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Mechanical Properties and Formability Analysis on AA-LDH-GF & AA-CNT-GF Sandwich Sheets

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***Abstract* - In this paper high magnesium content and low weight aluminum sheet of 0.5mm thickness sheet is used as face material and Layered double hydroxide which is a flame retardant material and Carbon nanotubes which is low weight material and glass fiber of woven type is used as core material in order to improve mechanical properties and thermal properties. In addition to this Carbon nanotubes have high electrical conductivity than copper by adding Carbon nanotubes electrical properties can also be improved.**

Formability analysis is done to find out forming parameters by using Erickson cupping test. Experimental investigation helps in identifying the some of the parameters such as density, Poisson's ratio, yield strength, ultimate tensile stress, total elongation, strain hardening coefficient, plastic strain ratio, etc. of materials

Keywords— Carbon nanotubes; Formability analysis; flame retardant material.

I. INTRODUCTION

Sandwich composite material is a combination of two or more different materials which consists of three layers i.e two face sheets and one core material as in the form of layer. These materials have great advantages such as low weight and considerably higher shear stiffness to weight ratio than an equivalent beam made of only the core material or the face-sheet material and also high tensile strength to weight ratio. The high stiffness of the face-sheet leads to a high bending stiffness to weight ratio for the composite.

There are different manufacturing process for sandwich composite materials .They are cold working and hot working process. In cold working process there in no external heat is used in hot working process external heat is supplied to the material to improve its properties and also to minimize curing time.

Sandwich theory describes the behavior of a beam, plate, or shell which consists of three layers - two face sheets and one core. The most commonly used sandwich theory is linear and is an extension of first order beam theory. Linear sandwich theory is of importance for the design and analysis of sandwich panels, which are of use in building construction, vehicle construction, airplane construction and refrigeration engineering.

Metal forming and machining are two prominent methods of converting raw material into a product. Metal forming involves changing the shape of the material by permanent plastic deformation. After converting a solid metal piece into product form by metal forming processes, the mass as well as volume remains unchanged. The advantage of metal forming processes includes very little wastage of the raw material, better mechanical properties and faster production rate.

II. LITERATURE REVIEW

Johnson and Sims (1) reported the design and mechanical properties of sandwich materials. Sandwich materials consisting of a low density core with stiff skins offer considerable potential for weight saving in panel applications, where the main loads are flexural. Sandwich materials of interest for car and van body panels, seat shells, etc, include steel/plastic laminates, integral skinned plastic foams and glass fibre-reinforced polyester skins with foamed plastic cores. In their Work, basic design formulae for the flexural stiffness and strength of such sandwich materials are reviewed and a method for designing optimum sandwich structures for least weight or cost is given. Mechanical property data are presented on a range of sandwich materials of potential interest for vehicle panel applications. It is then shown how use of the least weight design method enables core and skin thicknesses to be determined and gives a means of improving the flexural properties of existing sandwich constructions.

Gibson and Triantafillou (2) obtained the minimum weight design of a foam core sandwich beam or plate of a given strength by constraining the face and core fail simultaneously using the failure equations. They also make use of property-density relationships for foam cores to include the density of core as of the beam design parameters to be found in the optimization analysis. The results give the face and core thickness and core density which minimize the weight of a foam core sandwich beam or plate of a given strength.

Fleck and Steeves (3) presented a systematic procedure for comparing the relative performance of sandwich beams with various combinations of materials in three-point bending. These comprise the three face sheet materials CFRP,

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GFRP, steel plate and core materials Divinycell H 100 PVC foam, Steel core composed of a square honey comb. This study shows hybrid carbon-fiber composite-steel square honeycomb core beam is optimal.

Akay and Hanna (4) have made a comparison of honeycomb-core and foam-core carbon-fiber/ epoxy sandwich panels. Cellular core sandwich panels of carbon-fiber/ epoxy fabric laminate skins, simulating the construction of an aircraft flap, were cured and bonded in a single -step autoclave operation. Nomex honeycomb and Rohacell WF foam of different densities were employed as the core materials. The panels were examined to identify voids in the laminate skins and cell collapse and coalescence in the foam core. Test pieces were subjected to low-energy impact and the induced damage was examined by C- scan. The maximum damage area in the face-skin was comparable to the projectile cross sectional area. Residual compressive capacity showed an asymptotic decrease with increasing impact levels, most panels gave similar values but the modes of failure were different depending on the type of core.

Fleck and Steeves (5) Investigated Collapse mechanisms of sandwich beams with composite faces and a foam core, loaded in three -point bending. Analytical predictions are made for the three-point bending collapse strength of sandwich beams with composite faces and polymer foam cores. Failure is by the competing modes of face sheet micro buckling, plastic shear of the core, and face sheet indentation beneath the loading rollers.

III. PREPARATION OF SANDWICH SHEET

The actual sheet dimension is 1220mm length and 1020mm width. By using of tin cutter cut the sheet into 9 pieces of each having dimensions of 406 mm length and 340mm width

By using high quality emery paper rub the shine surface side of sheets which provides scratches in order to provide grip to sandwich sheet without causing de-lamination. With the help of emery paper manually can rub the sheet

Before starting work with epoxy ware face mask and rubber gloves why because resin and hardener smell is very bitter and it is difficult to work with it without wearing face mask which helps in covering your nose and chemicals in resin and hardener are highly reactive while coming in contact to skin leads skin diseases and allergies in order to overcome this wear gloves, allow proper work space i.e prepare sheet at proper ventilation area.

Fig 3.2: Resin and Hardener mixture

For 1000gms of resin mix 400 grams of hardener and stirrer the combination using stirrer for 20 to 30 minutes. Now epoxy mix is ready to apply

Now cover the both sides of sandwich sheet with plastic cover which helps in removing of sheet easily after curing why because by application of load upon sheet leads to squeeze the epoxy mixture to outer edges of sheet which will stick to other surfaces in order to overcome this plastic cover is used to cover both sides of sandwich sheet

Fig 3.1: Covering of aluminum sandwich sheets with plastic cover

After completion of above steps place a plywood piece which is larger in dimension of sheet upon the sandwich sheet, on application of load upon wood leads to equal distribution of load to all sides of sheet. After that apply load of around 40 to 50kgs and allow the sheets to curing as curing time is 19 hours, after curing remove the sheets and cut the extra glass fiber on each edges of sandwich sheet gently and sandwich sheet is ready for testing. Load can be applied by using any weight, but approximately 40kgs and above has to be applied.

PREPARATION OF LDH AND CNT IMPREGATED SANDWICH SHEET

In order to prepare 3% of LDH or CNT sandwich sheet 30gms of resin is to be removed from 1000gms and then LDH or CNT is poured into resin and mixed for some time and then hardener is mixed and further work is continued as described as above.

In this project LDH reinforced sheets with 3%,4% and 5% sheets and CNT reinforced sheets with 3%,4% and 5% are to be manufactured. For 4% sheets 40gms of resin has to be removed and for 5% sheets 50gms of resin has to be removed. And for proper epoxy mix respective amount of hardener has also be removed improper mixing or low quantity mixing leads to damages such as de-lamination of sheet can takes place

In order to get proper mix and good adhesion respective amount of hardener is also to be removed and poured in another bottle with lid or a closed container. If 30gms of resin is removed from the 1000gms bottle then 12gms of hardener has to be removed from the 400gms of hardener. If 40gms of resin is removed from the 1000gms bottle then 16gms of hardener has to be removed from the 400gms of hardener. If 50gms of resin is removed from the 1000gms bottle then 20gms of hardener has to be removed from the 400gms of hardener. Why this is because the resin and hardener mix ratio is 1000gms of resin to 400gms of hardener

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FIG 3.3: Removing of extra hardener

Sonication can be used to speed dissolution, by breaking intermolecular interactions. It is especially useful when it is not possible to stir the sample. Sonication is commonly used in nanotechnology for evenly dispersing nanoparticles in liquids.

IV. EXPERIMENTAL WORK.

4.1 TESTS TO BE CONDUCTED:

i. Tensile Test.
ii. Flexural Test.
iii. Impact Resistance Test.
iv. Ericission Cupping Test.

4.1.1 TENSILE TEST:

THE ASTM STANDARD FOR TENSILE TEST IS D638

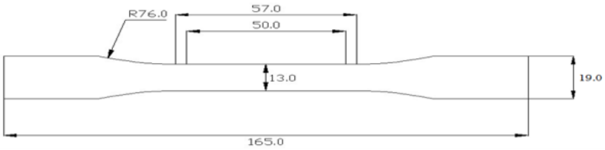

Fig 4.1 ASTM standard figure for tensile test

Fig. 4.2: Tensile testing setup

Fig. 4.3: Tensile test specimens before and after testing

4.1.2 FLEXURAL TEST:

THE ASTM STANDARD FOR FLEXURAL TEST IS [D790] ALL DIMENSION ARE IN MM.

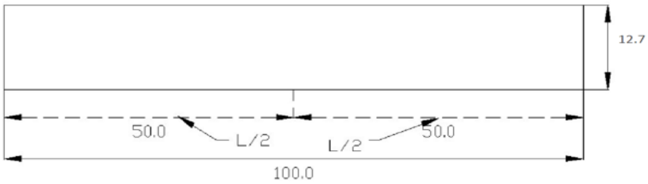

Fig 4.4 ASTM standard figure for flexural test

FIG. 4.4: Flexural test specimens before and after testing

4.1.3 IMPACT RESISTANCE TEST:

TEST CONDITIONS:

Temperature : Room Temperature (25 ± 20c).
Diameter Of Impact Core : 12.7mm.
Height Of Weight Fall (1kg) : 100cm & 150cm.

Fig 4.5 impact resistance test setup.

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Fig 4.6 Impact resistance specimens before and after testing

ERICISSION CUPPING TEST:

Test method: IS10175

Fig 4.7 Ericission cupping test setup

Fig 4.8 Ericission cupping test specimen before and after testing

4.1.4 TENSILE TESTS (STRESS VS STRAIN)GRAPHS:

FOR CNT 3% IMPREGNATED SHEETS:

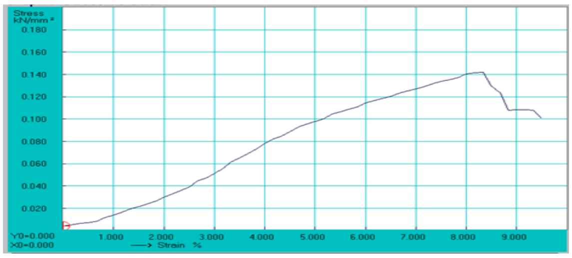

Fig 4.9 CNT 3% Tensile (stress vs strain) graph 00.

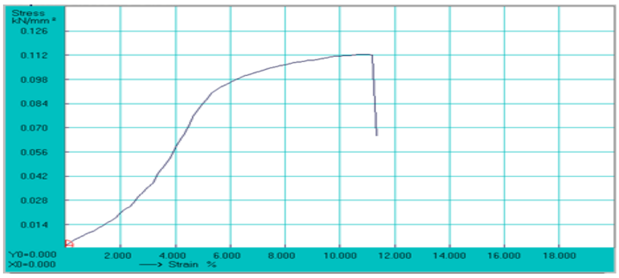

Fig 4.10 CNT 3% Tensile (stress vs strain) graph 45^0.

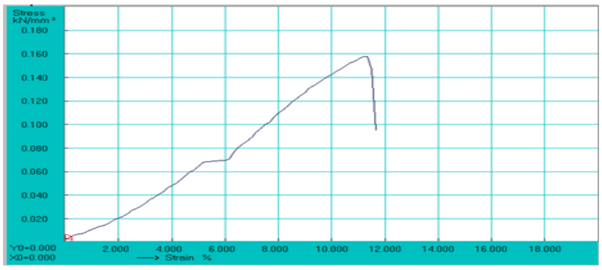

Fig 4.11 CNT 3% Tensile (stress vs strain) graph 90^0

V. RESULTS & DISCUSSIONS

5.1 FLEXURAL TEST RESULTS:

For CNT impregnated sheets**:**

CNT impregnated Sandwich sheets	Disp at FMax (mm)	Max Disp (mm)	Area (mm^2)	Ult Stress KN/mm^2
3%	8.200	12.100	30.035	0.003
4%	3.300	10.900	30.035	0.003
5%	5.200	12.200	30.035	0.002

Table 5.1. Flexural test results of CNT impregnated sheets.

For LDH impregnated sheets**:**

LDH impregnated Sandwich sheets	Disp at FMax (mm)	Max Disp (mm)	Area (mm^2)	Ult Stress KN/mm^2
3%	2.000	14.700	33.715	0.003
4%	5.500	17.200	31.232	0.003
5%	3.600	12.500	28.995	0.004

Table 5.2. Flexural test results of LDH impregnated sheets.

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For GF impregnated sheet:

GF impregnated Sandwich sheets	Disp at FMax (mm)	Max Disp (mm)	Area (mm^2)	Ult Stress KN/mm^2
	3.700	15.700	37.602	0.004

Table 5.3. Flexural test results of GF impregnated sheet.

5. 2 IMPACT RESISTANCE TEST RESULTS:

FOR CNT IMPREGNATED SHEETS:
i) For CNT 3% sheet: No cracks observed at the height of 1kg weight fall-150cm.
ii) For CNT 4% sheet: Cracks observed at the height of 1kg weight fall-150cm.
iii) For CNT 5% sheet: Cracks observed at the height of 1kg weight fall-150cm.

FOR LDH IMPREGNATED SHEETS:
i) For LDH 3% sheet: No crack observed at the height of 1kg weight fall-150cm
ii) For LDH 4% sheet: No crack observed at the height of 1kg weight fall-150cm
iii) For LDH 5% sheet: Crack observed at the height of 1kg weight fall-150cm

FOR GF IMPREGNATED SHEET: No crack observed at the height of 1kg weight fall-150cm

Ericission Cupping Values:

ERICISSION CUPPING		Sample 1	Sample 2	Sample 3	Average
GF		5.95	6.46	7.28	6.55
LDH	3%	6.31	6.28	6.60	6.41
	4%	7.05	7.93	5.71	7.04
	5%	7.93	7.09	8.24	7.72

Table 11. Erecssion cupping values of GF,LDH,CNT impregnated sheets.

VI. OBJECTIVES:

- The epoxy resin is proposed as the core material in this research due to its cheaper cost.
- This research work will be carried out in room temperature condition and with simple cost effective experimental setup (Hand Lay Up Technique)
- Glass Fiber (GF) will be used as reinforcement in the core (epoxy).
- The mechanical properties of the core shall be improved by adding Carbon Nano Tubes (CNT).
- The fire retardant material like Layered Double Hydroxide (LDH) compounds will be used in the core material helps to improve fire/smoke retardant properties of the core.

5.4 OBSERVATIONS:

It has been found that by mixing of LDH and CNT powder to epoxy, curing time can be reduced due to the chemical reaction.

It has been found that by mixing of LDH and CNT powder to epoxy, mechanical properties of sandwich sheets can be improved.

It has been found that by mixing of various percentages of LDH to epoxy, impact resistance can be improved and by increasing percentage of CNT powder mixed to epoxy, impact resistance can be reduced.

It has been found that flexural strength of sandwich sheets can be improved by increasing in percentage of LDH powder mixed to epoxy.

It has been found that ductility of sandwich sheets can be improved by varying in percentage of CNT powder mixed to epoxy.

VII. CONCLUSION

Mechanical Properties of AA/GF/AA sandwich sheets has been improved by adding of carbon nanotubes powder and layered doubled hydroxide powder Mechanical Strength for CNT and LDH sandwich sheets is more compare to GF sandwich sheets. Layered doubled hydroxide impregnated sheets have more mechanical strength when compared to carbon nanotubes impregnated and glass fiber impregnated sheets based upon different directions also.

Impact resistance of carbon nanotubes impregnated sandwich sheets is low when compared to layered doubled hydroxides impregnated sandwich sheets and glass fiber impregnated sandwich sheets.

Flexural strength of LDH impregnated sandwich sheets is more when compared to CNT impregnated sandwich sheets and GF impregnated sandwich sheets.

CNT impregnated sandwich sheets have more ductility when compared to LDH impregnated sandwich sheets and glass fiber impregnated sandwich sheets.

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