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NEW TRENDS TO IMPROVE IMPACT RESISTANCE FOR AUTOMOTIVE BUMPER

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ABSTRACT

Bumpers play an important role in preventing the impact energy from being transferred to the automobile and passengers. Saving the impact energy in the bumper to be released in the environment reduces the damages of the automobile and passengers. Therefore researchers have sought to make bumpers lighter without sacrificing strength, ability to absorb impact, or passenger safety. This study investigates the possibility of adding filling material between the bumper and front car body. The experimental tests were conducted and applied on front bumper of Fiat- Sahin vehicle.

The results showed the improvement in bumper impact resistance about 260% when using one layer of honey comb cardboard cell and cardboard sheets as filling materials.

KEY WORDS

Cardboard bumper, impact resistance and filling material.

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INTRODUCTION

Automotive bumper systems are designed to prevent or reduce physical damage to the front and rear ends of passenger motor vehicles in low speed collisions. To protect the hood, trunk, grill, fuel, exhaust and cooling system as well as safety related equipment such as parking lights, headlamps and taillights in low speed collisions. By limiting physical damage to expensive components, bumper systems reduce insurance expenses for OEMs (Original Equipment Manufacturer).

Many countries have different performance standards bumper systems. Bumper systems on vehicles sold in North America are required to meet 4 km/hr FMVSS (Federal Motor Vehicle Safety Standard) pendulum and barrier impact resistance [1] and 8 km/hr CMVSS (Canadian Motor Vehicle Safety Standard) pendulum and barrier impact requirements. In addition, most bumper systems are also designed to meet 8 km/hr IIHS (the Insurance Institute for Highway Safety) 30° corner and flat barrier impact. Bumper systems on vehicles sold in Europe and Japan are typically designed to withstand 4 km/hr ECE42 pendulum impact and 15 km/hr offset Allianz barrier impact. Future front bumper systems sold into European markets will need to meet pedestrian safety requirements in addition to ECE42 and Allianz barrier requirements. Besides many global vehicle platforms will be sold unchanged in European, Japanese and North American markets. This will require a focus on vehicle structure and styling that is flexible enough to meet all of the global legislative impact requirements.

Many energy absorbing bumper systems have been proposed to meet the challenges faced by the bumper designer. An energy absorbing bumper system made of a foam type resin of polypropylene, polyurethane or the like is one concept [2]. Another foam type energy absorbing bumper is a semi-rigid resilient fascia spaced forwardly of the bumper structure and the volume defined there between filled with an integral skin urethane foam that is resiliently deformable and integrally bonded to both members [3]. However, a non-foam type injection-molded thermoplastic energy absorber made of PC/PBT [4, 5] has been demonstrated as having the highest efficiency of energy absorption and more consistent impact performance over a range of temperature.

Davoodi [6] focused on a hybrid of kenaf/glass fiber to enhance the desired mechanical properties for car bumper beams as automotive structural components with modified sheet molding compound (SMC). A specimen without any modifier is tested and compared with a typical bumper beam material called glass mat thermoplastic (GMT). The results indicate that some mechanical properties such as tensile strength, Young's modulus, flexural strength and flexural modulus are similar to GMT. On the other hand impact strength is still low, and shows the potential for utilization of hybrid natural fiber in some car structural components such as bumper beams. There are two main methods, flexibilisation and toughening, for modifying the resin in order to improve the impact properties of epoxy composite. They form single phase or two-phase morphology to make modifier as epoxy or from separate phase to keep the thermo-mechanical properties.

Liquid rubber, thermoplastic, core shell particle and rigid particle are different methods of toughening improvements [7]. In this research, thermoplastic toughening

has been used to improve impact properties in hybrid natural fiber epoxy composite for automotive bumper beam and has achieved reasonable impact improvements. Two general approaches to reducing the severity of pedestrian lower limb impacts were identified: a- Provide cushioning and support of the lower limb with a bumper and a new lower stiffener, or b- Use the bumper as a platform for impact sensors and exterior airbags [8].

The selection of the best design for the automotive front bumper beam for passenger cars depends on the variety of factors which include: energy absorption (EA), cost (CT), manufacturing process (MP), weight consideration (WE), maintenance (MTN) and strength (ST) [9].

The aim of the present paper is to investigate the effect of adding filling material between the bumper and front car body on bumper impact resistance, and compare it with that of conventional bumpers.

EXPERIMENTAL WORK

The experimental work is presented in three main parts. The first part includes the description of the bumper. The second part shows different types of filling material and its preparation. The third part comprises the different tests conducted on bumper to evaluate the impact resistance of the bumper. The detail of each group is given below.

Tested Bumper Description

The bumper used was a front bumper of Fiat- Sahin car. The impact test is measured at three locations as indicated in Fig. 1. Fig. 2 shows cross-section shapes of specimens (impact location) A, B and C.

Filling Material and Preparations

Different materials were used such as foam with different density and cardboard (slices and honey comb). Figures 3 to 7 show specimens with different filling materials.

Figures 6 and 7 show the preparation steps of double layers cardboard cells and sheets. First step is the preparation of honey comb cardboard cells to cave area under bumper. Second step is assembling cells with carton sheets bumper. Last step is filling cardboard layers and cells cave area under bumper as shown in Fig. 7.

Impact Testing

Impact testing is a method to evaluate object's ability to resist high-rate loading through the determination of energy absorbed in fracturing a test piece at high velocity. Most of us think of it as one object striking another object at a relatively high speed.



a- Location – A



b- Locations – C & B

Fig. 1. Test bumper locations.



a- Cross-section shape at location – A



b- Cross-section shape at location– B



c- Cross-section shape at location – C

Fig. 2. Cross-section shape at impact test locations (A, B & C).



Fig. 3. Specimen with sponge 30 in intensity.



Fig. 4. Specimen with sponge 70 in intensity.



Fig. 5. Specimen with sheets of cardboard.



(a) Honey comb cell of cardboard.



(b) Specimen with honey comb cells of cardboard.



(c) honey comb cell & cardboard sheet



(d) specimen with honey comb cardboard and cardboard sheets

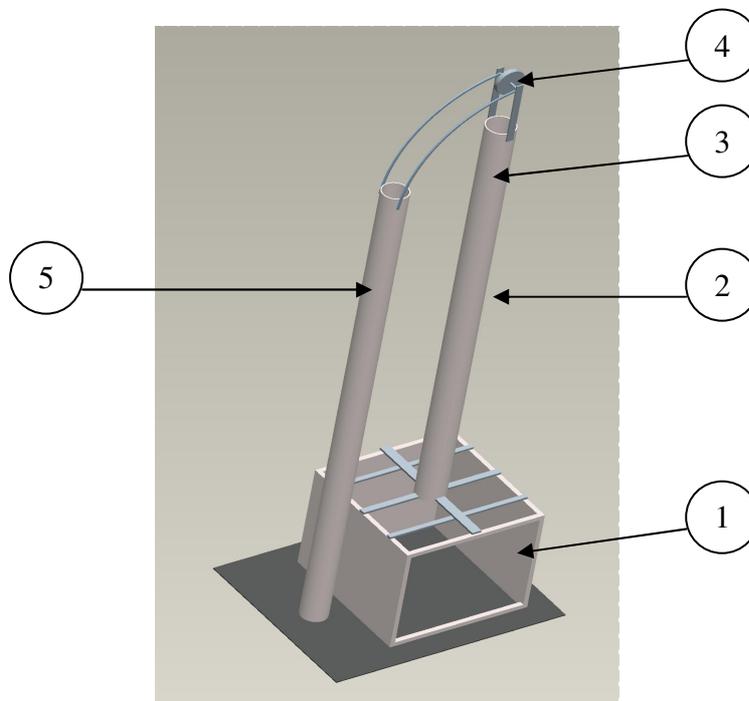
Fig. 6. Steps of preparation the specimen with honey comb cardboard and cardboards sheets.



Fig. 7. Double layers of honey comb cardboard cells and cardboard sheets.

Floating weight impact device is used to apply dynamic load on the specimens of the bumper as shown in Fig. (8). The impact test device consists of base box (1) used to hold the specimen test, hollow shaft (2) , drop weight with wire (3), pulley (4) and fixed arm (5).

The drop weight impact test was considered as a comparison factor between the bumper with any filling material and that with different types of materials [1]. For simplicity the height of drop weight was one meter and the change will be in drop weight values. Each test run was repeated 4 times at least. All of the tests were conducted under the same conditions.



1- base box 2- hollow shaft 3-drop weight with wire 4- pulley 5-fixed arm.

Fig. 8. Impact test device

Figures from (9 to 11) show the shape of the tested specimen broken at the end of impact test under different drop weights. Case (I) when the bumper (specimen) without filling material. Case (II) when the bumper (specimen) is charged with different filling materials.



Fig. 9. Broken specimen(tested without filling material)



Fig. 10. Broken specimen(tested with filling material -sponge 30 in intensity)



Fig. 11. Broken specimen (tested with filling material double layer of carton as a honey comb)

RESULTS AND DISCUSSION

This section presents experimental results obtained for different broken impact drop weights at different positions A, B and C, in case (I) when the bumper (specimen) without filling material and case (II) when the bumper (specimen) with different filling materials. Each test indicated substantial improvements when the specimen (bumper) charged with different filling materials, due to higher impact resistance.

Figures (12 and 13) show comparative results of impact drop weights at different positions for both cases (I) & (II) using four different filling materials.

The two Figures indicate clearly the benefit of using filling materials between the bumper and front car body. The increasing in impact resistance referring to the evaluation of impact resistance that bumper without filling materials is as conventionally used. The increase in impact resistance is found to be from 5% (for

spongy 30) to 18% (for spongy 70) to 20% for cardboard sheets and to 260% (for one honey comb cell and cardboard sheets).

Figure (14) shows average improvement of impact resistance at the above mentioned cases.

The detailed analysis of the results revealed that the impact resistance of bumper is greatly affected by the type of filling material, especially when using one honey comb cell and cardboard sheets.

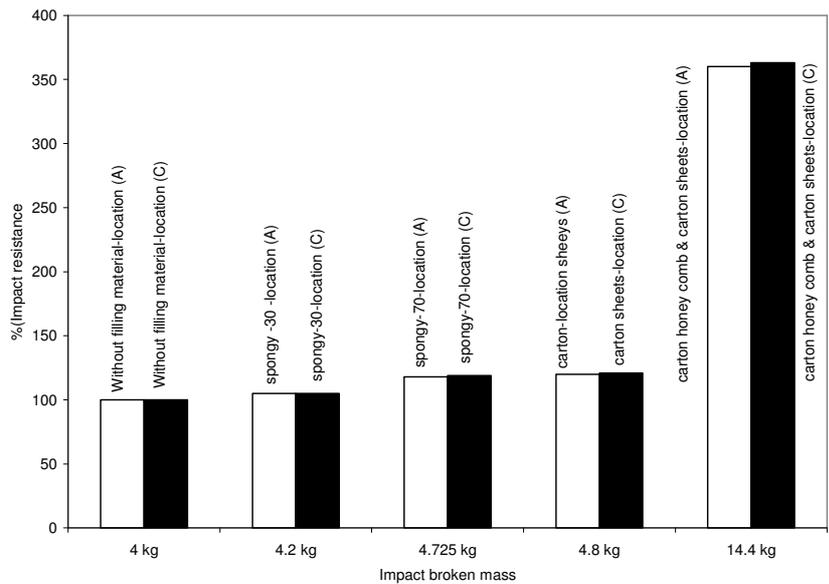


Fig. 12. Impact broken resistance (locations-A & C).

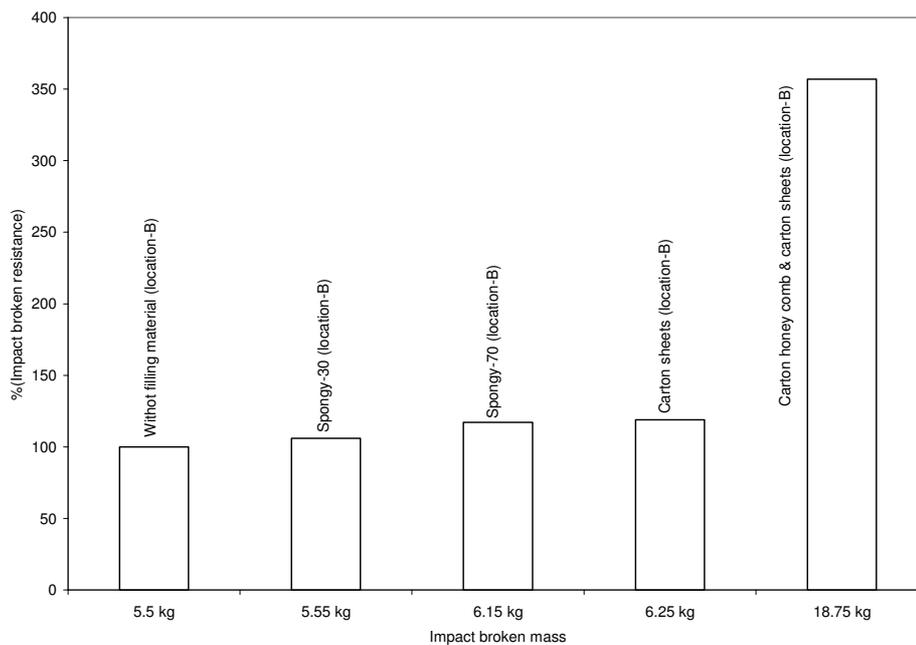


Fig. 13. Impact broken resistance (locations-B).

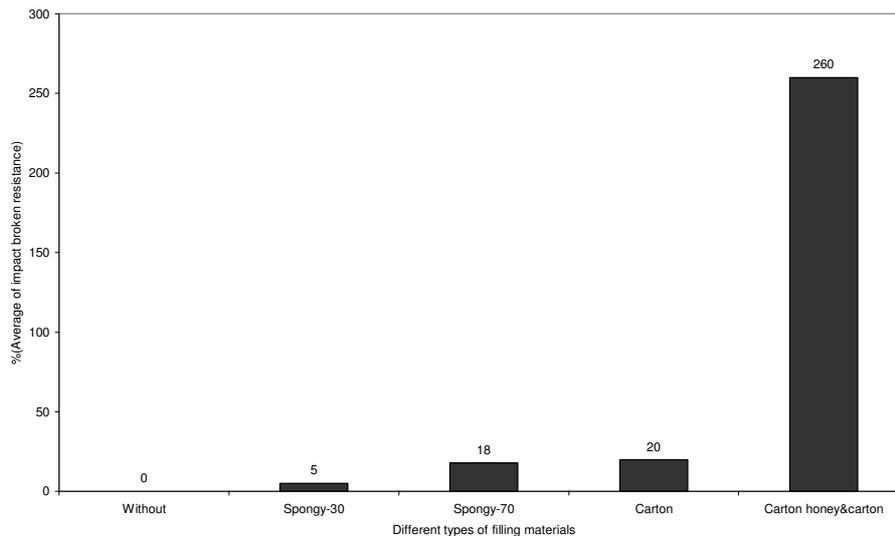


Fig. 14. Average impact broken resistance of bumper.

CONCLUSIONS

- The analysis of the laboratory results indicated that the impact resistance of bumper is affected by the types of filling materials.
- The results showed the improvement about 260% in bumper impact resistance when using one layer of honey comb cardboard cell and cardboard sheets.
- The filling materials selected to lower weight and cost.

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