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FINITE ELEMENT ANALYSIS OF COMPOSITE SPUR GEAR FOR CONTACT STRESS

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ABSTRACT

Gear is one of the most critical component in a mechanical power transmission system and in most industrial rotating machinery. New gear design is needed because of the increasing performance requirement. Contact stress refers to the localized stresses that develop as two curved surfaces come in contact and deform slightly under the imposed loads. Also due to contact stresses wear takes place at gear tooth. Consequently tooth thins down and gets weakened. Material in the fatigue region gets removed and a pit is formed. Conventional materials like Steel, Brass, and Aluminium etc will fail without any indication. To overcome this problem, conventional materials are replaced by Aluminium alloy materials. Aluminium alloy materials found to the best alternative with its unique capacity of designing the materials to give required properties. In this work, Aluminium Silicon Carbide is used as a gear material.

Keywords: ANSYS16.0, Contact Stress, Finite Element Analysis, Hertz Equation, Spur Gear

I INTRODUCTION

The rapid growth of heavy industries such as vehicle, shipbuilding and aircraft industries require extensive application of gear technology. Spur gear is a cylindrical shaped gear in which the teeth are parallel to the axis. Spur gears are easy to manufacture and it is mostly used to transmit power from one shaft to another shaft up to certain distance & it is also used to vary the speed & Torque. e.g. Watches, gearbox etc. The replacement cost of of spur gear is very high and also the system down time is one of the effect in which these gears are part of system. Failure of gear causes breakdown of system which runs with help of gear. E.g. automobile vehicle. So it becomes very important to increase the strength of gear to avoid the failure

Composites provide much improved mechanical properties such as greater strength to weight ratio, increase in hardness, and hence less chances of failure. So this work is concerned with replacing metallic gear with gear of composite material of Aluminium Silicon Carbide so as to improve performance of machine and to have longer working life. P.B. Pawar has developed a metal matrix composite of Aluminum based Silicon Carbide [1]. The composition of Silicon Carbide is varied in Aluminum and mechanical tests were performed. They proposed to use

this material for power transmitting element like gears. Author P.B. Pawar has manufactured the spur gear from composite material of Aluminum Silicon Carbide. He has done FEA using Ansys 14.0 and concludes that composite gears offer improved properties over steel alloys and can be used as alternative for replacing metallic gears [2]. Neelima Devi and co authors worked on the mechanical characterization of Aluminum Silicon Carbide [3]. They found that the weight to strength ratio for composite is about three times that of mild steel and it is two times less in weight than aluminum of same dimension. Seok-Chul Hwang presents a contact stress analysis for tooth in contact of gears during rotation [4]. Contact stress analysis for spur and helical gears is carried out between two gear teeth at different contact positions during rotation. The variation of contact stress values during rotation is compared with the values of contact stress at the lowest point of single tooth contact. Ali Raad Hassan has developed a program to plot paired teeth in contact [5]. This program was run each 30 of rotation of pinion to create 10 cases. The program gave graphic results for different FE models and stress analysis was carried out in ANSYS. Sushil Kumar Tiwari found out the contact stress and bending stress for involute spur gear teeth in meshing by finite element method and the results are checked with those obtained by Lewis formula, Hertz equation and AGMA/ANSI equations [6]. They observed that Hertz theory is the primary basis of contact stress calculation and for determining bending stress in a pair of gear, Lewis formula is used. Vivek Karaveer has done the modelling of FEA of spur gear using ANSYS 14.5. He has compared the stress values and deformation for steel and grey cast iron [7].

II DESIGN OF GEAR

The material properties of steel and Aluminium Silicon Carbide composite are given in the table 1.

TABLE 1

MATERIAL PROPERTIES OF GEAR MATERIALS

Material Property	Steel	AlSiC
Young's Modulus	210 GPa	150 GPa
Poisson's Ratio	0.3	0.3
Ultimate tensile strength N/mm^2	200	151

The comparative study of steel gear and composite gear is done. So the basic design of spur gear is same for both the gears. The various parameters of gear design are given in the table below.

TABLE 2

GEAR DESIGN PARAMETERS

Parameter	Gear Pair
No. of teeth	20
Gear Ratio	1
Module	4.5
Pressure angle	20
Pitch diameter	90
Face width	45
Center Distance	90
Torque (Nm)	302
Speed (rpm)	1000

III FINITE ELEMENT ANALYSIS

Finite Element Method is the easy technique as compared to the theoretical methods to calculate the stress developed in teeth of gears. Therefore FEM is widely used for the stress analysis of mating gears. FE analysis is done in ANSYS Workbench 16.0 to determine the maximum contact stresses for steel and composite material. Also the deformation is found out for both the gears. CAD model of gear is created in CREO 2.0. It is imported as a IGES file in ANSYS 16.0.

Fig. 1. CAD Model of Gear

3.1 Meshing

Meshing is done using Hexagonal mesh with number of elements of 499900 and number of nodes of 2125654. The element size is 0.8 mm. This mesh is used as it is fine and gives least number of elements with good results. So the

calculation time is reduced.

Fig.2. Mesh Model of gear

3.2 Boundary Conditions

Fixed support is applied on inner rim of the gear. Frictionless support is applied on the inner rim of pinion to allow its tangential rotation. Moment of 302Nm is applied on the surface of second gear.

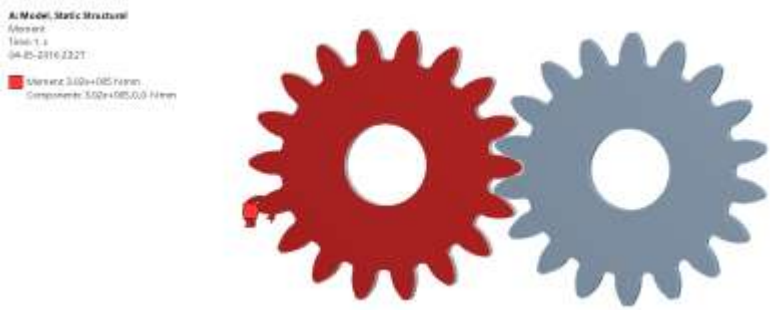

Fig. 3. Boudary Conditions of Ansys

IV RESULT AND DISCUSSION

Contact stress for steel and aluminium silicon carbide is calculated in ANSYS 16.0. Figure 4 shows the contact stress for steel which gives a stress of 52.14 MPa. Figure 5 shows contact stress for composite gear which gives a stress value of 39.18 MPa. Figure 6 presents the comparison of stress of steel and composite gear in bar chart form.

Fig. 4. Stress Diagram of Steel

Fig. 5. Stress Diagram of Aluminium Silicon Carbide

Percentage difference of stress for steel and composite material using analytical method and FEA is calculated. It is shown in table 3.

TABLE 3

PERCENTAGE DIFFERENCE BETWEEN ANALYTICAL AND FEA

	Steel	Composite Material	% Reduction in Stress
FEA Method	52.14	39.18	24.87

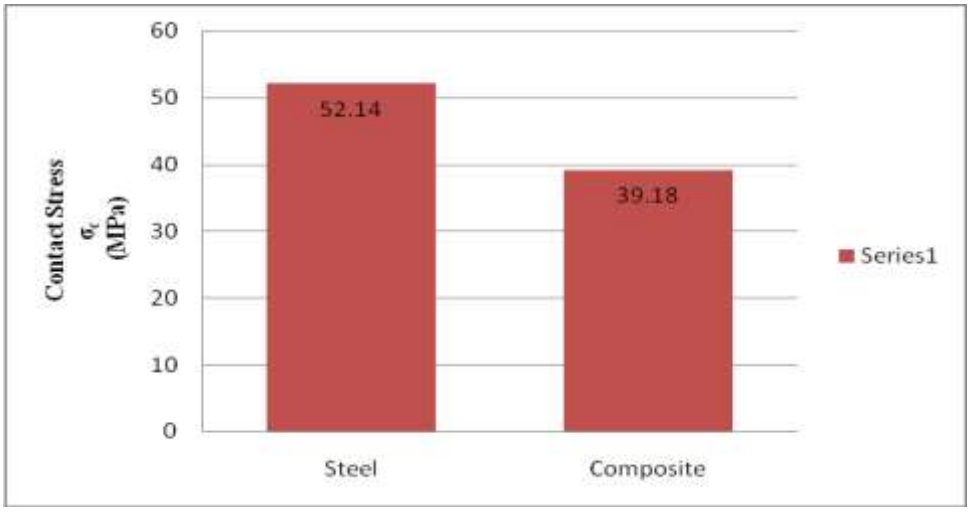

Fig. 6 Contact Stress comparison of steel and composite material

V CONCLUSION

Here the theoretical maximum contact stress is calculated by Hertz equation. Also the FE analysis of spur gear is done to determine the maximum contact stress by ANSYS 16.0. It was found that the results from both Hertz equation and Finite Element Analysis are comparable. It is observed that stress is reduced by nearly 25% due to the use of composite material.

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