VARIATION OF BEAM STRENGTH OF STEEL GEAR FOR MARINE APPLICATIONS

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ABSTRACT

Gears are one of the most critical components in mechanical power transmission system and they are advantage over friction and belt drives. They are positive drives, a feature which most of the machine tools require, since exact speed ratios are essential. Gear design has evolved to a high degree of perfection, the constant pressure to build less expensive, quieter running, lighter weight, reliable, less cost and more powerful machinery has lead to steady change in gear design. The work is to focus on investigating the effects of gear ratio, face width, normal module, speed, pressure angle on beam strength of tooth of steel helical gear for marine applications.

Keywords: *Optimization, Helical Gear Design, Modeling, Beam Strength.*

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1.0 INTRODUCTION:

The motion may be transmitted from one shaft to another shaft with belts, ropes and chains. These drives are mostly used when the two shafts are having long center distance. But if the distance between the two shafts is very small, then gears are used to transmit motion from one shaft to another. In case of belts and ropes, the drive is not positive. There is slip and creep that reduces velocity ratio. But gear drive is a positive and smooth drive, which transmit velocity ratio. Gears are used in many fields and under a wide range of conditions such as in smaller watches and instruments to the heaviest and most powerful machineries like lifting cranes. Gears are most commonly used for power transmission in all the modern devices. They have been used extensively in the high-speed marine engines.

In the present era of sophisticated technology, gear design has evolved to a high degree of perfection. The design and manufacture of precision cut gears, made from materials of high strength, have made it possible to produce gears which are capable of transmitting extremely large loads at extremely high circumferential speeds with very little noise, vibration and other undesirable aspects of gear drives.

Helical gears are the modified form of spur gears, in which all the teeth are cut at a constant angle, known as helix angle, to the axis of the gear, where as in spur gear, teeth are cut parallel to the axis. The following are the requirements that must be met in the design of gear drive, the gear teeth should have sufficient strength, so that they will not fail under static and dynamic loading during normal running conditions. The gear teeth should have clear characteristics so that their life is satisfactory, the use of space and material should be economical. The alignment of the gears and deflections of the shafts must be considered, because they affect the Performance of the gears. The lubrications of the gears must be satisfactory.

Popular standards are ISO and AGMA. These standards vary in selected approaches as well as models and methods resulting in different design solutions obtained for the same gear under the same set of working conditions. Gear transmissions are widely used in various industries and their efficiency and reliability are critical in the final product performance evaluation. Gear transmissions affect energy consumption during usage, vibration, noise and warranty costs among other factors. These factors are critical in modern competitive, manufacturing, especially in the aviation industry which demands exceptional operations requirements concerning high reliability and strength, low weight and energy consumption, low vibrations and noise. Considering their reliability and efficiency as some of the most important factors, problems of distributions of loads and stresses in the whole gear transmission, particularly in teeth of mating gears, need to be thoroughly analyzed.

DESIGN METHODOLOGY:

The helical gear is design based on AGMA Procedure:

According to Lewis equation Beam Strength of helical gear tooth

$F_b = [\sigma_b] \cdot b \cdot \pi m_n \cdot y_v$

Number of teeth $Z_v = (Z/\cos^3 \boldsymbol{\beta})$

Design tooth load $F_D = F_t.K_s.C_v = (F_t.K_s.C_v/v)$

Dynamic load acting on gear according to Buckingham equation $F_d = F_t + \frac{21v(Cb\cos^2\beta + F_t)\cos\beta}{21v + \sqrt{Cb\cos^2\beta + F_t}}$

Wear Strength of tooth load $F_w = \frac{d_1 \cdot b \cdot Q \cdot K_w}{Cos^2 \beta}$

RESULTS & DISCUSSION

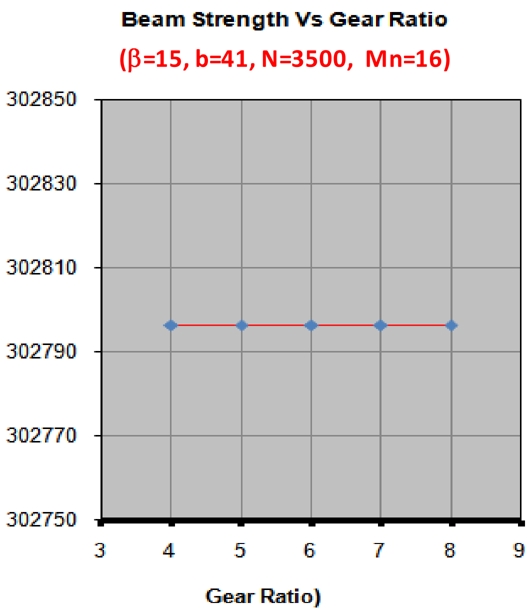
To obtain optimum values of beam strength to achieve low cost of manufacturing for steel gear have been carried out.

Beam Strength- The effect of gear ratio, face width, helix angle and normal module

The effect of beam strength for different input variables are shown in figs. 1(a) – (d). The fig 1(a) shows the relationship between Beam Strength and gear ratio. The helix angle, face width, speed and normal module except gear ratio are kept constant. When gear ratio is increased from 4 to 8, the corresponding Beam Strength remained constant. The fig 1(b) shows the relationship between Beam Strength and Face width. The Helix angles, gear ratio, Speed, normal module except face width are kept constant. When face width is increased from 41 to 49, the corresponding Beam Strength increased from 3320kgf to 3960kgf. The fig 1(c) shows the relationship between Beam Strength and Helix angle. The face width, gear ratio, speed and normal module except Helix angle are kept constant. When helix angle is increased from 15^o to 35^o, the corresponding Beam Strength remained constant. The fig 1(d) shows the relationship between Beam Strength and Normal module. The face width, gear ratio, speed and Helix angle except Normal module are kept constant. When Normal module is increased from 16mm to 24mm, the corresponding Beam Strength found to increase from 3300kgf to 4890kgf.

Variation of Beam Strength for different Input variables

1 Unit = 1 Kgf



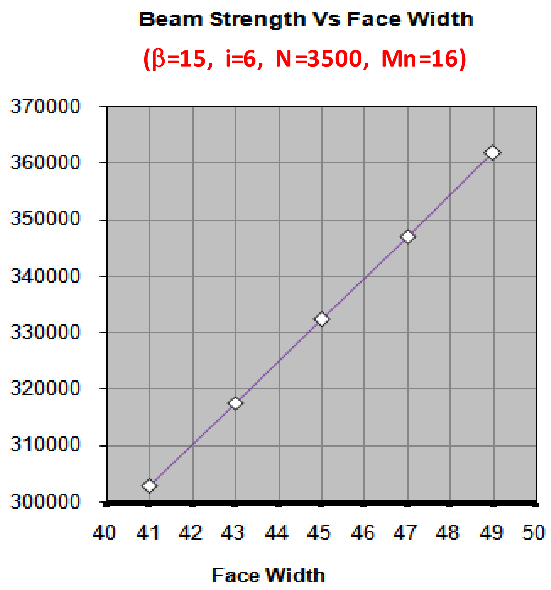
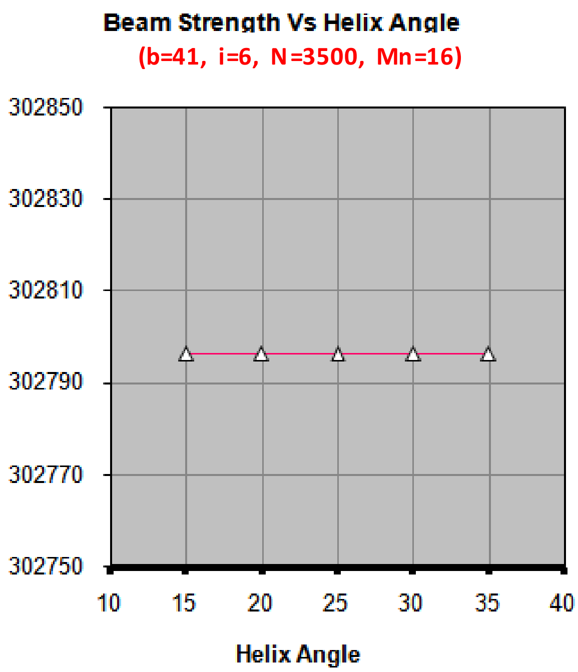


Fig.1(a)	Fig.1(b)



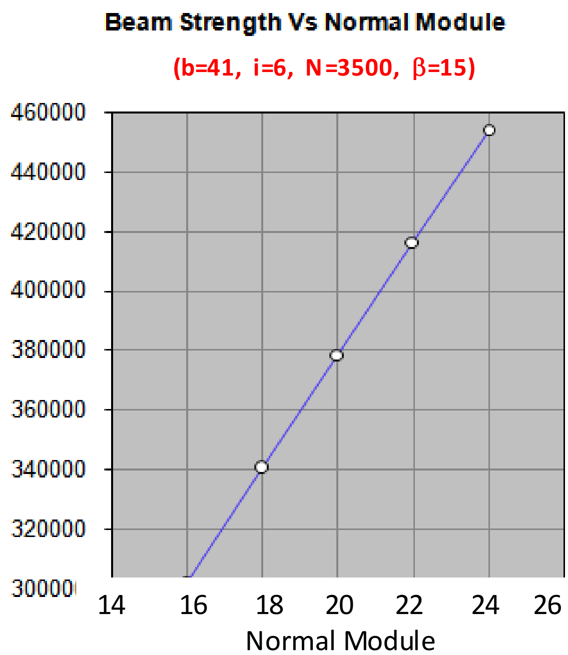


Fig.1(c)	Fig.1(d)

OPTIMUM PARAMETERS FOR MAXIMUM BEAM STRENGTH:

The effect of gear ratio, face width, helix angle, normal module on optimum beam strength is carried out. If the helix angle, face width, speed and normal module except gear ratio are kept constant and gear ratio is increased, the corresponding beam strength remained constant. The helix angles, gear ratio, speed, normal module except face width are kept constant and when face width is increased, the corresponding beam strength increases. The face width 49cm, corresponding to maximum beam strength is taken as constant. The face width, gear ratio, speed and normal module except helix angle are kept constant and helix angle is increased, the corresponding beam strength remained constant. The face width, gear ratio, speed and helix angle except normal module are kept constant and normal module is increased, the corresponding beam strength found to increase. The normal module 24mm, corresponding to maximum beam strength is taken as constant.

CONCLUSIONS

The study helps to identify the effect of beam strength on the optimum design of helical gears for marine applications. The analysis yielded a beam strength of 361879 kgf for gear ratio of 6, face width of 49, helix angle 15^0, speed of 3500 rpm and normal module 16. The helical gear parameters that constitute the design are found to be safe from strength and rigidity point of view. Hence 40 Ni2 Cr1 Mo28 alloy steel is best suited for marine gear in the high speed applications.

NOMENCLATURE:

σb = Design Bending stress in Kgf/cm^2

E= Young’s modulus in Kgf/cm^2

[Mt] = design torque in Kg-cm

β = Helix angle in degrees

Fd = Dynamic tooth load in Kgf

F_b = Beam strength of the gear tooth Kgf

FD = Design tooth load kgf

m_n = Normal Module mm

Yv = Lewis Form factor

b =Face width in mm

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