International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 02 | Feb -2017 www.irjet.net p-ISSN: 2395-0072

Review on Hybrid Composite Materials and its Applications

Mr.N.Subramani[1] *Assistant Professor, Mechanical Engineering, Karpagam College of Engineering, Coimbatore*
Dr.J.Ganesh Murali[2], *Professor, Karpagam College of Engineering, Coimbatore.*
Dr.P.Suresh[3], *Professor, Karpagam College of Engineering, Coimbatore.*
Mr.V.V.Arun Sankar[4] *Assistant Professor, Mechanical Engineering, Karpagam College of Engineering, Coimbatore*
Mr.T.Aravind [5], *Assistant Professor/CSE, Muthayammal Engineering College, Rasipuram, Namakkal District, Tamilnadu.*
V.K.Buvanesvari[6], *Research Scholar, Anna University, Chennai.*

---****---

Abstract - *The review article of this paper represents the reduced availability of natural resources, the increasing costs of production, and the apparent limit to our ability to fabricate high strength-to-weight metallic components necessitated the development of new materials to meet the demands of aerospace technology. These materials are called advanced composite materials and will be used to replace some of the metals currently used in aircraft construction. Advanced composites are materials consisting of a combination of high-strength stiff fibers embedded in a common matrix (binder) material, generally laminated with plies arranged in various directions to give the structure strength and stiffness. The much stiffer fibers of boron, graphite, and Kevlar have given composite materials structural properties superior in strength to the metal alloys that they have replaced.*

Key Words: *Advanced Composite Materials, Composite Types, Applications*

1. Introduction

Composite material is a material or alloy mixture with the reinforcement and made from two or more essential materials with pointedly different physical or chemical properties that, when combined, produce a material with physiognomies different from the specific components. The specific constituents remain separate and distinct within the finished structure. The novel material may be favoured for many reasons: common examples include materials which are stronger, lighter, or less expensive when associated to traditional materials. More recently, researchers have also commenced to actively include sensing, actuation, computation and communication into composites, which are known as Hybrid Materials.

Table 1: Properties of Composite Reinforcing Fibers

Material	E (GPa)	σb (GPa)	εb (%)	P (Mg/m³)	E/ρ (MJ/kg)	σb / ρ (MJ/kg)	Cost (Rs/kg)
E-Glass	72.4	2.4	2.6	2.54	28.5	0.95	61.6
S-Glass	85.5	4.5	2.0	2.49	34.3	1.8	1232-1848
Aramid	124	3.6	2.3	1.45	86	2.5	1232-1848
Boron	400	3.5	1.0	2.45	163	1.43	18480-24640
HS Graphite	253	4.5	1.1	1.80	140	2.5	3696-6160
HM Graphite	520	2.4	0.6	1.85	281	1.3	12320-36960

1.1 Modern Composite Materials and its applications:

Aerospace Applications:
Fuselage, Wings, Control surfaces, Fan blades, Tail cones, Interiors
Materials: Aluminium, Steel, Plastics

Automobiles:
Monocoque/ Chassis, Body closures, under the body, Interiors, Front cabin (train)
Materials: Aluminium, Steel, Iron, Plastics

Wind Turbines:
Wind blades, Nacelles, Spinners
Materials: Steel, Iron

Constructions
Bathtub, Doors & Windows, Roofing & Cladding, Pultruded profiles, Swimming pools
Materials: Concrete, Steel, Plastics

Marine:
Hull, Decks, Fly bridges, Radomes, Mast, Rudders & Centreboards
Materials: Aluminium, Wood, Steel, Plastics

1.2 Advanced Composite Materials & Technologies for Defence:

Composites For Armour Solutions role of Armour is to protect a person, structure or device Achieved by absorbing kinetic energy of the projectile ™Energy may dominantly be absorbed by plastic deformation and/or fracture processes ™Fragments as a result of fracture process should not cause damage to what is being protected and should be arrested by another layer at the back. Armour plate may have to fulfil two roles: a protective role and structural role ™Both roles can be fulfilled by having sufficient strength at high strain rate and appropriate thickness to provide both protection and structural requirements of the Platform (Integral Armour /Structural Armour).Desirability of composite solutions for armour- better mobility and transportability ™Ability of material to provide resistance to impact depends upon -Hardness to blunt projectile -High strain to failure to absorb energy via a global deformation process involving brittle fracture in ceramics and composites or plastic deformation in metals. ™Composites rely primarily on brittle micro fracture events to absorb energy. Ultimate energy absorption is largely controlled by strain to failure of fibers. ™Composites are soft and are not effective against hard projectiles (AP ammunition) However, when coupled with ceramics as laminates, they provide effective solution Composites also provide best protection against HESH ammunition.

2. Particle-reinforced composites

This class of composites is most widely used composites mainly because they are widely available and cheap. They are again two kinds: dispersion-strengthened and particulate- reinforced composites. These two classes are distinguishable based upon strengthening mechanism – dispersion-strengthened composites and particulate composites. In dispersion-strengthened composites, particles are comparatively smaller, and are of 0.01-0.1μm in size. Here the strengthening occurs at atomic/molecular level i.e. mechanism of strengthening is similar to that for precipitation hardening in metals where matrix bears the major portion of an applied load, while dispersions hinder/impede the motion of dislocations. Examples: thoria (ThO_2) dispersed Ni-alloys (TD Ni-alloys) with high-temperature strength; SAP (sintered aluminium powder) – where aluminium matrix is dispersed with extremely small flakes of alumina (Al_2O_3).

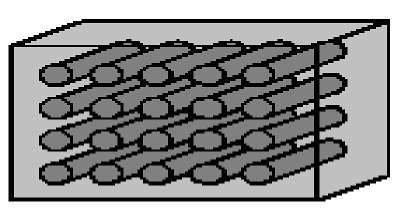

Fig.1 Particulate Reinforce Composites

Particulate composites are other class of particle-reinforced composites. These contain large amounts of comparatively coarse particles. These composites are designed to produce unusual combinations of properties rather than to improve the strength.

3. Nanocomposites

A broad class of materials, with microstructures modulated in zero to three dimensions on length scales less than 100 nm. • Materials with atoms arranged in nano sized clusters, which become the constituent grains or building blocks of the material. Any material with at least one dimension in the 1-100 nm range. • Constituents have at least one dimension in the nano meter scale. – Nanoparticles (Three nano-scale dimensions) – Nanofibers (Two nano-scale dimensions) – Nano clays (One nano-scale dimension).

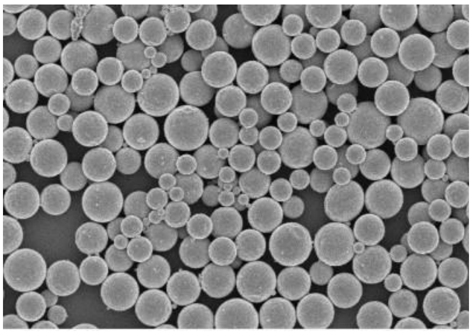

Fig.2 Nano Particles

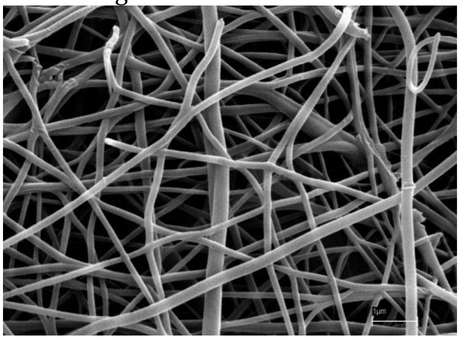

Fig.3 Nanofibers

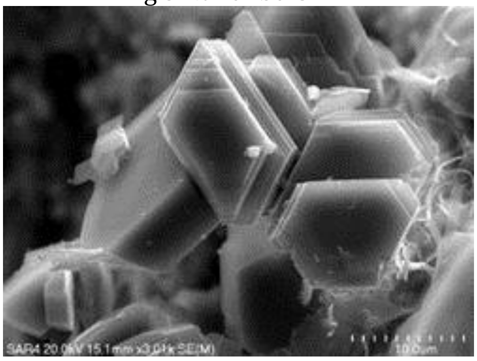

Fig.4 Nano clays

4. Natural composite materials

The second level of classification refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibre Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibres. Fibre Reinforced Composites are composed of fibres embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fibre length. On the other hand, when the length of the fibre is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fibre reinforced. Fibres are small in diameter and when pushed axially, they bend easily although they have very good tensile properties. These fibres must be supported to keep individual fibres from bending and buckling. Laminar Composites are composed of layers of materials held together by matrix. Sandwich structures fall under this category. Wood is a good example of a natural composite, combination of cellulose fiber and lignin.

The cellulose fiber provides strength and the lignin is the "glue" that bonds and stabilizes the fiber. Bamboo is a very efficient wood composite structure. The components are cellulose and lignin, as in all other wood, however bamboo is hollow. This results in a very light yet stiff structure. Composite fishing poles and golf club shafts copy this natural design.

Requirements for the fiber should be smaller in diameter and fiber must be much stronger than the bulk material with High tensile strength examples (whiskers, fibers, wires).Matrix Phase should be Binds fibers together and Acts as a medium through which externally applied stress is transmitted and distributed to the fibers, Protects fiber from surface damage. Separates fibers and prevents a crack from one fiber propagating through another.

Fig.5 Natural Fibres

5. Graphene-based composite materials

Graphene sheets—one-atom-thick two-dimensional layers of sp^2-bonded carbon—are predicted to have a range of unusual properties. Their thermal conductivity and mechanical stiffness may rival the remarkable in-plane values for graphite (~ 3,000 W m^{-1} K^{-1} and 1,060 GPa, respectively); their fracture strength should be comparable to that of carbon nanotubes for similar types of defects; and recent studies have shown that individual graphene sheets have extraordinary electronic transport properties. One possible route to harnessing these properties for applications would be to incorporate graphene sheets in a composite material. The manufacturing of such composites requires not only that graphene sheets be produced on a sufficient scale but that they also be incorporated, and homogeneously distributed, into various matrices. Graphite, inexpensive and available in large quantity, unfortunately does not readily exfoliate to yield individual graphene sheets. Here we present a general approach for the preparation of graphene-polymer composites via complete exfoliation of graphite[9]and molecular-level dispersion of individual, chemically modified graphene sheets within polymer hosts. A polystyrene–graphene composite formed by this route exhibits a percolation threshold of ~0.1 volume per cent for room-temperature electrical conductivity, the lowest reported value for any carbon-based composite except for those involving carbon nanotubes[11]; at only 1 volume per cent, this composite has a conductivity of ~0.1 S m^{-1}, sufficient for many electrical applications[12]. Our bottom-up chemical approach of tuning the graphene sheet properties provides a path to a broad new class of graphene-based materials and their use in a variety of applications.

6. Advanced Composite Materials

An advanced composite material is made of a fibrous material embedded in a resin matrix, generally laminated with fibers oriented in alternating directions to give the material strength and stiffness. Fibrous materials are not new; wood is the most common fibrous structural material known to man.

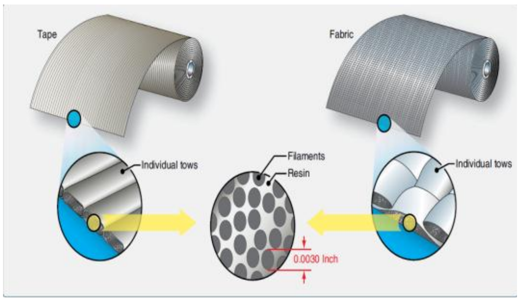

Fig.6 Natural Fibres

A matrix supports the fibers and bonds them together in the composite material. The matrix transfers any applied loads to the fibers, keeps the fibers in their position and chosen orientation, gives the composite environmental resistance, and determines the maximum service temperature of a composite.

7. Conclusion:

The following studies help us to know the recent technology aided with the composite materials manufacturing and its applications. It will give an outline to the researches to carry out their research effectively in this stream.

8. References:

[1] Wei Wang∗, Qing-yu Shi, Peng Liu, Hong-ke Li, Ting Li, 2009, A novel way to produce bulk SiCp reinforced aluminum metal matrix composites by friction stir processing, journal of materials processing technology 209, pp.2099–2103. Science Direct.

[2] Qiang Liu, Liming Ke , Fencheng Liu , Chunping Huang , Li Xing b,2012, Microstructure and mechanical property of multi-walled carbon nanotubes reinforced aluminum matrix composites fabricated by friction stir processing, Materials and Design 45 343–348,Science Direct.

[3] J. Gandraa, R. Mirandaa,∗, P. Vilac¸ ab,c, A. Velhinhod, J. Pamies Teixeiraa, 2011,Functionally graded materials produced by friction stir processing Journal of Materials Processing Technology 211 pp.1659– 1668. Science Direct.

[4] Mehdi Zohoor a, M.K. Besharati Givi b, P. Salami a, Available online 7 March 2012, "Effect of processing

parameters on fabrication of Al–Mg/Cu composites via friction stir processing".

[5] Dolatkhah , P. Golbabaei, M.K. Besharati Givi, F. Molaiekiya, Available online 22 September 2011, "Investigating effects of process parameters on microstructural and mechanical properties of Al5052/SiC metal matrix composite fabricated via friction stir Processing".

[6] A. Shafiei-Zarghani, S.F. Kashani-Bozorg⁎, A. Zarei-Hanzaki ,Available online 21 December 2010 Wear assessment of Al/Al2O3 nano-composite surface layer produced using friction stir processing.

[7] M. Azizieh ⇑, A.H. Kokabi, P. Abachi, 29 November 2010 Effect of rotational speed and probe profile on microstructure and hardness of AZ31/Al2O3 nano composites fabricated by friction stir processing.

[8] A. Devaraju, A. Kumar, B. Kotiveerachari 20 September 2012 Influence of Rotational speed and Reinforcements on Wear and Mechanical properties of Aluminum Hybrid Composites via Friction Stir Processing.

[9] Qiang Liu, Liming Ke, Fencheng Liu , Chunping Huang , Li Xing , 2011, A novel technique for development of A356/Al2O3 surface nanocomposite by friction stir processing, Journal of Materials Processing Technology 211 pp.1614– 1619,Science Direct.

[10] Aerospace Material data sheet Inc., (Website Reference)

[11] C.M. Chen, R. Kovacevic (2003) Finite element modeling of friction stir welding thermal and thermomechanical analysis International Journal of Machine Tools & Manufacture 43 1319–1326 accepted 10 June 2003.

[12] A.Kurt, I. Uygur, E. Cete, 2011, "Surface Modification of Aluminium by Friction Stir Processing", Journal of Materials processing technology 211. pp. 313-317.

[13] Buffa, G., Hua, J., Shivpuri, R., Fratini, L., 2005, A continuum based fem model for friction stir welding– Model development, accepted for publication at Mat. Science and Eng.

[14] C.J. Lee, J.C. Huang, P.J. Hsieh, 2012 "Mg based nano-composites fabricated by friction stir processing".Science Direct.

[15] C.M. Chen, R. Kovacevic "Finite element modelings of friction stir welding —thermal and thermo mechanical analysis" International Journal of Machine Tools & Manufacture 43 (2003) 1319–1326.

[16] D. Yadav, R. Ranjit, 2011, "Processing, Microstructure and Mechanical Properties of Nickel Particles Embedded Aluminum Matrix Composite", Materials Science and Engineering A528, pp. 1326-1333.

[17] Hossein Bisadi, Asghar Abasi, 2011, "Fabrication of Al7075/TiB2 Surface Composite Via Friction Stir Processing" American Journal of Materials Science. 1(2): pp.67-70.

[18] R.S. Mishra, Z.Y. Ma, 2005, "Friction stir Welding and processing:" Materials Science and Engineering R 50 pp.1–78, Science Direct.

[19] R. Nandan, T. DebRoy and H. K. D. H. Bhadeshia, 2008, "Recent advances in friction stir welding–process, weld ment structure and properties", Materials Science, vol.53, pp.980-1023.

[20] N.Subramani, Dr.J.Ganesh Murali, Dr.P.Suresh, Dr.R.Kesavan "Enhancement Of Aluminium 2024 Properties By Reinforcing With Alumina And Graphite" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.85 (2015

[21] N.Subramani, Dr.J.Ganesh Murali, "Experimental and investigation of A6061/Sicp/B4c" by Using Tig welding process" International Journal of Advanced Engineering Technology, Int J Adv Engg Tech/Vol. VII/Issue I/Jan.-March.,2016/354-356.

[22] C. Muthazhagan, A. Gnanavelbabu, K. Rajkumar, G.B. Bhaskar ,Corrosion behavior of Aluminium-Boron carbide-Graphite composites, AdvancedMaterials Research, Applied Mechanics and Materials Vol. 591 (2014) pp 51-54.

[23] S. Rama Rao , G. Padmanabhan ,Fabrication and mechanical properties of aluminium-boron carbide composites , International Journal of Materials and Biomaterials Applications 2012; 2(3): 15-18.

[24] Sachu George Benny, Abu zuhaib Kandappath, N.Subramani, Dr.P.Suresh "Experimental Investigation on Aluminium Alloy 6061-T6 Using Multi Profile Tool by Friction Stir Welding" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Special Issue 4, March 2016.

[25] Graphene-based composite materials Sasha Stankovich1,4, Dmitriy A. Dikin1,4, Geoffrey H. B. Dommett1, Kevin M. Kohlhaas1, Eric J. Zimney1, Eric A. Stach3, Richard D. Piner1, SonBinh T. Nguyen2 and Rodney S. Ruoff1 Nature 442, 282-286 (20 July 2006) | doi:10.1038/nature04969; Received 18 January 2006; Accepted 5 June 2006

[26] ACI 318-71, American Concrete Institute, Building Code Requirements for Reinforced Concrete, Detroit, Michigan, 1971.

[27] Park, R and Paulay, T, Reinforced Concrete Structures, John Wiley & Sons, 1975

[28] Paulay, T. and Priestley, M.J.N., 1992, Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons, New York.

[29] Priestley, M.J.N., Seible, F., and Calvi, G.M., 1996, Seismic Design and Retrofit of Bridges, John Wiley & Sons,New York.

[30] SANZ, Standards Association of New Zealand, NZS 3101:1995 Concrete Structures Standard, Parts 1 and 2, 1995, Wellington.

[31] Wang, Y.C. and Restrepo, J.I., "Strength Enhancement of Concentrically Loaded Reinforced Concrete Columns

[32] Using TYFO S Fibrwrap Jackets," Research Report 96-12, Department of Civil Engineering, University of Canterbury, Christchurch, 1996, 25 pp.
[33] G.V.Mahajan, Prof. V. S. Aher, Composite Material: A Review over Current Development and Automotive Application, International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012.