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WORM GEAR ANAYLASIS OF WINCH MACHINE GEARBOX USING EXPERIMENTAL & FEA

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Abstract - The worm & worm wheel is used in gear box of Winch machine for lifting sand bucket. During working worm Wheel fails due to load coming on the teeth. The failure is due to stress concentration. The crack appears at central thickness of tooth. Hence the tooth breaks at the central thickness. The failure of wheel occurs within period of about 20 days. So the company has to replace the worm wheel which is not cost effective. The stress calculation of worm wheel at tooth thickness is a three dimensional problem. This paper represents the review of analysis of stress pattern by using 3D Photo elasticity techniques & FEA technique.

Key Words: Worm Gear, Photo elasticity, Polaris cope, Stress Freezing, FEA, Winch Machine Gear Box.

I.INTRODUCTION

A. Worm Gearing

Worm gears are that types of gears which are used to transmit power between two non-intersecting, non-parallel shafts. These gears are generally at right angles to each other. It consists of worm and worm wheel. The worm is threaded screw and worm wheel is toothed gear. The figure shows meshing of worm and wheel. The teeth on the worm wheel envelope the treads on worm. This gives line contact between mating parts. In other types of gears, the drive can be given to any one of the two mating parts. But in worm gears, the drive can be given to only worm. The worm can rotate worm wheel but worm wheel cannot rotate worm.

Figure 1 - Worm Wheel as a Pattern

B. Failure of Gears

Failure of gears may be classified into four categories:

1. Surface fatigue (pitting)
2. Wear
3. Plastic flow
4. Breakage

The appearance of the various distress and failure modes can differ between gears that have through hardened. Teeth and those that have surface hardened teeth. These differences result from the different physical characteristics and properties and from the residual stress characteristics associated with the surface hardened gearing.

II. PROBLEM STATEMENT

The worm and worm wheel is used in winch machine gearbox. During operation it was observed that the worm wheel fails due to load coming on the teeth. The failure starts at the central thickness of tooth and continues up to the root of the tooth. The failure occurs once within operational period of about 20days. So the industry has to replace the worm wheel which is not cost effective. The material of worm is hardened steel and the material of the wheel is phosphor bronze PB2 having approximate composition in percentages as (Cu = 85, Sn = 12, Zn =0.3, Pb = 0.5, P = 0.4 and other = 2).

III. OBJECTIVES

Following are the main objectives of dissertation work.

1. To find out stresses at tooth root of wheel using experimental analysis using 3D photo elasticity.
2. To find out stresses at tooth root of wheel using FE analysis using ANSYS.
3. To validate experimentally obtained results with FEA results and plotting final results.

IV. WORKING METHODOLOGIES

The analysis work will be carried out by using following methodologies.

A. Theoretical Analysis

This includes theoretical calculations of worm gearing i.e. calculations of forces and bending strength using

Lewis equation.

$Pt = \sigma b Cv b \pi mn Y$

Pt = Permissible tangential tooth load or beam strength of gear tooth = 16732.57 N

σb=Bending stresses.

Cv= Velocity factor.= 0.9658

b = Face width. = 25.08 mm

mn= Normal module=3.878 mm

Y= Tooth form factor or Lewis factor = 0.392

σb = 144.64 N/mm2

As the ultimate tensile strength of the Phosphor Bronze (PB2) material is 320 N/mm2, the design of worm wheel is safe.

B. Experimental Analysis

Experimental analysis is one of the techniques to find out stress concentration areas. The experimental analysis will be done using 3D photo elasticity of worm wheel. The procedure includes)

A)Preparation of Model

Preparation of Pattern.

Prototype of worm wheel itself will be used as a pattern. Preparation of Rubber Mould. The rubber mould will be made out of "Sylartivi-11". Casting photo elastic material model and calibration disc. The model and calibration disc are will be prepared out of Epoxy Resin CY-203 IN araldite mixed with HY-951 hardener.

B) Designing and developing the loading frame.

Loading frame has to be designed and developed so as to simulate the actual loading conditions. Using loading frame, the required torque can be transferred and fringe pattern can be obtained. The figure shows the developed loading frame.

Fig 2.Photograph of Designed Loading Frame

C) Stress freezing.

A model & calibration disc with loading frames were placed in a stress freezing oven. A typical stress freezing cycle was followed.

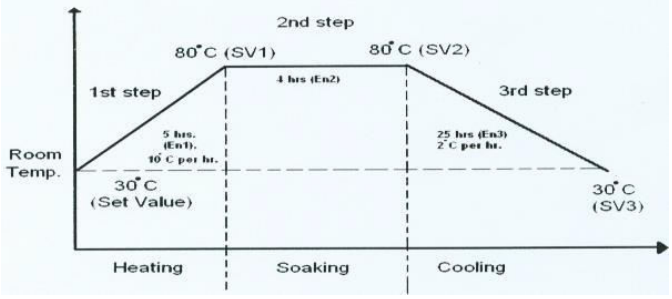

Fig 3.Stress Freezing Cycle

D) Slicing of model.

Using horizontal milling machine, slices were cut with high speed. Cutting oil was used at during cutting as a coolant. The thickness of slice was kept about 3 mm. After cutting, the surface of each slice was finished manually using zero number polish paper.

e) Stress analysis.

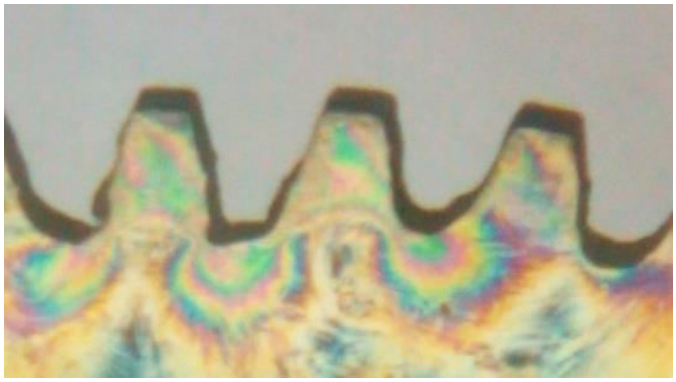

Fig 4.Fringe Pattern at the Tooth Root

C. FE Analysis

The Finite Element Analysis is the effective as well as convenient method to evaluate the stresses of the worm wheel. In this dissertation, the FE analysis will be done with the help of ANSYS software.

The procedure includes-

1. Modelling of worm wheel using suitable software using gear parameters.
2. Selection of proper element for meshing.
3. Specifying required material properties like modulus of elasticity, positions ratio, etc.
4. Applying boundary conditions and constraints.
5. Carrying out the Post

V. LITERATURE SURVEY

In spite of the wide use of worm gear drives, only few papers have been published on analysis and load distribution calculation of worm gears. Previous works addressing worm gear analysis published by some.

Authors is as follows.

Prashant Patil *et.al*, have discussed about 3D Photo elastic and Finite Element Analysis of helical gear. They have discussed an industrial problem which uses spreading machine to spread biogases. This spreading machine has Positive Infinite Variable (PIV) gearbox which contains helical gears. In working condition, helical pinion fails due to load coming on the teeth.

Bhosale Kailash *et.al*, have discussed about an experimental and finite element method of analysis. In their paper, they have analyzed bending strength of helical gear using photo elasticity technique. The experimentally obtained results are verified with finite element results.

W. T. Moody *et.al*, have published various techniques of analysis of mechanical component in Photo elastic and Experimental Analogy Procedures Engineering Monograph No. 23. Along with the theory of technique, they have explained all details including material requirement, instrument used for analysis, calibration techniques, the polar scope, nature of light and plane polarization, 3D photo elasticity, the photo elastic interferometer, the basinet compensator, the beggsdeformeter, the electrical analogy tray, the membrane analogy, photo elastic materials and model preparation, photo elastic model loading frame assembly.

Dr. V. B. Sondur *et.al*, have discussed about theoretical and finite element analysis of load carrying capacity of asymmetric involute spur gears. In this paper, they have presented a method for investigating the bending stress at the critical section of "Asymmetric Involute spur Gear". The gears with different pressure angle have been modeled by using CATIA software and analysis was carried out.

Pravin M. Kinge *et.al*, have analysed gearbox used in sugar industry. The main objective of analysis was to improve the life of the gear. The reason found for failure of the gear was due to wear of gear teeth edges. This is caused due to high stress concentration along gear teeth edges. To relieve these stress concentration three modifications in the design were done using ANSYS and again stress analysis of the modified gears carried out.

Gitin M. Maitra, V.B. Bhandari, PSG College of Technology, Norton, P. C. Gope, M. F. Spotts *et.al* have explained all the details of every type of gear including geometry, gear related parameters, force calculations, deflections, effect of heat generation, stress concentration, design criterion, load rating and efficiency of gears, friction in worm gears, material selection and strength rating of worm gears in their respective books.

VI. RESULT AND DISCUSSION

1. Results of Analysis

The theoretical analysis is done with the help of Lewis equation it gives bending stress value at the tooth of the warm wheel is . **64 N/mm2** .

The experimental analysis is done with the help 3D photoelasticity it gives the stress value at the tooth of the warm wheel is **118.29 N/mm2**.

The finite element analysis is done with the help of ANSYS it gives the maximum deformation is 0.33859, normal stresses is **122.28 N/mm2**, von-mises stresses **108.59 N/mm2**

2. Validation of theoretical result, experiment result, and FEA with bending stress

The following table shows the values of bending stress for Each of the analysis.

Bending Stresses by Theoretical Analysis N/mm^2	Bending Stresses by Experimental Analysis N/mm^2	Bending Stresses by FE Analysis N/mm^2
144.64	118.29	122.28

Table 2.1: -Validation of Bending Stresses

From the above table it is clear that the design of worm wheel is safe as the ultimate tensile strength of wheel material PB2 is 320 N/mm^2. All the values obtained from each analysis are far below the ultimate tensile strength of wheel material having factor of safety more than 2. Therefore, it is clear that the failure of wheel is not due to design parameters but due to some other reasons.

VII. Discussion

It is clear that the design for worm wheel is safe. But in actual working, the wheel fails. Thus this indicates that there is other reason of failure. Hence possible reasons of failures and their remedial actions are discussed with the Industry.

VIII. CONCLUSIONS

By determining the stress analysis by three methods i. e. theoretical, experimental and FE analysis, the following conclusions are made.

1. Though the worm wheel fails during working, the design of worm wheel is safe. Hence the reason for failure may be production method of the mating worm.
2. Among the three methods used for stress determination, the result obtained from FEA are closure to theoretical than experimental results.
3. Designing and developing a loading frame is very important factor in 3D photoelasticity so as to simulate actual loading conditions.
4. FEM and experimental method gives the actual visualization of stress pattern of the component under study.
5. Before going directly for failure analysis of any component, every possible reason should be checked out on primary basis.

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X.REFERENCES

[1] PrashantPatil, Narayan Dharashivkar, Krishnakumar Joshi, Mahesh Jadhav. “3DPhotoelastic and Finite Element Analysis of Helical Gear”, Machine Design, Vol.3 (2011) No.2, ISSN 1821-1259 pp. 115-120.

[2] BhosaleKailash C., A.D.Dongare, “Photoelastic Analysis of Bending Strength of Helical Gear”, Innovative Systems Design and Engineering, ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online) Vol. 2, No 3.

[3] W. T. Moody and H. B. Phillips, “Photoelastic and Experimental Analog Procedures”, Engineering Monograph No. 23, United States Department of the Interior Bureau of Reclamation.

[4] Dr.V.B.Sondur, Mr.N.S.Dharashivkar, “Theoretical and Finite Element Analysis of Load Carrying Capacity of Asymmetric Involute Spur Gears”, International journal of

research in aeronautical and mechanical engineering vol.1, July 2013, pp 67-73.

[5] Pravin M. Kinge, Prof. B.R. Kharde, Prof. B.R. Borkar, "Stress Analysis of Gearbox", IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.2, No.3, June 2012, pp 367-371.

[6] Gitin M. Maitra, "Handbook of Gear Design", Tata McGraw Hill Publication Company limited. pp 4.1-4.43.

[7] V.B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publication Company limited, third edition, pp 730-748.

[8] Faculty of Mechanical Engineering, PSG College of Technology, Coimbatore, "Design Data, Data Book of Engineers", KalaikathirAchchagam publications. 8.43-8.54.

[9] M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayaram and C. V. Venkatesh, "Design of Machine Elements", published by Pearson Education, Inc. pp 512-521.

[10] James W. Dally, William Franklin Riley, "Experimental Stress Analysis", McGraw Hill Inc, 1978.

[11] L. S. Shrinath, "Experimental Stress Analysis", Tata McGraw Hill Publication Company limited, 1984.

[12] James F. Doyle and James W. Phillips, "Manual on Experimental Stress Analysis", Society for Experimental Mechanics.