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EVALUATION ON FAILURE OF AN AUTOMOBILE DIFFERENTIAL GEAR BOX

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Abstract- The discussion in this paper is on the design and analysis of gears assembly in differential gear box. During operation of gears, there is a problem of failure at contact regions. This can be minimized by modification of the gear material by assuming the bevel gears in static and dynamic conditions.

The purpose of this paper is to develop the model of a bevel gear assembly and to determine the effect of meshing gear tooth stresses and displacement. In present market, the materials used for gears manufacturing are Cast Iron and Cast steel. In this study comparison was done between Ni-Cr steel and steel. The design is done in Solid works software and analyzed using ANSYS work bench. The justification has been done by considering a full literature review.

Keywords – Modeling, Analysis, Steel and Nichrome Steel.

I. INTRODUCTION

A differential is a device used to transmit the power from engine to the rear wheels. In automobiles the differential allows each of the driving road wheels to rotate at different speeds, while for most vehicles supplying equal torque to each of them. A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds.

When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult handling and damage to tires on roads and strain on entire drive system. The differential is a part of the final drive assembly and its objective is to rotate the inner wheels at different speeds whenever the vehicle takes turn from straight path and also to allow equal torques on each of the wheels even when they are rotating at different speeds.

II. LITERATURE REVIEW

Ronak P Panchal & Pratik B Umrigar discussed on the characteristics of a bevel gear in dynamic condition involving meshing stiffness and other stresses produce are discussed. By using numerical approach the author has developed theoretical model of bevel gear and determined the effect of meshing gear tooth stresses by taking material case hardened alloy steel (15Ni4Cr1)[1].

Luciana Sgarbi Rossinoa et al. made an investigation to determine the causes of surface contact fatigue failure of a case hardened pinion. The examination of the component revealed the presence of a cemented layer substantially thicker than that generally specified for pinions devised for this application. This associate with the massive presence of brittle threadlike carbon-rich cementite phase (Fe_3C) in prior austenite grain boundaries of the pinion

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teeth favored surface crack nucleation and propagation during cyclic loading leading to spallation of the contact surface with the counterpart gear which impaired the system's operation[2].

Gregory Antony., an analytical model was presented for assessing and predicting the mechanical friction losses occurring in differential gearboxes. Some of the parameters involved in this model can be determined quite easily (geometric parameters), while others depend directly on the type of friction occurring in the mechanism which affects the mechanical losses to a variable extent. In order to test the influence of these parameters and determine the ability of the model to predict any mechanical losses, a sensitivity analysis was conducted [3].

III.OBJECTIVE

To design the differential gear made of Ni-Cr steel and compare it with steel material. The design is done in Solid works software and analyzed using ANSYS.

IV. DESIGN OF DIFFERENTIAL GEAR

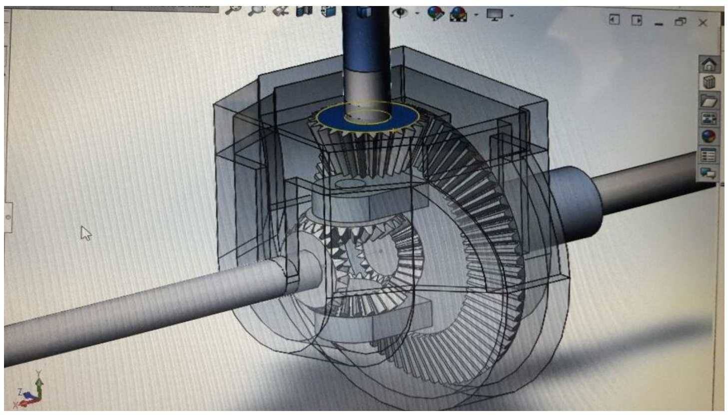


Fig.1. Differential Gear Assembly

V. ANALYSIS

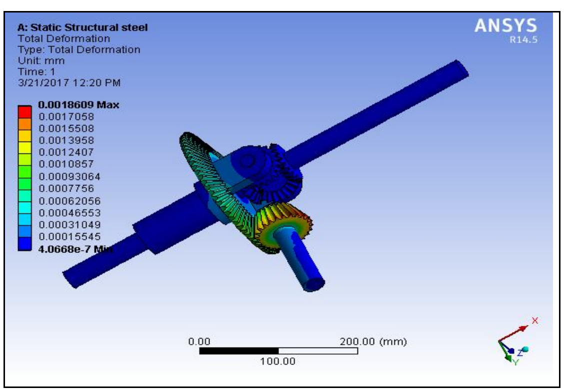


Fig.2. Total deformation of steel

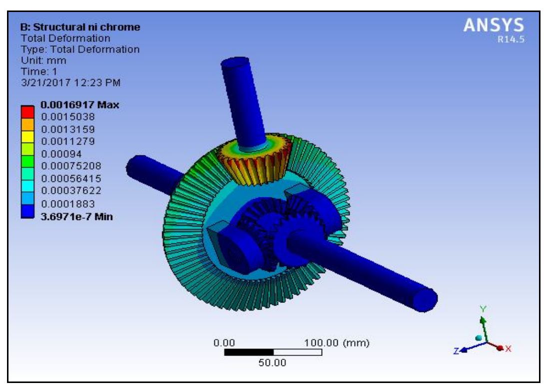


Fig.3. Total deformation of nichrome

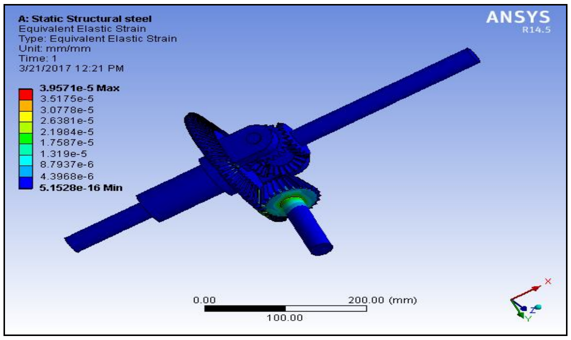


Fig.4. Strain of steel

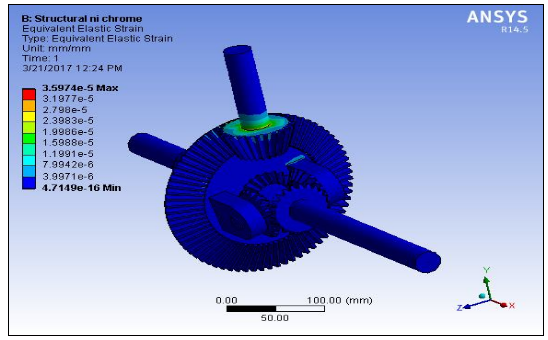


Fig.5. Strain of nichrome

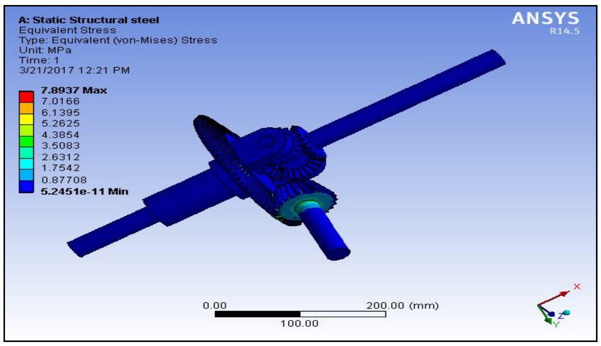


Fig.6. Stress of steel

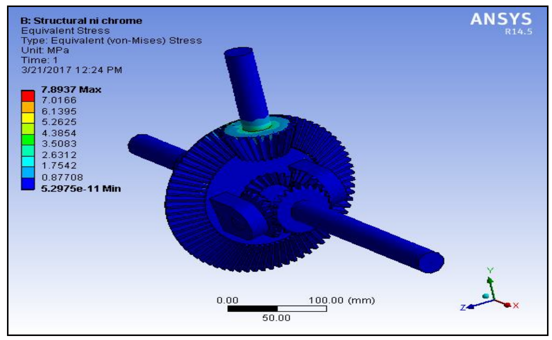


Fig.7. Stress of nichrome

Differential	Steel (Max & Min)	Nichrome (Max & Min)
Total deformation (mm)	0.0018609 & 4.0668e-7	0.0016917 & 3.6971e-7
Equivalent strain	3.9571e-5 & 5.1528e-16	3.5974e-5 & 4.7149e-16
Elastic stress (N/mm²)	7.8937 & 5.2451e-11	7.8937 & 5.2975e-11

Table.1. Static Analysis Result of Differential Gear

MODEL ANALYSIS OF DIFFERENTIAL:

Model: 1

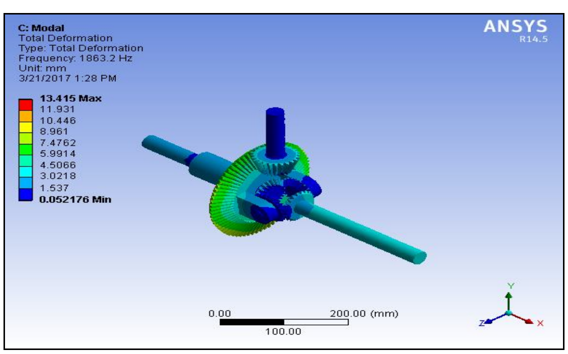


Fig.8. Total deformation of steel 1

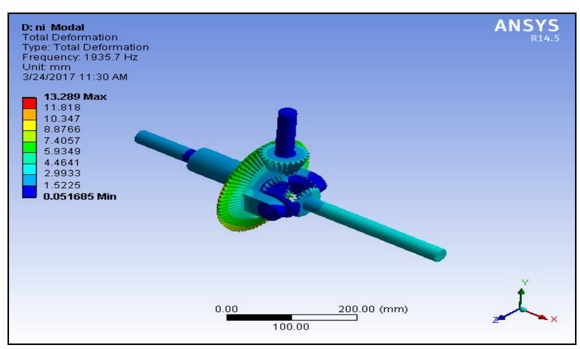


Fig.9.Total deformation of nichrome 1

Model: 2

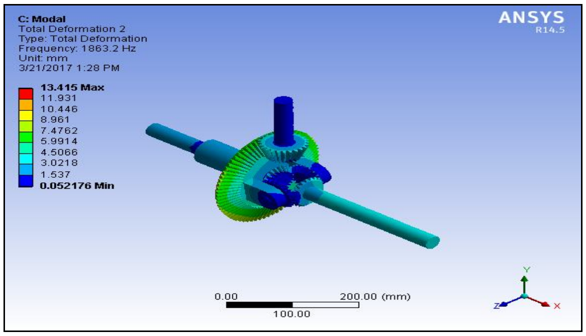


Fig.10. Total deformation of Steel 2

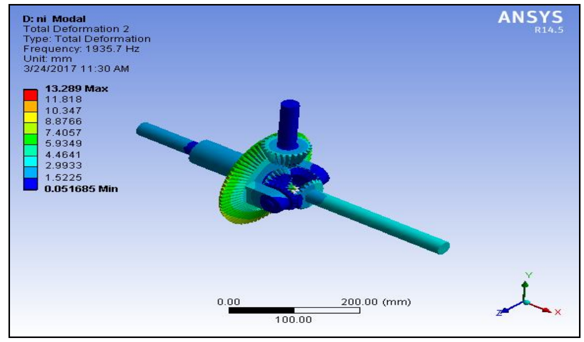


Fig.11. Total deformation of nichrome 2

Model: 3

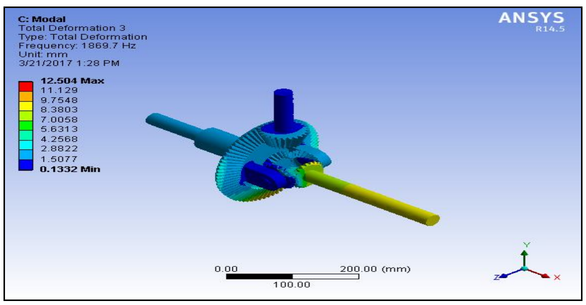


Fig.12.Total deformation of steel 3

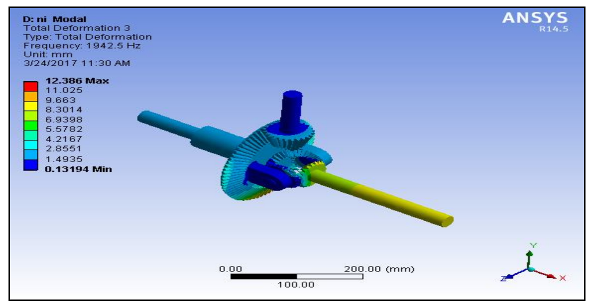


Fig.13. Total deformation of nichrome 3

Model: 4

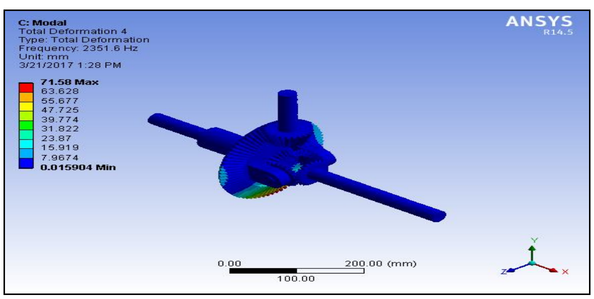


Fig.14. Total deformation of steel 4

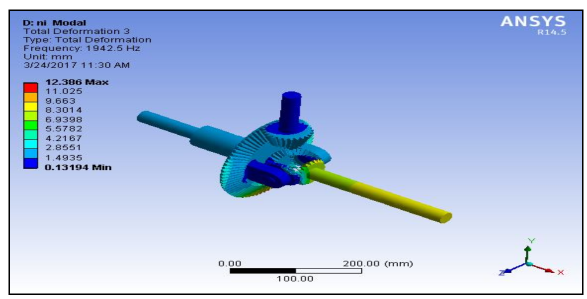


Fig.15. Total deformation of nichrome 4

Model: 5

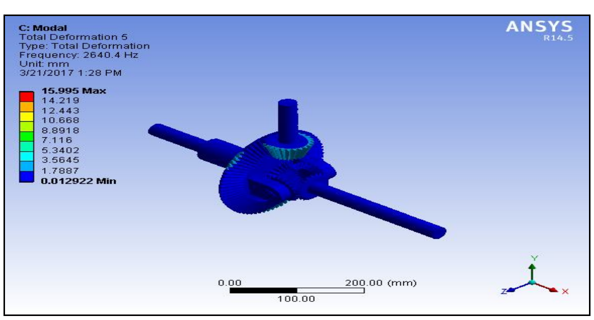


Fig.16.Total deformation of steel 5

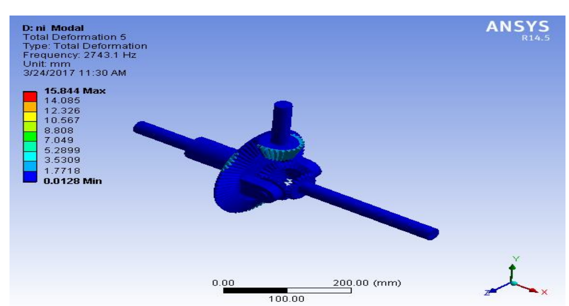


Fig.17. Total deformation of nichrome 5

Model: 6

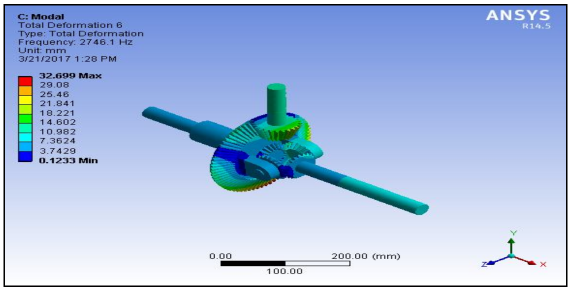


Fig.18.Total deformation of steel 6

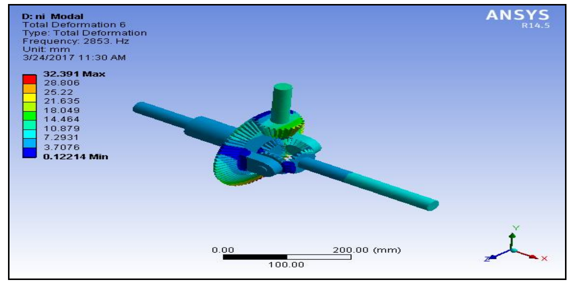


Fig.19. Total deformation of nichrome 6

Model: 7

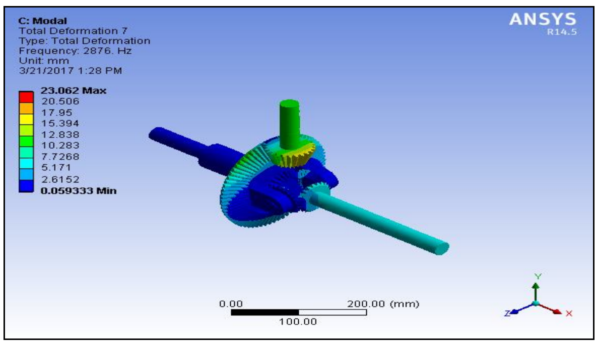


Fig.20.Total deformation of steel 7

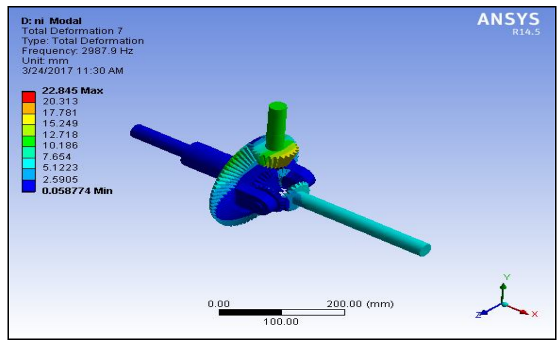


Fig.21. Total deformation of nichrome 7

Differential	Steel(Max & Min)	Nichrome(Max & Min)
Total deformation 1	13.415 & 0.052176	13.289 & 0.051685
Total deformation 2	13.415 & 0.052176	13.289 & 0.651685
Total deformation 3	12.504 & 0.1332	12.386 & 0.13194
Total deformation 4	71.58 & 0.015904	12.386 & 0.13194
Total deformation 5	15.995 & 0.012922	15.844 & 0.0128
Total deformation 6	32.699 & 0.1233	32.391 & 0.12214
Total deformation 7	23.062 & 0.059333	22.845 & 0.058774

Table .2. Dynamic analysis result of differential gear

The maximum value of deformation for steel (Model 4) is 71.58 and minimum value of deformation for steel (Model5) is 0.012922.

The maximum value of deformation for nichrome (Model 5) is 32.391 and minimum value of deformation for nichrome (Model 5) is 0.0128.

HARMONIC ANALYSIS:

Model: 1

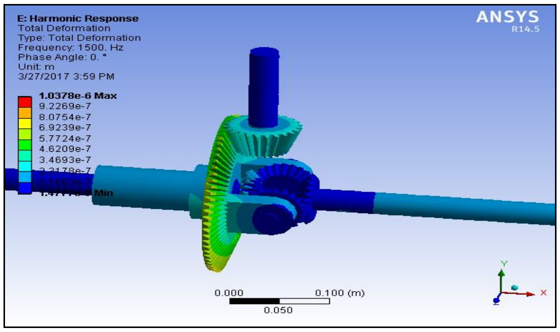


Fig.22. Total deformation of steel

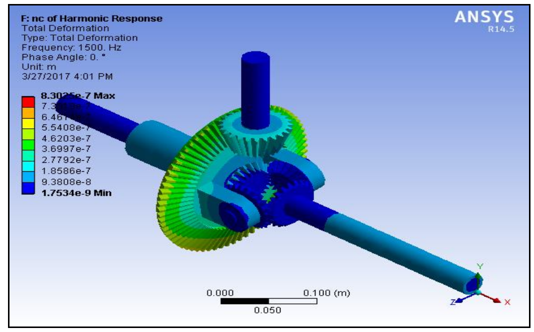


Fig.23.Total deformation of nichrome

Model: 2

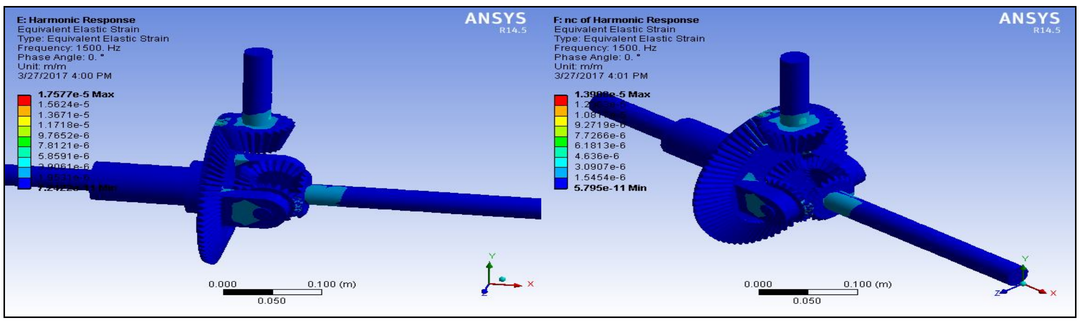


Fig.24. Elastic strain of steel

Fig.25.Elastic strain of nichrome

Model: 3

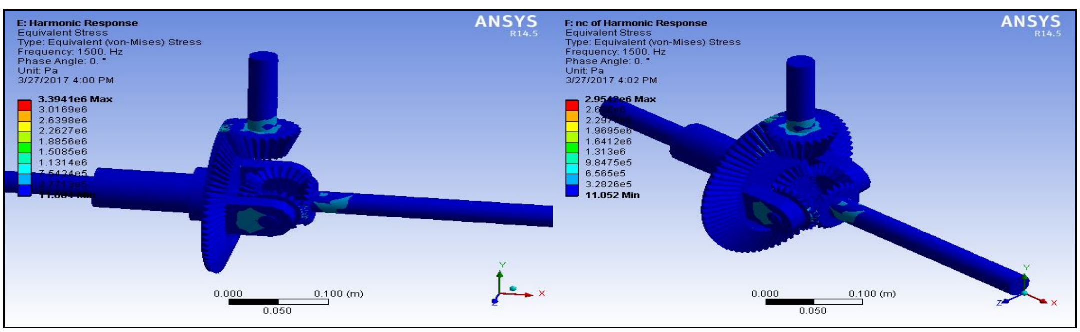


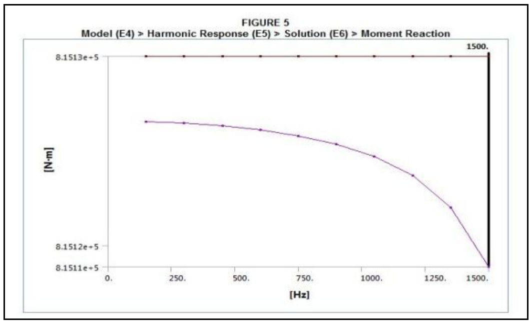
Fig.26.Equivalent stress of steel

Fig.27. Equivalent stress of nichrome

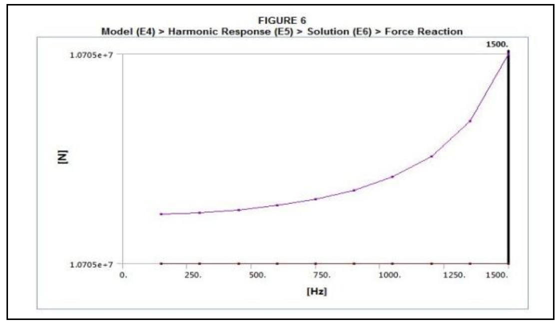
Harmonic Analysis	Steel (Max & Min)	Nichrome(Max-Min)
Total deformation	1.0378e-6 & 1.4777e-9	8.3025e-7 & 1.7534e-9
Elastic strain	1.7577e-5 & 7.2422e-11	1.3908e-5 & 5.795e-11
Equivalent stress	3.3941e6 & 11.684	2.9542e6 & 11.052

Table.3.Harmonic analysis result of differential gear

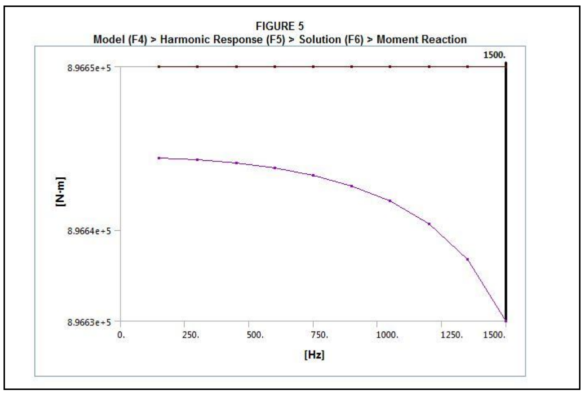
GRAPHS:



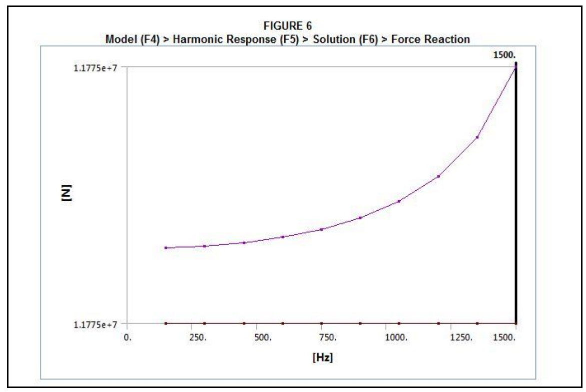
Graph.1.Harmonic analysis of steel (moment reaction)



Graph.2.Harmonic analysis of steel (force reaction)



Graph.3.Harmonic analysis of Ni-chrome (moment reaction)



Graph.4. Harmonic analysis of Ni-chrome (force reaction)

VI. RESULT

DIFFERENTIAL		
Differential	**Steel (Max & Min)**	**Nichrome (Max & Min)**
Total deformation (mm)	0.0018609 & 4.0668e-7	0.0016917 & 3.6971e-7
Equivalent strain	3.9571e-5 & 5.1528e-16	3.5974e-5 & 4.7149e-16
Elastic stress (N/mm2)	7.8937 & 5.2451e-11	7.8937 & 5.2975e-11
Model analysis		
Total deformation 1(mm)	13.415 & 0.052176	13.289 & 0.051685
Total deformation 2(mm)	13.415 & 0.052176	13.289 & 0.651685
Total deformation 3(mm)	12.504 & 0.1332	12.386 & 0.13194
Total deformation 4(mm)	71.58 & 0.015904	
Total deformation 5(mm)	15.995 & 0.012922	15.844 & 0.0128

Total deformation 6(mm)	32.699 & 0.1233	32.391 & 0.12214
Total deformation 7(mm)	23.062 & 0.059333	22.845 & 0.058774
Harmonic Analysis		
Total deformation(mm)	1.0378e-6 & 1.4777e-9	8.3025e-7 & 1.7534e-9
Elastic strain	1.7577e-5 & 7.2422e-11	1.3908e-5 & 5.795e-11
Equivalent stress(N/mm2)	3.3941e6 & 11.684	2.9542e6 & 11.052

Table.4. Over all result of differential gear

VII. CONCLUSION

By theoretical comparison between steel and Ni-Cr steel, Ni-Cr steel is better in differential gear box manufacturing because of its high strength.

Though the cost of Ni-Cr is high, it has long life compared to Steel.

VIII. ACKNOWLEDGEMENT

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