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Thermal Conductivity for (Zn_xT_{1-x})/Polystyrene Hybrid Composite

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***Abstract*:**
Used hand lay- up technique in this research to prepare samples from polystyrene resin reinforced by ($Zn_xTe_{1-x)}$ with different (x) and different weight fractions (4, 8, 12) wt%. The thermal conductivity of (Zn_xTe_{1-x}/PS) specimens were measured out using Lee's disk method. The experimental results showed that thermal conductivity increased with increase weight fraction .

Keywords: *Polystyrene , (Zn_xTe_{1-x}) , Thermal conductivity*

I. Introduction

The composites materials are the basis for change and developing designs that we need in engineering materials **[1]** the reinforced by particles use to improvement the thermal and mechanical and electrical properties of polymeric materials[2] .Polystyrene (PS) that use in this research it is an organic aromatic polymer made from styrene monomer . Polystyrene may be foamed or solid. is transparent , hard, and brittle. can heat it up above the glass transition temperature it become liquid and easy to molded it has many applications it enters in the made of computers and cooking tools and some car models and used for thermal insulation and packaging [3] as for the reinforced material it is (ZnTe) the materials that work on reinforcement the matrix materials and recognize by high elasticity modulus , high shear modulus ,high resistance ,and more solid from matrix materials the ductility of it high or low dependent on the type of reinforcement matrix and the purpose that use for it . reinforcement materials can be classification by shape and dimension to :Fibers ,Particles ,Flakes or as net of glass or metals or carbon materials [4]the reinforcement consider one of the basis's component of composite materials then added to matrix materials for reinforcement it and improvement their characterization the reinforcement process involve transfer stress acting from matrix materials to reinforcement materials throwing interface the reinforcement as polymers , ceramic, metals [5,6]

II. Theoretical part

The term physical of thermal conductivity can be defined the transfer of energy between two bodies with different methods in solid material where does the heat transfer from one location to another by phonons or electrons or both depending on the type of solid matter that were dealing with it .as for the thermal conductivity of solid materials electrically insulated it is only by phonons we know that the bodies saturated heat energy when it is hot and this is energy radiates by electromagnetic waves it absorb from other bodies and turns to energy in it . this is what happens with models when the ambient temperate rises because the particles of matter when absorb energy will increase its amplitude around the balance point without moving from its place [7] can be write as the relation :

$$Q = -k\frac{dT}{dx} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

- where Q: Is the heat flux.
- K: Thermal conductivity coefficient.
- $\frac{dT}{dx}$: Is the thermal gradient in the conductive medium

the negative signal in the equation above due that the direction of the thermal flow from the high temperature zone to the low temperature zone. ways of measuring thermal conductivity are divided into two categories, dynamic and static. Eq. (1) suitable for steady- state heat flow only. There are several methods to test the thermal conductivity of solid materials depending on the nature of these materials [8]. If the material is dielectric or has poor thermal conductivity as in polymers, coefficient thermal conductivity (k) is measured using Lee's disc method. Lee's disc method belongs to the static category. this method the substance (S) is placed between two copper discs (Aand B). The electric heater (H) is located in between two copper discs (B& C). The temperatures of the copper disks (A, B, C) are test by thermometers. heating coil in Lee's disc apparatus provides with D.C voltage V = 6 Volts and current I = 0.25Amp which are held constant for all samples [9]. The thermal conductivity (k) can be experimentally calculated using the following relationship [10]:

- $K\left(\frac{TB-TA}{ds}\right) = e\left[TA + \frac{2}{r}\left(dA + \frac{1}{4}ds\right)TA + \frac{1}{2r}dsTB\right] \ldots\ldots 2$
- When(e)as the thermal energy of material by cross section in unit time measured by $w/m^2.k°$ and can be calculated by :
- $H = IV = \pi r2e(TA+TB) + 2\pi re[dATA + ds\frac{1}{2}(TA+TB) + dBTB + dcTC] \ldots\ldots 3$
- Where (TA,TB,TC) the temperature of the samples . (dA,dB,dC) disk thickness =12.5 mm. (dS) thickness of the samples in(mm). (I) the current in (A) . (V) voltage in (V) . (r) the radius of disk . [11]

III.Experimental work:

Used materials

Polystyrene as a matrix

used the matrix material is polystyrene resin from Saudi basic corporation industries Kingdom Saudi Arabia, Riyadh. have 1040 $kg/m^3$and melt flow rate 4gm/10min and the melting point between 230 ℃ -240 ℃ and the reinforced materials are zinc ,tellurium, from BDH chemicals Ltd Poole England have 99.95 % purity . Polystyrene (PS)is an organic aromatic polymer made from styrene monomer. Polystyrene foamed or solid. polystyrene is transparent, hard, and brittle. It is. It is have poor resistance to oxygen and vapor water. Polystyrene was used widely in the plastics, it is clear but can be colored and not colored . uses of polystyrene that protective packaging such as packaging CD and DVD cases. As a thermoplastic polymer, it is glass in room temperature but it melts if heated to over 100℃ it represents the glass transition of it then request solid again when leave it cooled . Polystyrene (PS) very important materials from the modern plastics in the world, because have excellent physical properties and low-cost[12]

Table(1) polystyrene properties[13]

The property	The magnitude
Molar mass	104.15(g/mole)

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Cohesive energy	29.6 - 35.4(KJ/mol)
Enthalpy of Fusion	8.37 - 10(KJ/mol)
melting entropy	0.0153-.0168(KJ/mol)
Transition Temperature	373(K)
Heat capacity (100K)	0.04737(KJ/Kmol)
Thermal conductivity (amorphous, T=473K)	0.13(J/smK)
Solubility parameter	15.6 - 21.1(MPa)
Impact strength	$(35\text{-}84)\times 10^3$ kg/ m^2
Elongation	(1-2.5)%
Density	(1.04-1.09)g/ cm^3
Refraction indx	(1.59-1.60)
Dielectric Constant	(2.4-2.65)
Effect of sunlight	yellowing
Effect of acid	Attack from acid
Effect of Solvents	Solvent

Filler

Zinc telluride as a reinforcing powder

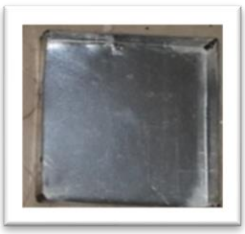
ZnTe is a binary chemical compounds it is solid and semiconductor material have a direct band gap of 2.26 ev . and grey , brownish red powder , red crystal can be prepared as rock salt crystal or in hexagonal crystal zinc telluride is p-type semiconductor it has cubic crystal structure and it is easily doped for this reason it is used in many optical application such as photovoltaic cells and solar cells ,LED laser, in microwave generator .in solar cells used (ZnTe/CdTe) layers and in PIN diode in some materials used ternary semiconductors such as CdxZn(1-x)Te theoretically a mixture composed from the end-members ZnTe and CdTe), which can be made with a different composition x to allow the optical band gap to be tuned as desired [14]properties of ZnTe explained in table :

Table (2)The properties of Zinc Telluride in this table :[15]

Chemical Formula	**ZnTe**
molar mass	192.99g/mole
appearance	red crystal
density	6.34g/cm3
melting point	1295℃
band gap	2.26ev
Thermal conductivity	108mw/cm.k
Refractive index	2.56
Crystal structure	Zinc blende

IV.Preparation The Samples :

Samples were prepared from polystyrene as a matrix and Zn_xTe_{1-x} as a reinforced material . Grinding of polystyrene beads by German windmill the matrix and reinforced materials manually with a mechanical mixer then put in the oven at 240℃ where mixing in different weight ratios (4%,8%,12%).the samples were as a circular discs with 4 cm in radius and 0.4 cm in thick then test thermal conductivity by the lees instrument that is made by George & Griffin company which that the heat is transfer from heater to the next disc until reaches to the last disc



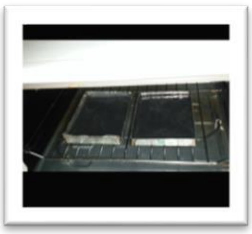


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Figure (1) mold , sample and instrument

V.Results and Discussion:

By using equations 1 , 2 from theoretical part get the results after took temperature of the tablets A,B,and C .In the first group of thermal conductivity show that the lowest value of it at first sample and at first ratio (4%) that (0.401345)watt/m ℃ that is gradually increasing when the ratio of Zn increasing to become (0.683841) watt/m℃ and the others range between these two values but at the second ratio (8%) the value of thermal conductivity is (0.452167) watt/m ℃ and increasing to become (0.765359) watt/m℃ .at the third ratio (12%) has (0.501494) watt/m ℃ Increasing to become (0.862527) watt/m ℃ the reason of increase in thermal coefficient that the density of crosslink of the component of polymer . Also the composite material consisting of reinforced with different particles have good value of thermal conductivity. This due to a higher effect is given by the dispersed phase and the adhesion between the components. increase in the adhesion between the components in the polymer or filled polymer cased decrease in heat resistance lead to increase in the coefficient of heat transfer of the material that is illustrate in the tables (3)(4)(5) and the figures (2)(3)(4)(5)this is results agree with [16].

Table (3) Thermal Conductivity of (ZnxTe1-x/PS)

G.N	Wt%	S.N	Sample composition	Thermal conductivity (watt/m℃)
G1	Ψ1=0.04	1	Zn(0%)Te (4%) + 96% Ps	0.401345
		2	Zn(0.8%)Te(3.2%)+96%Ps	0.473916
		3	Zn(1.6%)Te(2.4%)+96%Ps	0.507325
		4	Zn(2.4%)Te(1.6%)+96%Ps	0.578609
		5	Zn(3.2%)Te(0.8%)+96%Ps	0. 629813
		6	Zn(4%)Te(0%)+96% Ps	0.683841

Table (4) Thermal Conductivity of (ZnxTe1-x/PS)

G.N	Wt%	S.N	Sample composition	Thermal conductivity (watt/m℃)
G1	Ψ2=8%	1	Zn(0%)Te (8%) + 92% Ps	0.452167
		2	Zn(1.6%)Te(6.4%)+92%Ps	0.512008
		3	Zn(3.2%)Te(4.8%)+92%Ps	0.57396
		4	Zn(4.8%)Te(3.2%)+92%Ps	0.654856
		5	Zn(6.4%)Te(1.6%)+92%Ps	0.715706
		6	Zn(8%)Te(0%)+92% Ps	0.765359

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Table (5) Thermal Conductivity of (ZnxTe1-x/PS)

G.N	Wt%	S.N	Sample composition	Thermal conductivity (watt/m°C)
G1	Ψ3=12%	1	Zn(0%)Te(12%)+88%PS	0.501494
		2	Zn(2.4%)Te(9.6%)+88%PS	0.584656
		3	Zn(4.8%)Te(7.2%)+88%PS	0.688647
		4	Zn(7.2%)Te(4.8%)+88%PS	0.72924
		5	Zn(9.6%)Te(2.4%)+88%PS	0.779814
		6	Zn(12%)Te(0%)+88%PS	0.862527

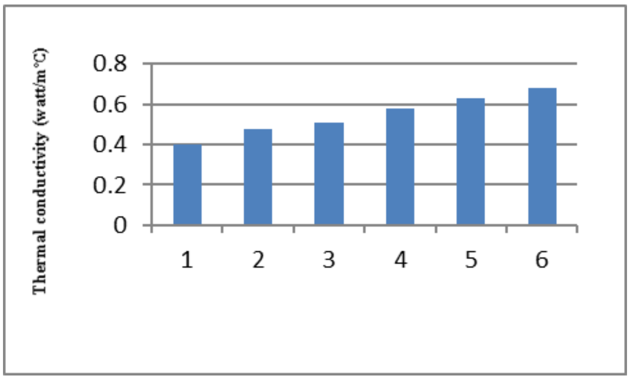

Figure (2)Thermal Conductivity of (ZnxTe1-x/PS)

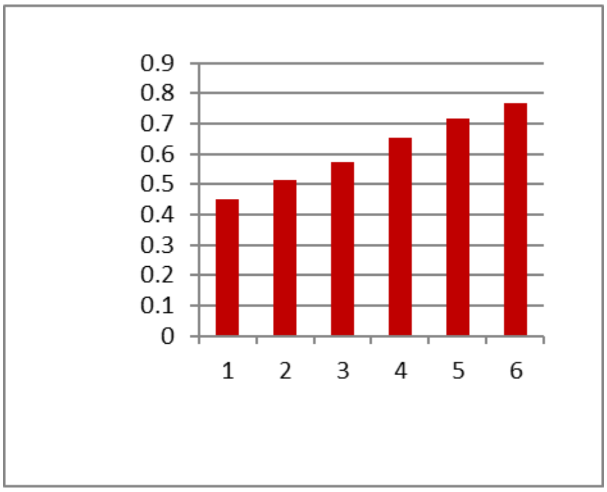

Figure (3)Thermal Conductivity of (ZnxTe1-x/PS

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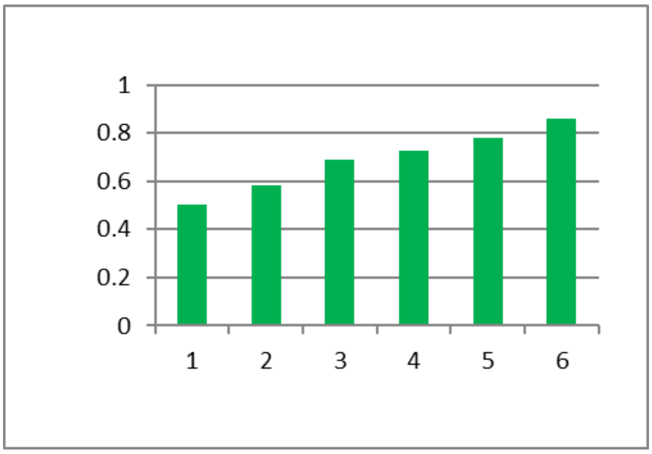

Figure (4)Thermal Conductivity of (ZnxTe1-x/PS

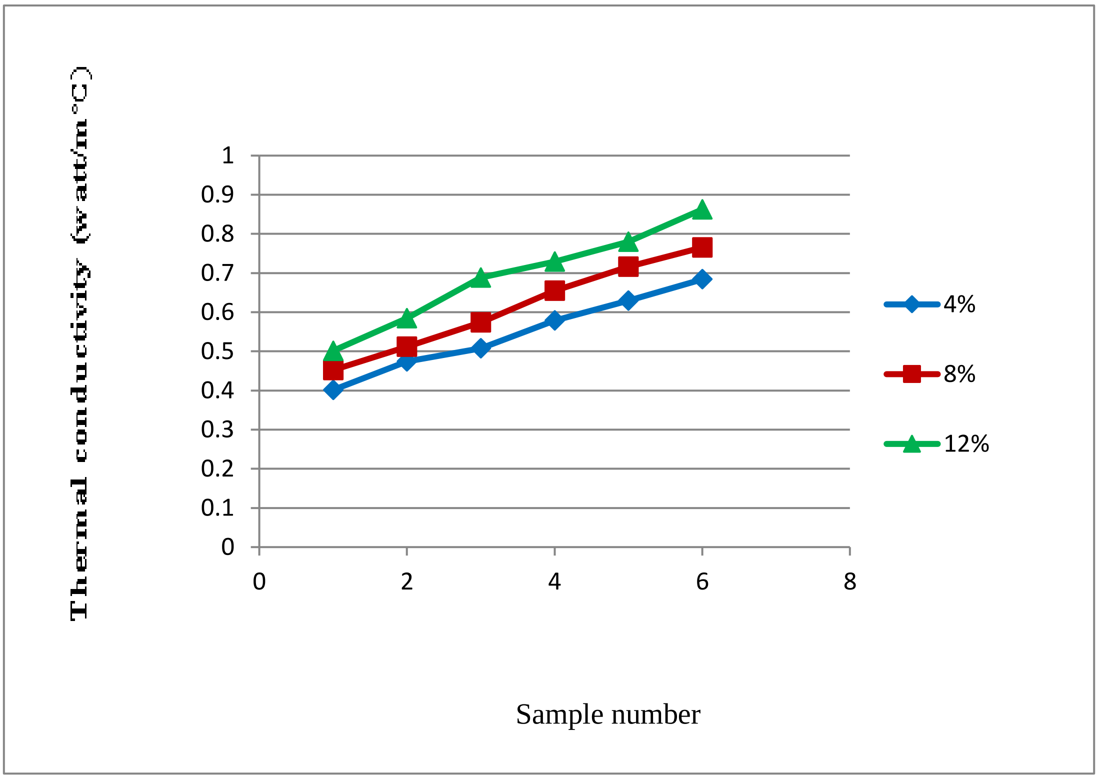

Figure (5)Thermal Conductivity Test For Weight Fraction Ψ1,Ψ2,Ψ3, G1 With Sample Number for (Zn_xTe_{1-x}/PS)

VI.CONCLUSION

Conclusion result that thermal conductivity increased linearly with increase weight fraction wt% that means the thermal conductivity increase with weight ratio of **Zn_xTe_{1-x}** increase

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