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Study Thermomechanical Properties of Unsaturated Polyester Composite Reinforced by Ceramic Particles (Al_2O_3)

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Abstract

In this study Alumina (Al_2O_3) particles were added in different volume fractions (0,5,10,15,20)% as reinforcement materials to unsaturated polyester (UPE) to improve thermo-mechanical (Shore (D) hardness, impact strength, bending strength, and thermal conductivity) properties of composites reinforced polyester composites were investigated. The result shows that the mechanical properties of particles (Al_2O_3) reinforced polyester composites are better than unreinforced (Al_2O_3) particles. It can be noticed that increasing of volume fractions of (Al_2O_3) increasing the values of shore (D) hardness, bending strength and enhance thermal conductivity, with decreasing in impact strength of composite materials.

Keywords: *Mechanical properties, thermal properties, Alumina (Al_2O_3) ceramic particles, impact strength, hardness.*

1. Introduction:

Composite is prepare by combining two or more materials (reinforcement and matrix) often the reinforcing material provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Particulate composites have advantages that dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuousfiber composites, but they are usually much less expensive[1]. The main advantages of Al2O3 particles which is used as reinforcement material due to it's high mechanical properties with relatively high thermal conductivity that enhanced the properties of composites.

2. Experimental Part:

2.1 Materials

Unsaturated polyester resin (UP) type was used as matrix material, supplied by (Turkey) company, the hardener was MEKP as hardener and the reinforcement was Al_2O_3 with particle size 7.5 µ in volume fractions as (0,5,10,15,20)%.

2.2 Manufacturing of Composite

Hand layup method was used to manufacture all composites specimens.

2.3 mechanical tests

2.3.1. Shore (D) Hardness

This test is performed by using hardness (Shore D) and according to (ASTM DI-2242) standard by using cylindrical sample , the diameter is (40 mm) and thickness is (5 mm)[ ].

2.3.2. Impact(Izod):

Impact test was done at room temperature according to (ISO- 179). The impact strength was calculated according to relationship bellow [4] :

$$G_c = U_c / A \qquad (1)$$

Where :

G_c: impact strength of material in (J/m^2).

Uc : impact energy in (J).

A : cross- sectional area of specimen in (m^2).

2.3.3 Bending:

Bending test was performed at room temperature according to (D790) with dimensions of specimens (191*13*5) mm[5]. Modulus of elasticity was calculated according to equations (2) and (3) as follows[4] :

$$I = \frac{bd^3}{12} \qquad (2)$$

where :

I: moment of inertia.

b : specimen width in (mm).

d : specimen thickness in(mm).

$$E = \frac{MgL^3}{48IS} \qquad (3)$$

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Where

M :mass inflicted on specimen in (gm).

g : acceleration (9.8 m/sec^2).

L :distance between bearing point in (mm).

S :bending resulting from load inflicted in (mm).

I: moment of inertia of cross section of specimen in (mm^4).

2.4 thermal conductivity

thermal conductibility was determined using lee's disc device.

3. Results and Discussion

3.1 Shore (D) hardness:

Table 1 : Shore (D) hardness of specimens

Volume fractions	***Shore(D) hardness***
0%	74
5%	76
10%	80
15%	82
20%	84

From table (1) it can be seen that increasing in shore (D) hardness values with increasing of volume fractions of Al_2O_3 comparing with unsaturated polyester (UP) specimen this due to enhance the resistance of plastic deformation of all composites specimens with ceramic fillers (Al2O3) as shown in fig.(1).

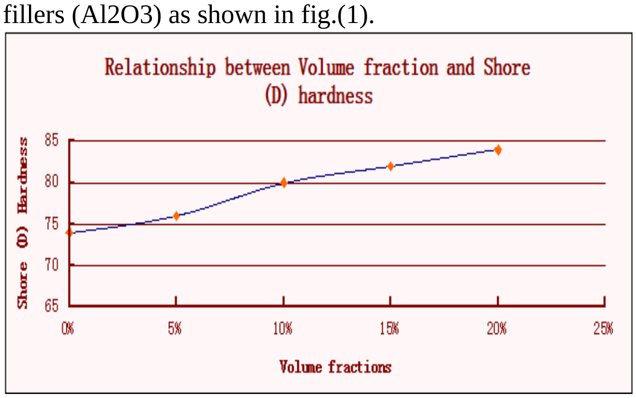

Fig. 1 volume fractions vs. Shore (D) hardness.

3.2 Impact:

The results of Izod Impact are shown in table(2):

Table 2 : Izod Impact of specimens

Volume fraction	***Impact strength j/m^2***
0%	12000
5%	4000
10%	2000
15%	3000
20%	4400

Table(2) shown a decreasing in impact strength at volume fractions (5%,10%,15%) of Al_2O_3 with slightly increased in impact strength at 20% volume fraction comparing with unfilled (UP) specimens this due to dispersion of fillers of Al_2O_3 particles also, another reason was interfaced between Al_2O_3 and unsaturated polyester are good specimen of volume fraction (20%) than specimens of volume fractions (5%, 10%, 15%) compared with (UP) specimens, as shown in fig.(2).

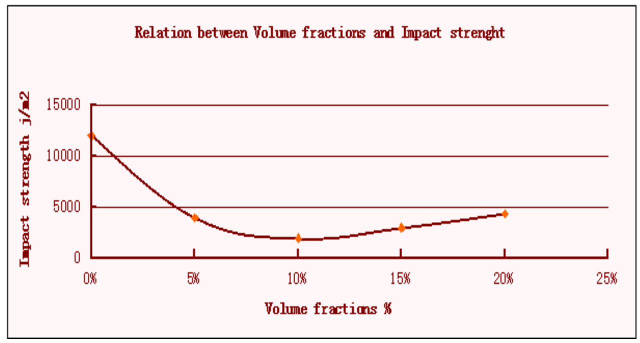

Fig. 2 volume fractions vs. impact strengths

3.3 Bending:

The results of young modules in bending are shown in table(3):

Table 3 : young modulus in bending

Volume fraction	***Young modulus in bending (GPa)***
0%	3.5
5%	7.4
10%	5.3
15%	6.2
20%	9.9

It can be noticed that increasing in bending resistance values with increasing of alumina fillers (table3) also, it was shown decreasing in bending value at volume fraction 10% of Al_2O_3 this may be due to time of mixing and manufacturing conditions of composites, from fig (3) specimen with 20% volume fraction obtained high bending resistance this may be due ot chemical compatibility between filler particles (Al_2O_3) and UP.

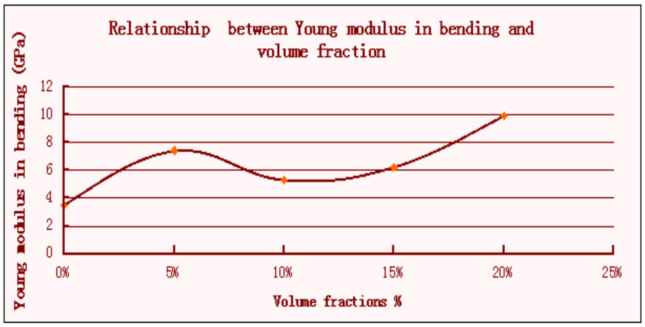

Fig. 3 volume fractions vs. young modulus in bending

3.3 Thermal Conductivity:

The results of thermal conductivity of specimens are listed in table(4).

table 4 : thermal conductivities of specimens

Volume fractions	*Thermal Conductivity (W/m.k)*
0%	0.2
5%	0.231
10%	0.242
15%	0.254
20%	0.271

From table (3) it can be seen that thermal conductivity of all composites specimens increase with increasing volume fractions of alumina the reason behind this due to high thermal conductivity of Al_2O_3 (30 W/m.K) so the thermal conductivity of composites enhanced with increased of Al_2O_3 filler compared with unsaturated polyester specimen as shown in fig.(4).

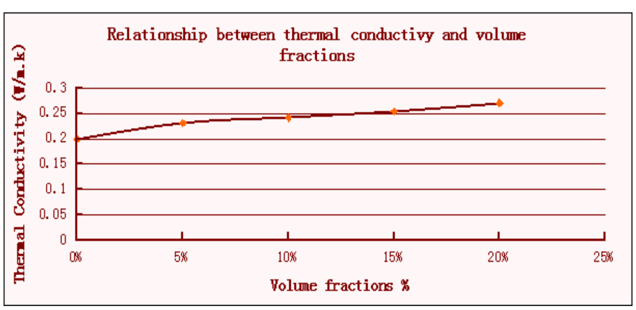

Fig.4 thermal conductivity versus volume fractions

4. Conclusions

1. Shore (D) hardness increasing with increasing volume fractions of Al_2O_3.
2. impact strength of composites reinforced with Al_2O_3 decreased with increasing volume fractions of Al_2O_3.
3. bending strength of composites specimens increased with increased in volume fractions of Al_2O_3 and reached maximum values 9.9 (GPa) at volume fraction (20%).
4. increasing volume fraction of TiO2(up to 9%) would reduce bending strength.
5. thermal conductivity increased with increasing volume fractions and showed maximum value 0.271 (W/m.k) at volume fraction (20%) .

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