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Study about stress and deformation of 3- Stage helical gearbox casing

Mitesh Patel[1], Prof. A.V.Patil[2]

[1]PG Student S.S.G.B.C.O.E & T Department of Mechanical Engineering, Bhusawan-425203

North Maharastra University, Maharastra, India

miteshpatel_karu@yahoo.com

[2]Faculty of S.S.G.B.C.O.E & T Department of Mechanical Engineering, Bhusawan-425203

North Maharastra University, Maharastra, India

aviyash@yahoo.co.in

ABSTRACT

The finite element analysis of 3 stage helical gearbox that constitutes the driving mechanism of a double bascule movable bridge was performed. The triple reduction helical gearbox was made of ASTM A36 Steel. The triple reduction helical gearbox was a three stage gearbox transmitting 112.5 H.P. at 174 rpm with a reduction ratio of 71.05:1. The reactions were used to apply loads to the finite element model of housing. Geometric model of 3 stage helical gearbox was built using NX-8 and meshed using the ANSYS finite element program. Static structural analysis was performed using a combination of shell and solid elements to determine the deflection and to estimate the stress distribution in the housing. The aim of this project is to reduce weight with less stress and deformation so that changes in materials. The detail analysis of casing by ANSYS software result for different steel alloys used in manufacturing the casing of 3 stage helical gearbox. It will make the reduce scale model and make several testing on that model and hence, it conclude that my model is capable to take the load on that conditions.

Keywords; *Stress, deformation, ANSYS, Geometric, Triple reduction*

I. INTRODTUCION

This work focuses on the force, deflection, and stress analysis of 3-stage helical gearbox housing designed and manufactured by steward machine company, Birmingham, Alabama. These gearboxes are designed for high torque and low speed applications for operating movable bridges, heavy hoisting machinery, or other lifting mechanisms. In this study consider the gearbox which is used on the movable bridge. Movable bridges are generally constructed over waterways where it is difficult to build a fixed bridge high enough for water traffic to pass under it. The common types of movable bridges are the lifting, bascule, and swing bridges. The bascule bridge is similar to the ancient drawbridge both in appearance and operation. It may be in one span or in two halves meeting at the centre. It consists of a rigid structure mounted at the abutment of a horizontal shaft about which it swings in a vertical arc. A single leaf bascule bridge is shown in Figure 1.

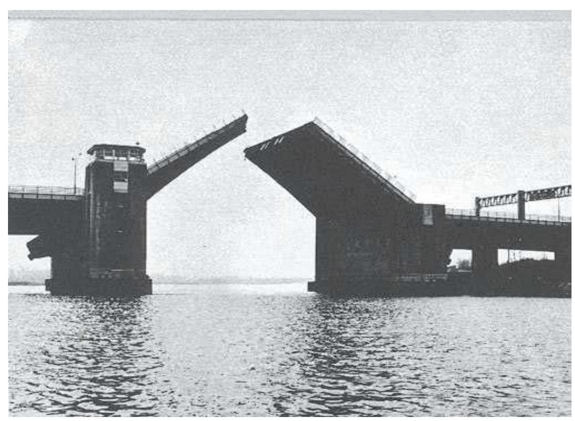

Figure 1. Single Leaf Bascule Bridge

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Figure 2. Movable Single Bascule Bridge with the Operating Gearbox Mechanism

A. PROBLEM STATEMENT

They are using this casing they have one major problem regarding the weight of the 3-stage helical gearbox casing. The material they are using is ASTM-A36 and it is heavy steel material and they are facing another problem is the stress is more so the deformation is more in the casing. The finite element method (FEM) is a versatile numerical method widely used to solve such engineering problems. In this research, the deflection and stress distribution in the triple reduction and differential gearbox housings are estimated using FEM. The different material and we will see that which material suits and meets all the requirement so that find out that material we will work with several material and make testing in software ANSYS.

B. GEARBOX SPECIFICATIONS

The triple reduction gearbox is the input to the main drive pinion of one leaf of the bridge. This gearbox weighs approximately 9000 kg and is driven by the differential gearbox. The material of the housing is ASTM A36 steel with a modulus of elasticity E of 30 x 106 psi and Poisson's ratio v of 0.29. The housing is joined together by a combination of welding and bolted joints. A schematic of the gearbox is shown in Figure 3. The triple reduction gearbox shafts are designated using capital S's and a numeral. The gearbox has two intermediate shafts S2 and S3 besides the input and output shafts S1 and S4. All shafts have helical gears and anti-friction bearing at shaft ends. The gearbox is designed to transmit 112.5 h.p. at 174 rpm with a reduction ratio of 71.05:1. The summary of shaft and gear specifications is shown in Table 1.

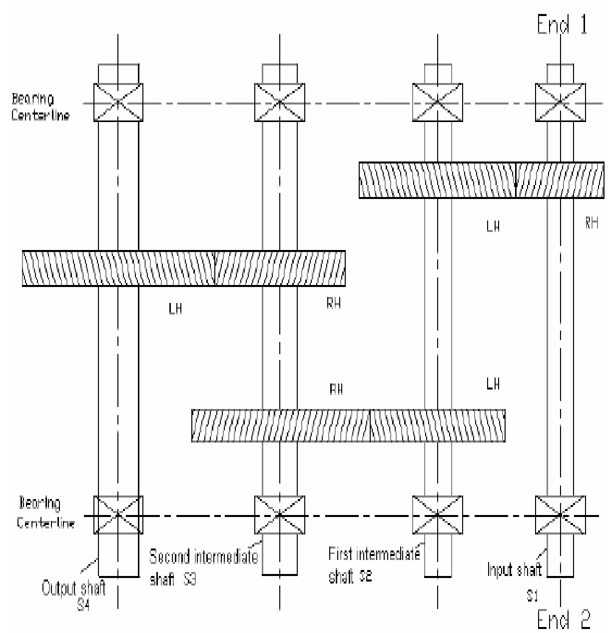

Figure 3. Sectional View of Triple Reduction Gearbox

Table 1. Shaft Data for the Triple Reduction Gearbox

Shaft	**Diameter(in)**	**Length between Bearing ends (in)**
Input Shaft	4.503	40.876
First Intermediate Shaft	7.004	
Second Intermediate Shaft	11.005	
Output Shaft	12.506	

C. Gear Ratio Calculations

If two gears are in mesh, then the product of speed and teeth is conserved.

Let's put this in terms of usable math. Let's say that we have two gears in mesh. Gear 1 (we'll call it the driver) is turning at speed S1 rpm and has T1 teeth. Gear 2 (the driven gear) is turning at speed S2 and has T2 teeth. Then our relationship above says that:

$S1 \times T1 = S2 \times T2$

Consider a simple example where:

S1 = 100 rpm
T1 = 30 teeth
S2 =?
T2 = 40 teeth

Solving the equation above for S2, we have:

$S2 = (T1/T2) \times S1 = (30/40) \times 100 = 75$ rpm

Let's add a third gear to the train. Assume gear 2 drives gear 3 and gear 3 has T3 = 50 teeth. What's the speed of gear 3? Well, since gears 2 and 3 are in mesh, our conservation law says that:

$S2 \times T2 = S3 \times T3$

We could do the arithmetic ($S3 = (T2/T3) \times S2 = (40/50) \times 75 = 60$ rpm) to find S3. Or, we could note that, since both S1×T1 and S3×T3 are equal to S2×T2, they must be equal to each other.

$S1 \times T1 = S3 \times T3$

So,

$S3 = (T1/T3) \times S1 = (30/50) \times 100 = 60$ rpm.

An idler gear between a driver and driven gear has no effect on the overall gear ratio, regardless of how many teeth it has

The easiest way to think about the problem is in terms of carriage motion. If my lathe has a Lead Screw Pitch (LSP) of L tpi, then if the spindle is connected to the lead screw with 1:1 gearing, one revolution of the spindle will move the carriage 1/L inches. Let's assume I want to cut a thread of pitch D tpi ('D' for Desired). Therefore I want the carriage to move 1/D inches for each revolution of the spindle. Clearly, I need a gear ratio (R) determined by:

$$\frac{\frac{1}{L}}{\text{lsrot}} \times \frac{R\ \text{lsrot}}{\text{srot}} = \frac{\frac{1}{D}}{\text{srot}}$$

Where, lsrot = lead screw rotation, srot = spindle rotation.

$$R = \frac{L/D\ \text{lsrot}}{\text{srot}}$$

speed	$\text{speed} = \frac{\text{Tire raidus} \times \text{Rotation velocity}}{168 \times \text{Gear Ratio}}$
Rotational velocity	$\text{Rotation velocity} = \frac{168 \times \text{Gear Ratio} \times \text{speed}}{\text{Tire raidus}}$
Gear ratio	$\text{Gear Ratio} = \frac{\text{Tire raidus} \times \text{Rotation velocity}}{168 \times \text{speed}}$
Tire radious	$\text{Tire raidus} = \frac{168 \times \text{Gear Ratio} \times \text{speed}}{\text{Rotation velocity}}$

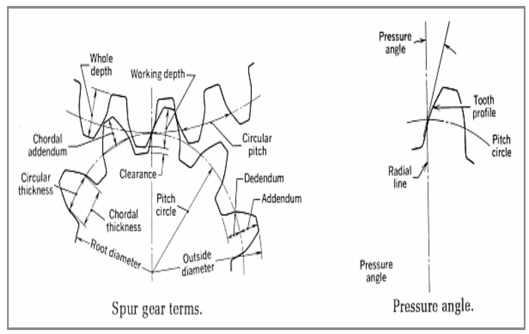

Figure 4. Gear Specifications

II. FINITE ELEMENT MODELING AND ANALYSIS

This chapter describes modeling, meshing, loading, and solving the FE models of the gearbox housings, FEM is a numerical method widely used to solve engineering problems. In this method of analysis, a complex region defining a continuum is discretized into simple geometric shapes called finite elements.

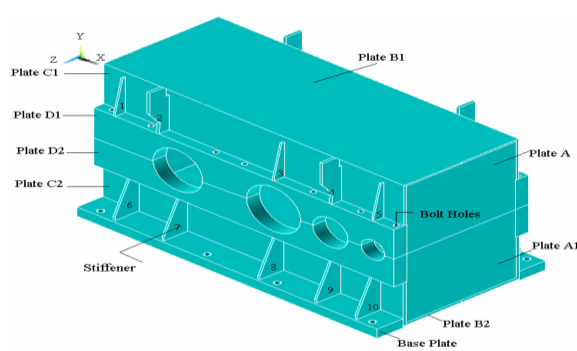

Figure 5. Geometric Model of Triple Reduction Gearbox

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A. CREATING AND MESHING THE FE MODELS

Modeling is based on a Conceptual understanding of the physical system and judgment of the anticipated behavior of the structure. A Model is an assembly of finite elements, which pieces of various sizes and shapes. The element Skewness should also be avoided by keeping the corner angles in quadrilateral elements close to 90 degree. A suitable mesh should minimize the occurrences of high aspect ratio and excessive skewness. In addition, the mesh must have enough elements to provide accurate results without warning time in processing and in interpreting the results.

Geometric modeling and meshing of these gearboxes with suitable elements and optimum degrees of freedom was an iterative and challenging process, first, a coarse mesh was made and the overall response of structure was evaluated. Modeling was done using NX-8, meshing was done using the preprocessor in ANSYS.

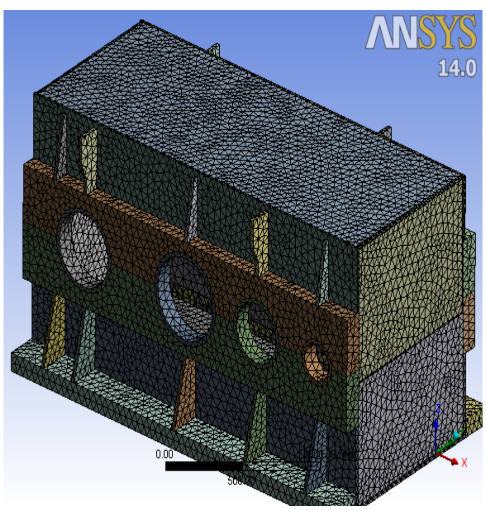


Figure 6. Discretized Geometry of 3 Stage Helical Gearbox Casing (Meshing)

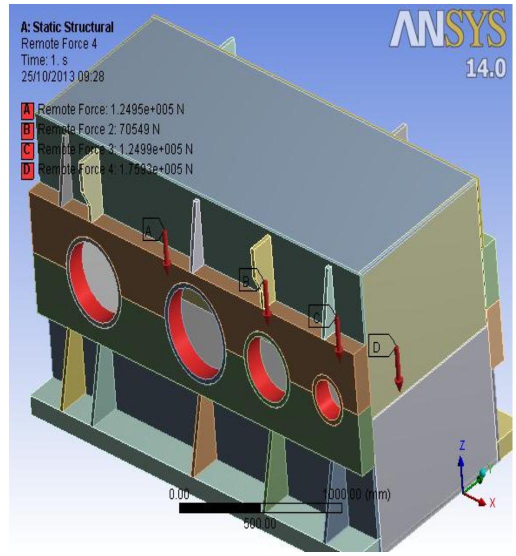


Figure 7. Axial Forces Acting on Holes

B. OBTAIN BETTER RESULT WITH DIFFERENT MATERIAL

So our main purpose was to reduce the weight of the gearbox casing and to increase the strength and it should withstand the more forces so that various steel alloys were tested analytically to obtain the best possible results in terms of stress, deformation and weight.

All steel alloys the same force applied on the body and analytical result discussed below.

Case 1: ASTM-A36 Steel

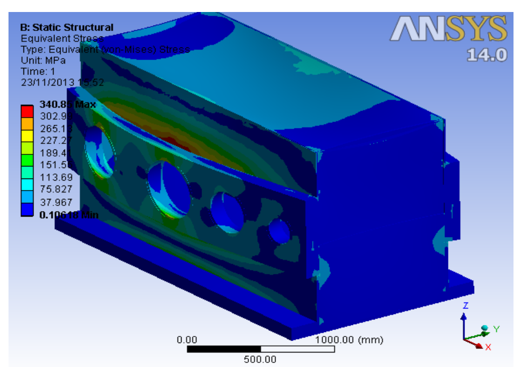


Figure 8. Equivalent Stresses on Gearbox ASTM A36

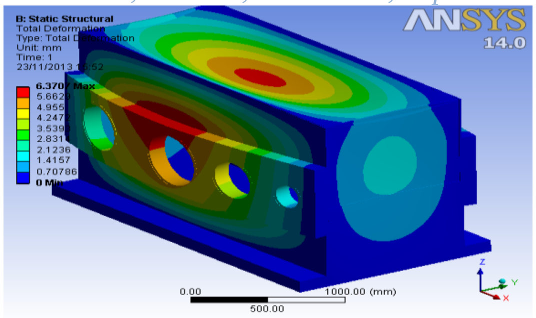


Figure 9. Total Deformation

Case 2: High Carbon Steel

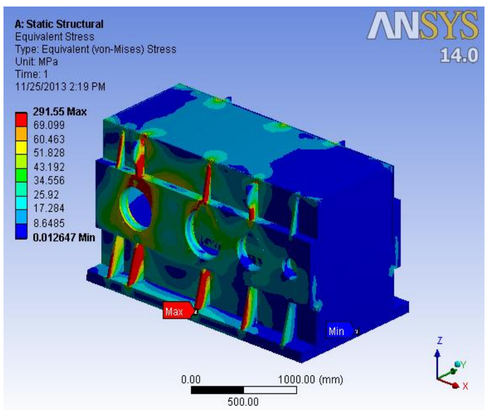


Fig 10. Equivalent Stress (High Carbon Steel)

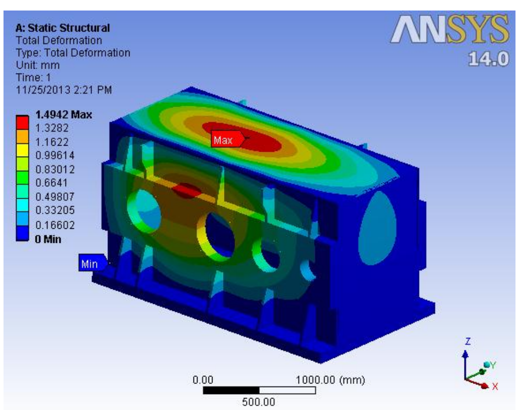


Fig. 11. Total Deformation (High Carbon Steel)

Case 3: Invar Steel

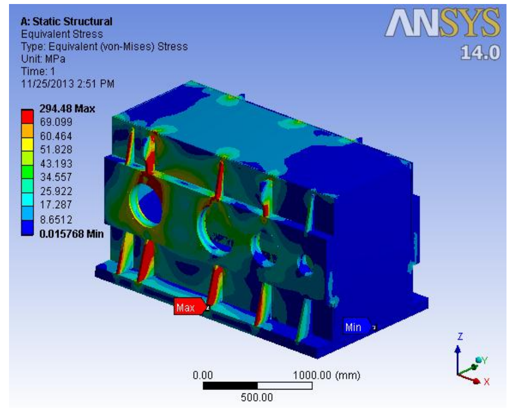


Fig 12. Equivalent Stress (Invar Steel)

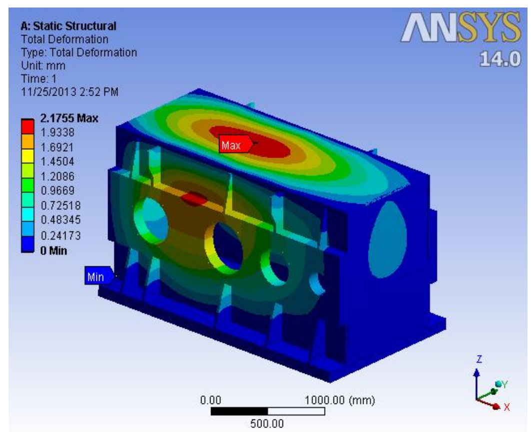


Fig 13. Total Deformation (Invar Steel)

Table 2. Result Comparison

Mate-rials	**Stress MPa**	**Total Defo-rmation mm**	**Defo-rmation in X Axis mm**	**Defo-rmation in Y Axis mm**	**Defo-rmation in Z Axis mm**	**Weig-ht Kg**
Astm-A36	292.17	1.5186	0.6308	1.3766	0.3809	5968.8
High Carbon Steel	291.55	1.4942	06209 9	1.3558	0.3749 1	5777.3
Invar Steel	294.49	2.1755	0.9015 8	1.9639	0.5448 8	5999.5

The comparison of different materials tested is shown table 2.From this table we can see that High Carbon Steel has less max. Stress, lowest deformation and weight compare to other form material .So, conclude that from analytical results high carbon steel is best choice.

III. RESULT AND DISCUSSION

In our project, form the theoretical and analytical details we got some result. Now we compare this result with the actual load acting upon the casing. Here is the comparison details of the value is below and as per our ANSYS analysis setup with the time interval of every 10 sec we got the several analysis result which is below and this result will shows that how accurate our work is, and how much difference is there between this experimental value and the Analytical value.

Table 3. Stress Comparison

Time(sec)	Stress(MPa) by ANSYS analysis	Stress(MPa) by experiment
0	0.1624	0.00
10	8.644	4.8478
20	38.614	22.687
30	59.128	54.556
40	103.374	91.754
50	195.241	169.870
60	291.550	262.710

Graph 1. Stress Comparison Graph For 3 Stage Helical Gearbox

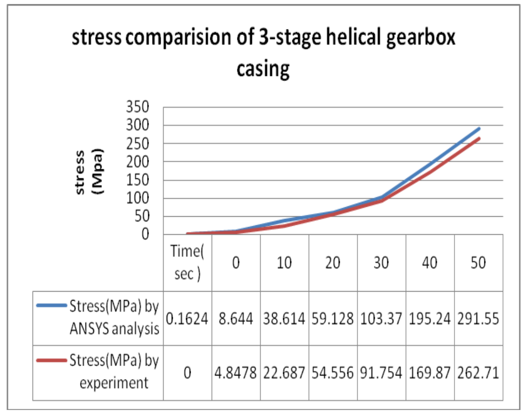
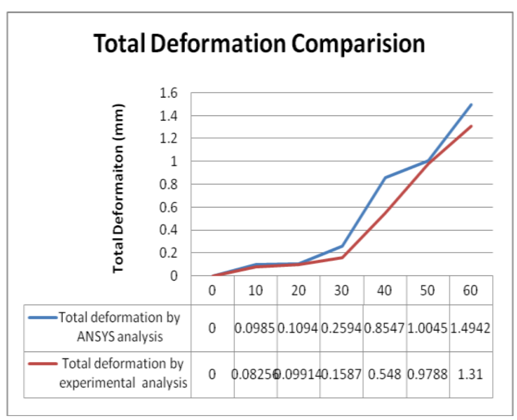


Table 4. Total Deformation Comparison

Time(sec)	Total deformation by ANSYS analysis	Total deformation by experimental analysis
0	0.00	0.00
10	0.0985	0.08256
20	0.1094	0.09914
30	0.2594	0.1587
40	0.8547	0.5480
50	1.0045	0.9788
60	1.4942	1.310

Graph 2. Total Deformation Comparison Graph for 3 Stage Helical Gearbox



From the above results we can see that there is little difference in amount of stress obtaining analytically and experimentally. In experimental result due to atmospheric condition some factors like force & loads play an important role while in ANSYS they don't. The comparison of the practical and theoretical results. We can see that the result is almost same. Here we got more stress in the software because in the real condition the force and the loads acting upon the casing might be some different due to some technical condition or due to some material selection condition so the result which we got it is accurate to the original value and Deflection is in the limit of the 0.26-1.61mm. So we can say that our study of the stress analysis and design modification of a 3 stage helical gearbox can work successfully in the real condition.

IV. CONCLUSION

The aim was to reduce the weight of the casing. For that we have tested several materials and out of that high carbon steel was confirmed because of lowest stress and deformation in analytical results carried out in ANSYS. Further experimental model using high carbon steel was prepared and tested for the industry and results were obtained for same conditions. Which also confirmed the lowest stress deformation for high carbon steel and also both analytical and experimental results were compared and were almost same.

V. FUTURE SCOPE

- In future modification in design can be made in order to minimize the weight and size of the casing
- Also, one can test the same model for more materials and obtained the better results deformation and stores.

VI. REFERENCES

1. Emmanual RIGUAD and Jens SABOT. "Effect of elasticity of shaft, baring, coupling and casing on the critical rotation speed of a gear box. 36, avenue Guy de Collongue. B.P. 163. 69131 Ecully Cedex. FRANCE.
2. Design & Analysis of Composite Material Gear Box by Pankaj Chhabra and Amit Bhatia.International Journal of Mechanical Science and Civil Engineering, Volume 1 Issue 1 December 2012
3. Dr Inż. Zbigniew Zdziennicki and Dr Inż. Andrzej Maciejczyk, DESIGN BASIC OF INDUSTRIAL GEAR BOXES Calculation and Design Case Example
4. Steady-state thermal stress analysis of gearbox casing by finite element method by P. D. PATEL & D. S. SHAH, Mechanical Engineering Dept., S.V.I.T , VASAD, India ,International Journal of Mechanical and Industrial Engineering (IJMIE) ISSN No. 2231 –6477, Vol-2, Iss-4, 2012
5. M. Sofian D. Hazry and Others ,A study of Vibration Analysis for Gearbox Casing Using Finite Element Analysis Proceedings of International Conference on Applications and Design in Mechanical Engineering (ICADME)11 – 13 October 2009, Batu Ferringhi, Penang, MALAYSIA

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