Stress Concentration Analysis of Rectangular Plate of Composite Material

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Abstract: *Metal matrix composites (MMCs) are the advanced materials. Automotive and aerospace industries prefer metal matrix composites because of their enhanced properties. Metal matrix composites have higher hardness, stiffness, strength to weight ratio as compared to conventional metals. Holes, keyways, notches and shoulders give geometric irregularities which leads to stress concentration. The present work compares the change in stress concentration of three materials aluminium alloy, Al_2O_3 and Boron carbide. For comparing the change in stress concentration a rectangular plate with circular hole at its centre is created in ANSYS 12. All degrees of freedom of plate are fixed on one side and the axial load is applied on the other. After analysis it was found that the stress concentration in all the three materials is same.*

Keywords — *composite material, Aluminium alloy, Al_2O_3, Boron carbide, ANSYS, FEM.*

I. INTRODUCTION

Now a days Metal matrix composites (MMC) are receiving much attention because they are having improved mechanical properties. Metal matrix composites are useful in many applications like aerospace, automotive and sports industries [1,2].

In machine elements geometric irregularities such as holes, notches, keyways etc can be observed. The stress distribution around the irregularities is not uniform. We cannot find the stress distribution in machine with the help of elementary equations. Photoelasticity, brittle coating and electrical strain gauges are experimental methods that can be used for stress analysis around irregularities, but they are quite expensive. Finite Element Analysis, Boundary Element Analysis and Complex Variable Approach [3] are analytical approaches for doing the same.

According to the type of reinforcement large numbers of fabrication techniques are currently used to manufacture the MMC. These techniques are stir casting (or compocasting) [4], liquid metal infiltration [5], squeeze casting [6] and spray co-deposition [7].

Homogeneity should be high to attain optimum mechanical properties for the composite material. To achieve a good quality composite the important parameters controlling, the process must be identified and corrected. Work on processing of advanced Al/SiC particulate metal matrix composites under intensive shearing was done by Tzamtzis et al. [8]. He found the improvement in distribution of the SiC particles in metal matrix.

Tzamtzis et al. [9] worked on processing of advanced Al/SiC particulate metal matrix composites under intensive shearing and found that the distribution of the SiC particles in the metal matrix was improved significantly when the composites were produced using the Rheoprocess. The effect of different orientations of the geometric irregularities on stress concentration using experimental and Finite Element Method is studied by Kawadkar et al. [9].

Vijaya et al. [10] did the fabrication process by stir casting method which involves mixing the required quantities of additives into stirred molten aluminium. The samples were prepared and tested after solidification to find the various mechanical properties like tensile, flexural, impact and hardness. Scanning Electron Microscope (SEM) is used to observe the internal structure of the composite.

Stress near the hole is more and can lead to failure of machine so it becomes important to study the stress concentration near the hole or irregularity. In the present work stress analysis of a composite plate with circular hole at its centre is done using finite element software ANSYS for three different materials. Analysis shows that stress concentration is more near the hole. For doing this analysis the mechanical properties are taken from the work of Vijaya et al. [10]. Vijaya et al. [10] found mechanical properties metal matrix composites (MMC) experimentally. Table 1 shows the mechanical properties of material.

Table 1: Properties of material

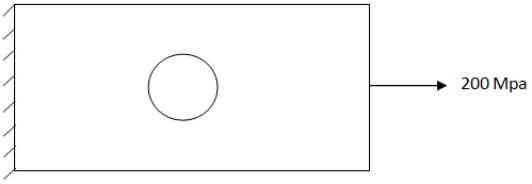
A. Material	B. Tensile strength(Mpa)	C. Density (g/cm^3)	Coefficient of Thermal expansion F. ($10^{-6}/^0C$)	Modulus of elasticity(Gpa)
Aluminium alloy LM 25 grade	I. 190-250	J. 2.68	K. 2.2	L. 71
M. Al_2O_3	N. 255.2	O. 3.98	P. 7.4	Q. 380
R. B_4C	S. 261	T. 2.3-2.55	U. 3.2	V. 362

Finite Element Method

In FEM the structural model to be analysed is divided into in small pieces of simple shapes called elements. Finite Element Analysis (FEA) program uses the equations which govern the behaviour of each element; it also considers the connectivity to other elements through nodes.

Thousands or even millions algebraic equations are assembled by this program for obtaining the stress distribution in model. Some of the FEA based softwares are ANSYS, LS DIANA, ABAQUS, and NASTRAN etc.

In the present work rectangular plate with circular hole at its centre is created in ANSYS 12. For analysis all degrees of freedom of plate is fixed on one side and the axial load is applied on the other.



II. Result and Discussion

In this paper, analysis is done in ANSYS. For analysis three materials are taken for comparing the stress concentration. Results of the present work are shown as follows. It is observed that after applying the axial load on these three plates of different material the stress distribution is same for shear stress as well as in Von Mises stress. For getting the accurate results the meshing is dense near the hole. After meshing of the plate total numbers of elements are 34844 and the nodes are 35491. The size of plate is 100mm×50mm which is fixed on one side.

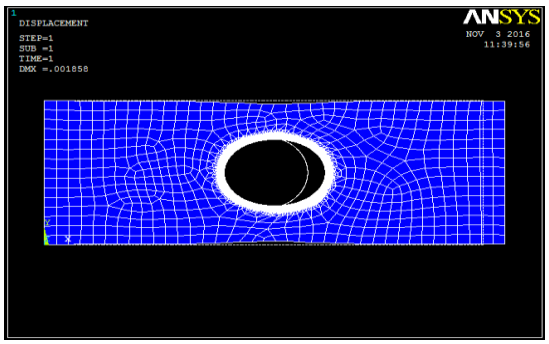


Figure 1: Deformed shape of plate

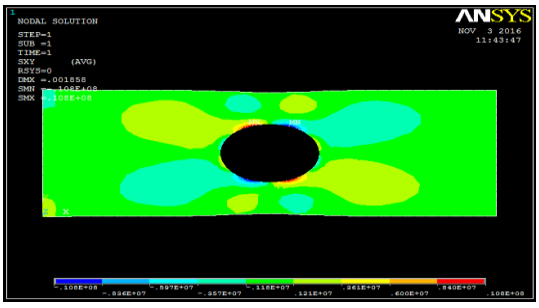


Figure 2: Shear stress in XY direction (LM25)

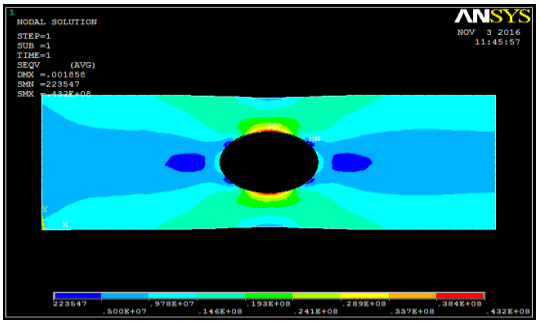


Figure 3: Von Mises stress (LM25)

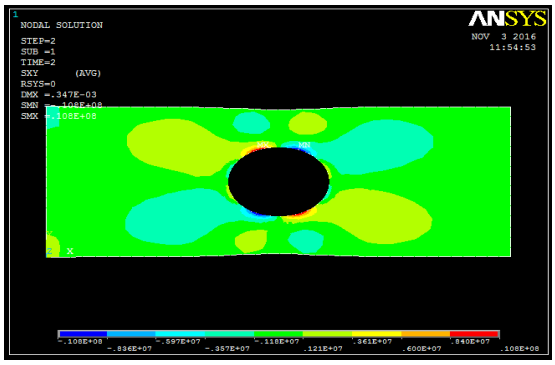


Figure 4: Shear stress in XY direction (Al_2O_3)

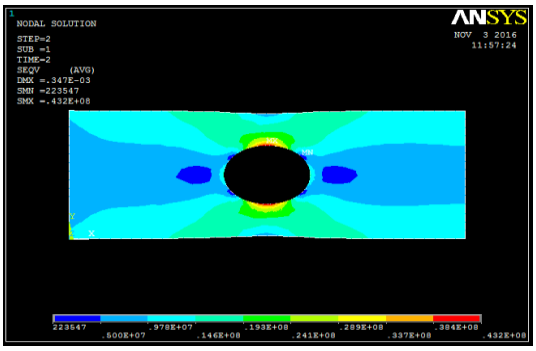


Figure 5: Von Mises stress (Al_2O_3)

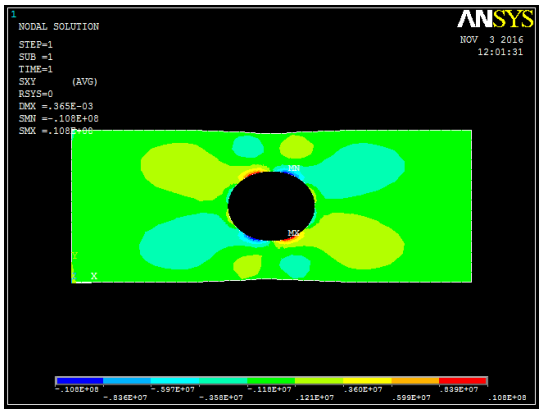


Figure 6: Shear stress in XY direction (B_4C)

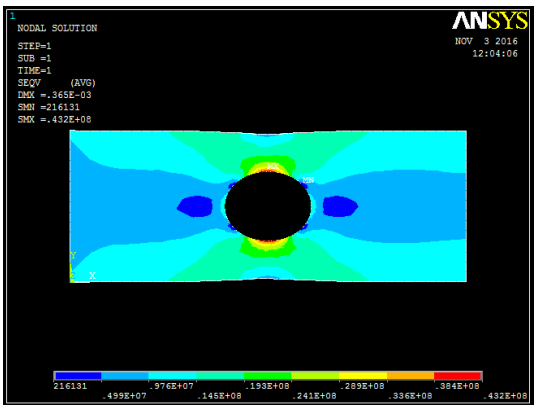


Figure 7: Von Mises stress (B_4C)

III. Conclusions

Metal Matrix Composites Are Getting Popularity Because Of Their Less Weight And Good Mechanical Properties. Automobile And Aerospace Industries Are Using Metal Matrix Composites. In This Work Stress Concentration Analysis Is Performed For Analysing The Change In Behaviour Of Three Materials In Terms Of Stress. It Is Found That Stress Value Is Same For All Three Materials. All Degrees Of Freedom Of Plate Are Fixed On One Side.

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