INTERNATIONAL RESEARCH JOURNAL OF AUTOMOTIVE TECHNOLOGY (IRJAT)

http://www.mapletreejournals.com/index.php/IRJAT
Received 22 June 2018 ISSN 2581-5865
Accepted 29 July 2018 2018; 1(4);27-33
Published online 30 July 2018

Design Analysis and Fabrication of Metal Matrix Composite Helical Gear

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ABSTRACT

Helical gears are widely used in industry where the power transmission is required at heavy loads with smoother and noiseless operation. Helical gear are generally used to transmit power or torque for transmission at very high speed when compared to other kind of gear transmissions .In our paper we are going to design , analyse and fabricate helical gear . This helical will be made up of composite material. We are going to use a metal matrix composite consisting of Aluminium and Nickel boride. This metal matrix composite will provide the better performance and will increase the life time of the gear compared to the traditional helical gears. Design of gear will be done with Creo, analysis will be done using ANSYS and fabrication will be based on stir casting.

Keywords: ***Helical gear, design, casting, metal matrix composite***

1. INTRODUCTION

A gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. The gears in a transmission are analogous to the wheels in a crossed, belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage.

In present times, helical gears are being utilized as a power transmitting gears because of their moderately smooth and quiet Operation, huge load conveying limit and higher working velocity and smoother engagement of teeth; power can be exchanged between two non-parallel shafts, they are highly effective and so on. Their tooth twisting anxiety and surface contact push had dependably been one of the explorations engaged, and numerous researchers have done a considerable measure of work on it .The tooth bending stress and surface contact stress of these gears had always been one of the major areas of research for scholars. The designing of a helical gear pair is a complex process. Generally, it needs a large number of iterations and datasets. Helical gear can fail due to excessive bending stress at root of gear tooth or surface contact stress. This can be changed by minimizing bending stress and contact stress or by modifying the geometry or parameters of the gear tooth.

Composite material (also called a composition material or shortened to composite) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as Robotic Materials. In the present work an attempt has been made to replace the conventional steel alloy gear material with composite material having an application in high power transmission system like a gearbox used in automobile industries. For this purpose 3-D model of the helical gear pair having the pinion as the driver and the gear as the driven for a particular transmission ratio. was made in the ansys based analysis software was used as the analysis tool to carry out the static structural analysis in order to determine the behavior of the conventional steel alloy gear material and the proposed replacements of three different composite material under the different loading condition and also the model analysis were carried out in order to determine the natural frequency of gear system at different modes under the free vibration condition in order to avoid the situation of resonance. The simulation result determines the total deformation, Equivalent Von misses stress, Maximum shear stress, and natural frequencies at different modes under actual boundary conditions.

2. METAL MATRIX COMPOSITE

An aluminum based composite generally comprises two components namely an aluminum alloy matrix and a hard reinforcing second phase. The composite typically exhibits at least one characteristic reflective of each component. An aluminum based metal matrix composite should have the high ductility and fracture toughness of the aluminum matrix and the high elastic modulus of the reinforcing phase.

Aluminum based metal matrix composites containing particulate reinforcements are usually limited to ambient temperature applications because of the large mismatch in higher temperature strength between the aluminum Another problem with aluminum based metal matrix composites is the difficulty of producing a bond between the matrix and the reinforcing phase. To produce such a bond, it is often times necessary to vacuum hot press the material at temperatures higher than the incipient melting temperature of the matrix. It has been proposed that this technique be avoided by mechanically alloying the matrix with the addition of the particular reinforcement. This procedure, referred to as solid state bonding, permits the reinforcing phase to be bonded to the matrix without heating the material to a temperature above the solidus of the matrix. Prior processes in which aluminum based alloys and/or metal matrix composites are mechanically alloyed by means of solid state bonding. The low density and high specific mechanical properties of aluminum metal matrix composites (MMC) make these alloys one of the most interesting material alternatives for the manufacture of lightweight parts for many types of vehicles. With wear resistance and strength equal to cast iron, 67% lower density and three times the thermal conductivity, aluminum MMC alloys are ideal materials for the manufacture of lightweight automotive and other commercial parts.

3. DESIGN

The procedure to model the gear of 20 number of teeth with the combination of the all above mentioned parameters in the Creo, other set of gears are modeled in the similar way. Part parameters are the basic parameters defining the gear. These part parameters determine all the other parameters that define the gear tooth profile using the Tools/Relation menu.

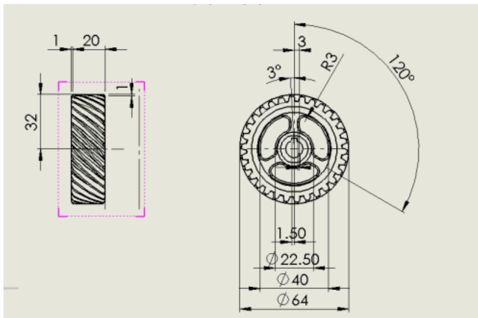


Fig.1

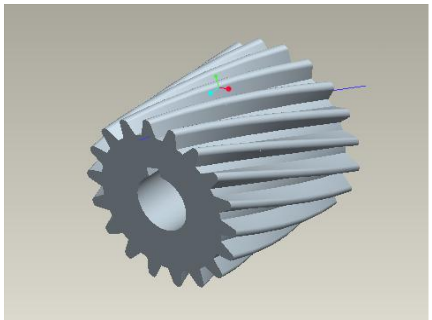


Fig.2

3.1 General Parameters

Helix angle (β) = 8 to 25 degree

Normal module = 2a cos β/(Z1 + Z2)

Center distance(a)= Z1 + Z2 / (2 cosβ)

Transverse module t = 2a /(Z1 + Z2)

Bottom clearance =0.25 mm

Tooth depth (h)= 2.25 mm

Pitch circle diameter

d1 = Z1 /cosβ,

d2 = Z1 /cosβ,

Number of teeth

Z1 = 2a cosβ / (i+1),

Z2= i Z1 (i=Z2 /Z1)

Width b = 22

Pressure angle (Φ)= 20deg

Power P = 0.25Kw to 2.2 Kw

Helix angle = arctan 2 πrm /L

Where

l is lead of the screw or gear

rm is mean radius of the screw thread or gear.

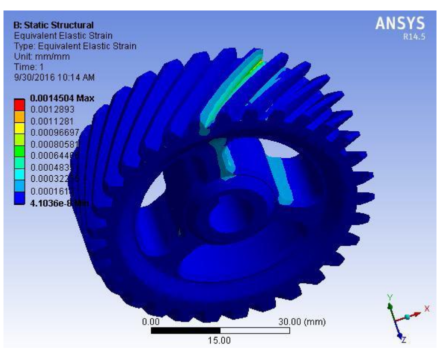
4. ANALYSIS

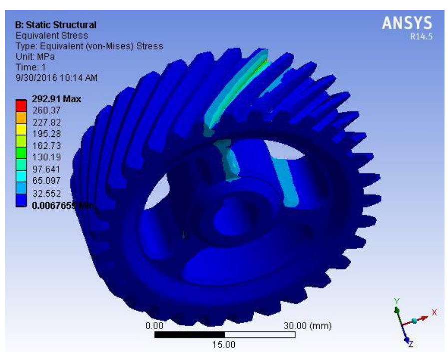
ANSYS is engineering simulation software which offers an entire range of multi-physics numerical solvers,providing access to virtually any field of engineering simulation that a design process may require. There is different type of analysis system in the ANSYS WORKBENCH like Fluid flow, linear buckling, rigid dynamics, explicit dynamic, static structural, thermal-electric and etc. for the static structural analysis uses FEA tool for product design validation. Computational analysis methodology that helps to determine the strength of a product (one part or both in pair) in response to loading that would typically be experienced in its operating environment. ANSYS static structural provide the ability to simulate every structural aspect of the product like linear static analysis that simply provides stresses or deformations.

A static structural analysis were done to analyze the behavior of the structure under the steady loading conditions while ignoring inertia and damping effects, such as those carried by time varying loads. All types of non-linearity are allowed such as large deformations, plasticity, creep, stress stiffening, contact elements etc. this result will determined whether the structure will withstand for the applied external loads.. If the stress values obtained in this analysis crosses the allowable values it will result in the failure of the structure in the static condition itself. To avoid such a failure, this analysis is necessary. In this project the FEA based analysis tool were used to study the structural behavior of the different composite material under the given boundary conditions by determining the total deformation.

Contact stress evaluation in gears has been a complex area of research, due to its non-linear and non-uniform nature of stress distribution. The high contact stress on gears results in pitting and scuffing, which leads to tooth failure. Furthermore the effects of friction on gear contacts make the problem more complicated.

The calculation of the tooth stresses in a helical gear is considerably more complicated than the corresponding calculation for a spur gear. The contact stress and the fillet stress in each tooth depend on the intensity of the load, and on its position. Since the load intensity varies, as the position of the contact line moves up or down the tooth face, it is not easy to decide when the maximum stresses will occur.





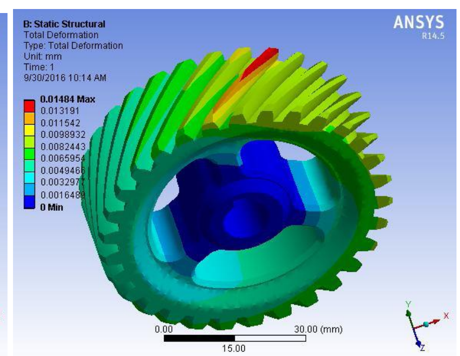


Fig.3 ***Von Misses Strain*** **Fig.4** ***Von Misses Stress*** **Fig.5** ***Deformation***

5. FABRICATION

5.1 Stir Casting

Stir casting is an economical process for the fabrication of aluminum matrix composites. There are many parameters in this process, which affect the final microstructure and mechanical properties of the composites. The higher stirring temperature (850 °C) also leads to improved ceramic incorporation. Among the variety of manufacturing processes available for discontinuous metal matrix composites, stir casting is generally accepted as a particularly promising route, currently practiced commercially. Its advantages lie in its simplicity, flexibility and applicability to large quantity production with cost advantage. The major problem of this process is to obtain sufficient wetting of particle by liquid metal and to get a homogenous dispersion of the particulates.

5.2 Reinforcement

The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system. All of the different fibres used in composites have different properties and so affect the properties of the composite in different ways. The properties and characteristics of common fibres are explained below. However, individual fibres or fibre bundles can only be used on their own in a few processes such as filament winding (described later). For most other applications, the fibres need to be arranged into some form of sheet, known as a fabric, to make handling possible. Different ways for assembling fibres into sheets and the variety of fibre orientations possible lead to there being many different types of fabrics, each of which has its own characteristics.

6. BENEFITS

- Light Weight: Composites are light in weight, compared to most metals. Their lightness is important in aircraft, where less weight means better fuel efficiency
- Strength Related to Weight: Strength-to-weight ratio is a material’s strength in relation to how much it weighs. Some materials are very strong and heavy, such as steel. Composite materials can be designed to be both strong and light. This property is why composites are used to build airplanes which need a very high strength material at the lowest possible weight.
- Corrosion Resistance: Composites resist damage from the weather and from harsh chemicals that can eat away at other materials. Outdoors, they stand up to severe weather and wide changes in temperature.
- Design Flexibility: Composites can be molded into complicated shapes more easily than most other materials. This gives designers the freedom to create almost any shape or form.
- Part Consolidation: A single piece made of composite materials can replace an entire assembly of metal parts. Reducing the number of parts in a machine or a structure saves time and cuts down on the maintenance needed over the life of the item.
- Dimensional Stability: Composites retain their shape and size when they are hot or cool, wet or dry. They are used in aircraft wings, for example, so that the wing shape and size do not change as the plane gains or loses altitude.

7. APPLICATIONS

- Fertilizer industries, printing industries, and earth-moving industries
- Steel, rolling mills, power and port industries
- Textile industries, plastic industries, food industries, conveyors, elevators, blowers, compressors, oil industries & cutters.

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