An Analysis of Effect on Surface Roughness & Their Dynamic Properties and Performance on Interface Material Contact Stress Area for Vehicles Engine Rubber Mount

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Abstract: *The first model of contact surfaces for the two rough surfaces was developed by Greenwood and Williamson. Using these rough surfaces the contact area and contact stresses for an interface material were determined. The present work focuses on developing new model, in order to determine the contact area and the contact stresses for a passenger car engine rubber mounts with reference to the model developed by Greenwood and Williamson. The mathematical model employed to represent the vehicle incorporates wheel rotational degrees of freedom and relationships expressing the longitudinal and lateral tire shear force components as analytical functions of tire normal load, sideslip and inclination angles, and longitudinal slip. The results obtained from the ANSYS software are compared with Greenwood Williamson results. Any rubber mount surfaces can be characterized as more or less randomly rough and these surfaces are used by technologists in their automotive sector. Usually some irregularities will be present in all solid surfaces. On account of this the contact between any two surfaces is Discontinuous and the real area of contact is a small fraction of the nominal contact area. In addition to contact area and contact stresses, the effect of orientation, surface roughness and interface material on contact area and contact stresses are also determined. APDL commands are used to create the program in the ANSYS*

Key words*: Orientations, APDL, Surface roughness, Contact stress, ANSYS.*

I. Introduction

Any rubber mount surfaces can be characterized as more or less. Contact between surfaces is thus discontinuous and the real area of contact is fraction of the nominal contact area. The stiffness of a rough surface layer thus influences the contact state as well as the behavior of the surrounding system. Microscopic and macroscopic irregularities are present in all practical solid surfaces. Surface roughness is a measure of the microscopic irregularity, whereas them a microscopic errors of form include flatness deviations, waviness and for cylindrical surfaces, out of roundness. Two solid surfaces apparently in contact, therefore, touch each other only at a few individual spots as in figure 1.

It is now well recognized that bearing surfaces are microscopically rough. Thus high spots on the contacting surfaces can directly contact each other, deforming elastically and plastically with critical consequences to the fatigue life, friction and wear behavior of the bearings of which they are a part. When real surfaces are pressed together they touch at a large number of high spots which deform elastically or plastically to form micro contact areas. An analysis is made of the influence of tire-mechanics characteristics on the behavior of an automobile undergoing maneuver requiring the tires to produce combined longitudinal and lateral forces. The results show that the contact stress is changing with orientations and actual area of contact changes with surface roughness. These results also were useful in the future to minimize the stresses and in possible to minimize vibration in-between chassis frame and engine. Hence we conclude that the theoretical calculation results are valid with ANSYS results

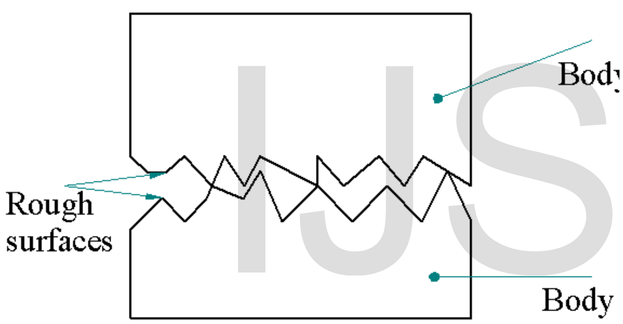

Figure 1: Two surfaces in contact

II. A Brief Introduction about Rough Surface

Nominal surface:

Representing the intended surface contour of the part, are defined bylines in the engineering drawing. The nominal surfaces appear as absolutely straight lines, ideal circles, round holes, and other edges and surfaces that are geometrically perfect.

Actual surfaces:

Actual surfaces of a part are determined by the manufacturing processes used to make it. The variety of processes results in wide variations in surface characteristics, and it is important for engineers to understand the technology of surface. The most commonly used measure of surface texture is surface roughness. With respected to figure 1.2, surface roughness can be defined as the average of vertical deviations from nominal surface over a specified surface length.

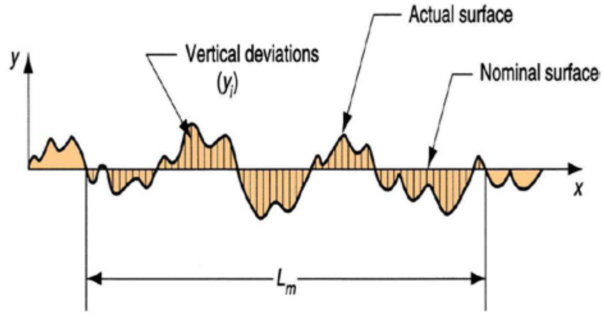

Figure 2: Deviations from nominal surface used in the two definitions of surface roughness

The quality of machined surface is characterized by the accuracy of its manufacture with respect to the dimensions specified by the designer. Every machining operation leaves characteristic evidence on the machined surface. This evidence in the form of finely spaced micro irregularities left by the cutting tool. Each type of cutting tool leaves its own individual pattern which therefore can be identified. This pattern is known as surface finish or surface roughness.

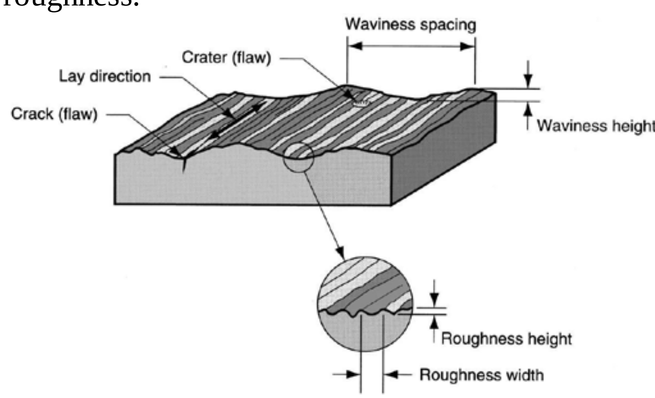

Figure 3: Surface texture features

A simple example of engine mounting system as shown in below figures:

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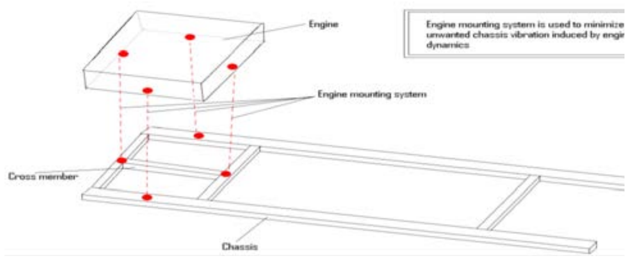
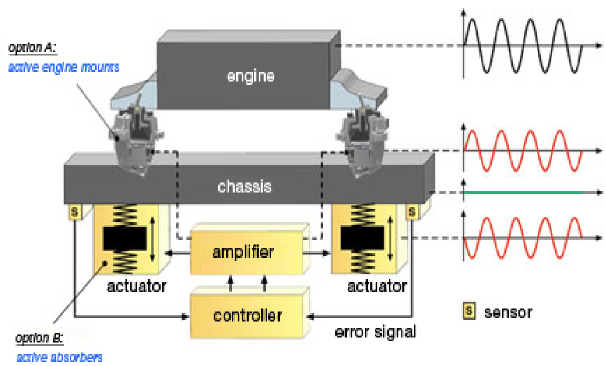


Figure 4: Engine mounting system



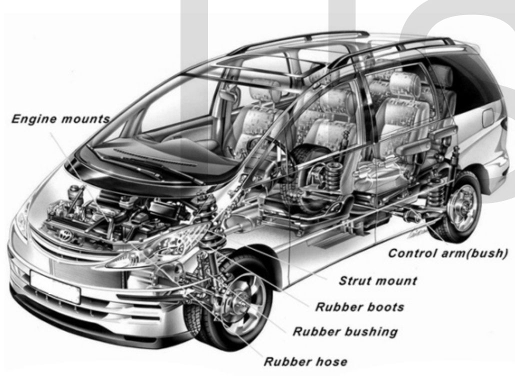


Figure 4a: Engine mounting system

III. Factors Affecting Surface Finish

Whenever two machined surfaces come in contact with one another the quality of the mating parts plays an important role in the performance and wear of the mating parts. The height, shape, arrangement and direction of these surface irregularities on the work piece depend upon a number of factors such as.

A) The machining variables which include,

a) Cutting speed
b) Feed, and
c) Depth of cut.

B) The tool geometry,

The design and geometry of the cutting tool also play a vital role in determining the quality of the surface. Some geometric factors which affect achieved surface finish include:

a) Nose radius
b) Rake angle
c) Side cutting edge angle, and
d) Cutting edge.

C) Work piece and tool material combination and their mechanical properties,

D) Quality and type of the machine tool used,

E) Auxiliary tooling, and lubricant used,

F) Vibrations between the work piece, machine tool and cutting tool.

IV. Roughness Parameter Definitions

Sampling length or cut-off length: It is the length of the reference line used for identifying the irregularities characterizing the surface.

Traverse length: This is also known as the assessment length and is the complete length of the pick-up movement along the surface being measured. It is normally greater than the evaluation length, due to the necessity to make an allowance at either end to ensure that mechanical and electrical transients are excluded from the measurement. For Subtonic 3+ instrument, traverse length = ¼ L_c+L_n

V. Objectives and Methodology

Objectives:

The main aim of present research work is to study and suggest a method to enhance contact area and in turn contact stress

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between a given set of work pieces and with interface material at low loads. The objectives include the study of effect of orientation, distance between planes on contact area and contact stress. The objectives of the present research work are listed as:

(1) To study the effect of orientation on contact area and effect of surface roughness and interface material on contact stress.
(2) To study and evaluate the effects of change in mean plane separation on contact area and contact stress with the presence of interface material.

Methodology:
The methodology of project can be summarized in the flow chart as given below. Finite element study of effect of orientation and distance between planes are studied. In the present work APDL commands are used to create the program in the Ansys, which will generate solid model, meshing, create the contact pair and also solve for given boundary conditions.

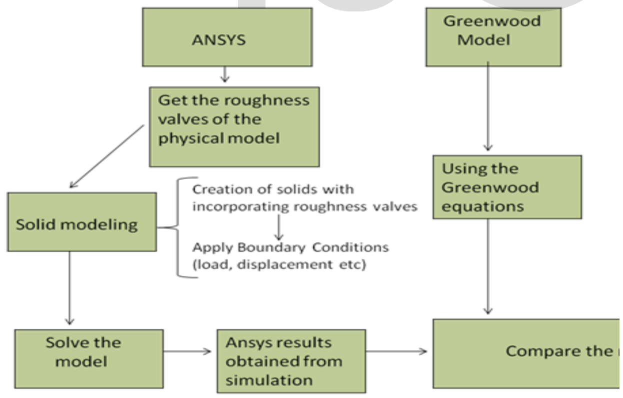

Figure 5: Methodology of project

The methodology of project can be summarized in the flow chart as given inFig1.9. In the present work APDL (ANSYS parametric design language) commands used to create the program in the Ansys. Finite element study of effect of surface roughness and distance between mean planes are studied which will generate solid model, mesh, contact pair and also solve for given boundary conditions. Greenwood model is used to find the contact stress for different roughness and different distance between mean planes. The results of finite element analysis and Greenwood model are compared. The Greenwood results are used to validate the finite element analysis results. In the present work, the main aim is not to find the exact area and stress, but it is to find variation in contact stress with roughness.

VI. Finite Element Analysis

In our project ANSYS 10 is used as simulation software.

About ANSYS 10

ANSYS 10 is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. With the advent of computers it is always desirable to verify or prove any theoretical concepts before verifying the same with experimental investigations. The primary investigation of research objectives is carried out with theoretical analysis. In this section finite element study of the research objectives is presented. Commercially available finite element software ANSYS 10 is used for the simulation. Simulation involves distinctly

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three steps namely preprocessing, solving and post processing. Preprocessing involves creation of geometrical model, nodes, elements, assigning material properties etc. ANSYS has huge library of elements. The ANSYS element library consists of more than 100 different element formulations or types. Solver part involves solution of equations. ANSYS provides various solvers like sparse direct, pre-condition conjugate gradient, iterative and frontal direct. Finite element solution results are viewed in post processor part.

VII. Results and Discussions

The theoretical and finite element analyses are carried out. Whenever one body is in contact with other body with different orientations, the variations in stress distribution are calculated. The results obtained from the orientation and distances between mean planes are discussed in this chapter.

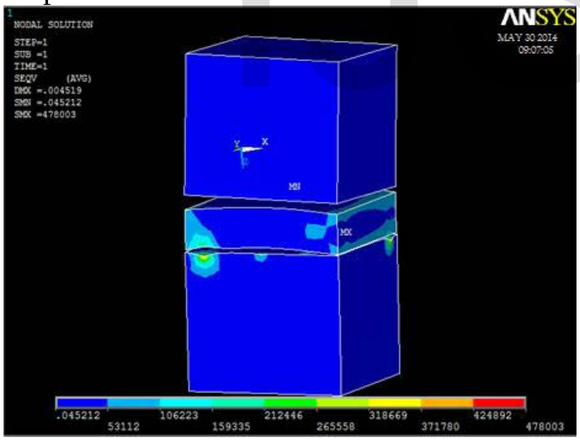

Figure 6: Stress distribution for orientation 1_5, set1 and distance between planes 0.001 mm and Summit radius 0.2mm

Interface material of (1_5) (1st quadrant is in contact with 5th quadrant)

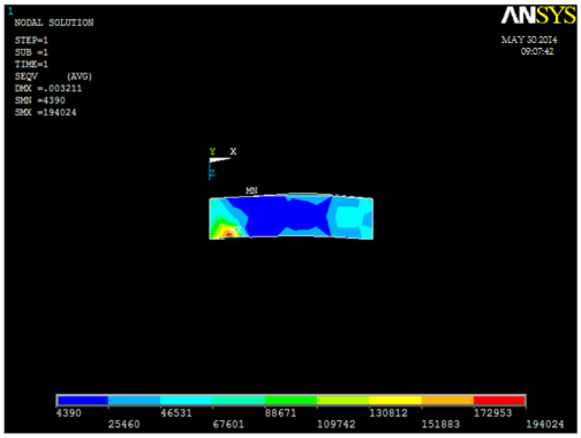

Figure 7: The stress distribution for the interface material of 1_5 set 1 show that, the contact Occurred in only few spots

Orientation (1_8) (1st quadrant is in contact with 8th quadrant)

In this orientation, the quadrant number 1 contact with quadrant number 8 which means 1 contact with 8 and remaining quadrants will contact with their pairs. The distance between planes 0.001 mm and the summit radius 0.2mm are used for this orientation.

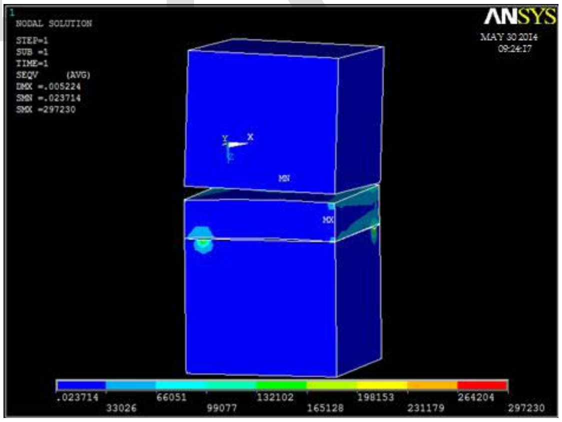

Figure 8: Stress distribution for orientation 1_8, set1 and distance between planes 0.001mm and Summit radius 0.2mm

Interface material of (1_8) (1st quadrant is in contact with 8th quadrant)

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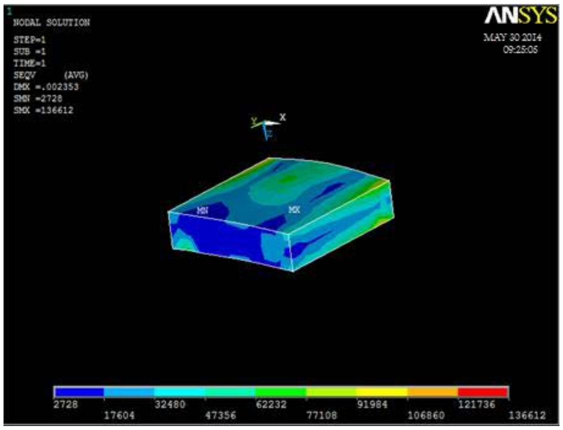

Figure 9: The stress distribution for the interface material of 1_8 set 1 show that, the contact Occurred in only few spots

Orientation (1_7) (1st quadrant is in contact with 7th quadrant)

In this orientation, the quadrant number 1 contact with quadrant number 7 which means 1

VIII. Conclusions

The main objective of present research work has been to study the effect on contact stress and effect of surface roughness and interface material on contact area and contact stress. The objective of present work is studied with theoretical analysis using Greenwood model and finite element analysis using ANSYS software. The finite element study of effect of orientation on contact stress is carried out. Different sets of surface parameters and distance between planes are considered for. The result of finite element analysis shows that, the orientation has the significant effect on contact stress. The finite element study of effect of surface roughness and interface material on contact area and contact stress is carried out. Different sets of surface parameters and distance between planes are considered for the analysis. The results of finite element analysis show that the contact stress increases with increasing surface roughness. The theoretical study of the research objectives is carried out using Green wood model. This analysis indicates that, the contact stresses between a pair of bodies changes with orientations and contact area decreases with increasing surface roughness. The results of Greenwood model are compared with those of finite element analysis. The trends of theoretical and finite element analysis results are same. The practical significance of the present research outcomes would be effectively applicable where contact stress plays an important role as in aircraft structural, electronic assembly, bolted and riveted joints, structural joints of machine tools, joints and other applications.

IX. Scope of Future Work

1. Simulation can be extended by considering the effect of self-weight of bodies and the application of external loads. Coupled field analysis can be carried out with structural and thermal analysis.
2. Mesh refinement can be checked.
3. Change density of peaks can incorporate in the model.
4. Better surface model can be produce.

X. References

[1] Ulf Sellgren, Stefan Bjorklund, Soren Andresson ***"A finite element-based model of normal contact between rough surface"*** *Machine Elements, Department of Machine Design, Royal Institute of Technology (KTH), Stockholm. Sweden. Wear254 (2003)*

[2] John I. McCool, ***"Comparison of models for the contact of rough surface"****, SKF Industries Inc., King of Prussia, PA 19406-1352(USA), wear 107(1986) 37-60*

[3] J. F. Archard, ***"Deformation and the laws of friction"*** *Proceedings of the Royal Society of London, Vol. 243, No.1233, (Dec. 24, 1957), pp. 190-205.1180-1188*

[4] J. A. Greenwood and J.B.P. Williamson, ***"Contact of Nominally Flat Surface*** *"Proceedings*

ISSN 2229-5518
of the Royal Society of London, Vol. A295, 1966, PP.300-319.

[5] Johnson, K.L, 1985, ***"Contact mechanics"****, Cambridge university press.*

[6] B. N. J. Person and E. Tosatti, ***"The effect of surface roughness on the adhesion of elastic solids"****, Journal of chemical physics, volume 115, number 12.*

[7] S. Kucharski, T. Klimczak, A. Polijanjuk, J. Kaczmarek, ***"Finite element model for the contact of rough surfaces"*** *institute of fundamental Technological Research of Polish Academy of Science, ul. Swietokrzyska 21, 00-049 Warsaw, Poland. Wear 177 (1994)1-13.*

[8] N. K. Myshkin, M. I. Petrokovets and S. A. Chizhik, ***"Simulation of real contact in tribology"****. Tribology International Vol.31. Nos 1-3, pp. 79-86, 1998.*

[9] G. Zavarise, P.Wriggers, E. Stein, B. A, Schrefler. "Real Contact Mechanics and Finite Element Formulation- A Coupled The mechanical approach. International Journal for Numerical Methods in Engineering, vol.35, 767-785 (1992).

[10] Prasanta Sahoo, Biplab Chatterjee, ***"A finite element Study of elastic-plastic hemispherical contact behavior against a rigid flat under varying modulus of elasticity and sphere radius"****. Department of mechanical engineering, Jadavpur University, Kolkata, 2010, 2, 205-211.*

[11] S.P.Timoshenko and J.N. Goodier, ***"Theory of elasticity"****, Third Edition.*