REVIEW ON HIGH TEMPERATURE APPLICATION COMPOSITES

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ABSTRACT

Composites are materials composed of at least two different solids, which exist as separate phases in the final material. thus a material can be manufactured to sustain at high temperature by combining the properties of two different solid in the form of composites. At higher temperature the driving force as thermal energy is more active due to more entropy thus ordinary exposed materials they starts to become soften consequently they may loose their property during service condition, therefore we need to look up one the combination of material in the form of composites. extensive research have been carried out in the field of aircraft industries body parts as they must possess the combination of strength and high temperature sustainability. Through this paper an attempt has been made to bring out the all research in the form of review to impart the knowledge of material and their applicability at the high temperature.

I. INTRODUCTION

1.1 History and Brief of Composites

All the engineering material obtained in this world has certain limitation i,e, metal, alloy, plastics because a single material can not possess all the desired properties of engineering application, due to which a concept off composite material comes into the exhistence. A composte is the mixture of two or more matters in fixed and calculated proportion to impart the specific property desired by the service condition, here combination of two properties performed by each matter combined will gives rise the desired property.

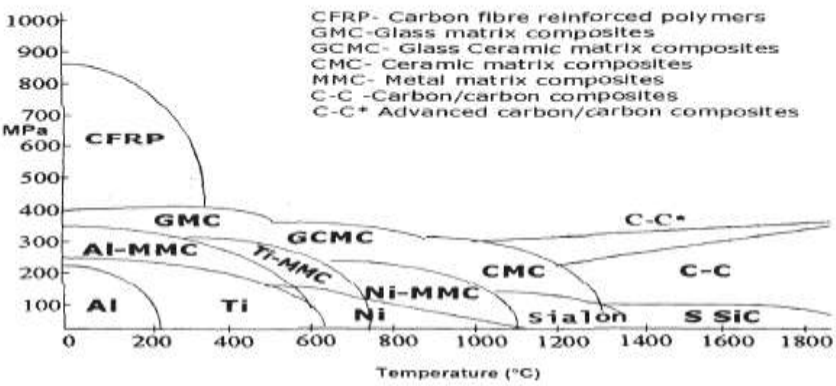
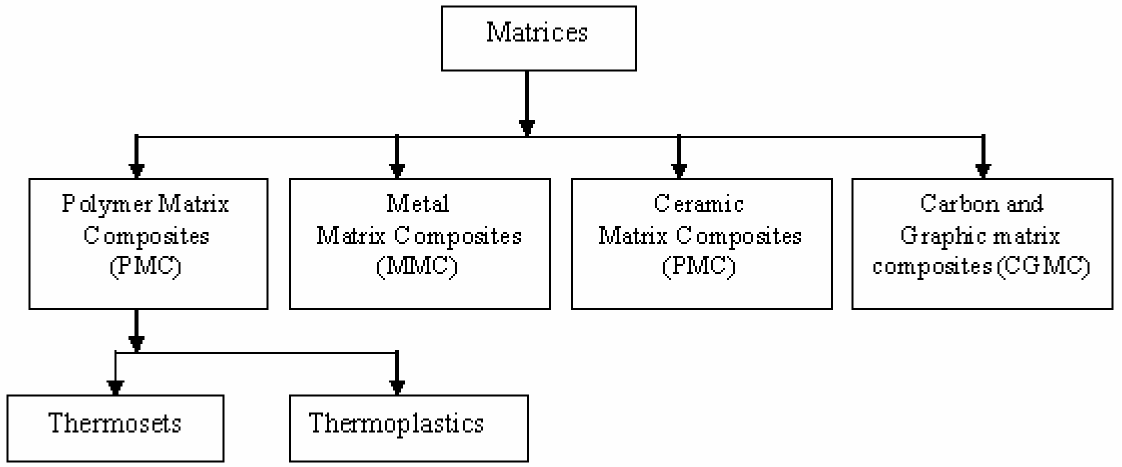


Fig 1 The Above Figure Shows The Sustainability of Different Material With Temperature,

Similarly the idea of composite material for higher temperature comes into the virtue. It is very difficult for the metal or alloy to sustain at the higher temperature because of their limited property and melting point due to which they become soft when exposed to high temperature usually above 1000^{o}C. But the composite material with proper matrix and fibre can be utilized to achive the combination of two distinct properties required for higher temperature application. A composite material can be classified into three different categories usually:-

1. Metal matrix composites
2. Polymer matrix composites
3. Ceramic matrix composite



This classification is often on the basis of its matrix their might be several modes of classification, and to sustain at the higher temperature either the matrix or the fibre needs to be modified.

Composites cannot be made from constituents with divergent linear expansion characteristics. The interface is the area of contact between the reinforcement and the matrix materials. In some cases, the region is a distinct added phase. Whenever there is interphase, there has to be two interphases between each side of the interphase and its adjoint constituent. Some composites provide interphases when surfaces dissimilar constituents interact with each other. Choice of fabrication method depends on matrix properties and the effect of matrix on properties of reinforcements. One of the prime considerations in the selection and fabrication of composites is that the constituents should be chemically inert non-reactive.

"Advanced composites" or so-called "high performance composites" are mostly based on reinforcement by continuous fibres . Rarely short fibres and whiskers are used for this purpose, **The** best reinforcement is obtained by the use of continuous fibres with a volume fraction above 50 usually 60 % and strictly controlled geometric arrangement of the fibres within the composite (" tailored material"). **The** special case of fibre arrangement in one direction. i . s easy to understand and offers the possibility for pre calculation of the strength and stiffness of the composites using the rule of mixture (1) . The disadvantage of such u unidirectionall reinforced (UD) composites i s the strong dependence of the composite properties on the fibre direction. In practical application two dimensional reinforcement is applied with fibre arrangement in different directions. The reinforcement by short fibres or whiskers and is catastrophic distribution of the fibers lead to a reinforcement effect of 1/6 of the precalculated values using the rule of mixture.

In the Eighties this new material was used in commercial aircrafts already. It is applied for the vertical stabilizer in the Airbus A 310; at the moment the largest part of industrially produced carbon fibre reinforced composites. The present world wide use of carbon fibre s is in the order of 5.000 t o 10.000 tons per year with a stongly increasing tendency. The expected broad application in surface transportation such as railways and cars in machinery, in pipelines s and apparates, i n sporting goods as well as in building materials was described in more detail last year here in Rome during the European Conference **on** Thermophysical Prop properties(2) . Most exciting for this material is the low energy need for raw material preparation in fabrication as compared with high energy consumption by conventional materials. There is however severe limitation for application of fibre reinforced polymer, that is the limitation in temperature caused by the softening or thermal decomposition of the polymers. The high temperature resistivity of the carbon fibre is not used by far in combination with the epoxy. For solving the future problem in aerospace and energy field, in industrialization in general and especially for the technology, composite for high temperature is needed.

1.2 What are the Needs at High Temperature Application

When we use the world high temperature that means we generally we take the temperature higher than the usual temperature i.e. above 800o C above which an epoxy resin cannot be utilized.

1.2.1 Light Weight

Any engineering material requires high specific strength i.e. strength to weight ratio thus strength with light weight is the primary concern for any material, take the example of aircraft industry, it is believed that 1kg reduction in weight can save the money in the order of 100 INR.

In supersonic aircrafts, for instance, the surface temperature can arise up to 500^{o}C that is a temperature range where no today's resin for fibre reinforced composites can withstand. In the space shuttle with surface temperatures above 1000 "C during the period of entering the earth atmosphere, this heat attack problem was solved by the use of thermal insulation bricks. On the tip cone and in the edges of the wings, however, the temperatures arose up t o 1500 "C. Here only carbon/carbon composites were applicable. The additional problem arising by this application is heat attack by the oxygen in the atmosphere and carbon materials without surface coating are not resistant against oxidation at those temperatures.

1.2.2 High Refractoriness

Refractoriness is the measure of ability of any material to withstand at the higher temperature, thus more will be the refractoriness more will be the high temperature sustainability.

1.2.3 Low Thermal Conductivity

A material with high thermal conductivity will conduct more, thus more heat transfer will takes place which is not desirable for high temperature application material, low thermal conductivity ensure the less heat transfer and thus the hightemperature sustainability will be more imparted.

1.2.4 Low Thermal Expansion

It is defined as the ability oof any material to retai its shape at high temperature working condition, this parameter for aircraft parts are specially considered as a little expansion while flight may cause the thin section at the expanded area which may lead to the ductile failure, and aircraft part may fail catastrophically to couse the fatal accidents.

1.2.5 High Temperature Corrosion

In addition to oxide ceramics, which include not only the SOFC materials along with new sensors and high temperature superconducting materials, silicon-based ceramics such as SiC, Si_3N_4, and sialons along with other borides, carbides, nitrides, silicides, and diamond and diamond-like materials are now common high temperature materials of scientific and technological interest in both bulk and coating configurations.[6]

II. AREA OF INNOVATIONS

2.1 High Performance Carbon–Carbon Composites

Carbon is a truly remarkable element existing as four allotropes, viz. diamond, graphite, carbynes and fullerenes, each having significant scientific and technological importance. Its most abundant allotrope, graphite, can take many forms with respect to microstructure, amorphous to highly crystalline structure, highly dense with density 2_2 g/cm3 to highly porous with density 0_5 g/cm3 and different shapes. These types of graphites are called synthetic carbons and in technical terms, engineered carbons. Examples are cokes, graphite electrodes, mechanical carbons, glassy carbons, carbon black, porous carbons, activated carbons, carbon fibres and composites etc.. Solid carbons are preferred for structural applications under extreme environmental conditions of temperature or corrosion (liquid as well as gaseous) etc. This is mainly because, theoretically, carbon materials with covalently bonded atoms possess very high specific strengths (40–50 GPa) and retain this strength at high temperatures in the temperature range over 1500_C (Ref 3).The strength and fracture of carbon/carbon composites are governed by the Cook–Gorden theory for strengthening of brittle solids (Cook & Gorden 1964), which states that if the ratio of the adhesive strength of the interface to the cohesive strength of the solid is in the right range, a large increase in strength and toughness of otherwise brittle material is achieved. Extensive work has been done in achieving highest possible translation of fibre properties in carbon/carbon composites.

2.2 Dielectromagnetic Composites for Microwave Applications

A lot of work has been done by Thanh Ba Do (Ref 4) according to him The combination of a ceramics with a polymer can be utilized because it provides a flexibility to control physical, dielectric, and magnetic properties of formulated composites. Advantages of this combination are lower costs, more facile processing, and low temperature production. Ceramics-polymer composites also contain properties that may not be present in their individual components

High-temperature composites are a major area of research today. Composite materials have been successfully used in many applications where temperature resistance is not an issue (i.e. exposed to temperatures under 300ºC), while helping reduce the weight of components and optimize their design.

2.3 Exhaust Ducts for Motorsports

An extensive work was done by Christopher buckler (Ref 5) on exhaust duct system for motorsports According to which Race car exhausts are complex systems where the use of composite was hardly thinkable less than 10 years ago.

Fig 2.3.1 Motorsport Duct Made of Composite Material

The elevated exhaust gas temperatures (600ºC to 1000ºC), part complexity and high levels of stress and vibration were major challenges that made Inconel or steel the only viable options for headers, collectors, mufflers and tailpipes. In 2006, Pyromeral Systems considered using Pyro Sic glass-ceramic matrix composites to manufacture composite components for exhaust systems, with the objective to reduce exhaust weight, improve thermal management, and give more flexibility to engineers when designing the components.

2.4 Heat Shields

Heat shields and fire barriers are important components of motorsports and aerospace systems. They are also one of the most difficult applications for traditional materials, especially when structural properties are also needed. Heat shields made of PyroSic are frequently used in motorsports applications, where the material has proven to be a reliable solution for lightweight structural heat shields located in tight spaces and exposed to both extreme heat (close to 800ºC in some areas) and high vibrations.

Fig 2.4.1 Heat Shield Made of Composite

The technical attributes of heat shields made of PyroSic glass-ceramic matrix composites include: - thin walls, typically ranging from 0.6 mm to 1.2 mm others are as follows.

1. possibility to design and manufacture complex shapes,
2. dimensional stability and absence of distortion, even in case of fast temperature increases,
3. no burn-through, even in case of fire,
4. possibility to combine the high-temperature composite with another composite to improve durability and mechanical performance (hybrid composites),
5. possibility to apply coatings to improve thermal management, e.g. reflective coatings for improved shielding against radiant heat.

III.FUTURE ASPECTS

Composite material retains the vast subject and its future is very bright due to combination of its properties desirable to any situation however right now we have a limited applicability of the same over the service condition. further research in the area of thermal conductivity of the composite material and its expansion at high temperature may lead to great advantages in the aircraft and high temperature exposure parts.

IV.CONCLUSION

Through this paper we finally reach to a conclusion that if any material has to withstand at high temperature then it requires certain specific properties, which if fulfilled than material can be withstand and composite material are one of them.

1. Modification of either matrix or the fiber reinforcement in the form of different refractory material can be selected to obtain the desired properties.

2. Reinforcement either in the form of particulates or the dispersed phase distribution can be altered to achieve the desired property.

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