



DETERMINATION OF MECHANICAL PROPERTIES OF ABS PLASTIC MATERIAL USED IN AUTOMOBILE BUMPER

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ABSTRACT

The research work presents analysis of Mechanical behaviour of 3D printed ABS parts. 3D printing technology - an additive manufacturing process is a method of making Three Dimensional solid objects from a digital file. The emergence of 3D printing technology is challenging many products that have been traditionally made. In an additive process an object is created by laying down successive layers of material until the entire object is created. In this work, the mechanical properties and behaviour of a 3D Printed object is to be studied by varying parameters such as layer thickness, orientation etc. Various tests such as tensile test, compression test, flexural test and impact test to determine failure characteristics of such materials will be conducted. Based on experimental results, stress-strain relationship and failure criterion can be proposed.

Keywords: Automobile Bumper, 3D Printing, ABS Plastic

1. INTRODUCTION

In the automotive industry most of the structural materials used today are metals, especially aluminium and steel. Composites have recently received more attention as a possible substitute to these because of their lightweight potential and design possibilities. The demands on fuel efficiency and environmental friendliness of cars are constantly getting stricter. Reducing the weight is one efficient way to increase the fuel efficiency of a car, and composite materials seem to offer a way of accomplishing this. However as the automotive industry is very cost sensitive the weight decrease needs to be done in a cost efficient manner. Implementing composites in the high volume production automotive industry has been prevented by the higher material costs compared to metals and limitations of the manufacturing such as cycle times. Although non-structural composite components are used, structural composite components are primarily limited to low volume applications such as sports cars, the naval and the aerospace industry. Bumpers absorb most of the impact during low speed collisions to help protect you, your vehicle, and passengers from more serious damage. Due to this, bumpers are considered standard safety equipment. The binding polymer is often a thermoset resin such as epoxy, but other thermoset or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used. Originally plated steel was used for entire body of a car, including the bumper. This material worked well, as it was very strong in a crash.

2. TYPES OF BUMPER



Figure 1 (a) Standard Bumper (b) Deep Bumper

- a. Deep drop bumpers (also known as cowboy bumpers) sit a little taller or longer than standard bumpers. This type of bumper is designed for heavy workloads as well as damage prevention. The unique shape of a deep drop bumper is extremely durable and allows for extra towing capacity

- b. A standard bumper is a simple, below-the-grille bumper that stretches from the front left of a truck to the front right. Most standard bumpers are produced directly by a vehicle's manufacturer to specifically fit that vehicle. However, the quality often leaves something to be desired. Cheap materials might look the part, but in an actual collision, they wouldn't do a very good job protecting your truck.



Figure 2 (b) Tube Bumper (b) Step Bumper

- c. Tube bumpers are popular not only for their functionality but also for their style. Rather than sitting directly below the grill, the thin, tubular shape of this bumper allows it to rest over the truck's lights as well. When made with the proper materials, tube bumpers are lightweight as well as durable, and efficient as well as stylish.
- d. A step bumper is essentially a standard bumper with a step in the middle. It makes it easy to swing a leg up into your truck bed. You can purchase a step bumper with or without a towing hitch.

3. GENERAL MATERIALS USED IN BUMPER

- a. **Polypropylene (PP)** Polypropylene is a thermoplastic polymer used in a wide variety of applications. A saturated addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. Application: automotive bumpers, chemical tanks, cable insulation, gas cans, carpet fibers.
- b. **Polyurethane (PUR)** Solid Polyurethane is an elastomeric material of exceptional physical properties including toughness, flexibility, and resistance to abrasion and temperature. Polyurethane has a broad hardness range, from eraser soft to bowling ball hard. Other polyurethane characteristics include extremely high flex-life, high load-bearing capacity and outstanding resistance to weather, ozone, radiation, oil, gasoline and most solvents. Application: flexible foam seating, foam insulation panels, elastomeric wheels and tires, automotive suspension bushings, cushions, electrical potting compounds, hard plastic parts.
- c. **Poly-Vinyl-Chloride (PVC)** PVC has good flexibility, is flame retardant, and has good thermal stability, a high gloss, and low (to no) lead content. Polyvinyl chloride molding compounds can be extruded, injection molded, compression molded, calendared, and blow molded to form a huge variety of products, either rigid or flexible depending on the amount and type of plasticizers used. Application: automobile instruments panels, sheathing of electrical cables, pipes, doors.
- d. **ABS Acrylonitrile Butadiene Styrene** is a copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The styrene gives the plastic a shiny, impervious surface. The butadiene, a rubbery substance, provides resilience even at low temperatures. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. Application: automotive body parts, dashboards, wheel covers.
- e. **Polyamide (PA, Nylon 6/6, Nylon 6)** Nylon 6/6 is a general-purpose nylon that can be both molded and extruded. Nylon 6/6 has good mechanical properties and wear resistance. It is frequently used when a low cost, high mechanical strength, rigid and stable material is required. Nylon is highly water absorbent and will swell in watery environments. Application: gears, bushes, cams, bearings, weather proof coatings.
- f. **Polystyrene (PS)** Naturally clear, polystyrene exhibits excellent chemical and electrical resistance. Special high gloss and high impact grades are widely available. This easy to manufacture plastic has poor resistance to UV light. Application: equipment housings, buttons, car fittings, display bases.
- g. **Polyethylene (PE)** Polyethylene has high impact resistant, low density, and exhibits good toughness. It can be used in a wide variety of thermoplastics processing methods and is particularly useful where moisture resistance and low cost are required. Application: car bodies (glass reinforced), electrical insulation.
- h. **POM (polyoxymethylene)** POM has excellent stiffness, rigidity, and yield strength. These properties are stable in low temperatures. POM also is highly chemical and fuel resistant. Application: interior and exterior trims, fuel systems, small gears.
- i. **Polycarbonate (PC)** high performance plastics Amorphous polycarbonate polymer offers a unique combination of stiffness, hardness and toughness. It exhibits excellent weathering, creep, impact, optical, electrical and thermal properties. Because of its extraordinary impact strength, it is the material for car bumpers, helmets of all kinds and bullet-proof glass substitutes. Application: bumpers, headlamp lenses.
- j. **Acrylic (PMMA)** A transparent thermoplastic, PMMA is often used as a lightweight or shatter-resistant alternative to glass. It's cheaper than PC but is also more prone to scratching and shattering. Application: windows, displays, screens.

4. SPECIFICATION OF MARUTI SUZUKI SWIFT

Table 1 – Specifications of Maruti Suzuki Swift.

Parameter	Value
Engine	1248 cc, 4 Cylinders Inline, 4 Valves/Cylinder, DOHC
Engine Type	DDis Diesel,CRDI
Fuel Type	Diesel
Max Power (bhp@rpm)	74 bhp @ 4000 rpm
Max Torque (Nm@rpm)	190 Nm @ 2000 rpm
Mileage (ARAI)	22.9 kmpl
Transmission	Manual - 5 Gear
Dimensions	3850 mm x 1695mm x 1530mm
Wheelbase	2430
Kerb weight	1060 Kg.

The Vehicle bumper is made of . ABS is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15% to 35% acrylonitrile, 5% to 30% butadiene and 40% to 60% styrene. The result is a long chain of polybutadiene crisscrossed with shorter chains of poly(styreneco-acrylonitrile). Various Automotive Parts That Look For Weight Reduction Factors Consider ABS Thermoplastic As A Great Substitute For Metals. Commonly Used Parts Include Dashboard Components, Seat Backs, Seat Belt Parts, Door Liners, Handles, Instrument Panels, Pillar Trim, Etc.

Multiple Every Day Use Home Appliances And Consumer Goods Like Control Panels, Housings For Vacuum Cleaners, Food Processors, Refrigerator Liners, etc Make Use Of ABS. Electrical And Electronic Applications Like Computer Keyboards, Electronic Enclosures, Etc. • Construction Applications Like Pipes And Fittings Are Made Using ABS Plastic. This Is Because Of Its Properties Like High Impact Strength, Resistance To Rust And Corrosion.

ABS Plastic possesses following Properties:

- Pyrolysis Thermal Degradation: 210°C
- Heat Resistance: 110°C
- Melting Temperature: 200°C (392°F)
- Elongation at Break : 3-75%
- Standard Tolerance : 0.1% With a Minimum of $\pm 200 \mu$
- Wall Thickness: 1mm-2.5mm
- Density: 1.01 - 1.21p(Mg/m³)
- Shrinkage: 8%

5. EXPERIMENTAL TESTING

5.1 Tensile Testing:

The specimen is cut in dog bone shape as per **ASTM D638 standard**. The testing is carried out by universal tensile testing machine (UTM). This test method covers the determination of the tensile properties of unreinforced and reinforced plastics in the form of standard dumbbell-shaped test specimens when tested under defined conditions of pretreatment, temperature, humidity, and testing machine speed. This test method can be used for testing materials of any thickness up to 14 mm (0.55 in.)

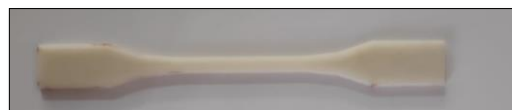
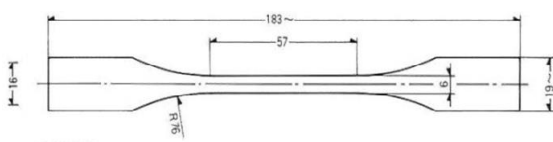
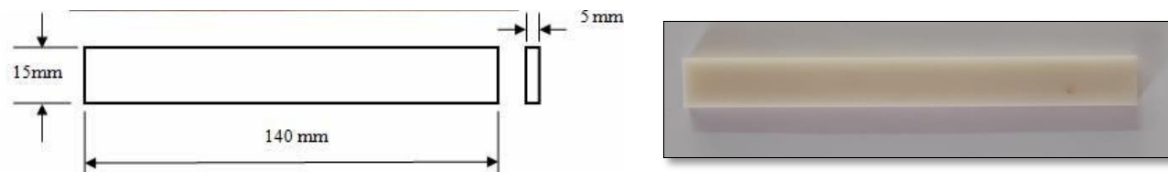
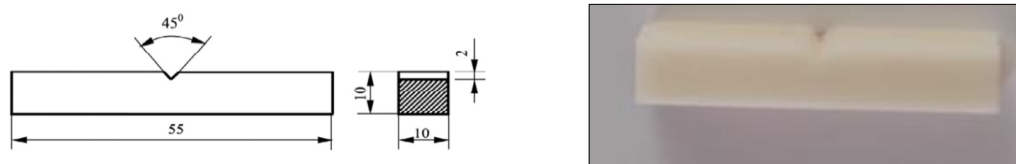


Figure 3. Sample Specimen for Tensile Test**5.2 Flexural Testing:**

Bend Test is been conducted using **ASTM-D790 Standards**. These test methods cover the determination of flexural properties of unreinforced and reinforced plastics, including high-modulus composites and electrical insulating materials in the form of rectangular bars molded directly or cut from sheets, plates, or molded shapes. These test methods are generally applicable to both rigid and semirigid materials

**Figure 4. Sample Specimen for Flexural Test****5.2 Impact Testing:**

The specimen as per ASTM D256 test procedure is clamped into the pendulum impact test fixture with the notched side facing the striking edge of the pendulum. The pendulum is released and allowed to strike through the specimen. If breakage does not occur, a heavier hammer is used until failure occurs. Since many materials exhibit lower impact appropriate at normal temperature that simulate the intended and use environment. The total energy absorbed by a specimen during fracture is found by needle and it is recorded.

**Figure 5. Sample Specimen for Impact Test****6. RESULTS AND DISCUSSIONS****Table 2 – Results of Strength**

Parameter	ABS
Ultimate Load (N)	457
Breaking Load (N)	406
Yielding Load (N)	453
Breaking Strength (MPa)	20.75
Ultimate Strength (MPa)	23.36
Yield Strength (MPa)	23.16
Flexural Strength (MPa)	504
Impact Energy Absorbed (J)	32
Impact Strength (J/m ²)	3200

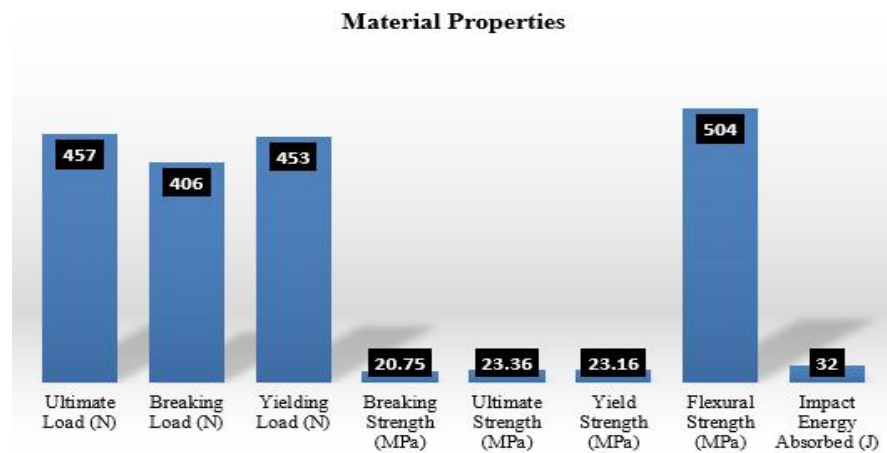


Figure 6. Strength of ABS Plastics

REFERENCE

- [1] S. gholizadeh, "A Review of Impact Behaviour in Composite Materials", International Journal of Mechanical and Production Engineering, Volume- 7, Issue-3, Mar.-2019.
- [2] Rohan Y Garud, "Structural Analysis of Automotive Chassis, Design Modification and Optimization", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 11 (2018).
- [3] Sachin Manojkumar Jain, et.al. "Impact Analysis of Automotive Bumper", International Journal of Scientific Research Engineering & Technology (IJSRET), Volume 7, Issue 4, April 2018.
- [4] M. Meghana, et.al. "Impact Analysis of Bumper and Car Chassis Frame Due to Frontal Collision for Different Materials", International Journal of Engineering and Management Research, Vol-6, Issue-1, January-February-2016.
- [5] Snehal G Sakhare, "Chassis Impact Analysis", International Journal on Theoretical and Applied Research in Mechanical Engineering (IJTARME)", Volume -6, Issue-1-2, 2017.
- [6] Dharmateja Kruthiventi, et.al., "Modelling and Impact Analysis of Four Wheeler Car Bumper: An Empirical Study", International Journal of Research, Volume 7, Issue 8 , August 2018 .
- [7] Md. Al Amin1, et.al. "Optimization of Design Parameters for Achieving Highest Impact Strength of Rice straw Based Polymer Composite Using Taguchi Method", International Journal of Emerging Engineering Research and Technology, Volume 5, Issue 10, 2017.
- [8] Prashanth. A, et.al., "Design and Analysis of a Automobile Chassis by using Composite Material E-Glass Epoxy", International Journal of Innovative Research in Science, Engineering and Technology", Vol. 6, Issue 10, October 2017.
- [9] Amit Chege et.al. "Design and Development of Impact Energy Absorbing Bumper", International Journal of Scientific & Engineering Research, Volume 8, Issue 3, March-2017.
- [10] Nagesh S. et.al. , "Analysis of Front Suspension Bracket under Pretension and Service Load", IJSRD - International Journal for Scientific Research & Development| Vol. 4, Issue 05, 2016.
- [11] Dinh Chi Pham, et.al. "An Optimization Tool for Impact Analysis of Composite Structures", 7th International Conference on Materials for Advanced Technologies, Science Direct, Elsevier Ltd, 2014.
- [12] Yong-Bum Cho, et.al. "A vehicle front frame crash design optimization using hole-type and dent-type crush initiator", Science Direct, Elsevier Ltd, 2016.
- [13] Mohd Azizi Muhammad Nor, et.al. "Stress Analysis of a Low Loader Chassis", International Symposium on Robotics and Intelligent Sensors", Science Direct, Elsevier Ltd, 2012.
- [14] R. V. Patil, et.al. "Optimization of Three Wheeler Chassis by Linear Static Analysis", International Journal on Advancements in Aeromechanical Materials for Manufacturing, Science Direct, Elsevier Ltd, 2016.
- [15] Dasaradh Palagiri, et.al. "Static, Dynamic and Harmonic Analysis of Heavy Vehicle Chassis System", International Journal of Research in Mechanical Engineering & Technology, Vol. 7, Issue 2, May - Oct. 2017.