Review of investigating on design and thermal analysis of sugar mill planetary gearbox

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Abstract

In today's scenario objective of manufacturing industries to manufacture good machine, which give more efficiency and help in increase in industry's profit. lets us focus on planetary gearbox, as we all know epicycles gearbox machine in manufacturing industry. Planetary gearbox has no. of gear- pinion pair and size is large. That's why the selection of correct lubricant quantity is important. In gearbox suitable level of lubrication in the gearbox defined specification of capacity, speed range and workspace requirement. Now more amount of lubricant in gearbox which induced more churning and windage power loss which affect the efficiency and temperature of lubricant.so we try to more heat dissipate from gearbox casing and find minimum require quantity of lubricant.

Keywords*—planetary gearbox, power loss, lubricant quantity..*

I. INTRODUCTION

Planetary gearbox is a machine used to achieve high torque density, and high reduction ratio achieve. It is generally used in mid-level precision industry, such as printing lathe, automation assembly, sugar mill and wind turbine systems. Now a days in sugar mill roller drives with uses of planetary gearbox which has 3-stage contain to achieve higher speed reduction and greater torque availability. Now the our gear box model name is SA400/PCF210.The full name of gearbox is single stage helical gearbox with three stage of planetary gear with foot mounted. The most common planetary gearbox for sugar mill is three planetary stages with a helical stage at the end of the drive train This type of gear box contain 4 planetary gear, number of planetary gear will increase the torque density on gear train will increase.

Motive of this paper to review for importance of **quantity of lubricant require** for planetary gearbox to achieve minimum power loss or reduced temperature of oil due to churning and windage power loss. Windage and churning power loss is plays important role in efficiency, and oil temperature. Generally, planetary gearbox used many industries but for our calculation, experiment and analysis convenient we have selected suitable level of lubricant to reduced oil temperature and required oil quantity.

II. REVIEW FOR PLANETARY GEARBOX

Literature review is carried out for finding the various type of power loss in gearbox and importance of quantity of require lubricant for satisfaction operation of gearbox, And to show the effect of more lubricant in gearbox spindle. Here we have done work on reduced oil temperate by only reduced lubricant quantity selection, for our calculation, experiment and analysis convenient this literature review is for power consumption.

Prof. Dr. Mihály Kozma[1] analyze the possibilities to reach the highest efficiency it is necessary to calculate the tooth friction loss. Calculations were performed to determine the efficiency of simple planetary gears, evaluating the influence of the tooth profile on the tooth friction loss at different gear ratios. The geometries of tooth profile were changed with different modules and different addendum modifications of the gears. The efficiency of planetary gears mainly depends on the tooth friction loss. I learn from that the possibilities to reach the highest efficiency it is necessary to study the parameters determining the tooth friction loss. Increasing the pressure angle above 20°, the efficiency of planetary gear enhance a little, Increasing the module decreases the efficiency of planetary gear drive.

Carlos M.C.G.Fernandes, PedroM.T.Marques RamiroC.Martins, JorgeH.O.Seabra [2] work is devoted to the analysis, modelling and validation of gearbox power loss, considering the Influence of the gears, rolling bearings and seals, the influence of operating condition of oil formulation. They effective to determine the values of µbl and **µ**EHD for different different gear oil formulations. And correct value of µbl and µEHD the model can accurately predict the torque loss of rolling bearing. Surface finish.

Attila csoban[3] investing this research paper is bearing friction loss is a significant part of the friction losses. I learn from that research paper varying the inner gear ratios of the planetary gear drives the value of power loss rates change significantly only in the range of lower gear rations.

J. Durand de Gevidney C. Changenet F. Ville P.Velex S.Becquerelle[4] investing is to not only load dependent power loss is generated heat, but also no-load dependent power loss is significant part of heat generated. This paper present investigate the power losses into planetary gear unit.

No load dependent power loss is

(1) Windage loss.

(2) Oil churning loss.

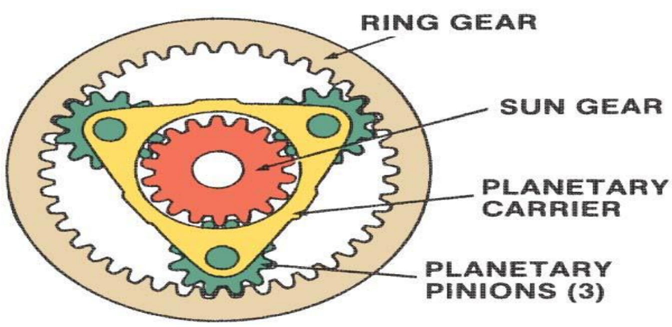
(3) Oil seal loss.

A. Kahraman D.R. Hilty A. Singh[5] investigates the contributions of the key components of load independent(spin) power losses of planetary (epicyclic) gear sets. A dedicated test set-up is developed to operate a planetary gear set under unloaded conditions in various hardware configurations within a wide range of speed. Torque provided to the gear set is measured as the spin torque loss. They investing the Impact of the rotational speed and oil temperature levels on each component. First of all, the main premise of this study was that the spin power loss of a planetary gear set could be represented by a set of components consisting of viscous drag power losses on the sun gear and the planet carrier, gear mesh pumping losses in the planet–sun meshes and planet–ring meshes, and losses in the planet bearings attributed to viscous and mechanical (centrifugal load dependent) friction. Power losses caused by viscous friction within the planet bearings were shown to be by far the most dominant sources of spin power loss, accounting for about one-half of the spin power loss at all temperatures in a 6-planet gear set with the mechanical bearing losses Tool wear.

P.D. Patel & D.S.Patel[6] carried out thermal analysis and stress analysis of Gearbox casing. They prepare gearbox model in ProE and then carried out thermal analysis (heat transfer of gearbox casing) &mechanical analysis in Ansys 14.0.

Attila Csobán, Mihály Kozma[7] carried out thermal capacity of a heavy-duty gear is the function of the heat generation from the power losses during operation. In order to lowering the heat generation in the gearboxes it is very important to find the best gearbox construction for a given application and to reach its highest efficiency and load carrying capacity. The efficiency of planetary gearboxes mainly depends on the tooth- and bearing friction losses but in some application also the oil churning and windage losses have to be determined.

.Bernd-Robert Höhn, Klaus Michaelis and Michael Hinterstoißer[8] investigated In some applications only the simple change to a highly efficient lubricant can save some 20% power loss. For maximum efficiency optimization alternative solutions have to be found for gear and bearing design as well as lubricant type, viscosity and supply to the components.



Planetary gearbox

Nutako A.Klodowski A Mikkola J. Sopanen[9]investigated to the developed model was used to simulate conditions with addendum contact ratios, helix and pressure angles,module sizes, face width, and lubricant base oil formulation to quantify their influence on power loss reduction. They find that they are two type of power loss in which one is load dependent loss and no load dependent loss, both are significant effect on heat generation. they study the effect of oil squeezing power loss of gear pair using a CFD Simulation.

Thermal rating is defined as the power can be continuously transmitted at a predetermined ambient temperature without resulting in the damage of the inner working or the declaration of the lubrication.

Oil churning and windage loss that are the result of interaction between the oil/air and moving/rotating element likes gears and shafts, into pocketing losses due to pumping effect of mating gear and into other viscous dissipation like those of the bearings.

Power loss calculation in bearing

Bearing power loss:

$$P_{Bi}{}^{[10]} = \frac{(M1+M2)*n}{9549}$$

$$M_1{}^{[10]} = \frac{f_1*(p_1)^a*(d_m)^b}{1000}$$

where

M_1 is the bearing load dependent torque, in newton metres;

f_1 is the coefficient of friction ;

p_1 is the bearing dynamic load, in newtons ;

d_m is the bearing mean diameter, in millimeter.

$$d_m{}^{[10]} = \frac{(d_i+d_o)}{2}$$

where

d_i is the bearing bore diameter, in millimetres;

d_o is the bearing outside diameter, in millimetres.

$$M_2{}^{[10]} = \frac{f_2*F_a*d_m}{1000}$$

where

M_2 is the axial load dependent moment, in newton metres;

f_2 is a factor depending on bearing design and lubrication;

F_a is the axial bearing load, in newtons.

Tapered roller bearings

P=F_r where $F_a/F_r \le$ e

P=0.4 F_r+YF_a where $F_a/F_r >$ e

Gear windage and churning power loss :

Arrangement constant A_g[10] = 0.2

Roughness factor R_f [10] = 7.93 - $\frac{4.648}{m_t}$

Where, R_f = roughness factor;

m_t = transverse tooth module.

Gear windage and churning losses encompass three types of loss.

1. For smooth outside diameters,
2. For smooth sides of discs,
3. For tooth surfaces,

For smooth outside diameter,

$$P_{GWi}{}^{[10]} = \frac{7.37 * f_g * v * n^3 * D^{4.7} * L}{A_g * 10^{26}}$$

For smooth sides of disc,

$$P_{GWi}{}^{[10]} = \frac{1.0474 * f_g * v * n^3 * D^{5.7}}{A_g * 10^{26}}$$

For tooth surfaces,

$$P_{GWi}{}^{[10]} = \frac{7.37 * f_g * v * n^3 * D^{4.7} * F\left(\frac{R_f}{\sqrt{tan\beta}}\right)}{A_g * 10^{26}}$$

Where, P_{GWi} = power loss for each individual element, in kilowatts;

f_g = gear dip factor;

D= outside diameter of the element.

A_g = arrangement constant;

F = total face width, in millimetres;

L = length of the element, in millimetres;

β = generated helix angle, in degrees. For helix angles less than 10°

RESULTS AND CONCLUSION

This review is done to show the power loss generation in gearbox which effect the oil temperature. the company has no any particular method to how much amount of lubricant required. more quantity of lubricant more churning power loss which effect the efficiency. My literature review is for investigating on design and thermal analysis of sugar mill planetary gearbox which will help to minimize the temperature of oil.

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