ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 09, pp.38780-38784, September, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

INVESTIGATION OF THERMAL ANALYSIS OF COMPOSITE SLABS

***Madhavarao, S., Seshu Kumar, G. S. V., Ch. Ramabhadri Raju and Anil Kumar, M.**

Department of Mechanical Engg,, S.R.K.R. Engg College, Bhimavaram-534204, India

ARTICLE INFO

Article History:
Received 22nd June, 2016
Received in revised form
24th July, 2016
Accepted 07th August, 2016
Published online 30th September, 2016

Key words:

Thermal conductivity, Composite slabs.

ABSTRACT

In this study, the experiments carried out to investigate heat transfer through conduction over composite slabs of different materials such as Copper, Aluminum, Stainless steel, Mild steel and Glass. The sizes of slab materials are 10 cm of diameter, 6 mm of thickness. The effects of different voltages and currents values are evaluated. In this experiment materials are taken in three different combinations. Based on the experimental results the theoretical overall heat transfer, resistance and experimental overall heat conductance and resistance are evaluated and depicted graphically based on the results and explanations the reason for difference in thermal conductance of composite slabs.

Citation: Madhavarao, S., Seshu Kumar, G. S. V., Ch. Ramabhadri Raju and Anil Kumar, M. 2016. "Investigation of thermal analysis of composite slabs" *International Journal of Current Research*, 8, (09), 38780-38784.

INTRODUCTION

Heat transfer through thermal conduction over composite slabs or walls are found in many physical problems and engineering applications such as in fields of nuclear reactors, Internal combustion engines, steam turbines and boilers, refrigeration, ventilations and many other real life applications. The thermal conductivity of a material depends on so many factor the most important factors are Material structure, Density of material, Moisture content and operating conditions like pressure and temperature. Brian Y. Lattimer and Jason Ouellette (2006) conducted the Properties of composite materials for thermal analysis involving fires. Inverse heat transfer analysis was used to determine thermal and physical properties of a coupon size glass reinforced vinyl ester composite sample from ambient to 800 °C these apparent specific heat capacities were input into a transient heat conduction model to predict the temperature profile through a sample.George S. Springer and Stephen W. Tsai (2016) reported the Thermal Conductivities of Unidirectional Materials. The composite thermal conductivities of unidirectional composites are studied and expressions are obtained for predicting these conductivities in the directions along and normal to the filaments. The results of the shear loading analogy agree reason ably well with the results of the thermal model particularly at filament contents below about 60%. Hasselman and Lloyd F. Johnson (2015) developed the Effective Thermal Conductivity of Composites with Interfacial Thermal Barrier Resistance.

***Corresponding author: Madhavarao, S.**
Department of Mechanical Engg,, S.R.K.R. Engg College, Bhimavaram-534204, India.

Literature Survey

Haktan Karadeniz *et al*. (2007) conducted A numerical study on the coefficients of thermal expansion of fiber reinforced composite materials the effective coefficients of thermal expansion (CTE) of fiber reinforced composites are studied by micromechanical modeling using the finite element method the expansion behavior of different material systems with respect to fiber content was determined numerically Jianwei Che *et al*. (2000) developed the Thermal conductivity of carbon nanotubes. As the sizes of electronic and mechanical devices are decreased to the micron and nanometre level, it becomes particularly important to predict the thermal transport properties of the components. The anisotropic character of the thermal conductivity of the graphite crystal is naturally reflected in the carbon nanotubes. We found that the carbon nanotubes have very high thermal conductivity comparable to diamond crystal and in-plane graphite sheet. Savoia and Reddy (1995) conducted the stress analysis of multilayered plates subject to thermal and mechanical loads are presented in the context of the three-dimensional quasi-static theory of thermo elasticity. Polynomial and exponential temperature distributions through the thickness are considered. Numerical results for plates with the simply supported boundary conditions are presented. Asma Yasmin and Isaac M. Daniel

(2004) conducted Mechanical and thermal properties of graphite platelet/epoxy composites. An hydride-cured diglycidyl ether of bisphenol A (DGEBA) reinforced with 2.5–5% by weight graphite platelets was fabricated The storage modulus and glass transition temperatures (Tg) of the composites also increased with increasing platelet concentration, however, the coefficient of thermal expansion decreased with the addition of graphite platelets. Dvorak (2009) presented the Thermal Expansion of Elastic-Plastic Composite Materials Exact relationships are derived between instantaneous overall thermal stress or strain vectors and instantaneous overall mechanical stiffness or compliance, for two binary composite systems in which one of the phases may deform plastically The method is extended to discretized microstructures, and also to the analysis of moisture absorption and phase transformation effects on overall response and on local fields in the two composite materials.

Griffis *et al*. (2016) conducted the Thermal Response of Graphite Epoxy Composite Subjected to Rapid Heating A one-dimensional finite difference analysis describing the transient thermal response of fiber-reinforced organic matrix composite plates subjected to intense surface heating is presented A steady state analytic solution is also given which provides a reasonable estimate of the surface recession rate over much of the surface irradiation period. Shen (1998) conducted the Thermal expansion of metal–ceramic composites: a three-dimensional analysis the thermal expansion response of macroscopically isotropic metal–ceramic composites is studied through micromechanical modeling. Three-dimensional finite element analyses are carried out for the entire range of phase concentration from pure metal to pure ceramic, using the aluminum–silicon carbide composite as a model system the three-dimensional analysis allows the thermal deformation behavior of interpenetrating composites to be examined in a realistic manner

Heat transfer through thermal conduction over a composite slab are found in many physical problems and engineering applications such as in manufacturing furnaces, internal combustion engines, heat exchangers, heating and cooling purposes etc. For this the material to be selected to manufacture that component is very important. Because it has to sustain to that operating conditions like temperature and pressure etc. without failure. The primary objective of this experiment is to find the overall conductance of the metals using in the composite slab. Different materials used in this experiment are copper, aluminium, and mild steel, and stainless steel, glass.

Experimental Setup

The aim of the experimentation is to find practical results of a heat transfer taken place in different types of composite slab plates with finite wall thickness exposed to an ambient medium of water at constant wall temperature. The thermal conduction at the inner wall corresponds to the case of constant heat flux. To find average surface temperature, over all thermal conductivity and thermal resistance both experimentally and theoretically for the four composite slabs. The experimental setup are constructed by used the various elements are Ana log voltmeter (0-300v) is an instrument used for measuring electrical potential between difference two points in an electric circuit, Ana log ammeter (0-3A) is a measuring instrument used to measure the electric current in a circuit, Heater (250kw)is Used to heat external surface with a connected to rotary switch, Thermocouples are measures heat upon the heat transfer taken place in the different composite slab plates by producing voltage and it is connecting to rotary switch, Rotary switch is rotating switch equal to 10 switches arranged linearly, AC controller (220/240v) is used for adjusting voltage given to heater Glass wool is used as an insulating material for the tubes

Fig. 1. Experimental setup

The four slabs are clamped using bolts and nuts. On the bottom side of the composite wall a heater is fitted and at the top there is a cooling jacket. The losses from Composite wall are minimized by providing thick insulation all around it to ensure undirected heat flow. The thermocouples are arranged at three different position of each slab. The connections are shown in circuit diagram Fig.2.

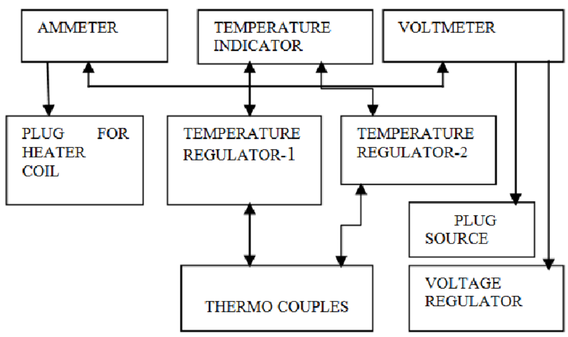

Fig.2. Circuit Diagram

In the test section previously the heater coil is arranged as a permanent joint but we made the joint now as the temporary joint using slots by bolts and nuts for easy removal. The circular slab surface temperature is measured by 3 thermo couples arranged along the circular slab. The thermocouples are attached to the circular slab by drilling 3 holes of 3mm diameter along the circular slab. All the thermocouples wires are attached with the help of studs. The distance between these thermocouples are varied constantly. The three thermocouples are used to measure the surface of the circular slab and one thermocouple is used to measure the ambient temperature. The test section consists of circular plate with a slab thickness of 0.1 mm and length 5mm.The circular plate with finite wall thickness is exposed to ambient medium of water at a constant wall temperature. 'The heat flux varies constantly (i.e., 10 V) from 70v to 90v for every orientation. The diameter of the circular plate is 10 cm, thickness of the slab is 6 mm. The length of the heater is 410 mm. The experimental chamber outer and inner diameters are 26 cm and 23 cm respectively. The apparatus consists of materials having same thickness of copper, aluminium, mild steel, stainless steel and glass. This five different materials are arranged in 3 different combinations there are mention below

Combination: 1 Aluminium, Copper, Stainless steel, Glass
Combination: 2 Copper, Aluminium, Stainless steel, Glass
Combination: 3 Copper, Aluminium, Mild steel, Glass

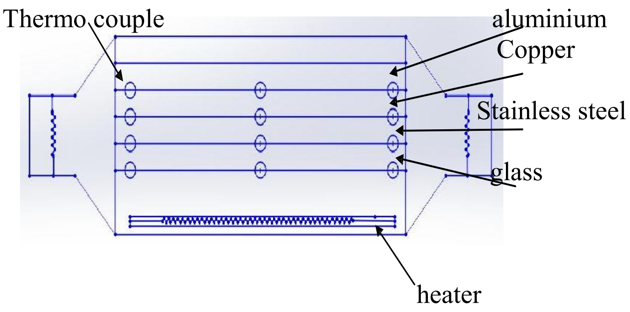

Fig. 3. Wire frame module of the experimental setup

To carry out the experiments the following procedure was followed. The slabs were adjusted as required in composite wall instrument. The electrical heater was switched on and the heater input power then adjusted to give the required heat flux at particular value. The apparatus was left at least one hour to establish steady state condition the thermocouples readings were measured every half an hour by means of the Analog thermometer until the reading became constant, a final reading of temperature. The input power to the heater could be increased to cover another run in a shorter period of time and to obtain steady state conditions for next heat flux. Subsequent runs for other ranges of slabs were performed in the same previous procedure. During each test run, the following readings were recorded: The readings of the thermocouples in °C. The heater current in amperes. The heater voltage in volts The inlet and outlet water temperatures using thermometers. The above same producer have been repeated for the another two more combinations and readings have been taken

Fourier's Law of Heat Conduction

The law of heat conduction is also known as Fourier's law. Fourier's law states that "the time rate of heat transfer through a material is proportional to the negative gradient in the temperature and to the area."

Mathematically,
$Q \propto A\, dt/dx$
$Q = -kA\, dt/dx$
Where Q is the rate of heat flow,
A is the area perpendicular to the flow,
'dt' is the temperature difference between length 'dx'
k is thermal conductivity
–ve sign indicates that decreasing temperature along increasing the length or thickness

Heat taken over by water $q = V \times I$
Overall thermal conductance $U_{exp} = q/A\,(T_1 - T_2)$ (w/m2.k)
Thermal resistance $R_{exp} = 1 / U_{exp}$
Theoretical Overall thermal conductance $U_{th} = 1 / ((l_1 / k_1) + (l_2 / k_2) + (l_3 / k_3) + (l_4 / k_4))$
Theoretical thermal resistance $R_{th} = 1/ U_{exp}$

RESULTS AND DISCUSSION

Average temperature variations

The variations of average surface temperature(^{o}c) over a composite slab made of different materials such as brass, asbestos, mild steel, stainless steel, aluminium for different combinations with respect to thickness (mm) along the slab is studied on the corresponding graphs are plotted and depicted in Fig 4,5 & 6.

Overall thermal conductance variations

The variations of Overall thermal conductance(w/^{o}k) over a composite slab made of different materials such as brass, asbestos, mild steel, stainless steel, aluminium for different combinations with respect to average temperatures (^{o}c) of respective materials along the slab are studied on the corresponding graphs are plotted and depicted in fig 7,8 &9

Thermal resistance variations

The variations of Thermal resistance(^{o}k/w) over a composite slab made of different materials such as brass, asbestos, mild steel, stainless steel, aluminium for different combinations with respect to average temperatures(^{o}c) of respective materials along the slab are studied on the corresponding graphs are plotted and depicted in fig 10,11&12

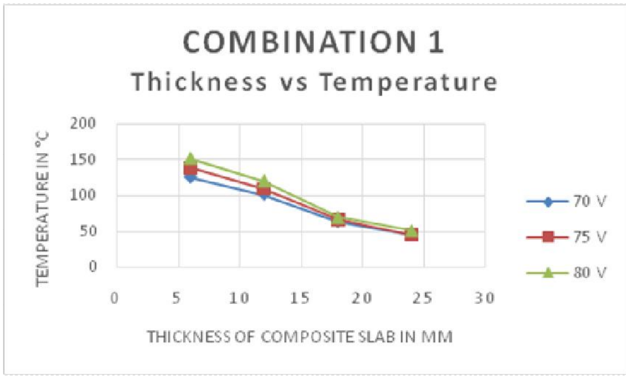

Fig4. Variation of temperature of composite slabs in combination-1 w. r. t thickness of the slab

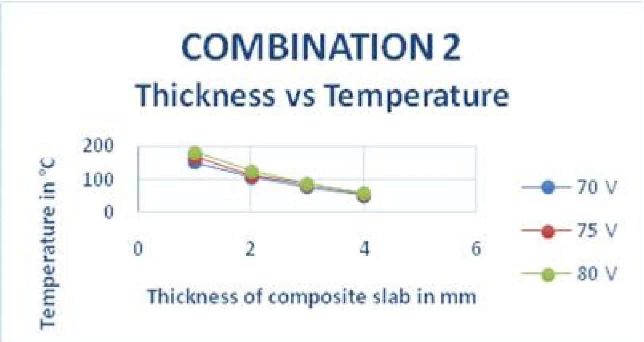

Fig5. Variation of temperature of composite slabs in combination-2 w. r. t thickness of the slab

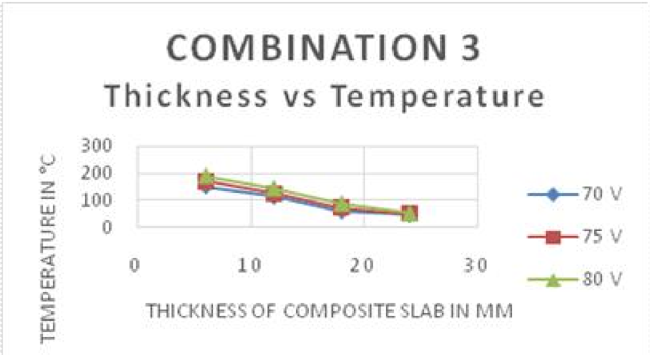

Fig6. Variation of temperature of composite slabs in combination-3 w. r. t thickness of the slab

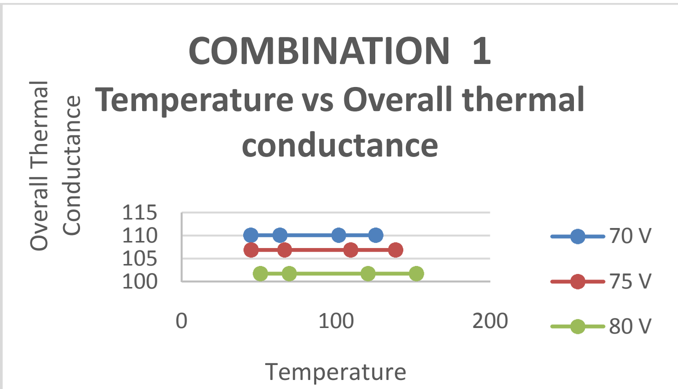

Fig 7. Variation of overall thermal conductance of composite slabs in combination-1 w. r. t temperature

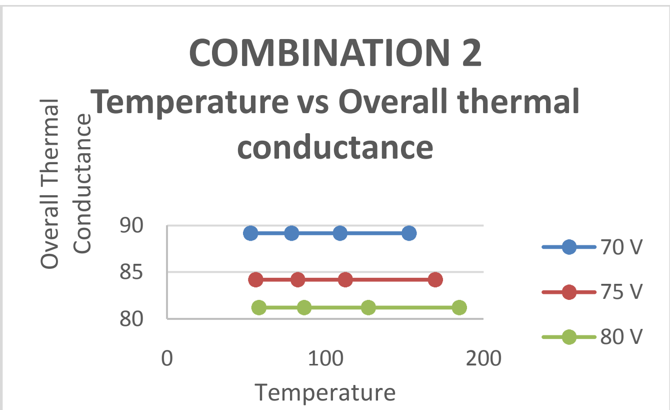

Fig 8. Variation of overall thermal conductance of composite slabs in combination-2 w. r. t temperature

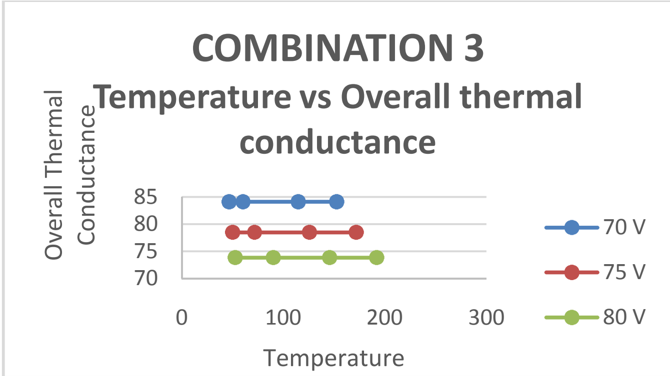

Fig 9. Variation of overall thermal conductance of composite slabs in combination-3 w. r. t temperature

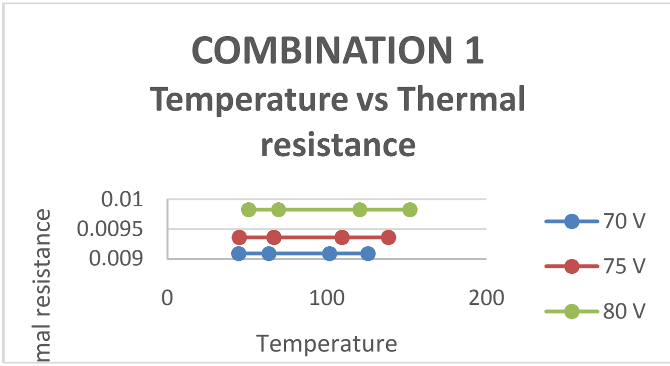

Fig10. Variation of Thermal resistance of composite slabs in combination-1 w. r. t temperature

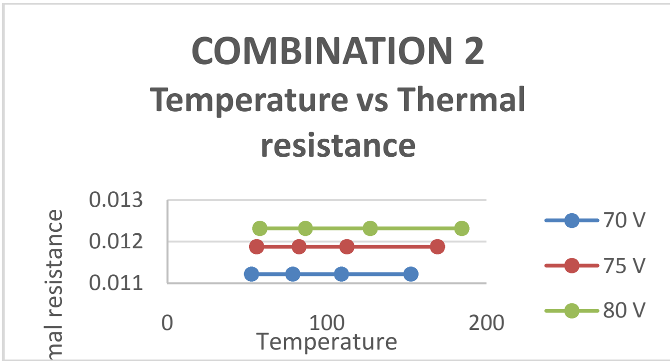

Fig. 11. Variation of Thermal resistance of composite slabs in combination-2 w. r. t temperature

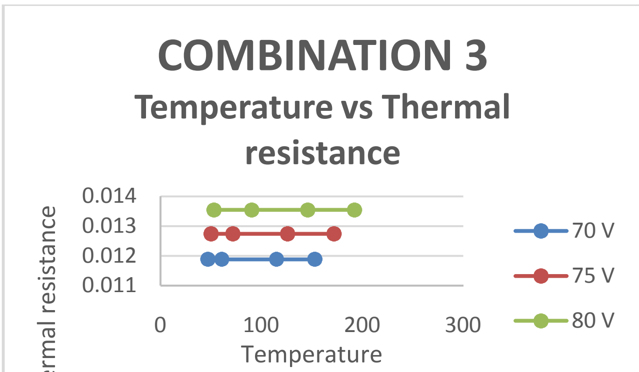

Fig. 12. Variation of Thermal resistance of composite slabs in combination 3 w. r. t temperature

Conclusion

Heat transfer of thermal conduction were conducted on composite slabs of three different combinations that are with different materials such as brass, asbestos, mild steel, stainless steel, aluminium in order to study various theoretical overall thermal conductance, experimental overall. Thermal conductance, theoretical thermal Resistance and experimental thermal resistance for different heat inputs. Based on Experimental observations the following conclusions were observed. Experimental setup was developed for analysing the heat transfer of thermal conductance over a different composite slab. From the experimentation results overall thermal conductance values are relatively high for first combination compared to other two combinations. It is observed that at lower heater inputs the materials shows good conductance values in respective combinations. Based on experimentation results the thermal resistance values are a slight higher in case of third combination when compared to other two combinations. Due to thermal contact resistance the heat which we supply is decreasing from bottom to top.

REFERENCES

Ahmet Sarı and Ali Karaipekli, Thermal conductivity and latent heat thermal energy storage characteristics of paraffin/expanded graphite composite as phase change material, 3 January 2007

Asma Yasmin and Isaac M. Daniel, Mechanical and thermal properties of graphite platelet/epoxy composites, *McCormick School of Engineering and Applied Science*, 21 September 2004

Beyeler E. P. and S. I. Güçeri, Thermal Analysis of Laser-Assisted Thermoplastic-Matrix Composite Tape Consolidation, October 20, 2009

Brian Y. Lattimer and Jason Ouellette, Properties of composite materials for thermal analysis involving fires, *Applied Science and Manufacturing*, Volume 37, Issue 7, July 2006, pp 1068–1081

Dasgupta A. and R.K. Agarwal, Orthotropic Thermal Conductivity of Plain-Weave Fabric Composites Using a Homogenization Technique, Materials Science, Composites, 11 out of 25, 2015

Dasgupta A. *et al*. Three-dimensional modeling of woven-fabric composites for effective thermo-mechanical and thermal properties, *Composites Science and Technology*, Volume 56, Issue 3, 1996, pp209-223

David E. Bowles and Stephen S. Tompkins, Prediction of Coefficients of Thermal Expansion for Unidirectional Composites, Materials Science, Composites 11 out of 25, 2016

Dilek Kumlutas *et al*, A Numerical and Experimental Study on Thermal Conductivity of Particle Filled Polymer Composites, Materials Science, Composites 16 out of 25,2015

Dilek Kumlutaş *et al*, Thermal conductivity of particle filled polyethylene composite materials, *Composites Science and Technology*, Volume 63, Issue 1, January 2003, pp 113–117

Dvorak, G. J. Thermal Expansion of Elastic-Plastic Composite Materials, *J. Appl. Mech*., 53(4), 737-743, July 21, 2009

Geon-Woong Lee et al, Enhanced thermal conductivity of polymer composites filled with hybrid filler, *Applied Science and Manufacturing*, Volume 37, Issue 5, May 2006, pp 727–734

George J. Dvorak, Transformation Field Analysis of Inelastic Composite Materials, Published 8 May 1992

George S. Springer and 1.Stephen W. Tsai, Thermal Conductivities of Unidirectional Materials, Materials Science, Composites 11 out of 25, 2016

Ghasemi Nejhad M.N. *et al*. Thermal Analysis of in-situ Thermoplastic Composite Tape Laying, Materials Science, Composites 16 out of 25, 2016

Griffis C.A. *et al*. Thermal Response of Graphite Epoxy Composite Subjected to Rapid Heating, Materials Science, Composites, 2016

Haktan Karadeniz, Z. and Dilek Kumlutas, A numerical study on the coefficients of thermal expansion of fiber reinforced composite materials, Composite Structures Volume 78, Issue 1, March 2007, pp 1–10

Hashin, Z. Thermo elastic properties of fiber composites with imperfect interface, Mechanics of Materials Volume 8, Issue 4, February 1990, pp 333-348

Hasselman D.P.H. and Lloyd F. Johnson, Effective Thermal Conductivity of Composites with Interfacial Thermal Barrier Resistance, 2015.

Jianwei Che *et al*, Thermal conductivity of carbon nanotubes, Nanotechnology, Volume 11, Number 2, 2000, pp 65-69

Jiawen Xiong *et al*, The thermal and mechanical properties of a polyurethane/multi-walled carbon nanotube composite, Carbon Volume 44, Issue 13, November 2006, pp 2701–2707

Klein N. *et al*. Determining the role of interfacial transcrystallinity in composite materials by dynamic mechanical thermal analysis, Volume 26, Issue 10, 1995, pp 707-712

Kuen Y. Lin, Thermo-Viscoelastic Analysis of Composite Materials, Science, Composites 11 out of 25, 2016

López Manchado M.A. *et al*. Thermal and mechanical properties of single-walled carbon nanotubes–polypropylene composites prepared by melt processing, Carbon Volume 43, Issue 7, June 2005, pp 1499–1505

Progelhof, R. C. Methods for predicting the thermal conductivity of composite systems, Polymer Engineering & Science, 25 AUG 2004

Puglia D. *et al*. Analysis of the cure reaction of carbon nanotubes/epoxy resin composites through thermal analysis and Raman spectroscopy, 5 February 2003

Savoia M. and J.N. Reddy, Three-dimensional thermal analysis of laminated composite plates, *International Journal of Solids and Structures*, Volume 32, Issue 5, March 1995, pp 593-608

Shen, Y.-L. Thermal expansion of metal–ceramic composites: a three-dimensional analysis, 26 August 1998

Tapas Kuilla *et al*. Recent advances in graphene based polymer composites, 27 July 2010

Tuttle, M.E. A Mechanical/Thermal Analysis of Prestressed Composite Laminates, Materials Science, 2016

Yiqiang Zhao and David A. Schiraldi, Thermal and mechanical properties of polyhedral oligomeric silsesquioxane (POSS)/polycarbonate composites, 6 October 2005

****