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Design and Performance Analysis of Hobbing Milling Cutter

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Abstract:

Hobbing milling is machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the work piece by a series of cuts made by a cutting tool called a hob. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities. It is the most widely used gear cutting process for creating spur and helical gears and more gears are cut by hobbing than any other process since it is relatively quick and inexpensive. A type of skiving that is analogous to the hobbing of external gears can be applied to the cutting of internal gears cutter. this project aim find out the hobbing milling cutter material behaviour and material structural analysis, total solid body deformation, external loads and impact loads, stress, strain, Mesh on the ansys software. The material are taken Kevlar/ epoxy, aluminium silicon carbide. Design the hobbing milling cutter with the help of catia software.

Keywords:hobbing milling cutter, ANSYS, CATIAV5R20, Model Analysis, structure design.

1. INTRODUCTION

Gear cutting is a machining process for creating a gear. The most common gear-cutting processes include hobbing, broaching, milling, and grinding. Such cutting operations may occur either after or instead of forming processes such forging, extruding, investment casting, or sand casting.

Gears are commonly made from metal, plastic, and wood. Although gear cutting is a substantial industry, many metal and plastic gears are made without cutting, by processes such as die casting or injection molding. Some metal gears made with powder metallurgy require subsequent machining, whereas others are complete after sintering. Likewise, metal or plastic gears made with additive manufacturing may or may not require finishing by cutting, depending on application.

1.2 Hobbing:

Hobbing is a method by which a hob is used to cut teeth into a blank. The cutter and gear blank are rotated at the same time to transfer the profile of the hob onto the gear blank. The hob must make one revolution to create each tooth of the gear. Used very often for all sizes of production runs, but works best for medium to high.

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the workpiece by a series of cuts made by a cutting tool called a **hob**. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities.

It is the most widely used gear cutting process for creating spur and helical gears and more gears are cut by hobbing than any other process as it is relatively quick and inexpensive.

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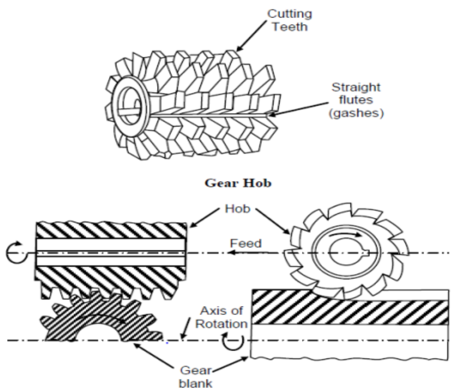

Figure 1.1 Schematic of Gear Hobbing Process

A type of skiving that is analogous to the hobbing of external gears can be applied to the cutting of internal gears, which are skived with a rotary cutter.

The gear hobbing process is widely applied for the construction of any external tooth form developed uniformly about a rotation center. The kinematics principle of the process is based on three relative motions between the workpiece and the hob tool. To produce spur or helical gears, the workpiece rotates about its symmetry axis with certain constant angular velocity, synchronized with the relative gear hob rotation. Depending on the hobbing machine used, the worktable or the hob may travel along the work axis with the selected feed rate.

The diesel internal combustion engine differs from the gasoline powered Otto cycle by using highly compressed, hot air to ignite the fuel rather than using a spark plug (compression ignition rather than spark ignition).

In the true diesel engine, only air is initially introduced into the combustion chamber. The air is then compressed with a compression ratio typically between 15:1 and 22:1 resulting in 40-bar (4.0 MPa; 580 psi) pressure compared to 8 to 14 bars (0.80 to 1.4 MPa) (about 200 psi) in the petrol engine. This high compression heats the air to 550 °C (1,022 °F). At about the top of the compression stroke, fuel is injected directly into the compressed air in the combustion chamber. This may be into a (typically toroidal) void in the top of the piston or a pre-chamber depending upon the design of the engine. Due to the explosion effect in the cylinder causes a raise in pressures inside the cylinder, which exerts a load on the piston, that in turn transfer to the connecting rod, which may cause a reason for failure of connecting rod.

Problem Statement:

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine, the gear hobbing process is widely applied for the construction of any external tooth form developed uniformly about a rotation center. . To produce spur or helical gears, the workpiece rotates about its symmetry axis with certain constant angular velocity, synchronized with the relative gear hob rotation. While constructing of tooth some external factors to be considered for better performance of machine. If we not consider factors like pressure, load, deformation during rotation there is a chance of breaking of hobbing cutter, so we have to take care of these factors while designing hobbing milling cutter.

Objective Work:

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines are progressively cut into the work piece by a series of cuts made by a cutting tool called a hob. Compared to other gear forming processes it is relatively inexpensive but still quite accurate, thus it is used for a broad range of parts and quantities.

It is the most widely used gear cutting process for creating spur and helical gears and more gears are cut by hobbing than any other process since it is relatively quick and inexpensive. A type of skiving that is analogous to the hobbing of external gears can be applied to the cutting of internal gears, which are skived with a rotary cutter (rather than shaped or broached)

Hobbing uses a hobbing machine with two skew spindles, one mounted with a blank work piece and the other with the hob. The angle between the hob's spindle and the work piece's spindle varies, depending on the type of product being produced. Hobbing milling cutter

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is designed by using different materials like forged steel, carbon epoxy, aluminum silicon carbide.

CHAPTER – 2

LITERATURE REVIEW:

The hobbing of gears is the most effective manufacturing process found in the gear industry. New suggestions and methods to improve the precision and efficiency of hobbing have been introduced by researchers.

Cluff [6] (1987) investigated how the generating accuracy of hob cutter was affected by cutter geometric peculiarities and resharpening errors.

Radhakrishnan [7] et al. (1982) proposed a method to obtain the grinding wheel profile of the twist drill flute in resharpening.

Ainoura and Nagano [12] (1987) investigated the conventional hobbing using a hob with its helix running in the direction opposite the gear, and they found it more effective for the high-speed manufacture of comparatively small module gears for automobiles.

In Koelsch's [10] research (1994), hobbing cutters with different coatings are tested in high-speed cutting, and cermet's were found to possess the best performance in high speed dry cutting.

More specifically, Phillips [4] (1994) indicated that hob cutter coated by titanium nitride made productivity realized.

Bouzoukis and Antonidais [9] (1995) proposed a computational procedure, which enables the determination of optimum values for the shift displacement and for the corresponding shift amount. In theory, the hob cutter may be considered to be a worm that is slotted in the axial direction to form a series of cutting blades. In Latvian's publication (1989), the axial section of the worm was considered as the rack. Most of the literature uses rack cutters to simulate the generating process of a hob cutter.

Tsay [2] (1988) investigated helical gears with involute shaped teeth, whose mathematical description was derived by straight-sided rack cutter.

Chang et al. [8] (1997a) proposed a general mathematical model of gear generated by CNC hobbing machine. Recent research, relevant to the hobbing process, includes the paper of Chang et al. (1996), in which the manufacture of elliptical gears was studied. Chang (1996) simulated the hobbing process through a computer numerically controlled (CNC) hobbing machine. Chang et al. (1997b) achieved design optimization by tuning parameters of modified helical gear train

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

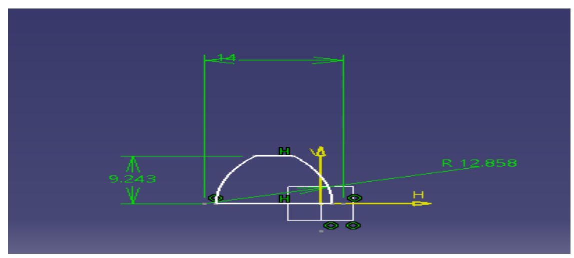

Fig3.1: model sketching

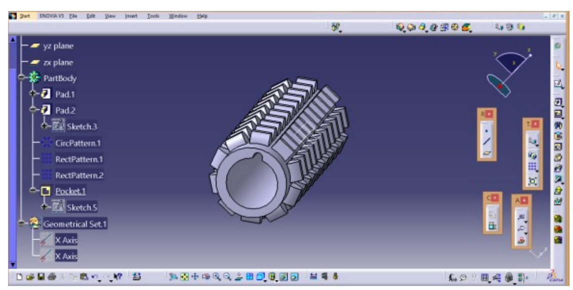

Fig3.2: 3d model

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

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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).

Mash:

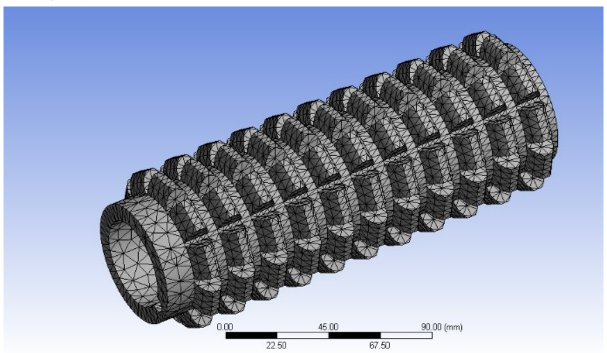


Fig 4.1: meshing

Static Structural

1. Analyze a simpler model first. A model of beams, masses, and springs can provide good insight into the problem at minimal cost. This simpler model may be all you need to determine the dynamic response of the structure.

2. If you are including nonlinearities, try to understand how they affect the structure's response by doing a static analysis first. In some cases, nonlinearities need not be included in the dynamic analysis.

3. Understand the dynamics of the problem. By doing a modal analysis, which calculates the natural frequencies and mode shapes, you can learn how the structure responds when those modes are excited. The natural frequencies are also useful for calculating the correct integration time step.

4. For a nonlinear problem, consider sub structuring the linear portions of the model to reduce analysis costs.

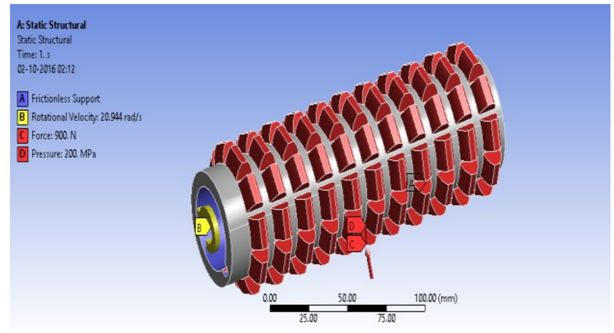
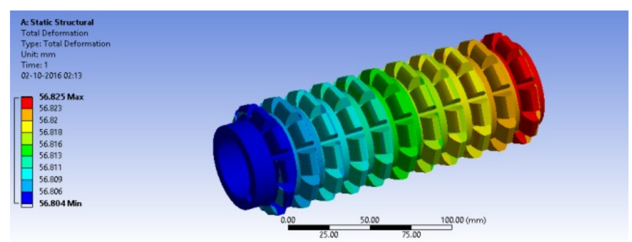


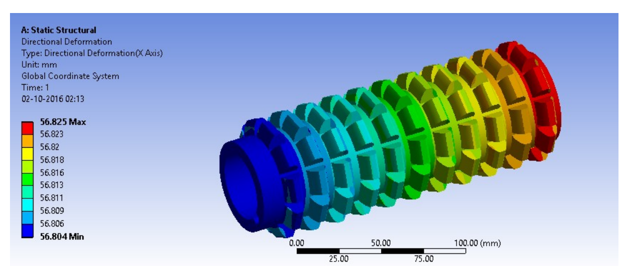
Fig 4.2: applying loads

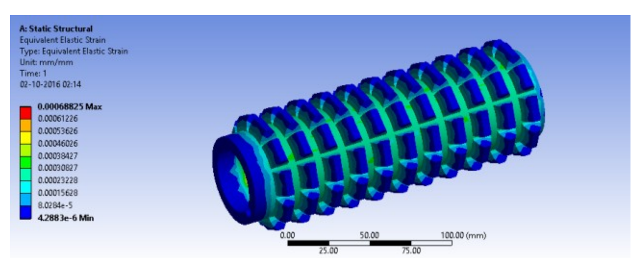
Carbon epoxy:

Density	1.8e-006 kg mm^-3			
Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	4.5e+005	0.3	3.75e+005	1.7308e+005

Analytical Result:







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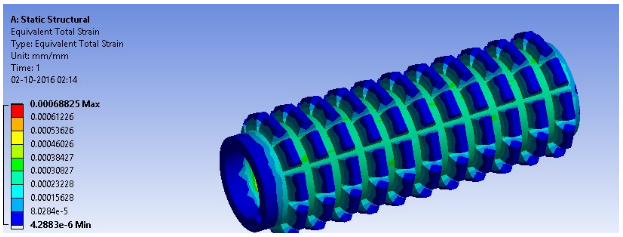
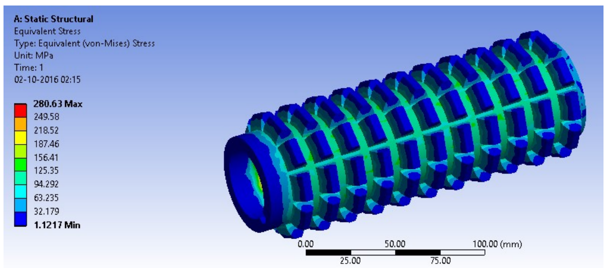
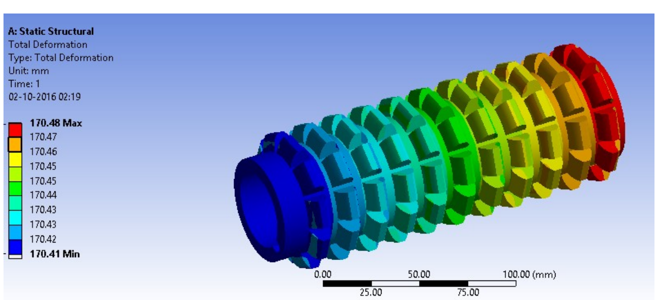


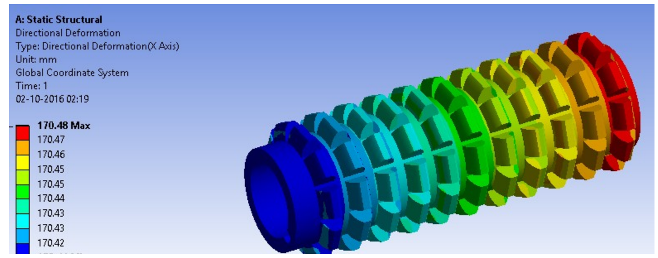


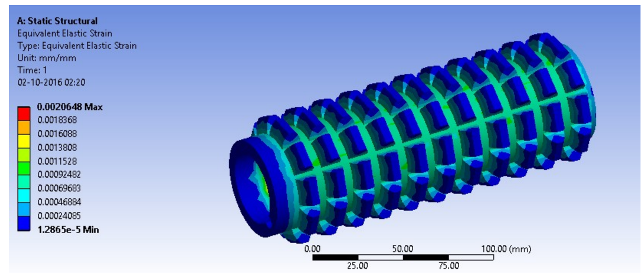
Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Equivalent Total Strain*	*Equivalent Stress*
Minimum	56.804 mm		4.2883e-006 mm/mm		1.1217 MPa
Maximum	56.825 mm		6.8825e-004 mm/mm		280.63 MPa

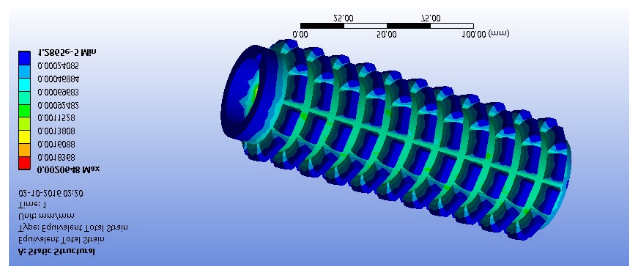
Aluminium silicon carbide:

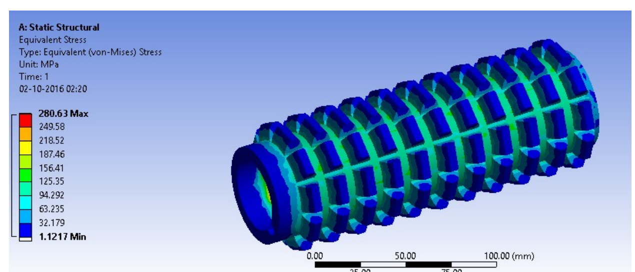
Density	2.81e-006 kg mm^-3			
Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	1.5e+005	0.3	1.25e+005	57692











Object Name	*Total Deformation*	*Directional Deformation*	*Equivalent Elastic Strain*	*Equivalent Total Strain*	*Equivalent Stress*
Minimum	170.41 mm		1.2865e-005 mm/mm		1.1217 MPa
Maximum	170.48 mm		2.0648e-003 mm/mm		280.63 MPa

Forged steel:

Density	7.38e-006 kg

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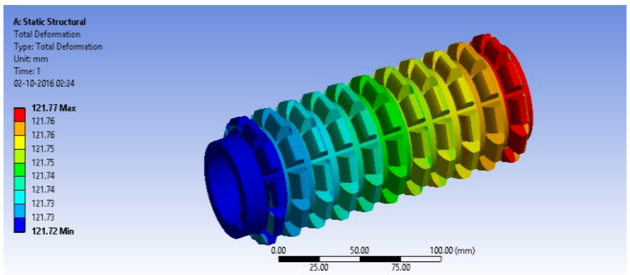
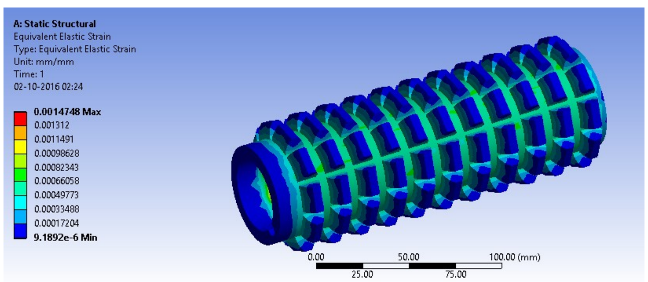
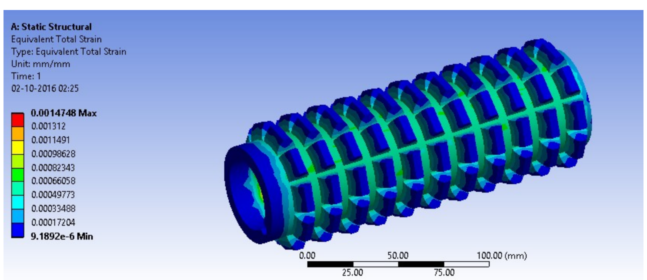
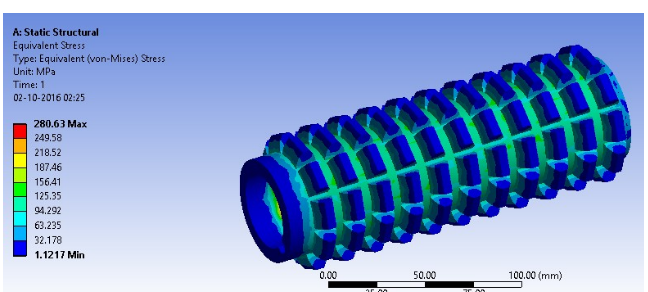
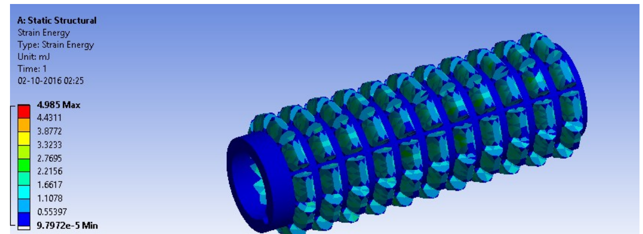
	mm^-3			
Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	2.1e+005	0.3	1.75e+005	80769











Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Total Strain*	*Equivalent Stress*	*Strain Energy*
Minimum	121.72 mm	9.1892e-006 mm/mm		1.1217 MPa	9.7972e-005 mJ
Maximum	121.77 mm	1.4748e-003 mm/mm		280.63 MPa	4.985 mJ

Conclusions :

1. Compressive, Vonmissesstresses were obtained by Ansys software for carbon epoxy, aluminium silicon carbide, forged steel.

2. From the results, it is observed that the deformation and compressive stresses of carbon epoxy are less than that of the other material.

3. Carbon epoxy reduces the weight up to50% compares to the other materials

4 carbon epoxy is having unique property (i.e. corrosive resistance), good surface finishing, hence it permits excellent silent operation.

6. Hence carbon epoxy is best suited for hobbing milling cutter in the high-speed cutting applications.

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