

A Survey on Fiber Metal Laminate Sandwich Panel

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ABSTRACT Weight reduction is targeted in different industrial sectors. This leads to increasing numbers of applications of fibre composites for primary structural components. In consequence the use of composites made of FRP and metals are highly attractive. Light weight structures have stimulated a strong trend towards the development of aluminium sandwich material. The main objective of this paper, to develop the basic techniques in order to apply aluminium sandwich sheets for an automotive body panel. The aluminium/glass fibre sandwich sheet is the material fabricated by adhering two aluminium skins to one glass fibre core. Therefore it is good substitutive material for improving the fuel efficiency. In this study, we developed aluminium glass fibre sandwich sheet for automotive hood. In this review paper recent developments in composite technology and also performance behavior of metal matrix composites (MMC) have been discussed. Metal matrix composites offer several advantages such as better damage tolerance to fatigue crack growth and impact damage especially for automotive and aircraft application.

I. INTRODUCTION

In much industrial and structural application the important parameter in material selection is specific strength, weight and cost. Composite materials are an ideal choice for the above applications. MMC is one of the types of composite materials in which a metal is used as matrix element and a non metal is used as the reinforcement. The aluminium/glass fiber sandwich material is 65% light weight than the steel sheet and 30% lighter than an aluminium alloy sheet. Generally mixed material along with aluminium and it's group such as silicon carbide, boron carbide, fly ash, RHA, graphite, cenosphere, silicon nitride, silicon carbide, etc. aluminium alloy have a strong resistance to corrosion, which is a result of an oxide skin the forms as a result of reactions with the atmospheres. As such Fiber Metal Laminates can be grouped under the types of MMC, since it is fabricated with inclusion of metal as matrix and a non metal as reinforcements.

II. LITERATURE SURVEY

Tamer Sinmazçelik et al [1]. During the past decades, increasing demand in aircraft industry for high-performance, lightweight structures have stimulated a strong trend towards the development of refined models for fibre-metal laminates (FMLs). Fibre metal laminates are hybrid composite materials built up from interlacing layers of thin metals and fibre reinforced adhesives. The most commercially available fibre metal laminates (FMLs) are ARALL (Agamid Reinforced

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Aluminum Laminate), based on agamid fibers, GLARE (Glass Reinforced Aluminum Laminate), based on high strength glass fibres and CARALL (Carbon Reinforced Aluminum Laminate), based on carbon fibers. Taking advantage of the hybrid nature from their two key constituents: metals (mostly aluminum) and fibre-reinforced laminate, these composite offer several advantages such as better damage tolerance to fatigue crack growth and impact damage especially for aircraft applications. Metallic layers and fibre reinforced laminate can be bonded by classical techniques, i.e. mechanically and adhesively. Adhesively bonded fibre metal laminate have been shown to be far more fatigue resistant than equivalent mechanically bonded structures.

Mohammad Alem Ardakani et al [2]. Fiber metal laminates (FMLs) are good candidates for advanced aerospace structural applications due to their high specific mechanical properties especially fatigue resistance. The most important factor in manufacturing of these laminates is the adhesive bonding between aluminum and FRP layers. In this study several glass-fiber reinforced aluminum (GLARE) laminates with different bonding adhesions were manufactured. Drop weight impact tests based on ASTM D7136 standard were then conducted to study the effects of interfacial adhesive bonding on impact behavior of these laminates. It was observed that the damage size is greater in laminates with poor interfacial adhesion compared to that of laminates with strong adhesion between aluminum and glass layers. In addition, FMLs with good adhesion bonding show better resistance under low velocity impact and their corresponding contact forces are about 25% higher than that of specimens with a weak bonding. Moreover, maximum central deflections in laminates with strong bonding are about 30% lower than that of FMLs with poor adhesion.

Kee Joo Kim et al [3]. Objective of this study was to develop basic techniques in order to apply aluminum sandwich sheets for an automotive hood part. The aluminum sandwich sheet is the material fabricated by adhering two aluminum skins to a polypropylene core. When it has the same bending stiffness as a steel sheet, it is 65% lighter than the steel sheet and 30% lighter than an aluminum alloy sheet. Therefore, it is notified exclusively as good substitutive materials for a steel body to improve the fuel efficiency. Through aluminum sandwich sheet, however, it has relatively lower formability than that of the steel sheet for automotive application. In this study, we developed application techniques of the aluminum sandwich sheet for automotive hood. The various formability evaluations were carried out in order to secure the fundamental data for the measurement of sheet metal forming and the establishment of optimum application conditions of the sandwich sheet. From these results, it was found that the sandwich sheet could reduce the weight and maintain the flexural rigidity simultaneously comparing to the steel sheet.

L. Mosse et al [4]. The effect of process variables on the stamp forming of Fibre-Metal-Laminate channel sections has been investigated. The process variables include blank holder force, process temperature and feed-rates. It was found that by judicious choice of the process variables it is possible to obtain parts that have better formability characteristics than parts made with monolithic aluminum.

Syed Mufeez Ahmed et al [5]. Composite materials have been a subject of interest with various special types of advanced materials during the last decades. However increasing demand in aircraft industry for high-performance, lightweight structures have stimulated strong trend towards the development of refined models for hybrid composite material known as Fibre Metal Laminates. Fibre Metal Laminates are hybrid composites built up from interlacing layers of thin metals and fibre reinforced adhesives. Metallic layers and fibre reinforced laminate can be bonded by mechanical technique and adhesive technique. Based on these approaches adhesive technique with plain and perforated aluminum sheet is used to determine its effect as a Fibre Metal Laminate. Tests are conducted to determine the mechanical properties of the Fibre Metal Laminate and the results are tabulated. The test results are validated using ANSYS 12. The weight optimization of Fibre Metal Laminates with perforation about 25% than that of without perforations.

D. Contorno et al [6]. The forming of the completed aluminium foam sandwich (AFS) panels would determine an improvement in the manufacturing of parts and panels. In this paper the authors have investigated the formability of AFS through experiments and numerical simulations. As far as the former are concerned, commercially prepared panels have been considered and bending and stamping processes have been taken into account. In addition, FEM analyses have been developed, utilizing a porous material model following the evolution of the material density throughout the forming processes.

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Mahendra boopathi.M et al[7]. Experimented to Development of hybrid metal matrix composites has become an important area of research interest in materials science. In view of this, the present study was aimed at evaluating the physical properties of aluminium 2024 in the presence of fly ash, silicon carbide and its combinations. Consequently aluminium MMC combination the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material. stir casting method was used for the fabrication of aluminium MMC. Structural characterization was carried out on MMC by x-ray diffraction studies and optical microscopy was used for the micro structural studies. The mechanical behaviours of MMC like density, elongation, hardness, yield strength and tensile test were ascertained by performing carefully designed laboratory experiments that replicate as nearly as possible the service conditions. In the presence of fly ash and silicon carbide [sic (5%) + fly ash (10%) and fly ash (10%) +sic (10%)] with aluminium, the result show that the decreasing the density with increasing harness and tensile strength was also observed but elongation of the hybrid MMC in comparison with unreinforced aluminium was decreased. The hybrid metal matrix composites significantly differed in all of the properties measured. Aluminium in the presence of sic (10%)-fly ash (10%) was the hardest instead of aluminium –sic and aluminium-fly ash composites.

Anilkumar et al [8]. Investigation that mechanical properties of fly ash reinforced aluminium alloy (Al 6061) composites fabricated by stir casting. They are three sets of composites with fly ash particle sizes of 75-100, 45-50 and 4-25 μm were used. Each set had three types of composite samples with the reinforcement weight fractions of 10 15 and 20%. The mechanical properties studied were the compressive strength, tensile strength, ductility and hardness. Unreinforced Al6061 samples also tested the mechanical properties. It was found that the compressive strength, tensile strength and hardness of the aluminium alloy composites decreased with the increase in particle size of reinforced fly ash. Increase in the weight fractions of the fly ash particles the ultimate tensile strength, compressive strength, hardness and decreases the ductility of the composite. The SEM of the samples indicated uniform distribution of the fly ash particles in the matrix without any voids.

Mathivanan Periasamy et al [9]. Aluminium - glass fiber reinforced plastics (GFRP) sandwich panels are hybrid laminates consisting of GFRP bonded with thin aluminum sheets on either side. Such sandwich materials are increasingly used in airplane and automobile structures. Laminates with varying aluminium thickness fractions, fiber volume fractions and orientation in the layers of GFRP were fabricated by hand lay up method and evaluated for their impact performance by conducting drop weight tests under low velocity impacts. The impact energy required for initiating a crack in the outer aluminium layer as well as the energy required for perforation was recorded. The impact load-time history was also recorded to understand the failure behavior. The damage depth and the damage area were measured to evaluate the impact resistance. Optical photography and scanning electron micrographs were taken to visualize the crack and the damage zone. The bidirectional cross-ply hybrid laminate (CPHL) has been found to exhibit better impact performance and damage resistance than the unidirectional hybrid laminate (UDHL). Increase in aluminium thickness fraction (A_{tf}) and fiber volume fraction (V_f) resulted in an increase in the impact energy required for cracking and perforation. On an overall basis, the sandwich panels exhibited better impact performance than the monolithic aluminium.

Mayank Dwivedi et al [10]. Adhesive lap joint between glass fibre/epoxy composites and aluminium alloy (2014 T4) was prepared by an *in situ* moulding process using a matched die mould. The surface of aluminium alloy was treated with chromic acid before adhesive bonding. Lap shear strength and fatigue life were evaluated in tensile mode and tension-compression mode (at 40% of lap shear load of adhesive joint), respectively. Knurling on the surface of aluminium alloy improved the lap shear strength of the adhesive joint but did not influence the fatigue life of the same. Lap shear strength and fatigue life of adhesive joint made with neat epoxy adhesive and reinforcement of an intermediate layer of Kevlar[®] between glass/epoxy composite and aluminium alloy were observed to be 0.44 kg/mm² and 3.6×10^5 cycles, respectively. In another case, lap shear strength and fatigue life of similar type of adhesive joint made from nanoclay (Cloisite 30B)-reinforced epoxy adhesive and without reinforcement of an intermediate layer of Kevlar[®] were observed to be 0.38 kg/mm² and 2.3×10^5 cycles, respectively. Whereas, lap shear strength and fatigue life of adhesive joint made from nanoclay-reinforced epoxy adhesive along with the reinforcement of an intermediate layer of Kevlar[®] were 0.48 kg/mm² and 3.9×10^5 cycles, respectively. Therefore, adhesive joint made from nanoclay-

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reinforced epoxy adhesive along with the reinforcement of an intermediate layer of Kevlar[®] was the best.

Y.D Dwivedi et al [11]. An increase in the application spectrum of composite materials necessitates cost effective high quality rapid processing in order to meet stringent design as well as market requirements. Material selection has become one of the major problems in aviation. The objective of the current study is to compare the bending strength of Glass Fiber Reinforced Polymer (GFRP) with the conventional material of aviation industry (ie., aluminium). The deflection test was performed on standard bending test equipment by applying the concentrated loads on the cantilever specimens, which were made of Glass Fiber Reinforced Polymer fabricated by hand layup technique and the Aluminium specimen was made and supplied with the test equipment. On performing the bending test it is observed that aluminium shows promising results where high modulus of elasticity is considered and the GFRP is found to be the cheap and best material where lower weight is considered and young's modulus of material is of low importance.

G.R. Rajkumar et al [12]. Present investigation was focused on the effect of strain rate and lay-up configuration on tensile and flexural behaviour of four combinations of fiber metal laminates. Tensile and flexural tests were conducted on universal test machine as per standards. The result shows that the tensile strength increased with increasing strain rate. However the flexural strength decreased with increasing strain rate. Both tensile and flexural strength are maximum for carbon based FML structures, minimum for glass based FML and hybrid FML structure lies between them. The observations on both tensile and flexural failure mechanisms deduced from a microscopic study of the fractured specimens are presented.

M.Vasumathi et al [13]. Natural fibres play a vital role in the area of composites and have found wide acceptance in this area. In this work, two kinds of hybrid laminates are studied, one with carbon, jute and aluminium termed as CAJRAL and the other, CARAL, with carbon and aluminium only. The purpose of this study is to analyse the effect of addition of natural fibre jute in the fibre metal laminate on its mechanical behavior. Experimental studies are undertaken on tensile, flexure and impact properties of both CARAL and CAJRAL. It is observed that,

CAJRAL's mechanical performance deviates from that of CARAL by only a maximum of 24%, with respect to axial and impact loadings. As far as the bending behaviour is concerned, CAJRAL performs even better than CARAL, due to the presence of jute fibre. Moreover the experimental findings are compared with analytical simulation and are found to be in close agreement. velamurali@gmail.com

Udhaya prakash et al [14]. Experimentally investigated on machinability of aluminium alloy (A413)/flyash/B4C hybrid composites using wire EDM. The objective of this work is to investigate the effect of parameters like pulse off time, wire feed pulsed on time, gap voltage, and percentage reinforcement on the responses material removal rate as well as surface roughness while machining aluminium alloy(A413)/flyash/B4C hybrid composites using wire EDM.

Experimentation has been done on taguchi's L27 orthogonal array under different combinations of parameters. Analysis of variance has been used to determine the design parameters significantly influencing the response. the responses has been evaluated using signal to noise ration analysis. The experimental result proposed optimal combination of parameters which give the maximum material removal rate and minimum surface roughness.

Adriana ştefan et al [15]. The metal/fibre hybrid laminates consist of an alternation of 0.2 ÷ 0.5 mm metallic sheets (Aluminum or Titanium in Aeronautical Engineering) and pre-pregs made of unidirectional carbon or aramid or glass fibre or of the two-dimensional fabric of these materials, bonded by a polymer adhesive (epoxy, especially). Compared with the monolithic metal foils, the essential quality of these hybrid laminates is their superior resistance to fatigue, impact and crack propagation (existing or made by notches). The paper presents some results regarding hybrid laminates aluminium-carbon fibre and aluminum-glass fibre achieved in the CEEEX project X1C05 (2005).

III. CONCLUSION

From literature review related to the metal laminated sandwich material we have concluded that, the pure metal mixed with sum other material through the process like stir, GPIT, and followed by different fabrication procedure. That the

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result show that increasing better mechanical properties than reducing the weight and cost.

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