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Research Article

NUMERICAL STUDY OF EFFECTIVE THERMAL CONDUTIVITIES OF ALUMINIUM PARTICULATE REINFORCED EPOXY MATRIX COMPOSITES USING FEA

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A R T I C L E I N F O

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A B S T R A C T

In this present article to calculate the Aluminum (Al) particulates reinforced epoxy composite of thermal conductivity experimentally and analytically. Measured thermal conductivity of the aluminum particulate strengthened epoxy composites with different particulate concentrations 2.5 weight %, 5 weight % and 7.5 weight % of Al in epoxy resin ANSYS APDL 17.2 software is used. Observations can be made that with 2.5% weight thermal conductivity has improved by around 1.4%, while with 5 weight % the thermal conductivity has improved by around 11.5% and with 7.5% weight thermal conductivity has improved by around 17% which is substantially higher than epoxy lattice. The conductivity values obtained with the investigative ones compared with FEM results. The FEM results reasonable agreement with experimental results.

INTRODUCTION

The form of fiber or particles are incorporated in the other phase called the matrix phase and the incorporated phase is called reinforcing phase. The combination of these two phases is called composite materials. The presence of fibers or particles embedded in composite improves its thermal and mechanical properties the primary function of the matrix is to protect the reinforcing material from mechanical and environmental damage and transfer stress to them.In a composite material matrix material and reinforcing material are insoluble in each other. Present days Composite materials are fascinating to manufacture because of good electrical and thermal properties, simplicity of creation and high strength to light weight proportion contrasted with metals to determine possible properties. Presently a days Composite materials are fascinating to manufacture because of good electrical and warm properties, simplicity of creation and high quality to weight proportion contrasted with metals.To ascertain viable properties.

METHODOLOGY

Materials

Table 1 material properties

Materials	Epoxy (Matrix)	Aluminium (Filler)
Density (g/cc)	1.1	2.7
Thermal conductivity (W/m-K)	0.363	250

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Table 2 composition of composites

Sample	Composition (Al filled Epoxy)
1	Epoxy+0 wt% (0 vol%) filler
2	Epoxy+2.5wt% (1.04 vol%) filler
3	Epoxy+5wt% (2.10 vol%) filler
4	Epoxy+7.5 wt% (3.31 vol%) filler

Composite Material Density

$$\rho_c = \frac{1}{\left\{\left(\frac{Wf}{\rho f}\right)+\left(\frac{Wm}{\rho m}\right)\right\}} \quad ......[1]$$

Where
ρc =density of composite
Wf = weight of the filler material
ρf = density of the filler material
Wm = weight of matrix material
Pm =density of the matrix material

Table 3 Designation and Composition of Composites

Sample	Composition	Density of composite (g/cc)
1	Epoxy+0 wt% (0 vol%) filler	1.1
2	Epoxy+2.5wt% (1.04 vol%) filler	1.11654
3	Epoxy+5wt% (2.10 vol%) filler	1.13359
4	Epoxy+7.5 wt% (3.31 vol%) filler	1.15116

Effective Thermal Conductivity of the Composite

For the parallel conduction model

$$K_e = (1-v)\,k_f + v\,k_m \quad ....[2]$$

Where
K_e=effective thermal conductivity of the composite
V=volume fraction
K_f =thermal conductivity of filler
K_m =thermal conductivity of matrix

For the series conduction model

$$\frac{1}{Ke}=\frac{1-v}{kf}+{}^{v}/_{km} \qquad \text{……………………[3]}$$

Fabrication of Composite Specimens

The hand lay-up technique is used to prepare the 4 types of composites with the same filler of changed weight fractions. The weight percentage of Epoxy, hardener and metallic filler Aluminium Particles are used.

Primarily the filler materials in powder form are patched before collaborating with the epoxy resin for the removal of moisture, before the adding of hardener the fillers are mixed with epoxy resin and it is stirred manually using a mechanical stirrer. This mixer is coated on the work side of the mold and poured into the mold. This procedure is continued until and then moulds are cured for at least 72 hours at room temperature.

Design and Analysis

Basic Steps in FEA

Preferences

Problem definition.

Preprocessor

- Select the element type.
- Material properties.
- Modelling.
- Meshing.

Solution

- Define loads.
- Solve.

Postprocessor

- Plot results
- To get required values.

The division of the domain into the number of elements is called as parts.

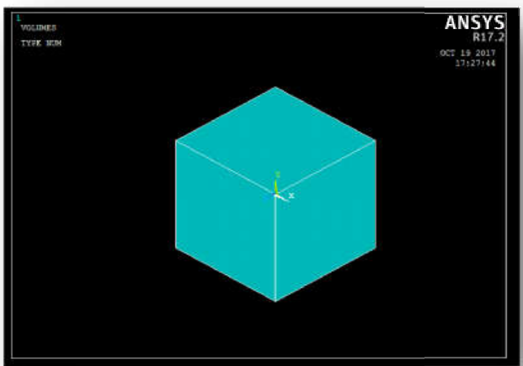

Fig FEM Model

The elements are three types they are 1-D,2-D and 3-D,the element having only length and no shape is a 1-D problem. If the problem having length and also shape is called the 2-D problem e. x. triangles, rectangles, and quadrilateral are the 2-D problems. The 2-D problems having curved or straight boundaries. For 3-D problems, parallelepiped and tetrahedron shapes having straight or curved surfaces.A domain of the problem divided into the number of elements is called mesh.

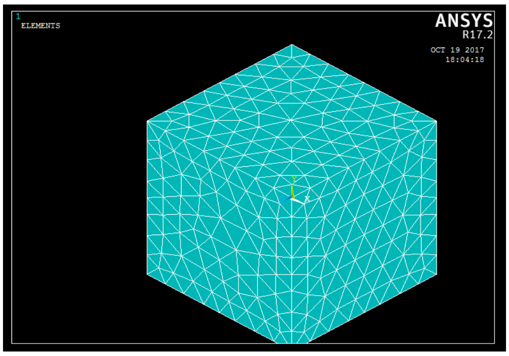

Fig FEM Model (Meshing)

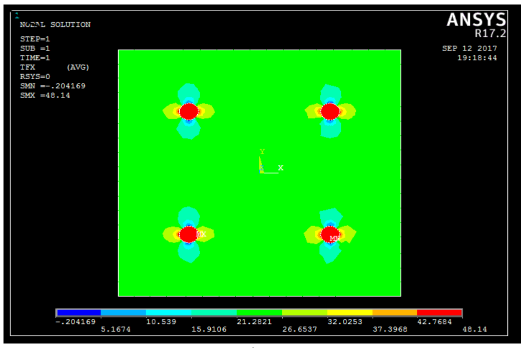

Fig.a

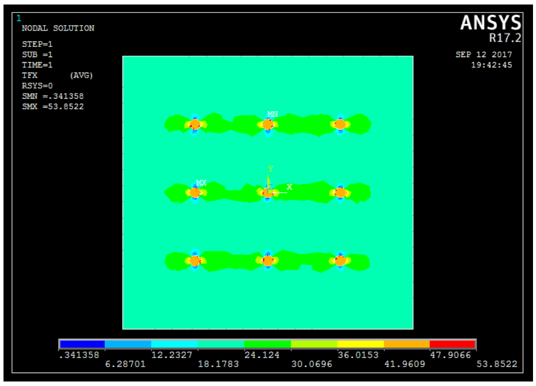

Fig.b

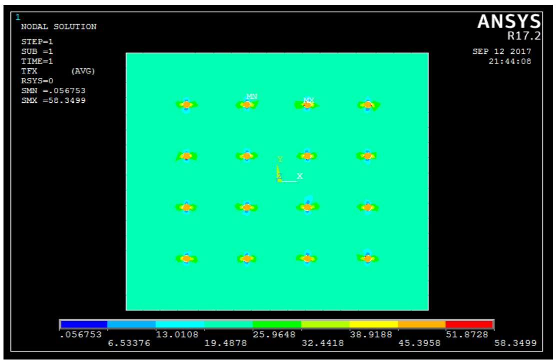

Fig c

Fig X component of heat flux for typical 2-D circles-in-square models with particle concentration of aluminum powder (a) 2.5 wt% (b) 5 wt% and (c) 7.5 wt% respectively

RESULTS AND DISCUSSION

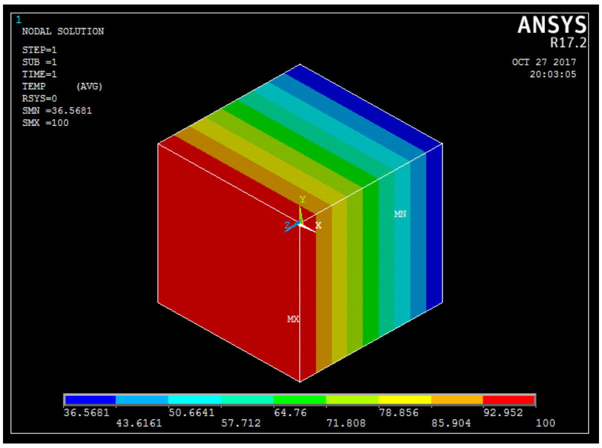

Fig a

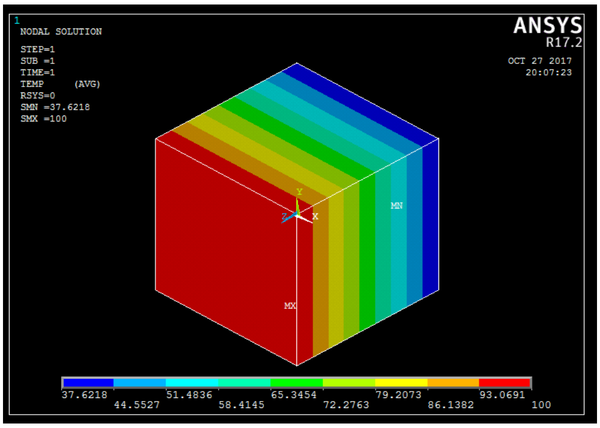

Fig b

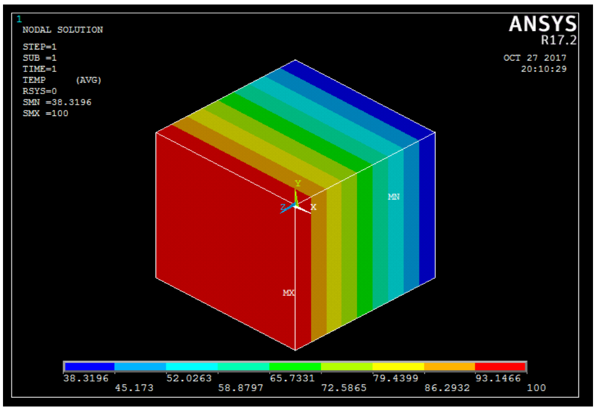

Fig c

Fig.4.1 Temperature distribution of typical 3-D spheres-in-cube models with particle concentration of aluminum powder (a) 2.5 wt% (b) 5 wt% and (c) 7.5 wt% respectively.

These temperatures are obtained with the help of finite-element program package ANSYS.

Table 1 Thermal conductivity for composites obtained from FEA and Experimental

Sample	Al Content (wt %)	Effective thermal conductivity of composites K_{ef} (W/m-K)	
		Experimental	FEA Values
1	0	0.363	0.363
2	2.5	0.372	0.3771
3	5	0.382	0.4257
4	7.5	0.392	0.4588

Table 2 Percentage errors w.r.t analytical value

Sample	Al Content (wt %)	Error (%)
1	2.5	0.51
2	5	4.37
3	7.5	6.68

The particulate concentrations of composites 2.5, 5, and 7.5 wt% for obtaining the temperature profiles from ANSYS are presented in Figure.1,2. The effective thermal conductivity of epoxy resin is enhanced by Al particulate reinforced.The thermal conductivity improved by about 11.5% and 17% with the addition of 5 wt% and 7.5 wt % w.r.t epoxy .The FEM results are reasonable agreement with experimental results.

Graph

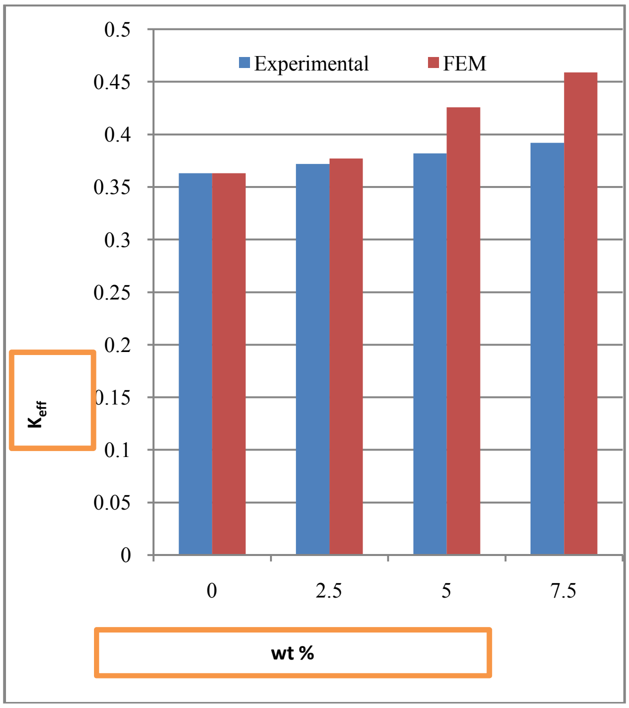

Figure 4.2 Comparison between experimental and FEA

CONCLUSIONS

To determine effective thermal conductivity of composite with different weight fractions can be gainfully employed in finite element analysis.

Comparison of the effective thermal conductivity obtained by experimental and finite element analysis shows reasonable agreement. Change in weight fraction of Al fillers has a significant effect on thermal conductivity.

Thermal conductivity of Al filled epoxy composite improves comparison with epoxy resin. The thermal conductivity of the composite (with the addition of 7.5 wt% of Al) improves by about 17% with respect to neat epoxy resin.

The applications of Al filled epoxy composites are thermal interface material, electronic packages etc.

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