

# Static Structural Analysis of a Spur Gear used in Lathe Machines using Different Materials on ANSYS

Pawan Kumar Patel<sup>1</sup> Prof. Ranjeet Kumar<sup>2</sup> Dr. R.S. Sikarwar<sup>3</sup>

<sup>1</sup>M.Tech Scholar <sup>2</sup>Guide & Head of Dept. <sup>3</sup>Co-Guide & Director

<sup>1,2</sup>Department of (Machine Design) Mechanical Engineering

<sup>1,2,3</sup>VITS, Bhopal (M.P.), India

**Abstract**— Spur gears are an important part of any mechanical engineering component. These are used in applications of power transmissions between two shafts where centre distance between shafts is very less. Gear drives provide higher efficiency than other type of power transmission drives. These are very sensitive in nature too hence a great degree of care must be taken in order to design gears. Current analysis focusses on comparative analysis of spur gears using different kinds of materials other than conventional material of mild steel so that its performance can be improved. In order to conduct the analysis six different materials Aluminium alloy, Gray Cast Iron, Carbon Fibre, E Glass, Epoxy Carbon & Epoxy E Glass have been used. All these materials have been tested on the basis of contact stress being generated. A CAD model of spur gear has been developed in CATIA V5-6 R2017 and Static Structural Analysis has been performed. This data has been compared with numerically solved data. After validation all the materials have been analysed in ANSYS 19.2.

**Keywords:** Spur Gear, Lathe Machines, ANSYS

## I. INTRODUCTION

Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery. It is possible that gears will predominate as the most effective means of transmitting power in future machines due to their high degree of reliability and compactness. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office automation tools will necessitate a refined application of gear technology.

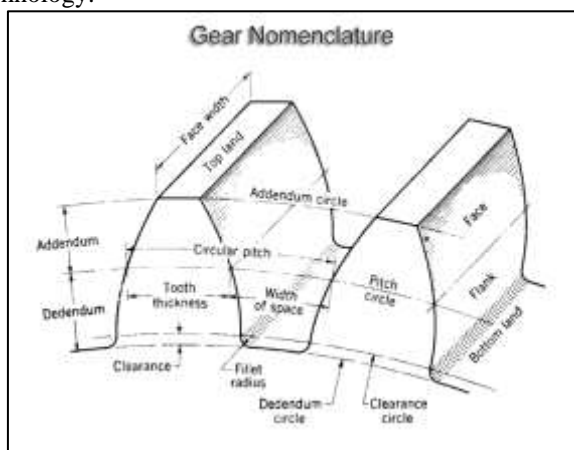


Fig. 1.2: Gear Terminology

Designing highly loaded spur gears for power transmission systems that are both strong and quiet requires analysis methods that can easily be implemented and also provide information on contact and bending stresses, along with transmission errors. The finite element method is

capable of providing this information, but the time needed to create such a model is large. In order to reduce the modelling time, a pre-processor method that creates the geometry needed for a finite element analysis may be used, such as that provided by Pro/Engineer. Pro/Engineer can generate models of three-dimensional gears easily.

While composites have an already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted several innovative manufacturing techniques currently being used the composites industry. It is obvious, especially for composites, that the improvements in manufacturing technology alone is not enough to overcome the cost hurdle.

## II. ANSYS SIMULATION FOR ALTERNATE MATERIALS

In order to begin with the ANSYS analysis of the spur gear following steps will be performed-

- Beginning with the analysis process by selecting the static structural module in ANSYS and renaming it as Spur\_Gear Analysis.
- Selecting various materials using engineering data sources.
- Assign the materials mild steel for analyzing the CAD model
- Meshing the component using default settings. In order to get the better results mesh size was refined to 2 mm.

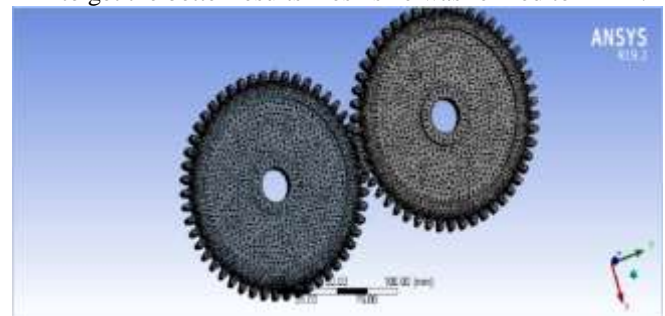


Fig. 1:

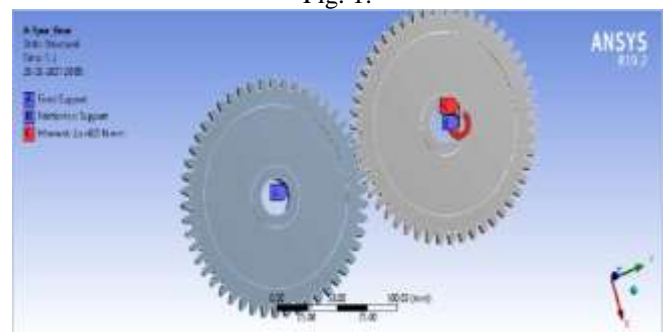


Fig. 2:

- Next step in the analysis is to apply the boundary conditions. One gear was provided with fixed support at

the inner rim. Other was provided with frictionless support which allows the gear to rotate and restricts the rotary motion. Second gear was also equipped with a moment load of 200 N-m

- Solving the analysis for various results which include equivalent stress, maximum principal stress, shear stress, total deformation etc.
- Accessing the report for this particular analysis and interpreting the results.

### III. RESULT ANALYSIS

After analyzing the spur gear in ANSYS, one can clearly see that value of contact stress (Von-Mises stress) for spur gear is 1179.33 MPa, total deformation is 0.00742 mm, maximum principal stress is 108.75 MPa, shear stress is 33.29 MPa and normal stress is 33.29 MPa.

When we compare the value of contact stress obtained by ANSYS analysis with numerically solved problem, it is found that numerically calculated value of contact stress is 171.81 MPa and simulated value is 179.33 MPa. These two values may be taken to approximately equal to each other as any simulation normally has some errors associated with it. Hence, we can say that our ANSYS model is thoroughly validated. This CAD model can now be analyzed further for different types of materials.

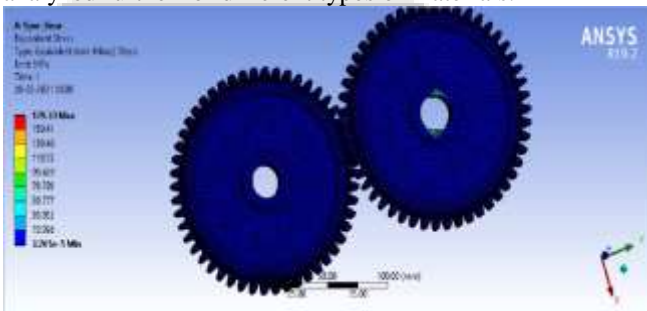


Fig. 3:

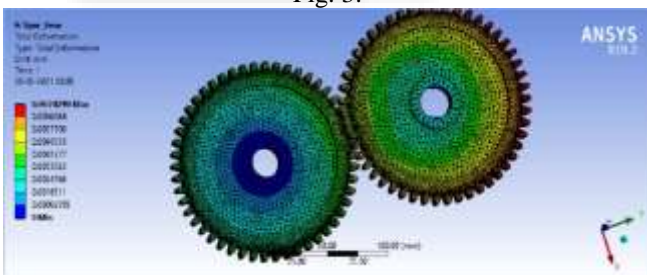


Fig. 4:

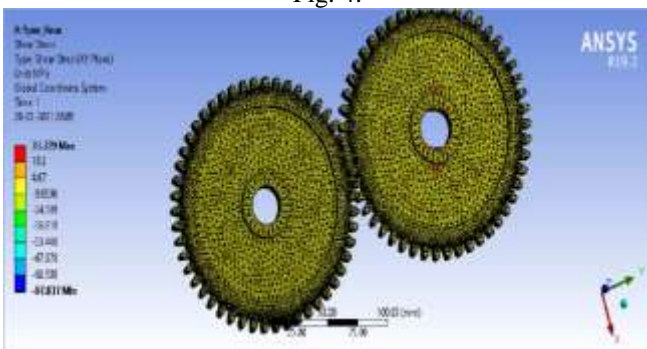


Fig. 5:

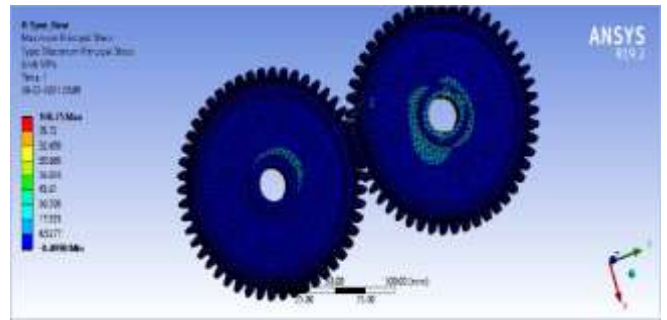


Fig. 6:

In current analysis 6 different materials have been selected for the comparative analysis which include, Gray Cast Iron, Aluminium Alloy, Carbon Fibre, E Glass, Epoxy Carbon and Epoxy E Glass. All these materials are tested against Mild Steel and a comparative analysis is performed among all these materials in order to identify a better suitable material other than Mild Steel. Results for all the materials have been plotted against each other for comparative analysis. Plots are represented here for reference.

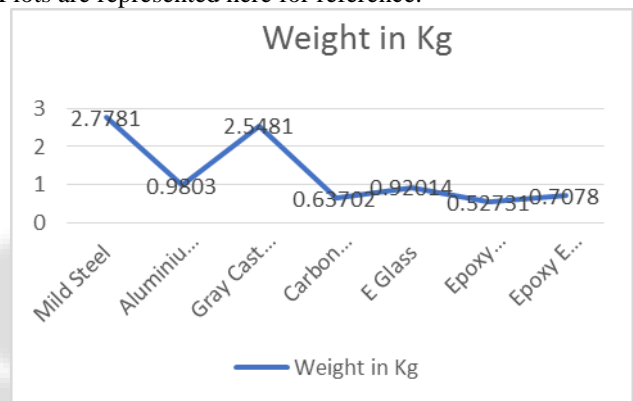


Fig. 7:

The plot of weight for all the materials have been plotted in above figure. Her one can clearly see that for mild steel, the weight of spur gear is 2.7781 Kg which significantly reduces for aluminium alloy and comes down to 0.9803 Kg. It suddenly rises to 2.5481 Kg in case of Gray Cast Iron. After that for all other materials it reduces and comes down to below 1 Kg. Hence this weight comparison plot shows that Aluminium alloy and all other composite materials are better suitable for spur gear according to weight criteria.

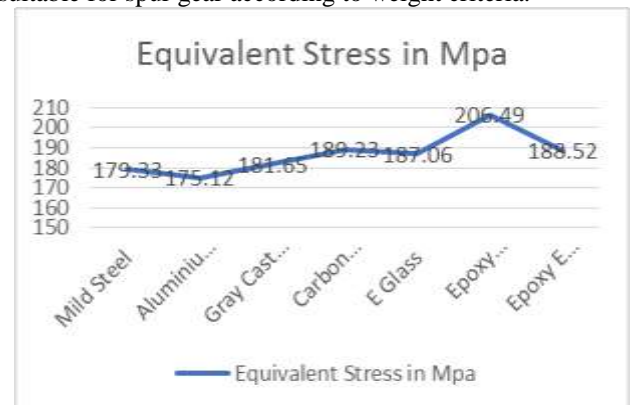


Fig. 8:

The plot of equivalent stress for all the materials have been plotted in above figure. Her one can clearly see that for mild steel, the equivalent stress of spur gear is 179.33 MPa

which significantly reduces for aluminium alloy and comes down to 175.12 MPa. It suddenly rises to 181.65 MPa in case of Gray Cast Iron. After that for all other materials it reduces and raises up to above 181 MPa.

The plot of total deformation for all the materials have been plotted in above figure. Her one can clearly see that for mild steel, the total deformation of spur gear is 0.0074299 mm which significantly increases for aluminium alloy and comes up to 0.020903 mm. It suddenly reduces to 0.013498 mm in case of Gray Cast Iron. After that for all other materials it increases and goes up above 0.020 mm

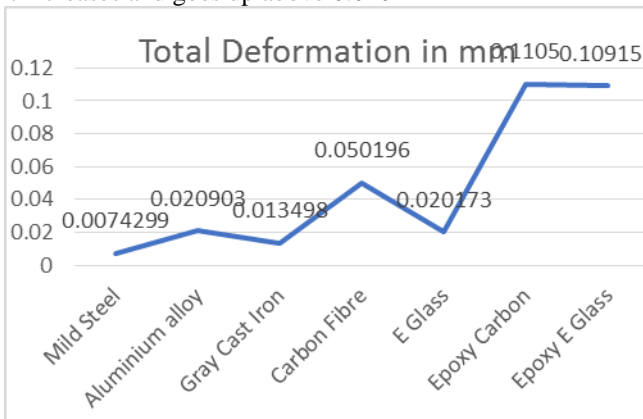


Fig. 9:

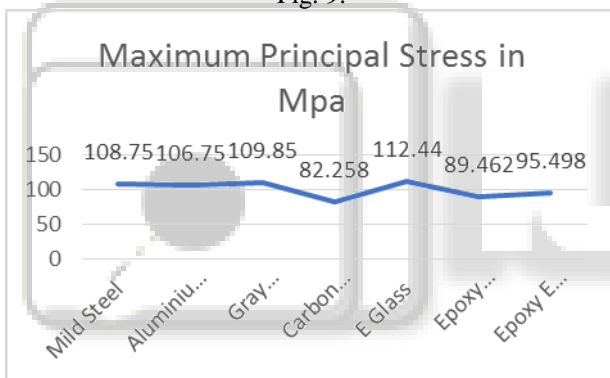


Fig. 10:



Fig. 11:

The plot of maximum principal stress for all the materials have been plotted in above figure. Her one can clearly see that for mild steel, the maximum principal stress in case of spur gear is 108.75 MPa which significantly reduces for aluminium alloy and comes down to 106.75 MPa. It suddenly rises to 109.85 MPa in case of Gray Cast Iron.

After that for all other materials it reduces and comes down to below 110 Kg.

The plot of shear stress for all the materials have been plotted in above figure. Her one can clearly see that for mild steel, the shear stress of spur gear is 33.729 MPa which narrowly reduces for aluminium alloy and comes down to 33.453. It slightly rises to 33.867 MPa in case of Gray Cast Iron. After that for all other materials it reduces and comes down to below 30 MPa except E Glass.

#### IV. CONCLUSIONS

After analysing the data all along until now following concluding points can be pointed out-

- Weight is reducing for aluminium alloy and all other composite materials which shows that these all may be used for designing spur gears.
- Total deformation is increasing in case of aluminium alloy but it will not affect adversely if we use aluminium alloy and other composite materials because the deformation incurred is less than even 0.1 mm.
- Maximum principal stress is also reducing for aluminium alloy and other materials when compared to conventional material.
- Equivalent stress reduces significantly when aluminium alloy is used.
- Shear stress and normal stress are also reducing when compared with conventional material.

#### REFERENCES

- [1] Husaini, Dzika M. Dawud, Teuku Edisah Putra, and Nurdin Ali. Failure Analysis of Spur Gears Used in Transmission System Applied on a Hand Tractor Key. *Engineering Materials Submitted: 2019-08-07 ISSN: 1662-9795, Vol. 841, pp 144-149*
- [2] V. A. Gavali, C. P. Satav. Review Paper on Analysis of Spur Gear. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, e-ISSN: 2278-1684, p-ISSN: 2320-334X PP. 04-07
- [3] Fatmir Azemi, Bekim Maloku, Musaj Terbutnja. A Review on Design, Analysis and Shape Optimization of Spur Gears of The Gear-Box Reduction of The Working Wheel of The Excavator Schrs 1300 24/5.0 Using CAD/CAE Software. *International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume- 4, Issue-7, Jul.-2016.*
- [4] G. C. Mohan Kumar, Bilal Basheer, Sanjay Sutar, and Mrityunjay Doddamani. Material optimization of spur gear tooth. *Cite as: AIP Conference Proceedings 2247, 020020 (2020) Published Online: 16 July 2020*
- [5] Putti Srinivasa Rao, Nadipalli Sriraj, Mohammad Farookh. Contact Stress Analysis of Spur Gear for Different Materials using ANSYS and Hertz Equation. *International Journal of Modern Studies in Mechanical Engineering (IJMSME) Volume 1, Issue 1, June 2015, PP 45-52*
- [6] Elsayed S. Aziz, C. Chassapis. An Intelligent System for Spur Gear Design and Analysis. *Conference Paper · September 2001 DOI: 10.1115/DETC2001/DAC-21037*
- [7] Deepika Potghan, Prof. Suman Sharma. Stress Reduction by Introducing Stress Relieving Features of Spur Gear

- Used in Lathe Headstock. ISSN: 2277-9655 (I2OR), Publication Impact Factor: 3.785, August 2015
- [8] Dr. D. M. Mate, Guide, D.Y.P.C.O.E & T. Ambi. An Investigative Study of Spur Gear Failure by FEA and Photoelastic method. *International Engineering Research Journal* Page No 746-751
- [9] Prafulla M. Chor, Dr. Priam Pillai, M. E. Machine Design, PHCET. Spur Gear Contact Stress Analysis and Stress Reduction by Experiment Method. *International Journal of Engineering Research and General Science* Volume 3, Issue 3, May-June, 2015 ISSN 2091-2730
- [10] Xiaohe Deng, Lin Hua, and Xinghui Han. Research on the Design and Modification of Asymmetric Spur Gear. *Hindawi Publishing Corporation Mathematical Problems in Engineering* Volume 2015, Article ID 897257, 13 pages.
- [11] Miss. Kachare Savita. A Comparative Study of Design of Simple Spur Gear Train and Helical Gear Train with An Idler Gear by Agma Method. *International Journal of Innovation in Engineering, Research and Technology [IJERT] ICITDCEME'15 Conference Proceedings* ISSN No - 2394-3696
- [12] Ms. Nilescha U. Patil, Mr. Sunil P. Chaphalkar, Mr. Gajanan L. Chaudhari. Stress Analysis of Spur Gear by using Different Materials: A Review. *International Conference on Ideas, Impact and Innovation in Mechanical Engineering (ICIIME 2017)* ISSN: 2321-8169 Volume: 5 Issue: 6 355 – 363
- [13] Fatih Karpat, Oguz Dogan, Celalettin Yuce and Stephen Ekwaro-Osire. An improved numerical method for the mesh stiffness calculation of spur gears with asymmetric teeth on dynamic load analysis. *Advances in Mechanical Engineering* 2017, Vol. 9(8) 1–12 The Author(s) 2017 DOI: 10.1177/1687814017721856
- [14] Sameer Chakravarthy N C and B Subbaratnam. Finite Element Analysis and Fatigue Analysis of Spur Gear Under Random Loading. ISSN 2278 – 0149 *www.ijmerr.com* Vol. 3, No. 4, October 2014 © 2014 IJMERR.
- [15] P.B. Pawara, Abhay A Utpatb. Analysis of Composite Material Spur Gear under Static Loading. *Condition Materials Today: Science direct, Proceedings 2 (2015)* 2968 – 2974.