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Detailed Contact Analysis of Spur Gear

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***Abstract*— FEA model could be used to simulate contact between two bodies accurately by verification of contact stresses between two spur gears in contact. These results reveal that Maximum allowable Contact Pressure and Von Mises Stresses on involute pair of spur gear teeth. Both analytical and ANSYS results follow same trend. At the end of the contact, the stress increased suddenly to a high value almost close to the maximum value, at this stage a sliding was occurred in the contact region at the maximum stress points.**

***Index Terms*—FEA model, Maximum Allowable Contact Pressure, Von Mises Stresses .**

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.

A gearbox as usually used in the transmission system is also called a speed reducer, gear head, gear reducer etc., which consists of a set of gears, shafts and bearings that are factory mounted in an enclosed lubricated housing. Speed reducers are available in a broad range of sizes, capacities and speed ratios. In this analysis, the characteristics of involute spur gears in a gearbox was studied using nonlinear FEM.

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. In the automobile industry, the largest manufacturer of gears, higher reliability and lighter weight gears are necessary as lighter automobiles continue to be in demand. In addition, the success in engine noise reduction promotes the production of quieter gear pairs for further noise reduction. Noise reduction in gear pairs is especially critical in the rapidly growing field of office-automation equipment as the office environment is adversely affected by noise, and machines are playing an ever widening role in that environment. Ultimately, the only effective way to achieve gear noise reduction is to reduce the vibration associated with them. The reduction of noise through vibration control can only be achieved through research efforts by specialists in the field.

The material used for the manufacture of gears depends upon the strength and service conditions like wear, noise etc. The gears may be manufactured from metallic or non-metallic materials. The metallic gears with cut teeth are commercially obtainable in cast iron, steel and bronze. The nonmetallic materials like wood, rawhide, compressed paper and synthetic resins like nylon are used for gears, especially for reducing noise.

The cast iron is widely used for the manufacture of gears due to its good wearing properties, excellent machinability and ease of producing complicated shapes by casting method. The steel is used for high strength gears and the steel gears are usually heat treated in order to combine properly the toughness and tooth hardness.

[1] presents the stress analysis of mating teeth of spur gear to find maximum contact stress in the gear teeth. The results obtained from Finite Element Analysis (FEA) are compared with theoretical Hertzian equation values. For the analysis, steel and Grey cast iron are used as the materials of spur gear. The spur gears are sketched, modeled and assembled in ANSYS Design Modeler. As Finite Element Method (FEM) is the easy and accurate technique for stress analysis, FEA is done in finite element software ANSYS 14.5.

[2] presented a paper to suggest that, thorough study of contact stress developed between the different matting gears are mostly important for the gear design. They used Hertz‟s equations which are current analytical methods of calculating gear contact stresses, originally derived for contact between two cylinders. So for contact stress they developed and determined appropriate models of contact elements, and calculated contact stresses using ANSYS and compared the results with Hertzian theory. Conclusions suggest that with increasing in module, contact stresses decreases for a pair of spur gears.

II. CONTACT ANALYSIS OF SPUR GEAR

Once the geometry is attached with static structural analysis tab, we have must define the contact between the two involute teeth. One of the most important things is to change the Interface Treatment to Adjust to Touch. This is helping us to define the kind of contact between the selected bodies.

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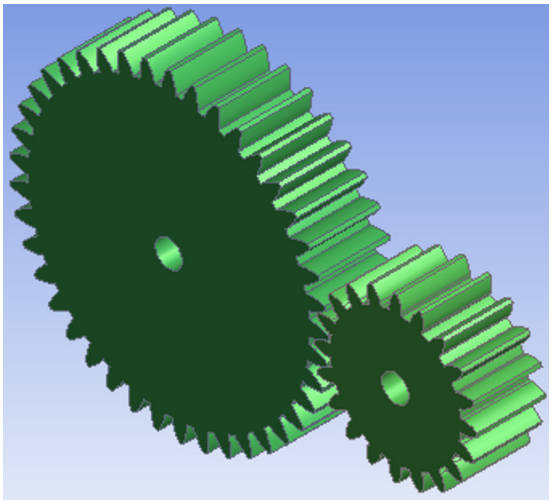

Fig.1. Spur Gear Model Imported in ANSYS

A SOLID 186 (20 nodes tetrahedron) solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elasto-plastic materials, and fully incompressible hyper elastic materials. Boundary condition refers to the external load on the border of the structure. Fig.2. shows the Mesh model of the spur gear.

No of Total Nodes 20411;
No of Contact Elements 204;
No of Solid Elements 3560; No of Elements 3765

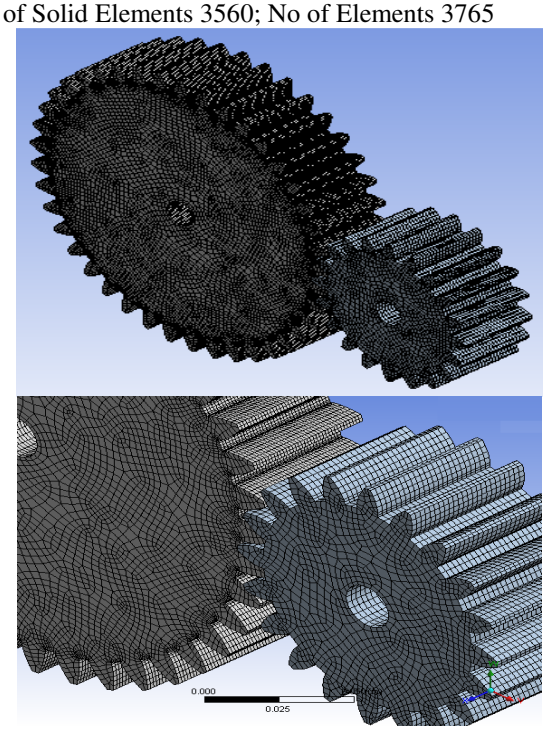

Fig.2. Spur Gear Mesh Model

Once the geometry is attached with static structural analysis tab, we have must define the contact between the two involute teeth; ANSYS has in built option, which automatically reads the attached geometry for any predefined contacts or other boundary definitions. Depending on the loads, materials, and boundary conditions, along with other factors, surfaces can come into and go out of contact with each other in a largely unpredictable manner. Secondly, most contact problems need to account for friction.

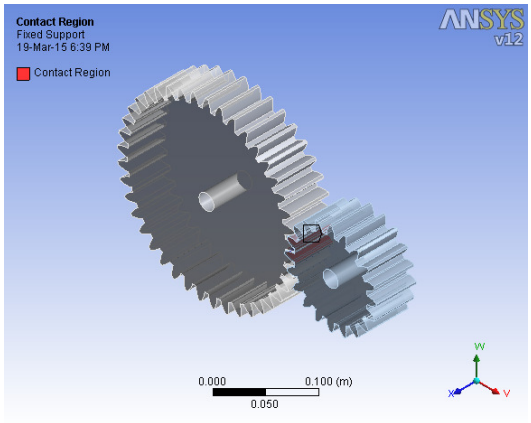

Fig.3. Contact region of the spur gear.

The modeling of friction is very difficult as the friction depends on the surface smoothness, the physical and chemical properties of the material, the properties of any lubricant that might be present in the motion, and the temperature of the contacting surfaces. Figure 4.3 shows the contact region of the spur gear.

One of the most important things is to change the “Interface Treatment” to “Adjust to Touch” This is helping us to define the kind of contact between the selected bodies. Despite the importance of contact in the mechanics of solids and its engineering applications, contact effects are rarely seriously taken into account in conventional engineering analysis, because of the extreme complexity involved. Mechanical problems involving contacts are inherently nonlinear. Figure 4.4 shows the zoom model of contact region of the spur gear.

III.RESULTS AND DISCUSSION

Fig.4. shows the Contact stresses for a pair of mating spur gears are calculated for module. Those spur gears are taken from rock crusher drives which are made of C 45 alloy steel material. Contact stresses obtained in Analytical calculations and analysis in ANSYS for module is given below. The maximum contact stress value for this model was 699 MPa.

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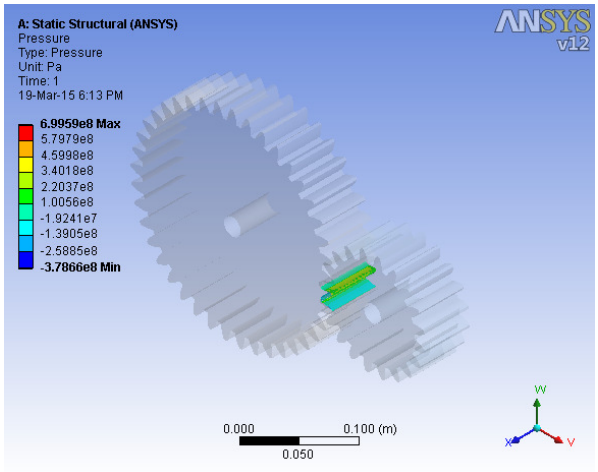

Fig.4. Contact stresses

TABLE – I
COMPARISON OF RESULTS

Parameters	Analytical Values	ANSYS Values	% of error
Contact Pressure (MPa)	702.97	699.59	0.48
Von Mises Stress (MPa)	75.15	74.75	0.53

Table 5.1 shows the comparison of Analytical and ANSYS values.

IV. CONCLUSION

FEA model could be used to simulate contact between two bodies accurately by verification of contact stresses between two spur gears in contact. These results reveal that Maximum allowable Contact Pressure and Von Mises Stresses on involute pair of spur gear teeth. Both analytical and ANSYS results follow same trend. At the end of the contact, the stress increased suddenly to a high value almost close to the maximum value, at this stage a sliding was occurred in the contact region at the maximum stress points.

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