Research Paper

DESIGN, MODELING, ANALYSIS AND MANUFACTURING OF HELICAL GEAR

Yaram Venkateswarareddy[1], V.Gopinath[2]

Address for Correspondence

[1] M.Tech student , [2] Associate Professor, Department of Mechanical Engineering, QIS College Of Engineering &Technology Ongole, Andhra Pradesh

ABSTRACT

The aim of the paper is to design a helical gear for marine applications by using empirical formulas. A 2D drawing is drafted from the calculations and a 3D model is designed using 3D modeling software Pro/Engineer. Structural analysis and thermal analysis are do using two materials Nickel Chromium Alloy steel and Aluminum Alloy A360. Structural analysis is done to validate the strength and thermal analysis is done to validate the thermal properties like nodal temperature, thermal gradient and thermal flux. In next stage of the paper is manufacturing the helical gear. For manufacturing helical gear following methods are used - 1.Casting 2.Hot-rolling 3.Powder metallurgy 4.Machining

From above methods we are using Machining method. In the machining method we are using reciprocating method. In this, first step is blank preparation; second step is gear cutting by using gear cutting machines. In third step is gear hobbling. After doing machining processes we have to do heat treatment processes. The helical gear is manufactured and a prototype is created. In prototype we are going to manufacture the scale model.

KEYWORDS: Design; Modeling; Analysis; Manufacturing; Helical Gear.

1.0 INTRODUCTION

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

When two gears of unequal number of teeth are combined, a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship.

In transmissions which offer multiple gear ratios, such as bicycles and cars, the term gear, as in first gear, refers to a gear ratio rather than an actual physical gear. The term is used to describe similar devices even when the gear ratio is continuous rather than discrete, or when the device does not actually contain any gears, as in a continuously variable transmission.

The earliest known reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian school in the 3rd century B.C. and were greatly developed by the Greek polymath Archimedes (287–212 B.C.). The Antikythera mechanism is an example of a very early and intricate geared device, designed to calculate astronomical positions. Its time of construction is now estimated between 150 and 100 BC.

1.1 Comparison with drive mechanisms

The definite velocity ratio which results from having teeth gives gears an advantage over other drives (such as traction drives and V-belts) in precision machines such as watches that depend upon an exact velocity ratio. In cases where driver and follower are in close proximity, gears also have an advantage over other drives in the reduced number of parts required; the downside is that gears are more expensive to manufacture and their lubrication requirements may impose a higher operating cost.

2.0 MODEL OF HELICAL GEAR

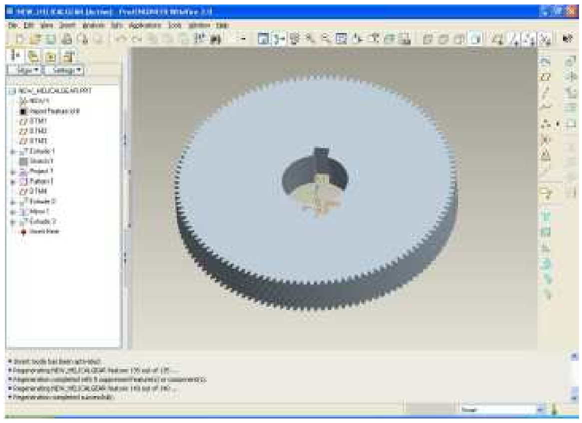

Figure.1: Model of Helical Gear

3.0 STRUCTURAL ANALYSIS OF HELICAL GEAR USING NICKEL CHROMIUM MOLYBDNUM ALLOY STEEL

Material Properties -

Young's modules – 210000MPa

Poisson ratio - 0.3

Density – 0.000008kg/mm^3

Pressure –18.210N/mm^2

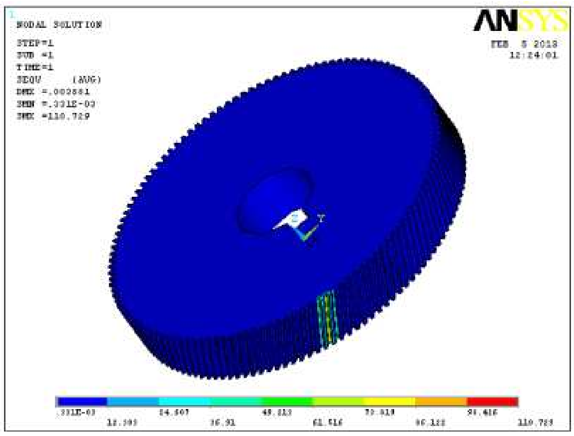

Figure.2: Stress – Von Mises Stress

3.1 STRUCTURAL ANALYSIS OF HELICAL GEAR USING ALUMINUM ALLOY A360

Material Properties -

Young's modules – 70000MPa

Poisson ratio - 0.33
Density – 0.0000026kg/mm^3
Pressure –18.210N/mm^2

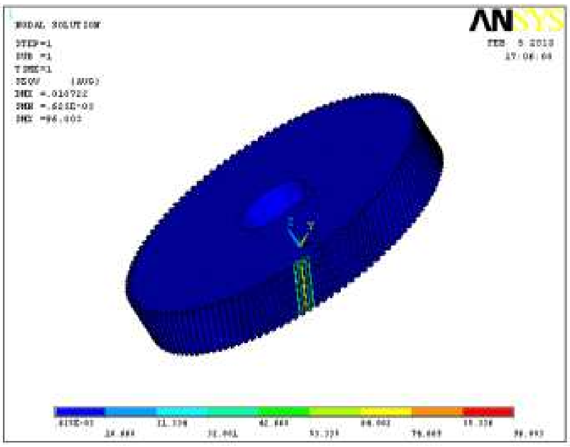

Figure.3: Stress – Von Mises Stress

4.0 Thermal Analysis of Helical Gear using Nickel Chromium Molybdenum Alloy Steel

Material Properties: Thermal Conductivity – 0.42w/mmk
Specific Heat – 477j/kg k
Density – 0.000008kg/mm^3
Temperature – 373k

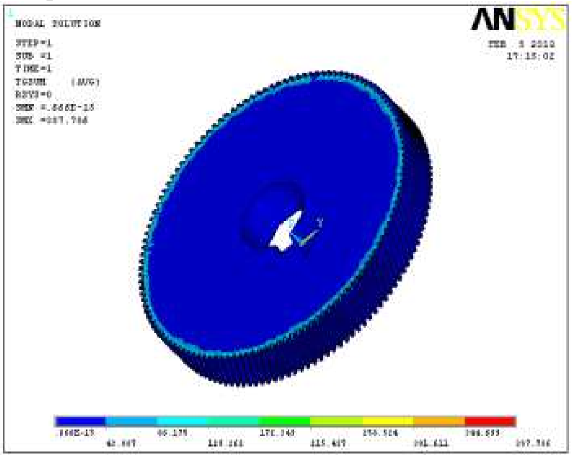

Figure.4: Thermal Gradient

4.1 Thermal Analysis of Helical Gear using Aluminum Alloy A360

Material Properties: Thermal Conductivity – 0.174w/mmk
Specific Heat – 963j/kg k
Density – 0.0000026kg/mm^3

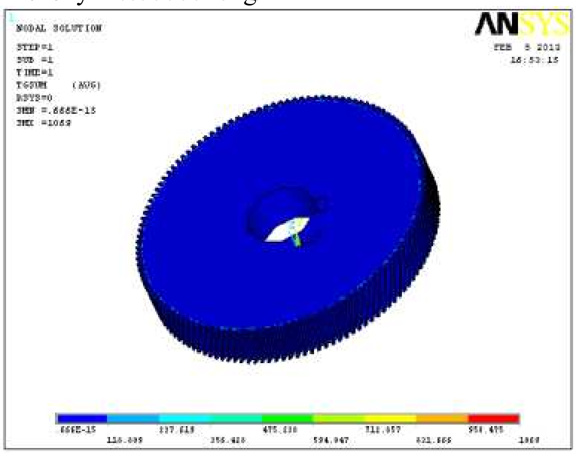

Figure.5: Thermal Gradient

5.0 RESULTS

As per the analysis images

	Displacement (mm)	Von Mises Stress (N/mm^2)	Nodal Temperature (K)	Thermal Gradient (K/mm)	Thermal Flux (W/mm^2)
NickelChromium Molybdnum Alloy Steel	0.003881	110.729	373	387.786	162.87
Aluminum Alloy A360	0.010722	96.003	373	1069	186.056

- The yield stress for Nickel Chromium Alloy Molybdenum Steel 360Mpa.
- The yield stress for Aluminum Alloy A360 is 165Mpa.

6.0 MANUFACTURING PROCESS OF HELICAL GEAR

Steps for the Manufacturing Process

1. Preparing production drawing from design calculations.

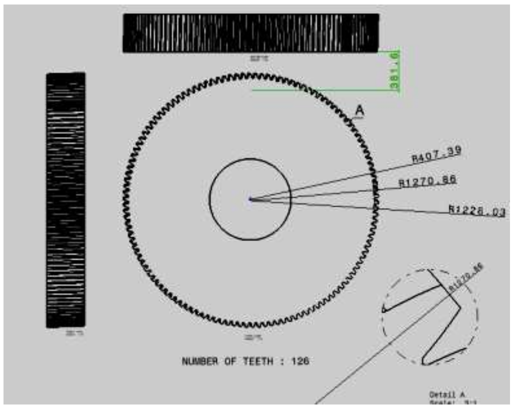

Figure.6: Manufacturing Process Of Helical Gear

2. Purchasing of material
3. We prepared the gear blank

6.1 Cutting a Helical Gear with a helical cutter

Clamping Devices:

- Work spindle is fixed in vertical
- Gear blank is fixed with fixtures
- After fixing the work piece. The Gear blank is fixed constant and vertical spindle is moved.

The gear blank is mounted on the vertical work spindle which in its lower and within the casing has an indexing worm gear operated by the change gears. These gears are driven from the cone pulley by means of a vertical shaft.

Rotation is gradual but continuous the vertically reciprocating cutter forms the teeth on the blank. The reciprocating moment of the ram casing the cutter is produced by mechanism with is the casing the machine is automatic inaction and cuts internal gear through somewhat modified may be adapted for cutting the teeth in racks. The cutting action being one of planning. The gear stopper cutting a helical gear with helical cutter.

6.2 Gear Hobbling Machine

The hobbling method is employed for cutting gears in large quantities the cutting tool is the hob a special form of milling cutter designed to cut gear teeth. On a continuous basis in appearance a hob resembles a screw thread that has been grooved axially to produce a large no. of cutting teeth. Each tooth is backed off as are the teeth of a form milling cutter to give needed clearance back of the cutting edge. If the hob is cut lengthwise through its center the teeth will be found to have straight sides (identical to a gear rack) which mate with the gear being cut.

The operation of gear hobbling machine consists of importing rotated motion to both the gear blanks and the hob. In addition feeding the hob in a direction parallel to the work axis which may be horizontal or vertical cutting gears. In this manner continuous in one direction until the blank is completely cut. In hobbling operation the gear and hob rotate together as though they are in a mesh. The gear blank rotating slowly and the hob rapidly their speed ratio depending upon the no. of teeth of the gear and on whether the hob is single or multiple threaded. All motions in hobbling are rotatory and contrary to the gear cutting methods. The advantages of the hobbling process as contrasted with ordinary milling of shapes or that the hob and work do not need to be located in any given relationships except for the helix angle. Furthermore several positions of the hob can be dulled before reshaping becomes necessary a very important advantage is that production capacities in a given time can be greatly increased where given time can be greatly increased where accuracy of shape of finished part is of prime importance it is advisable used to a roughing hob for removing the bulk of the material and the finishing hob for cutting the exact shape. This will extend the life of the finishing hob and produce better work multiple threaded hobs are recommended for roughing operations in order that a higher may feed for revolution of the hob may be achieved thus increasing production hobs are manufactured with and without a finish grind. In accuracy which are common to Hob's casing to a fault of manufacture to which the hobs are subjected or removed by grinding. Ground hobs are higher in cost but the expense is warranted when precision is demanded. Hobbling operations may be carried out conveniently on a milling machine.

6.3 Milling machine for helical gear cutting

The indexing or dividing head is very useful and versatile device which may be used in numerous milling operations, which require an accurate means of indexing to complete a certain task such as milling gears. The dividing or indexing head and tail stock are standard equipment of the universal milling machine under almost indispensable ,much of the work done on the milling machine involves indexing, this work is done with the indexing head which serves to support the work between centers where the machine is shown set up for milling the teeth of helical gear. The dividing head incorporates an indexing arrangement as well as gearing which is connected to the driving mechanism to import a rotary motion to the work as required when cutting helically. The dividing head is mounted on milling machine table at the operator's right as he faces the machine. The work may be indexed to any required portion of a revolution, thus providing means of spacing, notches and grooves on its periphery which may be straight or at an angle. The straight notches and grooves are parallel with the axis of the work those at an angle of helically.

7.0 CONCLUSION

- In our project, we have designed a helical gear used in marine applications using theoretical calculations and modeling of helical gear is done in Pro/Engineer.
- We have performed Structural analysis and thermal analysis on helical gear using Nickel Chromium Molybdenum alloy steel and Aluminum alloy A360.
- By observing the analysis results, the stress values obtained are less than their respective yield stresses for both materials. So we can decide that our design is safe under working conditions.
- By comparing the analysis for both the materials, the stress value is less for Aluminum alloy A360 than Nickel Chromium Molybdenum Alloy Steel and thermal conductivity is more for Aluminum alloy A360 than Nickel Chromium Molybdenum Alloy Steel.
- So we can say that using Aluminum alloy A360 for helical gear is more advantageous than using Nickel Chromium Molybdenum Alloy Steel as per our analysis.
- We also studied the manufacturing process of helical gear and prepared a prototype.

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Helical Gear Design. Khaled Barghouthi. February 27th, 2013. This is an assembly of two helical gears, drawn to the full details. Full dimension and 99% accurate way to draw the helical gear, i used swept boss and a helix path to draw the tooth. No interference was detected. P.s : i included an excel file containing all the calculations (SI units).