 rpm and load 1000N at which the stress and deformation are discussed bellow

- Less deformation accrued in Aluminum silicon carbide 5.6898e-009 m comparing to other materials
- Von misess stress more in High speed steel 3.1255e+006 Pa less in Boron nitride 2.1903e+006 Pa. so better stress acted withstand values more in born nitride.
- Observing results comparing with existing HSS material Aluminum silicon, carbide born nitride are gives better performance results so this materials are suitable to milling cutter comparing to existing material.

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