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Design and Fabrication of Bumper Material Using Sorbothane

Sharath Ramdas Udupa[1]*, Vani R.[2], Sharath Padmanabha Bhandary[3], Darwin Ammanna[4], Mohmad Razween Sulthan[5]

[1,3,4,5] Student, [2]Assistant Professor, Department of Mechanical Engineering, Yenepoya Institute of Technology, Mangalore Karnataka, India

ABSTRACT

Bumper is a structure which is integrated with the vehicle, to absorb impact energy from external source. It may be a minor impact reducing or to minimize repair costs. But the present bumpers are made up of Poly-Vinyl-Chloride or rubber materials which are not so suitable for both impact reduction and also for reduction of repairing costs. Hence implementation of viscoelastic material in the bumper may help to reduce both repair cost and impact reduction. Sorbothane is a viscoelastic polymer with shock absorption, good memory, vibration damping characteristics. It also combines all properties such as long fatigue life, low creep rate compared to other bumper material. Present work mainly focused in the fabrication of a composite structure which will replace an existing bumper material. By which the impact strength of the bumper can be increased also deformation of the bumper can minimized.

Keywords: *Bumper, sorbothane, viscoelastic polymer, composite structure*

Corresponding Author
E-mail: srudupa16@gmail.com

INTRODUCTION

Accidents are unintentional act. These are unplanned event which occur due to the unexpected circumstances which sometimes may or may not be prevented. The results of these accidents may be a small injury or a fatal one based on the severity of it. Accidents may occur at aviation, road accidents, sailing ships, train wrecks. If we consider all these possibilities, the measures followed are comparatively less for road accidents. For example, if we consider Aviation, safety measures like seatbelts, electronic devices should be shut down and there is a limitation for carriage of weights. Where as in road transport system, there are plenty of safety measures to avoid accidents or collisions. But these safety measures are followed in a very less number. Due to these, loss of property and vehicle damage occurs which adversely leads to financial losses. But more importantly it may result in the loss of lives. There are many features of vehicle like Airbags, body material, seat belt, power brakes, power steering, bumper, which have been studied to increase the safety of the vehicle. From some of these safety features we are focusing on bumper as they are not pretty much advanced when compared to other safety features and as our work is based on bumper material composition.

Bulsara YR et al. showed that the forces transmitted through a laminated mouth guard material with sorbothane intermediate layer between heat cured laminated EVA sheets, as used in the

fabrication of custom made sports mouth guard dissipate more significantly the force of impact [1]. Ravi Gondaliya et al. explained how composite sandwich structures with different impact resistance and are damage tolerant He used CFRP (Carbon Fiber and Reinforced Polymer) with core material of sorbothane. He found that Sandwiches with cores made with D30 (regd) and Sorbothane (regd) showed more ductility when compared with Nomex (regd) core sandwich composite [2]. Kenneth J. Sazalski et al. conducted an experiment for the purpose of obtaining efficient and statistical reliable data for the evolution on crash impact. In this two methods were used, one is factorial and the box-behnken and it was applied to a variety of energy absorbing materials including Ethafoam, Ensolite, sorbothane and expanded bed polystyrene. Results of the study showed that sorbothane could be used to efficiency reduce injury potential in vehicle areas which are size constrained using lighter but thicker energy absorbing padding materials [3]. John Lloyd conducted test on impact absorbing materials and more particularly relating to an impact absorbing composite material, having a plurality of cells that individually responds to an impact to reduce forces associated with linear and angular acceleration. This composite materials having impact absorbing cells are comprised of one or more of micro cellular open cell foams, micro cellular closed cell foams viscoelastic polymers (sorbothane) and elastomers. He concluded that geometry of impact absorbing materials is important for suitable absorption of forces [4].

BUMPER

Bumper is a structure attached to front and rear end of the vehicle to absorb or to reduce collision impacts. With the help of bumper, the damage to the vehicle can be reduced. Without it, this may lead to direct damage to the vehicle body. This may increase the repair cost for the vehicle and sometimes it also needs replace whole body part [5].

In the 20th century, the chrome bumper which is also called bullet bumpers was used widely in automobiles. Over the years the bumper came to be essential design parameter of automobile and helped in defining the brand. Considering metals as a bumper, which transfers the load applied from one end to other and also considering negligible losses. So, only metals are not perfectly suitable materials for the bumper. In the modern era, plastic bumpers are widely used. This is because they have the tendency to reduce the effect and absorb the load. Some of the plastic bumpers used are polyvinyl chloride, polyurethane, polypropylene [6].

In accordance with the bumper materials that are currently in use, to make it more efficient in impact absorption composite material which is made up of GI sheet and viscoelastic polyurethane sheet are used [7].

Requirement of bumper material

- More energy absorption while collision.
- It should be resistant to rust formation.
- It should have high strength.
- Easy to produce in large quantities.

COMPOSITE STRUCTURE OF A BUMPER

Nowadays the word composite arises in almost all the mechanical components or parts. Due to its less weight the composite materials are preferred. These composites nowadays are experimented in almost all the parts of the automobiles and also have arrived in bumpers of the automobiles because of the collision absorbing property [8–9].

Advantages of Composite Structure of a Bumper

- It has high impact strength.
- It absorbs more collision energy.
- Excellent corrosion resistance.
- Composite properties allow rapid response to release or induced stress.

Sorbothane Material

Sorbathane is a proprietary, viscoelastic polymer. Viscoelastic means that a material exhibits properties of both liquids (viscous solutions) and solids (elastic materials). Sorbothane combines shock absorption, good memory, vibration isolation and vibration damping characteristics. In addition, sorbothane is a very effective acoustic damper and absorber. While many materials exhibit one of these characteristics, sorbothane combines all of them in a stable material with a long fatigue life [10].

Properties of Sorbothane

- It has low creep rate compared to other polymers.
- It has superior damping coefficient over a wide temperature range.
- It absorbs shock efficiently for millions of cycles.
- It eliminates the need of metal springs to return the system to its equilibrium position after absorbing a shock.

DRAFTED MODEL OF THE BUMPER

Drafted Model of The Bumper is shown in Figure 1.

FABRICATION OF COMPOSITE STRUCTURE OF A BUMPER

In the fabrication process of a three layered composite structure of a bumper, the GI sheet of specific dimension is cut using shearing machine. The face sheets were visually inspected and cleaned to remove rust, oil traces, dust and water particles. And the sorbothane (viscoelastic polyurethane) of specific dimension was die cut, scissor cut, knife cut and water jet cut depending upon the accuracy requirement of the cut edge. It was freed from the surface silicon by washing the material with mild detergent, rinsed with clean water and air dried. Loctite 406 adhesive was used as a bonding material having the property to bond even with metal surface.

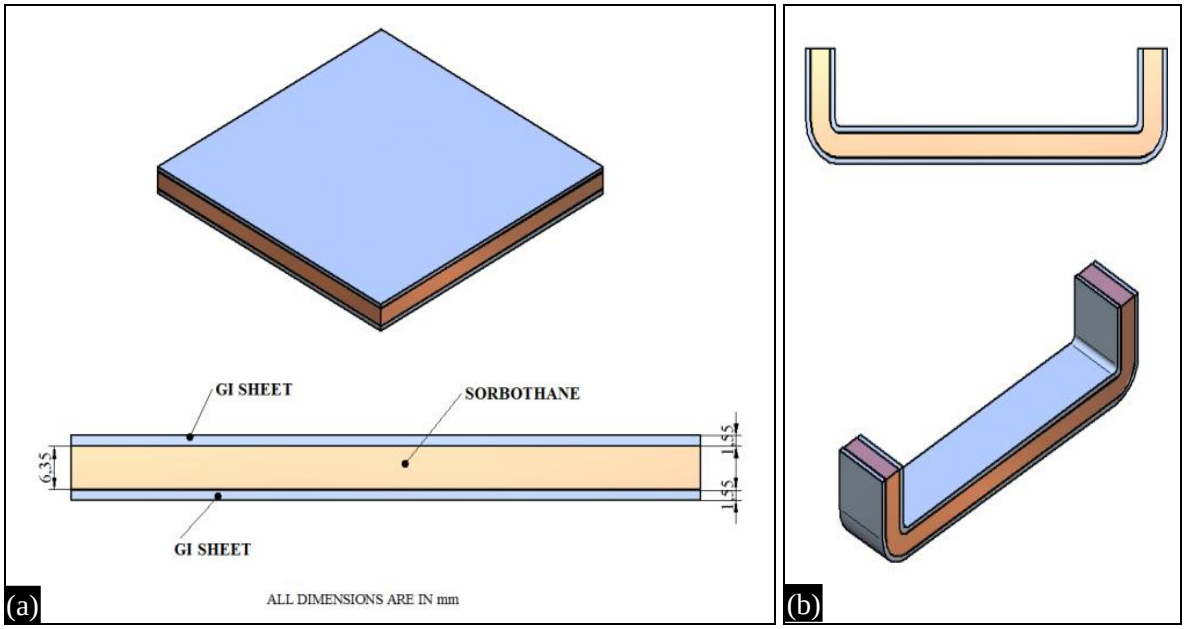

Fig. 1. *(a) Composite structure of bumper material and (b) composite structure of bumper material.*

Adhesive was uniformly spread to one face of the GI sheet and sorbothane layer is laid on top of it. Later adhesive is spread on the top of the sorbothane material on which the second GI sheet is laid. Thus sandwich composite of bumper is made and compressed with force to let excess adhesive out to assure the uniform distribution of adhesive and no bubbles are formed.

Basic Raw Material

- GI sheets
- Viscoelastic polyurethane (sorbothane)
- Loctite 406 adhesive

TESTING

Three-point Bending Test

The three-point bending test is also known as three-point bending flexural test. The purpose of conducting three-point bending test is to obtain the deflection, flex modulus and flex strength of the composite structure. When material is subjected to loading, it undergoes certain deformation that is displacement of longitudinal axis in the direction of load and it's called deflection. The test was conducted in ZWICK-ROELL Z020 (UTM), load cell 20 kN. The testing machine is shown in the Figure 2(a)–(b).

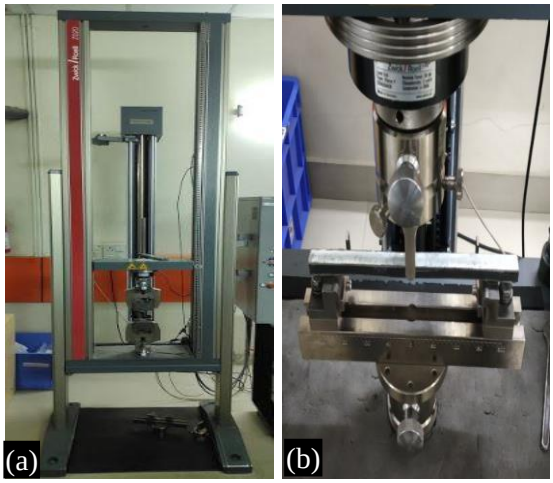

Fig. 2. *(a) Zwick-Roell Z020(UTM) and (b) Zwick-Roell Z020(UTM) with the Specimen.*

Test Specimen

For 3 Point Flexural Bending Test

Fig. 3. *Three-point flexural bending test specimens.*

The test specimen used for conducting bending test is shown in the Figure 3. The details of the specimen are given below.
Length of the specimen = 220 mm
Width of the specimen = 13 mm
Thickness of the specimen = 9.873 mm

Compression Test

Compression test is done to study the behaviour of the material under loading. The testing machine is shown in the Figure 4(a)–(b).

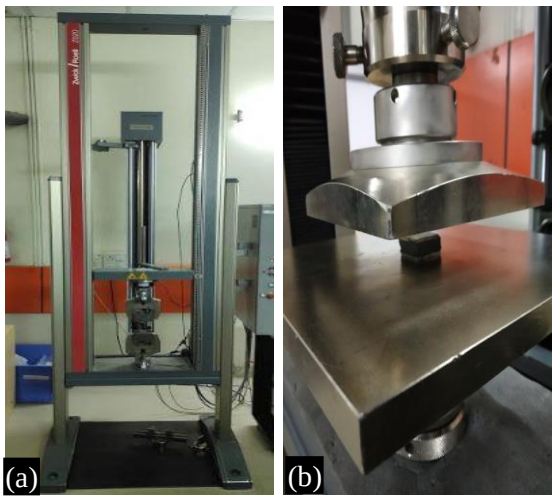

Fig. 4. *(a) Zwick-Roell Z020(UTM) and (b) Zwick-Roell Z020(UTM) with the Specimen.*

Test Specimen

For Compression Test

Fig. 5. *Compression test specimen.*

The test specimen used for conducting compression test is shown in the Figure 5. The details of the specimen are given.
Length of the specimen = 20 mm
Width of the specimen = 20 mm
Thickness of the specimen = 9.483 mm

RESULT AND DISCUSSION

Bending Test Results

Bending test was carried for three specimens. And the variation of deformation verses stress was shown in the Figure 6.

The average value of Young's modulus is 1300 MPa and bending strength is 22.9 MPa for the maximum load of 134 N.

Compression Test Results

Compression test was carried for three specimens. And the variation of strain verses force was shown in the Figure 7.
Table 1 gives the test values of composite structure.

Table 1. *Test values for the three-point bending.*

Legends	Specimen	F_{max} N	Flex Modulus Mpa	Flex Strength Mpa	T Mm	W mm	L mm
	1	136.31	1150	21.8	10.25	14.27	160
	2	131.52	1310	22.7	9.82	14.41	160
	3	134.16	1430	24.0	9.55	14.7	160

Table 2 gives the test values of compression test for composite structure used.

Table 2. *Test values for compression.*

Legends	Specimen Identifier	F_{max} N	Thickness Mm	Width mm
	1	19984.07	9.5	21.52
	2	19968.28	9.41	21.43
	3	19990.91	9.54	21.48

The average value of Young's modulus is 1300 MPa and bending strength is 22.9 MPa for the maximum load of 134 N.

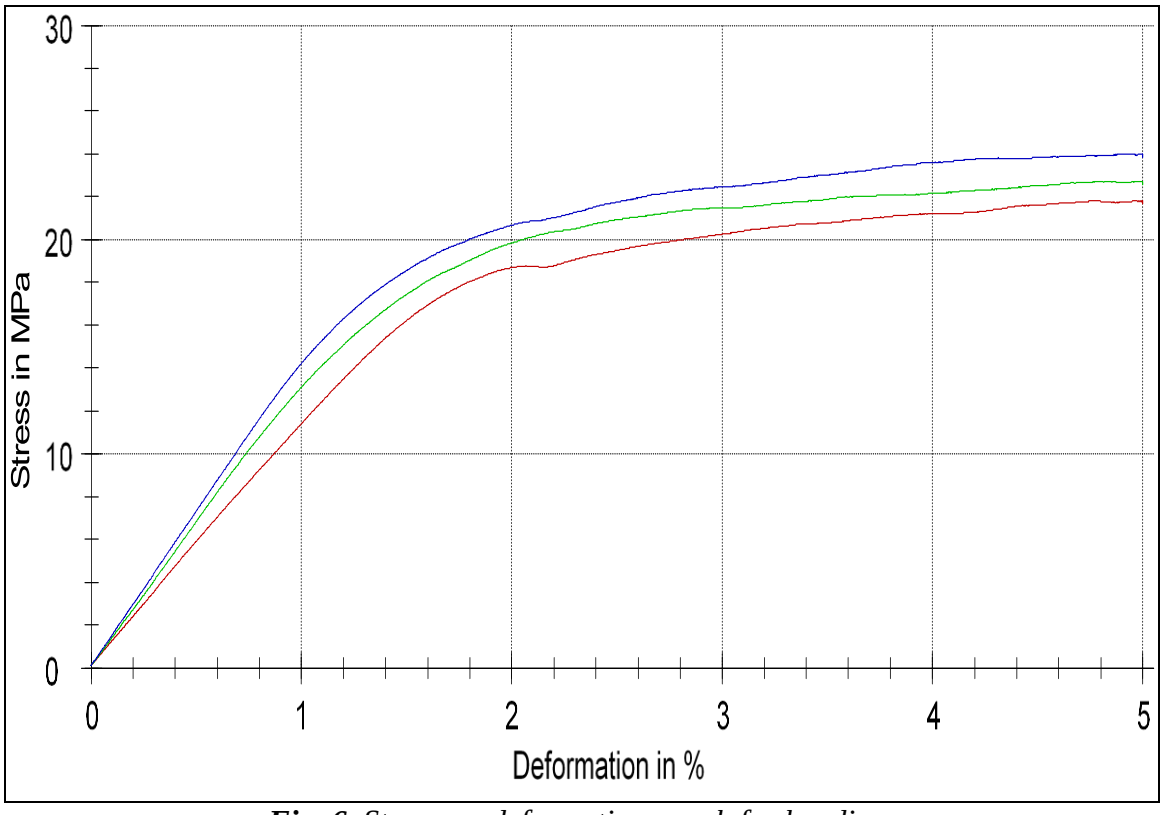

Fig. 6. *Stress vs. deformation graph for bending.*

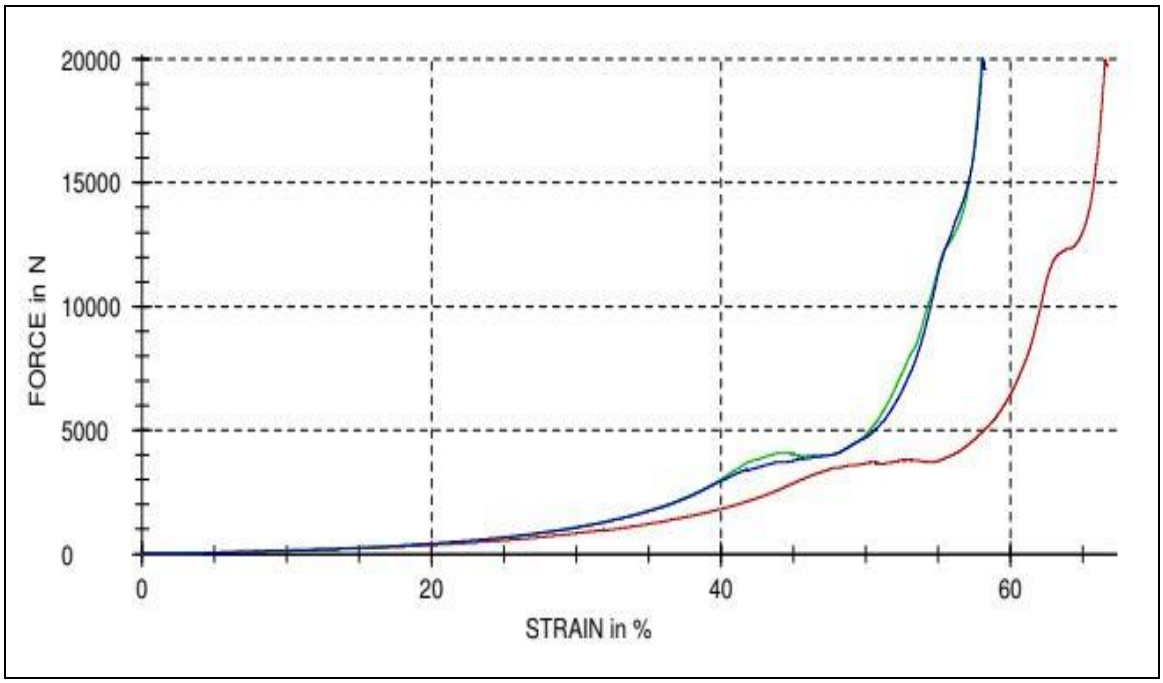

Fig. 7. *Force vs. strain graph for compression.*

CONCLUSION

The composite structure is fabricated by using the suitable adhesive agent and was tested for its flexural and compression strength. The test was conducted in universal testing machine and results were found. Material strength data concerning the flexural and compression strengths has been obtained. The sorbothane core material properties were best estimated for load resistance. Keeping the sorbothane as a reinforcement material the bending strength obtained was 22.9 Mpa. The results obtained for the test conducted for the composite structures were promising for given load deflections. Hence this enabled us to get firm on our reinforcement material used in the composite structures. The major limitation in our work was the fabrication of whole bumper.

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