ISSN 2456-8066
International Journal of Advanced Engineering and Management
Vol. 3, Issue. 2, pp. 43-50, 2018

Thermal Characterization and Analysis of Aluminium-Silicon Carbide-Graphite Hybrid Metal Matrix Composites

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Abstract

Thermal characterization and analysis of composite materials have been gaining greater importance. Thermal analysis of composites will be beneficial for comprehending the properties of materials as they change with temperature. The determination of thermal properties of composites have been constructive for the evaluation of thermal capacity, variation in the intensity of heat, heat diffusion and heat release rate. It has been customary to control the temperature in a predetermined way either by increase or decrease in temperature at a constant rate by the processes of linear heating or cooling. The thermal characterization of composite materials will depend on the factors that persuade on the thermophysical properties. It is a major challenge as composite materials are susceptible to the type of reinforcement and method of manufacture. The decisions based on the selection of materials for components are exposed to temperature variations and thermal gradient. For aerospace and automotive applications, low density, low coefficient of thermal expansion, moderate thermal conductivity and high electrical conductivity of composite materials .Hence it is mandatory for the design engineer to have a lucid comprehension about the thermal responses and characterize the thermal properties of a broad assortment of materials. Thermal analysis of composite materials are essential to examine the thermal properties viz., specific heat capacity, enthalpy, thermal diffusivity, thermal conductivity, temperature potential, thermal expansivity, latent heat, thermal displacement, thermal strain, thermal stresses, thermal gradient, thermal flux, rate of heat flow, and thermal shock resistances based on experimental and numerical approaches. This research paper emphasis the relevance and research scope of experimental and numerical thermal analysis of Aluminium hybrid composites.

Keywords

Thermal characterization, analysis, heat diffusion, composite materials, aerospace applications, thermal conductivity.

I. Introduction

Thermal analysis is often used as a term for the study of heat transfer to evaluate specific heat capacity and thermal conductivity. Thermal analysis of composite materials are essential to examine the thermal properties viz., specific heat capacity, enthalpy, thermal diffusivity, thermal conductivity, temperature potential, thermal expansivity, latent heat, thermal displacement, thermal strain, thermal stresses, thermal gradient, thermal flux, rate of heat flow, and thermal shock resistances based on experimental and numerical approaches. In thermal analysis, a cluster of techniques and experimental procedures are accessible which are challenging for studying the thermophysical and kinetic properties of materials. Thermophysical properties can also be used for the characterization of composite materials to evaluate the properties of the matrix material that are decisive for the scrupulous analysis of the composite [1].

The determination of thermal properties of composite materials is of paramount importance for the effective design and applications pertaining to aerospace and automotive engineering, electronic packaging, thermal management equipment, space science, power electronics and instrumentation, heat sinks, thermal power, and nuclear power engineering. The prominent properties influencing the thermal analysis

ISSN 2456-8066
International Journal of Advanced Engineering and Management
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of composite materials are specific heat capacity, thermal diffusivity, thermal conductivity and coefficient of thermal expansion. Thermal conductivity is regarded as the most noteworthy property in the thermal analysis of composites. It characterizes material capacity to conduct heat energy under certain temperature gradient. Thermal diffusivity is one of the important properties pertaining to the thermophysical nature of materials. It is an indispensable property for materials being used to establish the optimal work temperature in design applications referred under transient heat flow. It is the ratio of thermal conductivity to the product of density and specific heat capacity. It determines the speed of heat propagation based on the phenomenon of conduction during transformations with reference to temperature versus time. The propagation of heat is faster for materials with high thermal diffusivity. Thermal diffusivity and specific heat capacity are advantageous for determining thermal conductivity. Specific heat capacity characterizes material property to absorb heat energy subjected under the processes of heating and cooling [1, 2].

II. Need for Thermal Analysis

Aluminium matrix composites can be adapted to provide good coefficient of thermal expansion matching for the applications pertaining to thermal management equipment. It has been vital to assess composite materials for the thermal stability and to measure thermal properties viz., CTE and thermal conductivity for specialty products [3]. Aluminium matrix composites with high volume proportion depict acceptably high thermal conductivity. This factor leads to the possibility of customizing the CTE to fit the prerequisites of electronic systems. Aluminium based composites is one of the most resourceful materials among the classification of MMCs presently used for these applications [4, 5]. AMCs have exclusive and enviable thermal and mechanical properties. A striking feature of AMCs is the potential to adapt thermal conductivity and CTE [94, 95]. In general, the behavior of thermal expansion of a composite is depicted by the instantaneous linear CTE, which is the result of many factors viz., microstructure of the matrix, reinforcement volume proportion, internal stresses, thermal history, porosity and interfacial cohesive bonding between the matrix and the reinforcements [6, 7]. Thermophysical and thermomechanical properties of composite materials are required for numerous practical or industrial applications. These properties are studied comprehensively for the prediction of the behavior of material in a wide range of parameters characterizing their internal state (temperature and deformations) and structure (porosity and permeability). The changes of state parameters and structural characteristics of a material are caused by energy exchange and mechanical interaction of the material with environment.

The comprehension of certain factors that influences the thermophysical properties will emphasize a challenging chore for the researchers. The determination of the thermophysical properties are mandatory for the effective designing of heat transfer equipment, heat sinks, heat shields, nuclear reactors, power electronics and opto-electronic devices [8, 9, 10]. The behavior of composite materials are often responsive to changes in temperature. This is because, the response of the matrix to an applied load is dependent on temperature and transformations in temperature. The variation in temperature can cause internal stresses and result in differential thermal expansion and contraction processes of the constituents [3]. The coefficients of thermal expansion of matrices and reinforcements are the function of temperature. The behavior of the composites can be emphasized in terms of size of the particle and thermally induced stresses developed as a result of the coefficient of thermal expansion between the reinforcement and the matrix. Thermal analysis comprises test prediction, continuous validation tests and analysis. Generally, the temperature field is also extremely important and is more pertinent for the assessment of thermal stresses induced by thermal expansion [11]. The development, quantity and quality control of materials often necessitate the computation of the properties pertaining to thermophysical environment. This information can be decisive for a specific design, especially with the rapidly increasing requirements of cooling that result from the packaging of high performance devices. A variety of methods or techniques, involving both steady and transient techniques are accessible for the determination of thermal properties of composite materials.

III. THERMAL ANALYZERS

The thermophysical properties of materials and optimization of heat transfer of final products are becoming more and more crucial for the applications in industries. The objectives can be framed to determine the thermal properties viz., specific heat capacity, enthalpy, thermal diffusivity, thermal conductivity, thermal expansivity, latent heat, thermal displacement, thermal strain, thermal stresses, thermal gradient, thermal flux, rate of heat flow, and thermal shock resistances by adopting experimental and computational approaches. By the use of established thermo-elastic models, the theoretical values can be determined and using these thermoelastic or empirical models, validation shall be accomplished based on thermal expansion and thermal conductivity behavior of hybrid metal matrix composites. Thermal analysis of composites can be accomplished by employing various thermal analyzers viz., Differential Scanning Calorimeter (DSC), Laser Flash Apparatus (LFA), Dilatometer (DIL), Differential Thermal Analysis (DTA), Dynamic Mechanical Analyzer (DMA), Mechanical Thermal Analyzer and Thermogravimetric Analyzer (TGA). The thermal characterization of Al 6061-Silicon Carbide-Graphite hybrid metal matrix composites can be investigated. The characterization of mechanical, thermoelastic and thermophysical properties viz., Density, Tensile Strength, Moduli of Elasticity, Poisson's Ratio, Specific Heat Capacity, Thermal Diffusivity, Thermal Conductivity, and Thermal Expansivity of hybrid composites help to have a handle on the material behaviour. In order to investigate the thermophysical properties, composite materials are normally tested under varying temperature conditions. The observations and investigations are not only performed at room temperature but also at high temperatures or under cycling conditions. This is essential to comprehend the overall performance of the materials during its use [12].

AMCs have generated substantial interest in many engineering applications due to creditable mechanical properties viz., stiffness, wear and fatigue resistances and tailorable thermal properties viz., thermal conductivity, thermal capacity and thermal expansivity. These properties can be determined and customized for specific applications depending on volume proportions of matrices and reinforcements [13]. AMCs are principally governed by the conductivity of the individual phases, volume proportions, shape and size of the inclusion phase due to interface thermal resistance [14, 15]. It has been reported in the literature that, Aluminium matrix composites exhibit dependable thermophysical properties and find its applications in automotive components, aerospace engineering, military engineering, thermal management equipment and electronic packaging [16, 17]. Computational or numerical investigation can also be carried out for the characterization of mechanical and thermal behaviour of composite materials. Generally, it is accomplished by the use of finite element analysis. In the finite element approach pertaining to engineering problems, the imperative tasks for the generation of mesh, numerical processing, graphical depiction of results and interpretations are allocated to computer programs independently.

IV. COMPUTATIONAL THERMAL ANALYSIS

The computer programs can be embedded under a common interface to make possible for the user to interact with all segments in a single environment. They can also be implemented as separate sections by employing commercially available Computational Fluid Dynamics (CFD) or numerical packages. In numerical investigation, discretization is an important step that benefits in simplifying the computational procedure and is advantageous to ensure the authenticity of the numerical solution by convergence test. Discretization of the solution domain into an appropriate computational mesh is the elementary step in the finite element simulation. The important factors in the selection of a specific mesh design are domain geometry, type of finite elements, accuracy and cost of computation. The accuracy of the computational solutions depend on consistency of the mesh with the geometry of the domain, nature of the solution sought, type of elements selected and aspect ratio. The computational finite element method on a variety of composite materials allows the fabrication of metal matrix composites to be productive based on experimental information. For the analysis of metal matrix composites, numerous researchers have suggested unit cell analysis of a composite. Generally, there are computational difficulties to obtain agreeable results based on a small single unit owing to a lack of interaction between reinforcement and matrix. On the contrary, the computations with multiple unit cells allow consistent, satisfactory and feasible results due to considerable material interaction [18, 19, 20, 21, 22]. Finite element method is regarded as an efficient technique for the prediction and computation of the properties based on mechanical and thermal behaviour of composite materials. A promising application of metal matrix composites in the topic of engineering design necessitates an elaborate categorization of mechanical and thermal properties. The properties based on thermal expansion of composite materials play a noteworthy role in computing the computational thermal properties viz., thermal displacement, thermal strain and thermal stresses in components or structures of metal matrix composites. Analogously, the properties based on the thermal conductivity behaviour of composite materials play a dominating role for the computation of thermal gradient, thermal flux and rate of heat flow. The numerous factors in the process of characterization of composite materials have led a methodical way to comprehend several numerical and analytical techniques [23, 24, 25].

Thermal analyses of hybrid metal matrix composites with equal or varying proportions of Silicon Carbide and Graphite reinforcements can be accomplished by the use of a commercially available CFD package ANSYS. The main objectives in carrying out computational thermal analysis are to determine the values of temperature and heat distribution on the prominent nodes in both the matrix and reinforcements. In this research work, the computational investigation can be accomplished to compute the thermal properties viz., thermal displacement, thermal strain and thermal stresses based on thermal expansion behaviour of hybrid composites. Correspondingly, the computational thermal properties viz., thermal gradient, thermal flux and rate of heat flow can be explored based on thermal conductivity behaviour of composites. Numerical convergence test or mesh independence studies have been carried out. A comparative study has been brought out to corroborate numerical and analytical results. The major emphasis of computational or numerical investigation will lead to the development of numerical tools for the computational mesomodeling testing of materials. The accessibility of the resources for the computational investigation and simulation techniques are constructive to attain speed and accuracy. Consecutively, it saves development cost, production cost and computation time.

V. COMPUTATIONAL TOOLS

Certain tools pertaining to simulation can save development costs and have been employed to corroborate the numerical methods by means of small scale materials for parameter identification. Hence it is necessary to focus on maximum exertion for both experimentation and validation analyses. In computational modelling, homogenization will be achieved mandatorily for the complete refinement of nodes. Also, meshing will be accomplished by the selection of a particular element type. Homogenization is advantageous for the scrupulous analysis of materials. The prerequisite by the use of homogenization in the analysis of thermal properties is caused by a different selection of problems. Homogenization can be performed to abridge certain mechanisms and phenomena relating heat transfer by adopting specific tools of simulation. The application of homogenization to the properties of thermal material will facilitate to predict the profile of temperature of a structure. Any technique pertaining to thermal analysis of composites can be implemented and executed by adopting finite element

ISSN 2456-8066
International Journal of Advanced Engineering and Management
Vol. 3, Issue. 2, pp. 43-50, 2018

method. The design of materials on the basis of numerical testing of microstructures can be comprehended for the distinct materials and microstructural characterization can be carried out systematically. To extend experimental information, the computational modeling on a variety of composite materials allows the fabrication of AMCs to be productive. For the thermal analysis of Aluminium matrix composites, many researchers have suggested unit cell of composite. Generally, there are complexities encumbered in computation to obtain reasonable results based on a small single unit owing to a lack of interaction between reinforcement and matrix. On the contrary, the computational investigation with multiple unit cells allows consistent results due to considerable material interaction [17].

Composite materials pose various challenges in computational modelling because of the nature and behaviour of materials. However, composite materials pose exceptional modelling challenges because of their different constituent materials, excellent properties and orientations. With the appropriate simulation tools, designers can predict performance, analyze reliability and potential failures, optimize construction and export accurate information for manufacturing, all before a physical prototype is built [22, 23, 24, 25, 26]. Aluminium matrix composites have been productive for industrial applications, such as aerospace and automotive engineering, due to its admirable thermal and mechanical properties. Finite Element Method (FEM) supplies an institutional investigation taking advantages of postprocesses pertaining to graphical and mathematical approaches. It helps for meticulous analysis of the behavior of materials and associated properties, including the analysis of local stress and distribution of strain. Nevertheless, there are evocative reports pertaining to the study of finite element analysis based on the thermal properties of Aluminium Silicon Carbide system. Finite Element Analysis (FEA) has been used expansively to simulate the thermal and mechanical behavior of metal matrix composites. Aluminium has been acclaimed as a matrix material that possesses high thermal expansivity. Thus particles of Silicon Carbide in Aluminium matrix have been considered as a function of CTE reduction in Al-SiC system.

VI. FINITE ELEMENT APPROACH

The inferences for the different solutions pertaining to finite element analysis for the classification of composites can be compared with the results of mathematical models and with the experimental investigation. Computational simulations based on the thermal analysis of metal matrix composites comprise Aluminium and Silicon Carbide which can be examined by considering the volume proportions of Silicon Carbide. Computational thermal analysis of hybrid metal matrix composites having equal proportions of Silicon Carbide and Graphite reinforcements will be carried out by the use of commercially available Computational Fluid Dynamics (CFD) package ANSYS. In computational or numerical investigation, it is essential to emphasize the mode of computation, element type, type of characterization, selection of nodes and the pertinent boundary conditions. The experimental values can be used as the material properties and the computational investigation will be accomplished for the determination of thermal properties viz., thermal displacement, thermal strain, thermal stresses, thermal gradient, thermal flux, and rate of heat flow. A comparative study can be brought out to corroborate the computational and theoretical results. In computational analysis, numerical convergence or mesh independence study is extremely important to reduce the cost of computation and maintain utmost accuracy in the results. Finite element method identifies a broad spectrum of techniques. Two predominant classifications are formulation and solution based on FEM.

FEM formulation involves displacement, equilibrium, mixed and hybrid methods, whereas FEM Solution involves stiffness, flexibility and mixed method. But emphases have also been given to displacement formulation and stiffness solution. This combination is referred to as Direct Stiffness Method (DSM). Practically all finite element codes are based on DSM. The direct solvers that have been used for computational modelling are sparse direct solver,

ISSN 2456-8066
International Journal of Advanced Engineering and Management
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frontal solver and a wider preference of iterative solvers. Sparse direct solver utilizes the finite element matrices that are generally sparsely populated. This sparseness allows the system of simultaneous equations to be solved efficiently by minimizing the operation counts. On the contrary, frontal solver is designed to curtail the memory used in the solution process although the operation count is generally more than that of the sparse direct solver.
The sparse direct solver is the functional solver for all analyses, except for electromagnetic analyses that include polynomial elements and constraint equations, spectrum analyses and substructuring analyses. For nonlinear problems, the sparse direct solver provides robust solution with the satisfactory performance of the central processing unit, usually faster when compared to the frontal solver. In this research work, sparse direct solver has been used. In frontal (or wavefront) solution, the number of equations that are active after any elements have been processed during the solution procedure is referred to as the wavefront at that point. This method is approving for placing a wavefront restriction on the problem definition, which depends upon the amount of memory available for a given problem. Wavefront limits tend to be restrictive only for the analysis of arbitrary three-dimensional solids. In the wavefront procedure, the sequence in which the elements are processed in the solver is crucial to minimize the size of the wavefront. Computational modelling of composite materials is normally governed by mass, momentum and energy conservation equations. The mass and momentum equations are related to the constituent volume proportions and density of composite materials. It is recognized that, the weight proportions of composites is a direct consequence of relative motion between the constituents. Energy conservation equation relates the energy and heat transfer processes pertaining to the thermal characterization of composites. The computational investigations on thermal expansion and thermal conductivity behaviour of hybrid metal matrix composites can be carried out. The computational investigation on thermal expansion behaviour leads to the exploration of thermal displacement, thermal strain and thermal stresses. Analogously, the computational investigation on thermal conductivity behaviour helps to investigate thermal or temperature gradient, thermal flux and rate of heat flow.
The structural and thermal analyses comprise four main steps viz., build the model, apply loads & obtain the solution, analyze the computational elements and review the results. The main computational aspects that can be considered in structural and thermal analyses of hybrid metal matrix composites are the mode of computation, element type, material properties, type of model, method of meshing, boundary conditions, convergence test analysis and review of results. To investigate thermal expansion behaviour of hybrid metal matrix composites, the mode of computation that can be used is ‘structural’ and element type is ‘Solid’ Brick 8node 45. The pertinent material properties that have been considered are density, moduli of elasticity, Poisson’s ratio and thermal expansivities for the desired temperature range.

VII. CONCLUSION

The thermal properties viz., thermal displacement, thermal strain and thermal stresses can be investigated based on thermal expansion behaviour of composites. Analogously, to explore the thermal conductivity behaviour of hybrid composites, the mode of computation used is ‘thermal’ and element type that can be selected is Solid Brick 8node 70. The material properties that can be referred are density, specific heat capacity, enthalpy and thermal conductivity for the specific temperature ranging. For both computational conditions, temperature boundary condition is the major constraint. The thermal properties viz., thermal gradient, thermal flux and rate of heat flow can be investigated based on thermal conductivity behaviour of hybrid metal matrix composites. Mesh independence studies or numerical convergence test have to be accomplished for a particular composite specimen/sample based on thermal expansion and thermal conductivity behaviour of hybrid composites.

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VIII. REFERENCES

[1] Jasper Chiguma, Edwin Johnson, Preyah Shah, Natalya Gornopalskaya and Wayne E., "Thermal diffusivity and thermal conductivity of epoxy-based nanocomposites by Laser Flash and Differential Scanning Calorimetry techniques", Journal of Composite Materials, Vol. 3, No. 3, 2013, pp. 51-62.

[2] G. Dallas, Thermal Analysis, ASMHandbook-Composites, ASM International, Vol. 2, 2001, pp. 973-976.

[3] Thermal diffusivity by the Flash Method, TA Instruments, www.tainstruments.com, 2012.

[4] Garcia-Cordovilla C., Louis E. and Narciso J., "Pressure infiltration of packed ceramic particulates by liquid crystals", Acta Materialia, Vol. 47, 1999, pp. 4461-4479.

[5] Asthana R., Rohatgi P.K. and Tewari S.N., "Process advanced materials of particle compacts with bimodal size distributions", Scripta Materialia, Vol. 23, 1992, pp. 3126-3135.

[6] N. Chawla and K.K. Chawla, Metal Matrix Composites, Springer, New York, 2006.

[7] H.E. Nassini, M. Moreno and C. Gonzalez Oliver, "Thermal expansion behaviour of aluminium alloys reinforced with alumina planar random short fibres", Journal of Materials Science, Vol. 36, 2001, pp. 2759-2772.

[8] N. Chawla, B.V. Patel, M. Koopman, K.K. Chawla, R. Saha, B.R. Patterson, E.R. Fuller and S.A. Langer, "Microstructurebased simulation of thermomechanical behaviour of composite materials by objectoriented finite element analysis", Materials Characterization, Vol. 49, 2003, pp. 395- 407.

[9] Aleksey V. Marchenko, Thermomechanical Properties of Materials, Cold Regions Science and Marine Technology, Norway, 2008.

[10] Clynej T., "An introductory overview of MMC systems, types and developments", In: Kelly A., Zewben C., editors. Comprehensive Composite Materials, Vol. 3, Oxford, Elsevier Science: 2000.

[11] Xuan-hui Qu, Lin Zhang, Mao Wo and Shubin Ren, "Review of metal matrix composites with high thermal conductivity for thermal management applications", Progress in Natural Science: Materials International, Vol. 21, Issue 3, 2011, pp. 189-197.

[12] Jan Tessmer, Tom Spreowitz and Tobias Wille, "Thermal analysis of hybrid composite structures", 25th International Congress of the Aeronautical Sciences, 2005.

[13] N. Barekar, S. Tzamtzis, B.K.Dhindaw, J. Patel and Z. Fan, "Processing of Aluminium-Graphite particulate metal matrix composites by advanced shear technology", Journal of Materials Engineering and Performance, Vol. 18, Issue 9, 2009, pp. 1230 -1240.

[14] S. Ray, 'Review and synthesis of cast metal matrix particulate composites", Journal of Materials Science, Vol. 23, Issue 20, 1993, pp. 5387-5413.

[15] G. Korb and E. Neubauer, "Thermophysical properties of metal matrix composites", MMC-Assess Thematic Network, Australian Research Centres Seibersdorf, 2012, pp. 1-19.

[16] D.P.H. Hasselman and L.F. Johnson, "Effective thermal conductivity of composites with interfacial thermal barrier resistance", Journal of Composite Materials, Vol. 21, 1987, pp. 508-515.

[17] Y Benveniste and T Miloh, "The effective thermal conductivity of composites with imperfect thermal contact at constituent interfaces", International Journal of Engineering Science, Vol. 24, 1986, pp. 1537-1552.

[18] A.A. Cerit, M.B. Karamis, F. Nair and K. Yildizli, "Effect of reinforcement particle Size and volume fraction on wear behaviour of metal matrix composites", Tribology in Industry, Vol. 30, No. 3-4, 2008.

[19] Y.I. Xiao-Su, "Matrix resin improvement for aerospace polymer matrix composites", 46th International SAMPLE Symposium, May 6-10, 2001.

[20] Suchitra Mutlur, "Thermal analysis of composites using DSC", Advanced Topics in Characterization of Materials, 1978.

[21] M.J. Koezak, S.C.Khatri, J.E.Allison, M.G.Bader and A.Mortensen, "Fundamentals of metal matrix composites", Butterworth-Heinemann, Boston, 1993.

[22] Serhat Durmaz, Ph. D thesis on "A numerical study on the effective thermal conductivity of composite materials", January 2004.

ISSN 2456-8066
International Journal of Advanced Engineering and Management
Vol. 3, Issue. 2, pp. 43-50, 2018

[23] Karadeniz Z. and Kumulutas D., "A numerical study on the coefficient of thermal expansion of fibre reinforced composite materials", Composite Structures, Vol. 78, Issue 1, 2007, pp. 1-10.
[24] Ismar H. and Schroter F., "Modelling and numerical simulation of the thermomechanical cyclical behaviour of a cross-ply metal matrix composite", Computational Materials Science, Vol. 19, Issues 1-4, 2000, pp. 320-328.
[25] Bohm H., Eckschlager A. and Han W., "Multi-inclusion unit cell models for metal matrix composites with randomly oriented discontinuous reinforcements", Computational Materials Science, Vol. 25, 2002, pp. 42-53.
[26] Mondal D., Ramakrishnan N. and Das S., "Finite element modelling of the interface and its effect on the thermo-elastic behaviour of metal matrix composites", Materials Science and Engineering Part A, Vol. 62, 2006, pp. 286-290.

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