Effect of carbon nanotubes on sheet molding composite analysis for automotive application: FEA Method

P.Gunasekar, S.Manigandan, R.Gokul nath, S.Venkatesh, M.Rakesh Vimal, P.Booma devi

V. Dhinakaran

***Abstract*: Sheet Moulding Composite (SMC) is used in automotive body's for weight & tool cost reduction instead of sheet metal. As an alternative material SMC must fulfill the strength requirement as well as contribute less weight to Body-in-white (BIW). Hence, its mechanical properties & thickness selection must be done strategically. Further bending test setup has to be created & tested by FE analysis and followed by lab testing as a part of validation. Sheet moulding compounds (SMC) are fiber-reinforced thermosetting products. SMC is a generic term of different types of compounds together with the process to convert them into large composite parts by compression molding. SMC are widely used in the sectors like aerospace, agricultural, rail, marine, electrical and energy construction but the automotive and truck industries remain the drivers of SMC technology.**

***Index Terms*: Composite, Nanotubes, Reinforcement, Fibers**

I. INTRODUCTION

A lot of efforts are made to reduce the component weight and finding the alternative material for sheet metal and related industries. Steel sheet are replacing the existing material with an thinner steel or thicker aluminium sheet for its high strength and high durability [1-9]. In the automotive industry finding a material without losses in performance is huge challenging in the field of material science [23-27]. Several activities are made on sheet metal industries and their importance. SMC are used for its vital importance in most applications are the stiffness, damping and strength [28-30]. The purpose of this learning is to explore the importance of weight and the durability of finding the sheet material component [31,32].

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P.Gunasekar, Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India.

S.Manigandan, Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India.

R.Gokulnath., Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India.

S.Venkatesh, Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India.

M.RakeshVimal, Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India..

P.Booma devi, Department of Aeronautical Engineering, Sathyabama institute of science and technology, Chennai, India.

V.Dhinakaran, Department of Mechanical Engineering, Chennai institute of technology, Chennai, India

In several applications sheet metal parts do not carry any significant load but this paper discuss the effect of loading of different load.

II. METHODOLOGY TO RESEARCH & DEVELOPMENT

- FRP/Composite design process
- Design to control critical dimensions
- CAD Development
- Load calculation
- FE Analysis [10-17]

Table 1. Comparison of Sheet Metal Vs SMC

Parameters	Sheet metal (Stamped)	SMC (Compression moulded)
Part consolidation	Baseline	Excellent
Comparable mass	100%	75%
Corrosion Resistance	Baseline	Superior
Resistance to minor impact	Baseline	Better
Tooling cost	100%	30%
Raw material cost	100%	200%
Stiffness	100%	6%
Heat deflection temperature	N/A	Baseline

III. RESULTS AND DISCUSSION

The SMC material and it is mixed with 25 of carbon nanotubes to form a specimen. The specimen is taken and it is loaded with different types of load of 20kg, 40kg, 60kg and 80kg. The figure 1 shows the material which is inspected. Strain gauge pasted on the exact location of FE analysis [18-22] where max stress occurred. Instrumented part constrained on the location where it is constrained during FE analysis. Standard weights of 20 kg each is added on center of the part for loading. By assuming the fatigue thumb rule of testing, the impact test load is considered as below,

Vertical Loading – 3g (mass of impact)

Horizontal Loading – 2g (mass of impact)

Lateral Loading – 1g (mass of impact)

The dead mass of the complete hood assembly is calculated as 20kg using UG. So, the same load is considered for load calculations.

Load type – Vertical loading
Dead mass of hood - 20kg
Vertical Loading - 3g = 3x20 =60kg.
Final load considered for FE analysis - 70 kg (max)

Figure 1. Experimental Setup

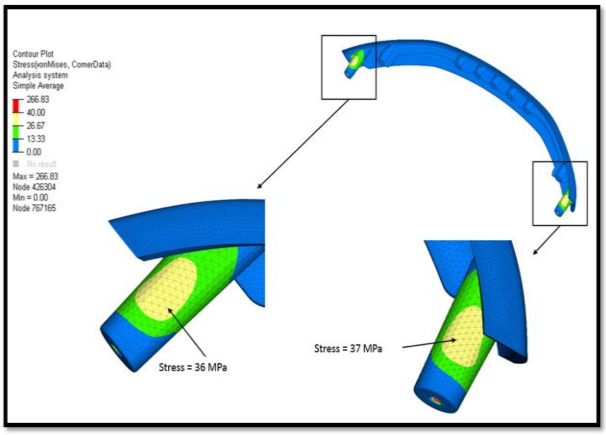

Figure 2. Stress distribution for the entire setup

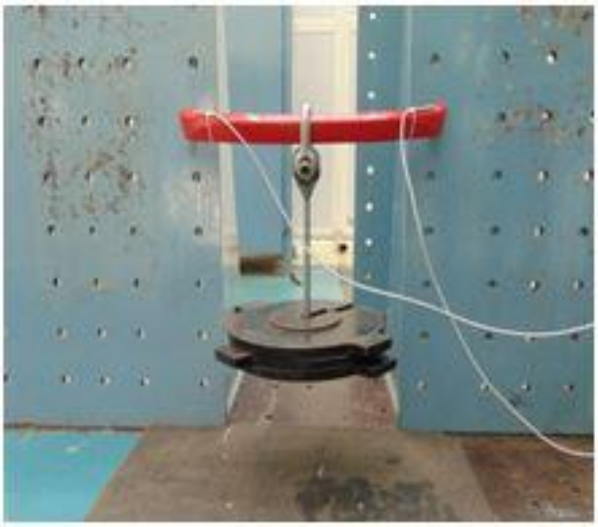

Figure 3.Weight Loading

It is proven from FE analysis & lab testing that the SMC with 5 mm thick sample showing equal load carrying capacity of sheet metal for that specimen. Deflection at the maximum load for SMC is less than sheet metal by 1.37mm. Also with intangible benefit of 30% weight reduction& less carbon foot prints in automobiles. The strain measured while adding 80 kg of standard weight is 4700 µƐ. The stress calculated for the 4700 µƐ of SMC is 40.7 MPa which is below the yield stress of 42MPa.

Material	Density (t/mm^3)	Young's Modulus (MPa)	Yield Strength (MPa)	Poisson's ratio	Ultimate Tensile Strength (MPa)
Sheet metal IS513	7.80E-09	210000	215	0.3	330
SMC Sheet molding composite (25% glass fiber)	1.70E-09	8500	40	0.25	80
SMC Sheet molding composite(30% glass fiber)	1.80E-09	8648	42	0.27	83

Table 2. Properties of the composite materials

Table 3. Recorded strain and calculated stress

Weight loading	Strain observed-LH (µε)	Strain observed-RH (µε)	Stress calculated RH (MPa)
20kg	547.7	454.5	3.93
40kg	2482	1818	16.02
60kg	4697	3310	28.22
80kg	6794	4708	40.72

Table 4. Result co-relation

FE predicted Stress	Actual Stress Measured	% of co-relation
37 MPa	40 MPa	92 %

The FEA and the experimental stress analysis is carried out and it is tabulated below. The 92% of correlation achieved between FE virtual & Physical Fatigue Testing.

IV. CONCLUSION

In this study, SMC material was designed and tested by both FE as well as experimental methods. Due to the assortment of advantages of SMC material, those material can be replaced the traditional sheet metal body parts. When SMC replaces the sheet metal for a specific application, an optimized thickness must be provided to it. The exact thickness was determined by FE analysis on bending test and also the physical part tested experimentally and results were compared. From the results it is evident that, SMC material yields more strength and less deformation than sheet metal. Further, It is non-corrosive and having high surface finish hence it can be molded in any shape and sizes. Thereby, SMC can be the best alternative material for sheet metal for automobile and aircraft body panels.

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