1. "PERFORMANCE INVESTIGATION OF A SPUR GEAR WITH COMPOSITE MATERIAL USING FEA"

Chaudhri Dhiren[1], *Prof D.A. Patel*[2]
student[1], *Assistant Professor* [2]
Department of M.Tech mechanical Engineering[1,2]
Sanckalchand Patel University, Visnagar , Gujrat, India[1,2]

Abstract

Gear Is A Rotating Circular Machine Part Having Cut Teeth Or, In The Case Of A Cogwheel Or Gearwheel, Inserted Teeth, Which Mesh With Another (Compatible) Toothed Part To Transmit (Convert) Torque And Speed. In The Conventional Material Gear Are Most Frequently Used In Industry, But Now Days Composite Material Used In Gear Manufacturing. Composite Material Are Effective Mechanical Properties Compare To The Conventional Material. Composite Materials Provide Adequate Strength With Weight Reduction And They Have Emerged As A Better Alternative For Replacing Metallic Gears. In This Work Metallic Gears Of Steel Alloy, Aluminium Silicon, Cast Alloy Steel, Silicon Nitride Composite Have Been Manufactured. Composites Provide Much Improved Mechanical Properties Such As Better Strength To Weight Ratio, More Hardness, And Hence Less Chances Of Failure. So This Work Is Concerned With Replacing Metallic Gear With Composite Material So As To Improve Performance Of Machine And To Have Longer Working Life. Composite Gears Offer Improved Properties Over Conventional Material And These Can Be Used As Better Alternative For Replacing Metallic Gears. In our Research we use four composite material like silicon nitride, cast alloy steel, alloy steel, AL-SIC and another material which have compare phosphorus bronze material. Mainly I was used Lewis theory to design a gear. And compare to each other beam strength and using a simulation software. And compare the result of each material.

Keywords: *module, composite materials, beam strength, factor of safety, spur gear*

1. Introduction

Gears are the most important components in modern mechanical engineering world. The use of gears has more common in all the industries. The advantages of spur gear are simplicity in design and can be manufactured easily, economically and less maintenance. Spur gears are one of the most popular types of precision cylindrical gears. These gears feature a simple design of straight, parallel teeth positioned around the circumference of a cylinder body with a central bore that fits over a shaft. In many variants, the gear is machined with a hub which thickens the gear body around the bore without changing the gear face. The central bore can also be broached as to allow the spur gear to fit onto a spline or keyed shaft at present scenario composite gears plays an important role in wide space of research especially in gear motors, gear pumps, electromechanical actuators and drive shafts for car etc. Composite gears have better

mechanical characteristics like wear resistance, corrosion resistance, lubricant free, noiseless, high strength to weight ratio. In this work composite, polymer and steel gears are taken to perform the analysis on different speed conditions. The Stress distributions, deformations and strains were obtained using finite element analysis software.

2. Literature review

P.B.Pawara, Abhay A Utpatb [1] has study on "Analysis of Compos item Material Spur Gear under Static Loading Condition" in 2015. Spur gears are the simplest and widely used in power transmission. In recent y ears it is required to operate machines at varying load and speed. Gear teeth no really fail when load is increased above certain limit. Therefore it is required to explore alternate materials for gear manufacturing. Composite materials prove ide adequate strength with weight reduction and they have emerged as a better alternative for replacing metallic gears. In this work metallic gears of steel alloy and Aluminium Silicon carbide composite have been manufactured. • Composites provide much improved mechanical properties such as better strength to weight ratio, more hardness, and hence less chances of failure. So this work is concerned with replacing metallic gear with composite material so as to improve performance of machine and to have longer working life. .

Bharat N. Bakshe and S.R. Patil [2] has study on "Contact stress analysis of steel and composite spur gear pairs" in 2018 .The density of composite gear is 2580 kg/m3 as compared to 7850 Kg/m3 of steel gear. Thus the weight is reduced by almost 3 times by the use of composite gears. • The Aluminium silicon carbide and fly ash composite material is having less weight and more strength; It is very much useful in practical aerospace applications. • It was found that the results from both Hertz equation and FEA are comparable with the experimental strain gauge technique. The results are well within the difference of 10%.

S.Vishwakarma, S. Sharmand, Rajiv Arya [4] has study on "STRUC TURAL ANALYSIS OF SPUR GEAR USING FEM" in 2017. This project work focuses three dimensional spur gear analyses under static conditions. The purpose of three-dimensional analysis is to predict the gear behaviour on real operating conditions. • In the static analysis, gear is fixed and rotational load is applied on pinion. In dynamic analysis of gear both gear and pinion are allowed to rotate in opposite direction on time basis. • From analysis it is proved as per theory that once the gear meshes and stars to rotate they are subjected to maximum deformation. The total deformation of Spur Gear has been observed 3.253 mm. • The Directional deformation of Spur Gear has been observed, its value is 3.2 7mm The Equivalent stress (von-misses stress) of Spur Gear has been observe d, its maximum value is 976.16 Mpa.

Belarhzal Samya, El Mostapha Boudi, Aziz Bashir, Yassin Amadanee[13] has study on Analysis of Profile Shift Factor's Effect on Bending g Stress of Spur gears Using The Finite Element Method in 2020 In spur gears, the shape of the teeth is purely related to the bending and contact t stress. The bending stress is calculated using the LEWIS approach and ISO equation for standard steel material. The results obtained are compared and vial ideated by the Finite Element Method (EFM) using ANSYS Workbench software. The bending stress analysis is done with three models of spur gears, using the same number of teeth (Z=24), the same pressure angle (α=20°), and the same module (m=2.5). However, the Profile Shift Factor x is different for each geometry, x=0, x=0,1, and x=0,2. The maximum bending stress generated on the root of the spur gear teeth depends directly on the Profile Shift Factor value when it changes from 0 to 0,2, the bending stress generated by ANSYS Workbench decrease by 7%, from σ ANSY S=89,595 MPa to σ ANSY S=83,95 MPa, and the theoretical results drops by 5%, from σ ISO=81,945 MPa to σ ISO=77,79 MPa. In other words, the higher the Profile Shift Factor of the spur gear teeth is, the lower the bending stress on the tooth root can be, which is very interesting in terms of minimizing the pitting failure, raising the life period of the material and reduce risks of complete systems damage.

3. Design Of Gear

Lewis took the application of load to be at the tip of the tooth. In his day, even the best gear were not very accurate. This meant that the load was usually carried by a single tooth instead of being shared between two teeth on a gear. If a single tooth carried full load, it is obvious that the greatest stress would occur when the tooth had rolled to a point at which the tip was carrying the load.

Sr.no	Material name	Beam Strength	Effective load	Factor of safety
1.	Phosphorus Bronze gear	4805.33 N	4389.21 N	1.09
2.	AL-SIC gear	5808.33 N	4219.99 N	1.37
3.	Alloy steel	5545.46 N	4525.58 N	1.22
4.	Cast Alloy Steel	6219.73 N	4970.53 N	1.25
5.	Silicon Nitride	5355 N	5542.47 N	0.96

Table 1. Gear Design

4. Finite modelling of spur gear

Models for numerical analysis have been prepared in solid works 2020 and these have been imported into simulation as .sldprt files for further analysis. Figure 3 shows FE analysis of gears for which model has been generated according to geometric dimensions obtained by calculation. The proportions of gear obtained from theoretical analysis have been used for preparing geometric model of gear. The condition for analysis has been assumed as static. For FEA analysis of gear manufactured from composite Young's modulus is calculated theoretically and Young's Modulus and Poisson's ratio for alloy steel have been taken from design data book & web site.

Material property	AL-Sic	Alloy Steel	Cast Alloy steel	Silicon nitride	Phosphor bronze
Young's modulus	80 Gpa	210 Gpa	190 Gpa	297 Gpa	117 Gpa
Poisson ratio	0.34	0.28	0.26	0.27	0.341
Ultimate tensile strength N/mm^2	205	723.82	448.0825	525	265

Table 2. Material property

Bending stress in gear is calculated theoretically from the equation; Sb = m.b.σ_b.Y

Following results have been obtained for above the materials. Von Misses Stress Plots for different Forces But it should same because of area and BC's are same for all five materials. Von misses stress and displacement values have been obtained for different values of tangential force and Meshing used for FEA and von misses stress force has been shown in Fig.2. Tangential force has been applied at the tip of tooth and von misses stress, displacement has been obtained for different force magnitudes. Von misses stress plots have been obtained for different forces but its magnitude should same because of area and boundary conditions are same for all three materials.

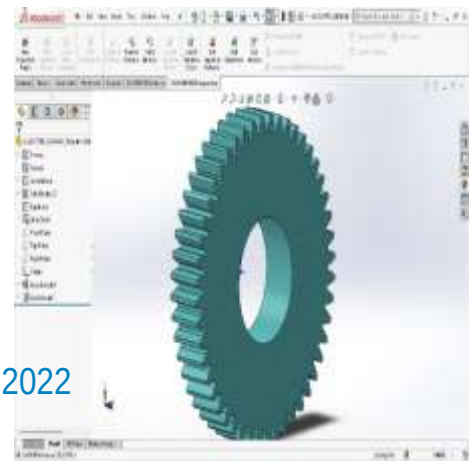

Figure 1. CAD Model of Spur Gear

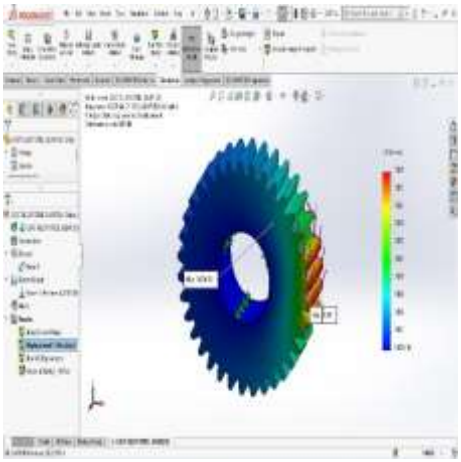

Figure 2. Analysis of Spur Gear

5. Conclusion

SR. NO	Material	Beam Strength	Von Misses Stress		Displacement	
			Max.Value	Min.Value	Max.Value	Min.Value
1	Phosphor Bronze	4805.33 N	353.167	0.003	0.00603	0.0603
2	AL-sic	5808.33 N	141	14.1	0.004	0.040
3	Cast Alloy steel	5545.46 N	308	0.00255	0.003	0.028
4	Alloy steel	6219.73 N	456.435	0.003	0.033	0.007
5	Silicon nitride	5355 N	222	0.00301	0.022	0.002

Table 3. Analysis Difference

From the above results, it is observed that the cast alloy steel gears are more effective beam strength compare to another four material. But effective load are less in AL-

SIC.Hence widely used in automobiles. It offers maximum factor of safety without compromising bending strength.

From the above post design summary, it is observed that the Silicon Nitride has lowest beam strength as well as lowest factor of safety in comparison with the other material used for gear manufacturing such as Phosphorous Bronze, Al-SIC gear, Alloy Steel and Cast Alloy Steel whereas cast alloy steel has beam strength 6219.73 N with factor of safety 1.25 and Al-Sic has beam strength 5808.33 N with factor of safety 1.37. Hence it is recommended to use Al Sic gear for automotive and industrial use in comparison with other conventional and composite materials.

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