FINITE ELEMEMNT MODELING OF SPUR GEAR: A COMPARISON REVIEW

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Abstract:

FEA is useful technique now a days and it has emerged as a helping tool for solving many complicated problems which are not possible by any other technique. FEA is used in many analysis problems like structural analysis, thermal analysis, computational fluids dynamics problems etc. In this paper the maximum stress developed i.e. Von Mises stress in spur gear is determined for two different materials i.e. S45C steel, Tempered and Sintered BT-126, Bronze under the same loading conditions for comparison of some aspect of materials. The maximum stress developed is compared for the two materials and factor of safety is calculated on the basis of this developed stress.

Keywords: Finite Element Analysis, Spur Gear, Stress.

1. INTRODUCTION

It is necessary for the designer to know the stress distribution in order to prevent failure. In the present work the developed stress in the gear is determined using FEA process with the help of ANSYS software. The gear geometry is generated using Pro-E and simulation work is carried out with the help of ANSYS. The increasing demand for quiet power transmission in machines, vehicles, elevators and generators, has created a growing demand for a more precise analysis of the characteristics of gear systems [1]. The geometry of the tooth and the gear is obtained using mathematical formulations for real cases of manufacturing and the profile of the tooth is an involute one and at the root region it has a trochoid form. The geometry of the gear includes rim geometry with a solid geometry and defined ratio parameters of the rim thickness to the tooth height more than 2 to 1. The number of the teeth taking into account is three, in order to simulate the single and double pair teeth in contact, over the whole roll angle [2].

2. GEOMETRIC DIMENSIONS OF SPUR GEAR

The same spur gear model is used for all the materials that are in the analysis. The dimensions of spur gear used are as follows:

No. of Teeth	-	120
Module	-	2 mm
Bore	-	194 mm
Pitch Dia.	-	240 mm
Outside Dia.	-	244 mm
Face Width	-	20 mm
Shape	-	S5
Pressure Angle	-	20^0

The Allowable Bending Strength is 366.3 N-m for the spur gear used.

3. STRESS ANALYSIS OF SPUR GEAR:

Total Number of elements generated in spur gear by ANSYS is 821219 approximately and element type considered is solid 185.

Boundary conditions are applied on the inner side of pulley i.e. it is fixed and load is applied on periphery of spur gear. Figure 1-6 shows the procedure of stress analysis. Figure 7-9 shows the von mises stress, strain and deformed/un-deformed plot for S45C steel Tempered. Figure10-12 shows the von mises stress, strain and deformed/un-deformed plot for BT-126 Bronze.

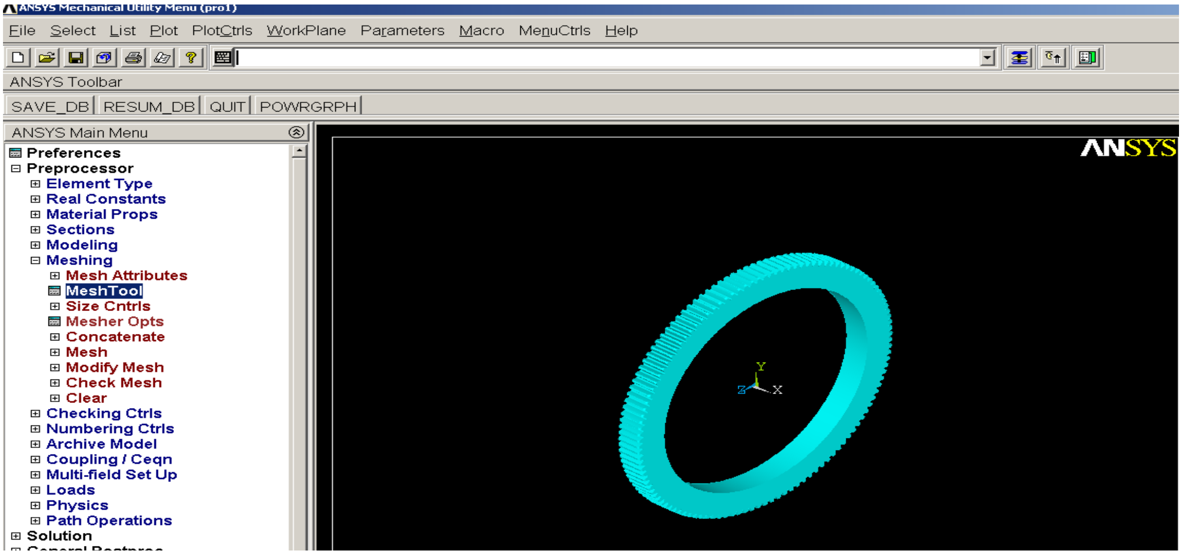

Figure 1: Imported view of spur gear in ANSYS

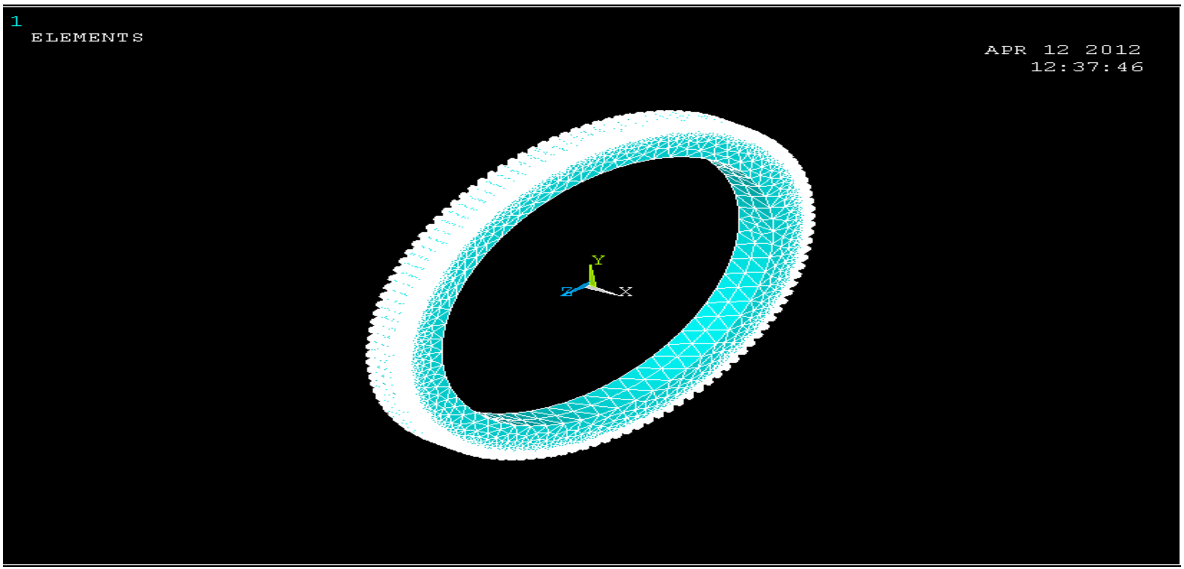

Figure 2: Meshing

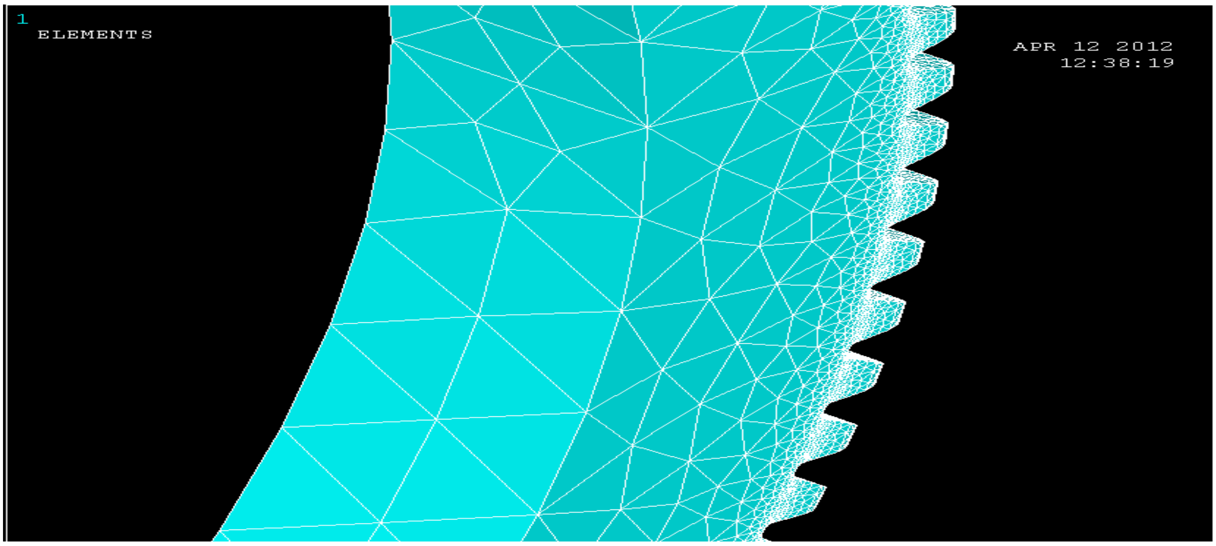

Figure 3: Meshing closer view

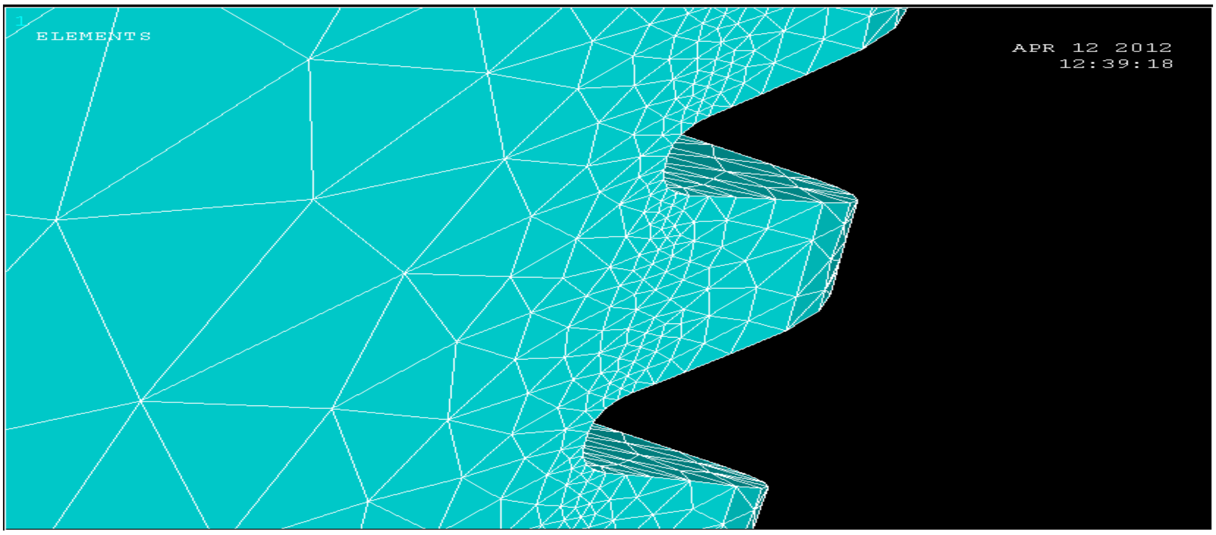

Figure 4: Meshing more closer view on Teeth

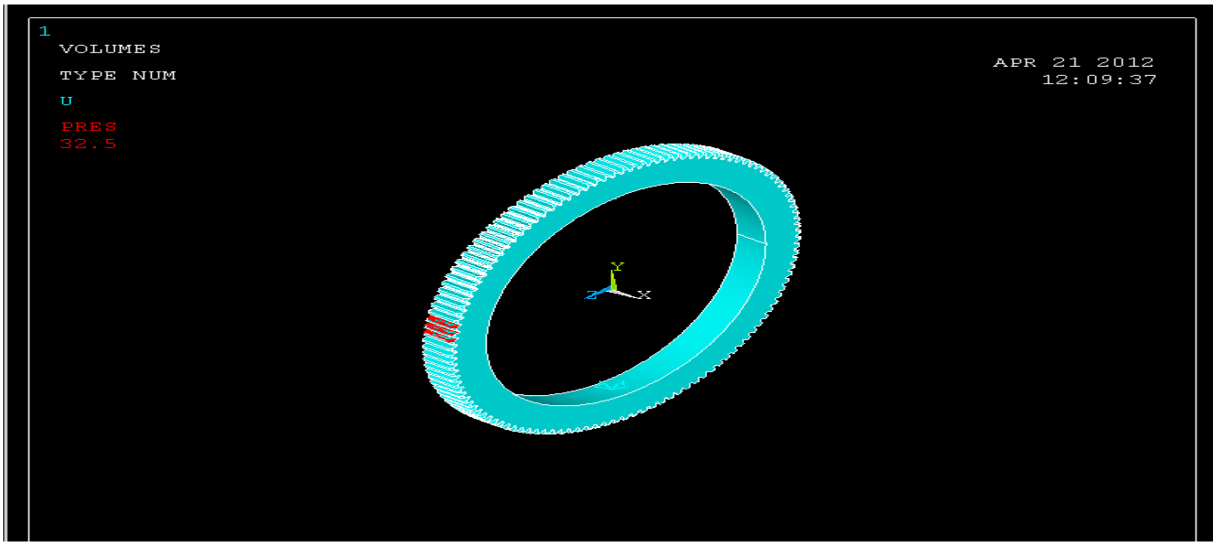

Figure 5: Load Case Applied

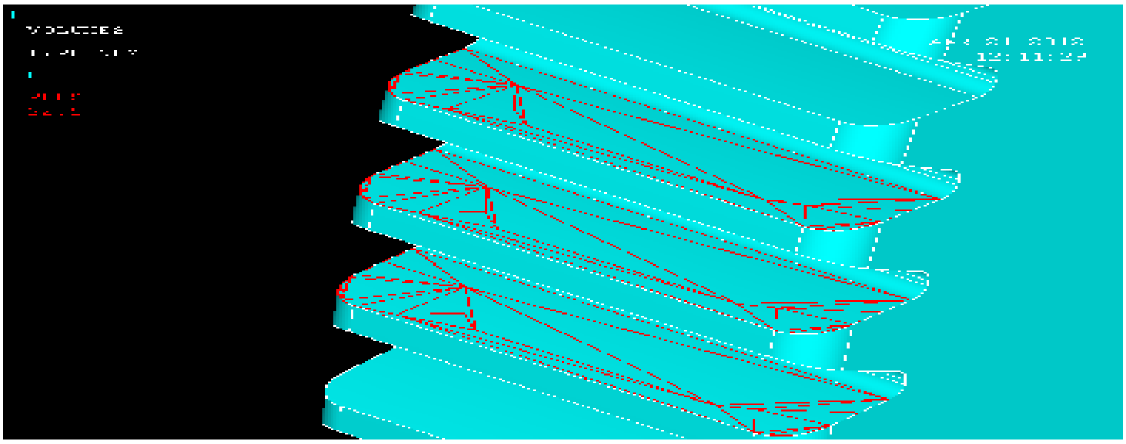

Figure 6: Loading Closer view on Teeth

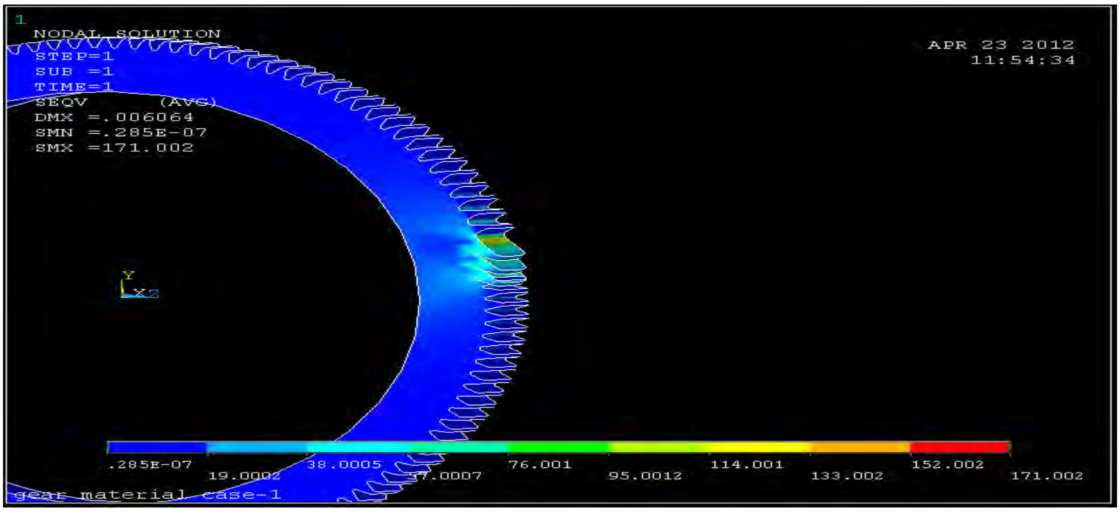

Figure 7: Von Mises stress developed in S45C steel, Tempered

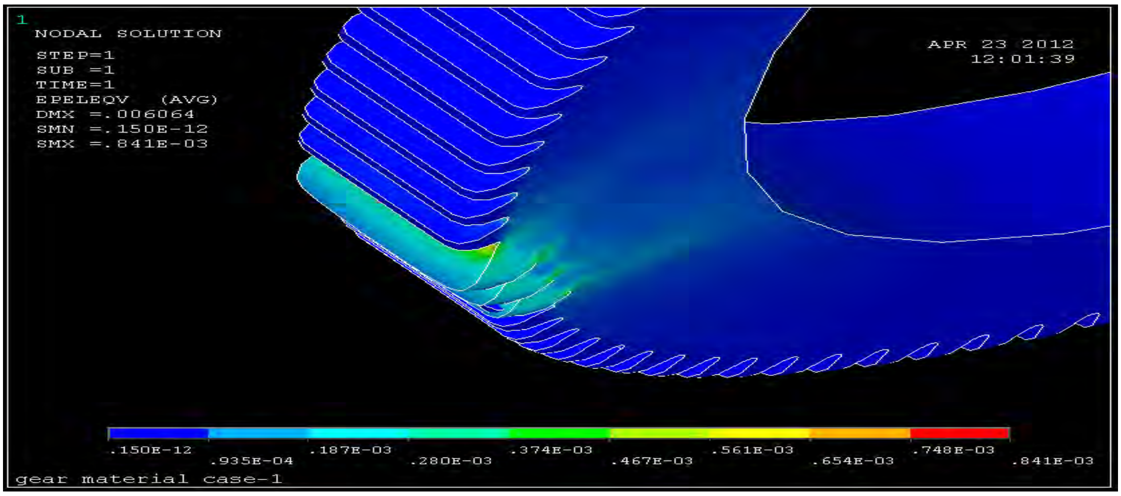

Figure 8: Von Mises strain in S45C steel, Tempered

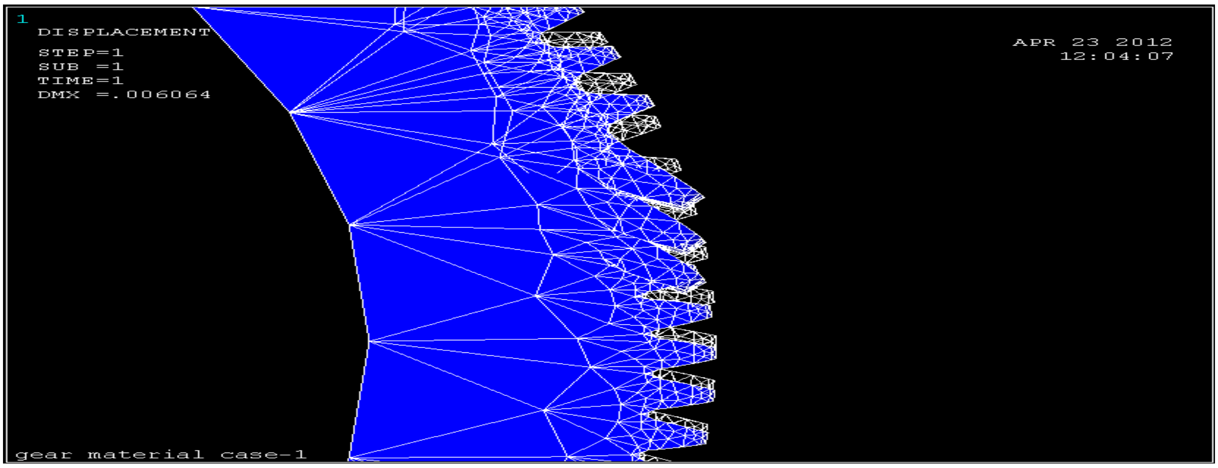

Figure 9: Deformed & Unreformed Plot for S45C Steel, Tempered

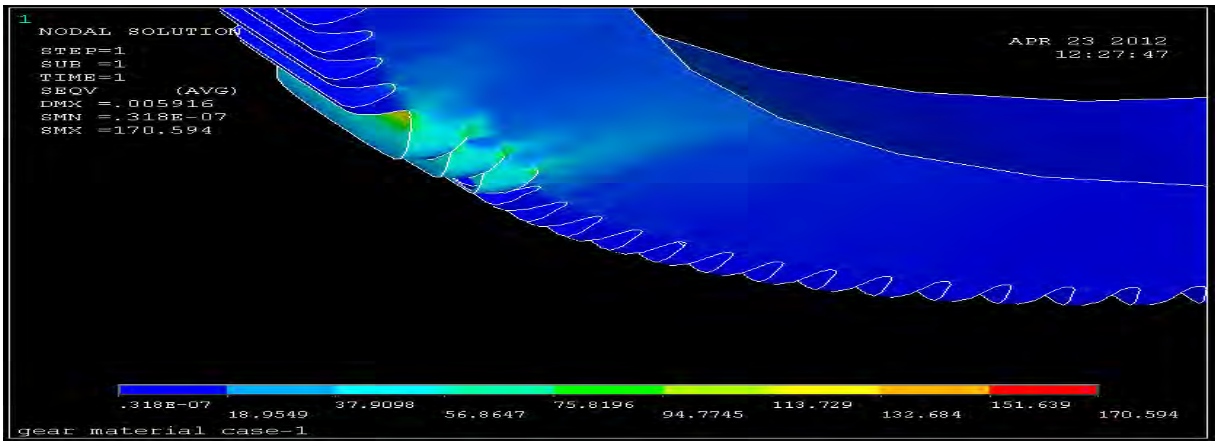

Figure 10: Von Mises stress developed in Sintered BT-126 Bronze

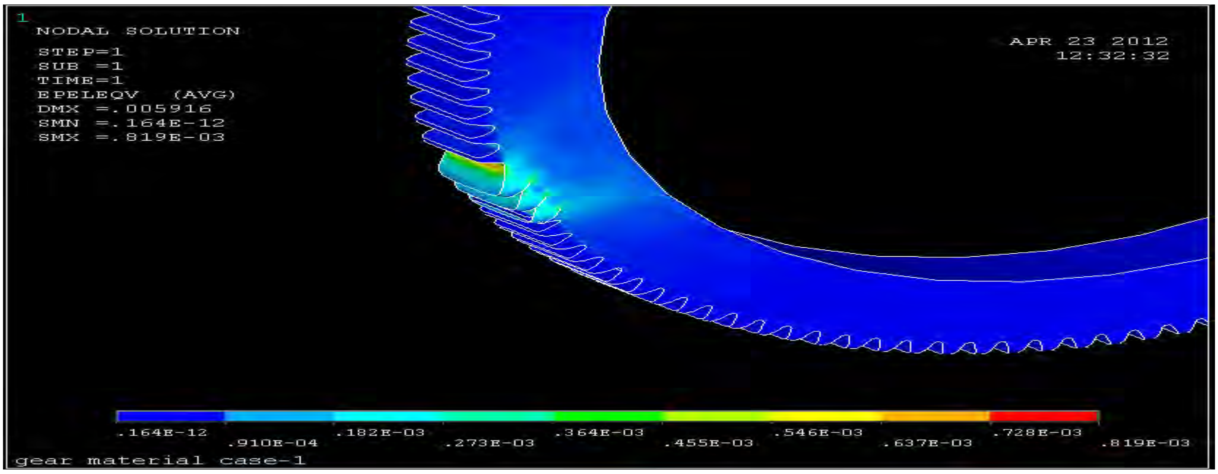

Figure 11: Von Mises strain in Sintered BT-126 Bronze

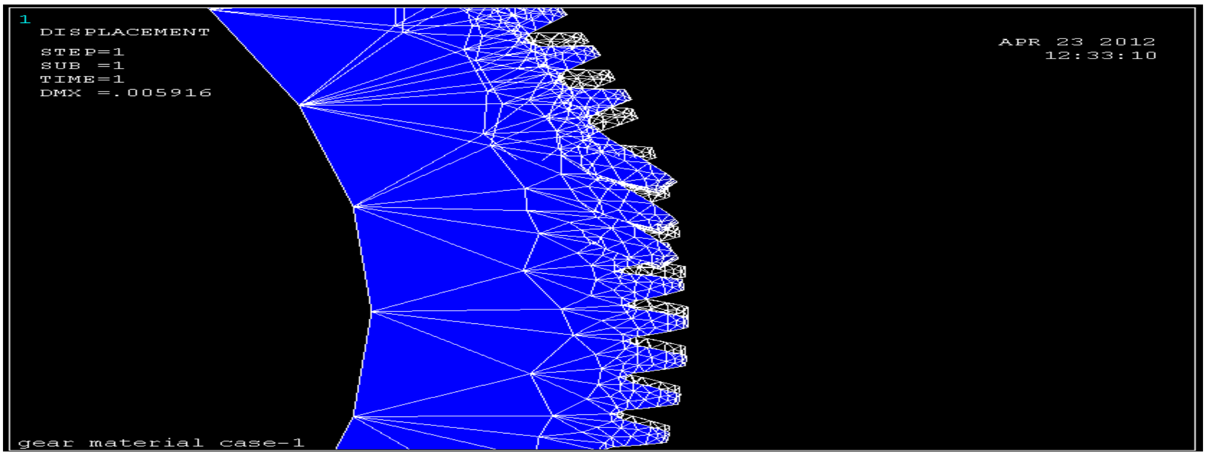

Figure 12: Deformed & Unreformed Plot for Sintered BT-126 Bronze

4. RESULTS AND DISCUSSIONS

Stress analysis of spur gear for these two materials is depicted in Table 1.

Table 1 - Results of ANSYS of stress for two material of Spur Gear [N/mm^2]

Sr. No.	Material	Stress	Strain
1.	S45C Steel, Tempered	171.002	0.000841
2.	Sintered BT-126, Bronze	170.594	0.000819

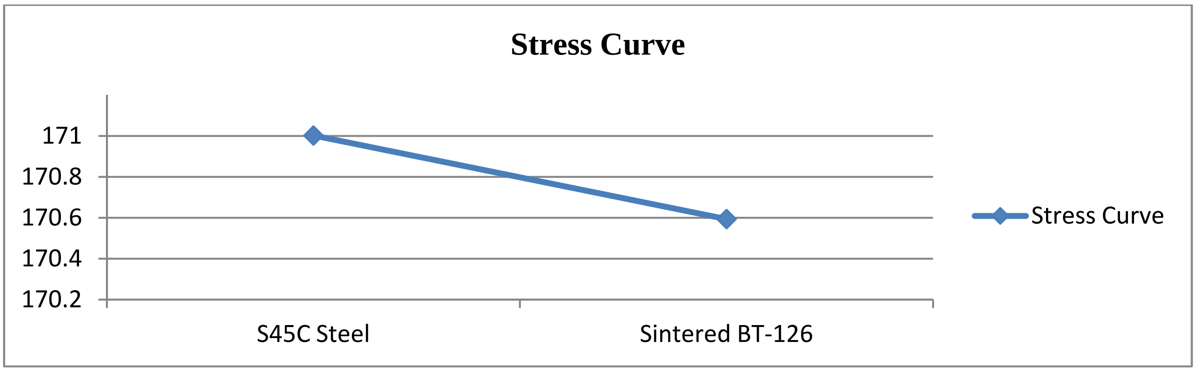

Figure 13: Stress Curve for S45C Steel and Sintered BT-126 Bronze

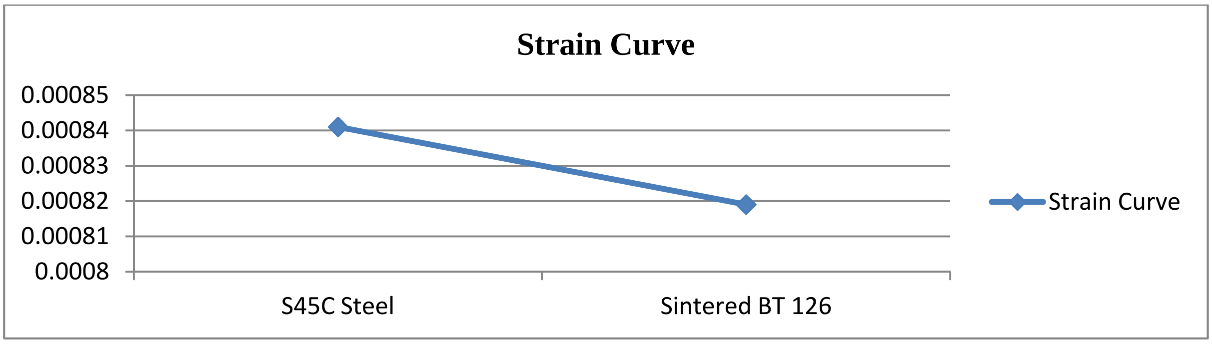

Figure 14: Strain Curve for S45C Steel and Sintered BT-126 Bronze

$$\text{F.O.S.}=\frac{\text{Yield Stress of Gear Material}}{\text{Developed Stress in Gear Material}} \qquad (1)$$

Factor of Safety is calculated for all the materials and S45C steel is found to be suitable for heavy load applications. Table 2 shows the factor of safety for these materials:

Table 2 - Calculated factor of safety

Sr. No.	Material	F.O.S.
1.	S45C Steel, Tempered	2.006
2.	Sintered BT-126, Bronze	1.018

Along with this, Theoretical stress developed is also determined in this paper from the load and net area in contact with the spur gear. Table 3 shows the comparison results:

Table 3 - Comparison of FEA and Theoretical Stress Results [N/mm^2]

Material	FEA Stress	Theoretical Stress	Variation %
S45C Steel, Tempered	171.002	160.507	6.14
Sintered BT-126, Bronze	170.594	160.507	5.19

5. CONCLUSION

After the investigations, the reason of the failure was determined to be associated with the material. It is seen that maximum Von mises stress for different gears are almost same and the effective factor of safety will be criterion for selecting material of gear. It is also observed that, the maximum stress present in gear varies for various material conditions but a little. Strain doesn't have so much impact on the gear, therefore, without considering strain we can concentrate on the factor of safety. It can be concluded that the ANSYS results with the assumption of load seems to be acceptable for all the cases that are considered in this analysis. Now among these two materials for the same loading conditions S45C steel, Tempered can replace Sintered BT126 bronze for the heavy duty gear load applications. As in the results, for the same load conditions maximum developed stress for both the materials are almost same. Hence S45C Steel can replace Sintered BT-126 Bronze for all presently used heavy duty gear load applications and also there will be reduction in the cost with the use of S45C Steel.

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