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Investigation of Mechanical Properties of AA8011/PP/AA1100 Sandwich Materials

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Abstract- The sandwich materials are new generation materials applied in automotive, aerospace and architectural applications. These materials are used in making panels and exteriors. The sandwich is made from two thin metal sheets with polymer/resin/layered between these sheets to bond and strengthen the sandwich material. In this investigation this sandwich material is fabricated using AA8011 and AA1100. These two are aluminium alloy sheet sandwich. The bonding is achieved by using an epoxy resin based adhesive through rolling process. The AA8011/PP/AA1100 sheets are 0.91mm, 1mm, and 0.91mm thickness respectively. The AA8011/PP/AA1100 sandwich sheets were subjected to tensile and flexural test to determine the respective strength parameters.
Keywords: Sandwich materials, Rolling, Tensile, Flexural, Application.

1. Introduction

Light-weight, high formability, delamination, damping resistance and low price sheet materials have been developed in recent years.[1] Among various sheet materials, the aluminium alloy/polypropylene /aluminium alloy sandwich sheets have generated a considerable interest as potential light-weight materials for the body panels because of its high specific strength, impact strength and acoustic dampening properties. The aluminium sandwich sheet consists of two aluminium skins with a thermoplastic core in between in order to achieve the lightest weight per unit area when flexural rigidity is the design criterion. In the present study, it was investigated from design for applying the aluminium sandwich sheets to automotive body panels.

2. Manufacturing of Sandwich Material

In current investigation the sandwich materials were researched, it was observed that they combine good corrosion behaviour with good damping behaviour and noise reduction. The sandwich material manufacturing method to be tested was a press joining process (roll bonding) [2]. This was performed discontinuously by a rolling machine. Aluminium alloy 8011 and Aluminium alloy 1100 with a thickness of 0.91 mm were first cleaned and degreased. A thin layer of adhesive was coated over aluminium skin. The used adhesive agent is a

conventional product based on epoxy resin. After activating the adhesive the upper sheet metal was joined with a 1mm thick polypropylene sheet in a rolling process.

During next step the produced upper sandwich was bonded with the lower sheet metal by rolling. For durability and reproducibility of the adhesive boding an activation temperature of 260 °C was needed. The necessary soaking time of the coated sheet metals was 60 seconds in a stationary conventional oven, and finally cooled for a time period of 45 seconds in a conventional cooler at room temperature.

3. Preparation of the Test Specimen

The roll bonded sandwich sheet using for dimensioning according to the ASTM standards. The ASTM standards E8/E8M a standard test method for tensile properties and D790 a standard test method for shear properties are followed while testing of sandwich materials. The Process of marking the lines over the roll bonded sandwich sheet according to the dimensions mentioned for specific test from ASTM standards.

For tensile test, specimens were cut from a roll bonding sandwich sheet of thickness 4mm along three directions namely longitudinal (0°), Diagonal (45°) and Transverse (90°) to the rolling directions of the sandwich sheet [2].

4. Experimental Procedure

These sandwich materials were examined in different test trials for the bond strength of the individual layers and for their mechanical properties and shear properties. The most important reason for the selection of aluminium alloy for the sandwich sheets are ultimate tensile strength and flexural rigidity, formability among others. It has been reported that dent resistance depends upon yield strength. The 8011 & 1100 aluminium alloy sheets were chosen as the materials in the present research of their mechanical properties [3].

Polypropylene was chosen for a core material since it could satisfy most of the requirements and density of 0.9 g/cm^3. A tensile test was carried out as per ASTM E8/E8M using specimen of 12.5mm wide with a gauge length of 50mm.Specimen were gripped at both ends and pulled at a constant rate in a 400KN in universal testing machine (UTM) . The flexural test was carried out as per ASTM D790 using specimen with a span length 150, 30 width and 4mm thick, the load was applied at the centre points of the span.

5. Result and Discussion

5.1. Mechanical properties of sandwich sheets

Mechanical properties of sandwich sheets were determined through conducting the tensile tests. The skin and core materials were cut in the required shapes directly and then bonded to sandwich samples. According to reference [4], the true stress-strain curves of the sandwich sheet can be predicted from those of the aluminium skin and the polypropylene core according to the rule of mixture. Fig.1. Shows the engineering strain-nominal stress curves of sandwich sheets determined by tensile tests and those calculated from the rule of mixture. Mechanical properties of sandwich sheets are summarized in Table 1. The tensile test revealed that, tensile strength of sandwich sheets decrease with increasing the thickness of polypropylene layer.

The results show that there are reasonably good agreements between the experimentally measured and the calculated values, which indicates that the rule of mixture can appropriately predict the tensile properties of the AA8011/Polypropylene/AA1100 sandwich sheet.

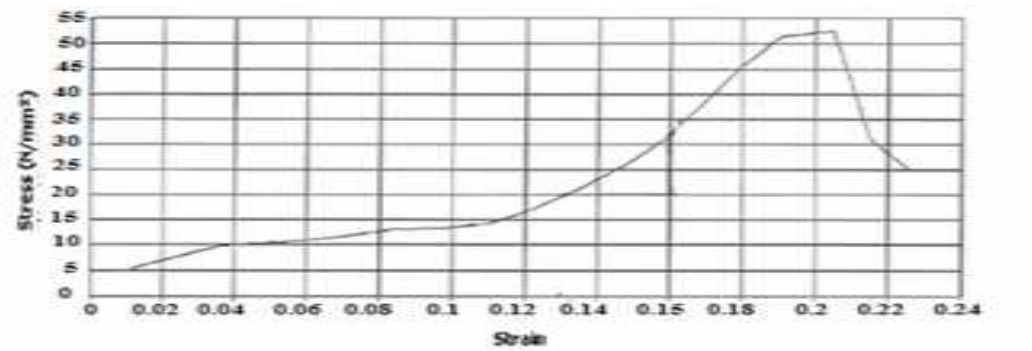

Fig.1. Stress strain curves of cross- head in tensile test

Table 1 Tensile Properties of Sandwich sheets, AA8011/Polypropylene/AA1100

Orientation relative to rolling direction	AA8011/PP/AA1100			
	Strain Hardening Index n	Strength Coefficient K (MPa)	Yield Strength σ_y (MPa)	Ultimate Tensile strength σ_u (MPa)
0°	0.47	255.29	54.29	65.87
45°	0.42	185.80	39.80	52.79
90°	0.44	190.31	45.56	52.69
Average *	0.44	210.67	46.55	57.11

5.2. Flexural bending test of sandwich sheets

In present study, the mechanical properties of sandwich sheets are explored through an experimental approach. According to reference [4], the true Load-deflection curves of the sandwich sheet can be predicted from those of the aluminium skin and the polypropylene core according to the rule of mixture. Fig.2. Shows load-mid span deflection of sandwich sheet in flexural test of sandwich sheets determined by flexural tests and those calculated from the rule of mixture. Flexural strength of the sandwich sheets are summarized in Table 2. The load and midspan deflection behaviour of sandwich materials, it is under three point bending. The deflection of sandwich specimen increased almost linearly with load up to final failure.

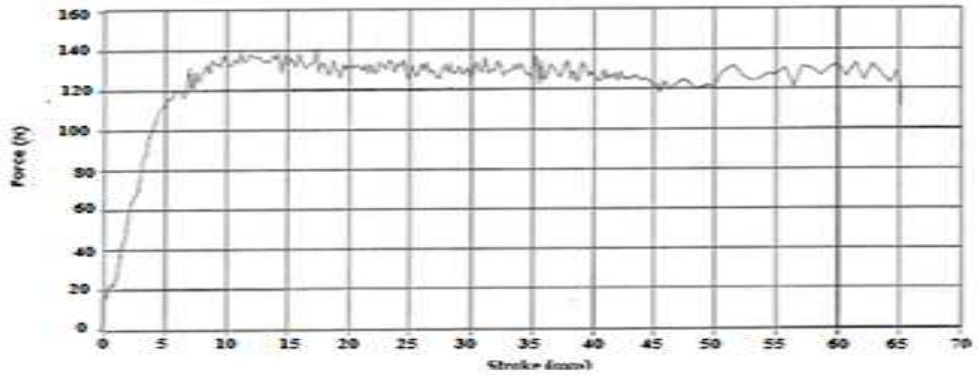

Fig.2. Load-mid span deflection of sandwich sheet in flexural test

Table 2 Predicted and calculated the Flexural strength of the Sandwich sheets, AA8011/PP/AA1100

AA8011/PP/AA1100				
Load P (N)	Maximum Deflection D (mm)	Flexural Stiffness S_f (N/mm)	Flexural Stress σ_f (Mpa)	Flexural Modulus E (Mpa)
140	28	5	81.56	324.44

6. Conclusion

The following conclusions can be made from the present study. The tensile test was performed on the sandwich sheet and result obtained are strain hardening index, strength coefficient, yield strength, ultimate tensile strength and to find the strength of the sandwich sheets flexural test was performed.

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