# DESIGN AND ANALYSIS OF HONEYCOMB HELMET FOR SPORTS TWO WHEELER RIDERS

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***Abstract***

*Motorbike riders are among the most susceptible road users. The improvement of the protection offered by motorcycle helmets through use of non-conventional energy absorbing materials could significantly reduce the number of motorcyclists' fatalities. Their structure and protective capacity are altered in high-energy impacts. Beside their energy-absorption capability, their volume and weight are also important issues, since higher volume and weight increase the injury risk for the user's head and neck. Every year many workers are killed or seriously injured in the construction industry as a result of head injuries. Wearing an inappropriate safety helmet significantly reduces the risk of injury or even death. Protective headwear could save your life. At present strength of the helmet using industry is less due to improper filling of material, uneven pressure distribution and blow holes. The aim of the project is to increase the strength of industrial helmet by making the modify material in existing one. Very purpose, shock absorbers such as honeycomb structures can be applied for crashworthiness improvement and the graded honeycomb structure is primarily introduced as a shock absorber, followed by the introduction of its absorbed energy and the force and acceleration applied to the occupant. This project investigates the coupling of hexagonal aluminum honeycomb with polymeric foams for the design of innovative and safer motorbike helmets. The structure of helmet will be modeled by means of ANSYS software and according to Indian standard IS9844 to simulate head impact by various initial velocities. Experimental finding are later used to validate a finite element model of the prototype will be test for improvement of energy absorption rate will be validate.*

***Keyword:*** *Energy Absorber, Helmet, Hexagonal Honeycomb, Impact, Polymer Foam.*

## I. Introduction

All helmets attempt to protect the user's head by absorbing mechanical energy and protecting against penetration. Their structure and protective capacity are altered in high-energy impacts. Beside their energy-absorption capability, their volume and weight are also important issues, since higher volume and weight increase the injury risk for the user's head and neck. Every year many workers are killed or seriously injured in the construction, manufacturing and power industry because of head injuries. Wearing an appropriate safety helmet significantly reduces the risk of injury or even death. Protective headwear could save your life. At present strength of the helmet using industry is less due to improper selection and filling of material, uneven pressure distribution and blow holes. The aim of the project is to increase the strength of industrial helmet shell by using composite material. The safety helmet selected should satisfy certain performance requirements including shock absorption, resistance to penetration. To achieve this improvement in shell material by using composite material will be studied in thisproject.

## II. LiteratureReview

Ankuloria [1] determined that when the glass fiber concentration increased in the processed ABS from 5,10, 20, 30 wt%, the tensile strength, tensile modulus was improved but strain value lowered. Increasing the concentration of glass fibers also shows better bond between ABS and SGF. 12]Yusuke Miyazaki [2] discovered that when foaming ratio of the liner and the shell-thickness were varied, indicated that there is an optimum combination where the shell part fails without the liner bottoming, improving the shock absorption ability of a helmet.1Anil Kumar. K [3] carried out mould flow analysis on helmet by using plastic advisor which is a module in pro/E. He found that the Nylon 4-6 plastic is good instead of ABS plastic and impact ABS plastic for manufacturing safety helmets by injection moldingprocess.Terry Smith [4] carried out three-dimensional finite element models [FEM] of the helmet components and the test head form were developed using MSC software and material properties were estimated. He concluded that there are a number of currently available materials from which energy absorbing [EA] liners could be fabricated that could improve the impact performance of the existing HGU-84/P helmet. FEA can be an effective tool for the analysis and design of both new and existing helmetdesigns.S. P. Soe [5] discovered that cellular structure-based inner liners, manufactured via additive manufacturing processes, have exciting potential towards improving bicycle helmet safety.N. J. Mills [6] performed Finite-element analysis [FEA] for bicycle helmets making oblique impacts with a road surface, to evaluate the linear and rotational accelerations of the head form.

## III. Selection ofComposite

Selection of material is a step in the process of designing any physical object. The main goal of material selection is to increase the material properties and to minimize cost in the context of product design, while meeting product performance goals. The selection of the best material for a given application starts with propertiesofmaterial and costs of candidate materials. The performance of an engineering component is limited by the properties of the material of which it is made, and by the shapes to which this material can be formed[3].The material used for shell must withstand stresses due to

1. Impact strength due to fall of heavy object fromabove
2. Compressive force due to entrapment of wearer in confinedspace
3. Fall of safety helmet from workingheight Materials commonly used for shellmaterial

- High density polyethylene[HDPE]
- Acrylonitrile-butadiene-styrene [ABS]

For safety helmet impact strength and compressive strength of material is of prime importance. Other mechanical properties such low density, high tensile and flexural strength are also important.Material should also possess other properties such as electrical non-conductivity, withstanding working temperature, low water absorption, corrosion resistant.Based on these criteria different material data is collected from commercial websites validating ASTM standards. It is seen that the polycarbonate composite with 10% glass reinforcement gives optimum material properties for safety helmet.

### 3.1. Selection of matrix material

It can be seen that ABS and Polycarbonate are two lightweight materials which have higher impactstrengththanHDPE.So,these materialsarefeasibleforsafetyhelmetmanufacturing.Furtheritcanbeseen that polycarbonate has higher impact strength thanABS.Third criteria-High hardnessFrom the data in table:2 it is clear that Polycarbonate has better hardness than ABS.Both ABS and polycarbonate has better tensile strength, low density and low raw material cost. Out of which polycarbonate have better mechanical properties than ABS.So we select polycarbonate as matrix material for the proposed composite material.

**Selection of reinforcingmaterial**Mechanical behavior of glass and carbon fiber reinforcementon composites:Glass fiber and carbon fiber are generally used as a reinforcing material in plastics. These carbon reinforced plastics are named as CFRP similarly the glass fiber reinforced plastics are named as GFRP. Let's discuss the result of glass and carbon fiber reinforcement into composites[20].Impact strength of GFRP composite is quite high when compared with the CFRP composite.The tensile strength of CFRP composite is the relatively more than GFRP composite.The percentage elongation of CFRP in tensile testing is found to be less than that of the GFRP composite. Therefore, the GFRP composite withstands more strain before failure in tensile testing than the CFRP compositeThe flexural strength of CFRP composite is the relatively more than GFRP composite [20].From the above discussion it is clear that for impact load applications GFRP are more suitable than CFRP. Glass fiber though doesn't increase impact strength, but it improves other mechanical properties such as compressive strength and hardness.

**So we select glass reinforcement in the proposed composite material.**

### 3.2. Selection of final compositematerial

After selection of matrix material and reinforcement material data is collected for ABS, HDPE and their composites for comparing their mechanical properties. Also other advanced engineering materials are compared with the proposedmaterial.

**Table: 1 Material mechanical properties data:**

| Type of Helmet | Property | EDPE | ABS | ABS 10GFRP | ABS 10CFRP | PC | PC10GFRP | PC10CFRP |
|---|---|---|---|---|---|---|---|---|
| Essential properties for safety helmet | IZOD impact, notched[j/cm] | **0.75** | 2.66 | 0.767 | 0.51 | 3.1 | **1.3** | 0.817 |
| | Rockwell hardness R | **47** | 108 | 106 | 105 | 118 | **114** | 113 |
| | compressive strength[MPA] | **18** | 97 | 97 | NA | 68 | **90** | NA |
| Desired properties for safety helmet | Youngs modulus[GPA] | **0.925** | 3.2 | 3.67 | 7.35 | 2.39 | **3.1** | 11.1 |
| | Tensile yield stress[MPA] | **24** | 44.2 | 59 | 74 | 56 | **64** | 100 |
| | Ultimate tensile strength[MPA] | **21.1** | 38.8 | 59 | 78 | 61 | **69** | 117 |
| | density[kg/m3] | **968** | 1070 | 1133 | 1119 | 1998 | **1267** | 1274 |
| | Flexural yield strength[MPA] | **29** | 65 | 87.7 | 97 | 85 | **105** | 175 |
| | Raw material price/kg | **83** | 87 | 83 | 87 | 80 | **80** | 74 |

From the data collected it is clear that Polycarbonate with 10% glass reinforcement gives better mechanical properties than other polymers and composites. It is also the much better than existing HDPE material. Hence, we select polycarbonate with 10% glass reinforcement as final material.

For theoretical analysis of the current model & proposed composite model; ANSYS software is used. A prototype of helmet shape outer shell is prepared in the form of half hollow hemisphere in Catia and imported in ANSYS. A sample compressive load of 2000N is applied from the top to both the prototype. The dimensions are taken from HDPE make safety helmet available in market.Sample dimension: 200mm inner dia, 205mm outer dia, 2.5mm thickness.

**Table 2: Properties of HDPE vs. PC composite**

| S. No | Property | PC 10 GFRP | FDPE |
|---|---|---|---|
| 1 | Youngs modulus[GPA] | 3.6 | 1.03 |
| 2 | tensile yield stress[MPA] | 64 | 26 |
| 3 | Ultimate tensile strength[MPA] | 67 | 27 |
| 4 | density[kg/m3] | 1270 | 970 |
| 5 | compressive strength[MPA] | 95 | 20 |

## IV. Result and discussion

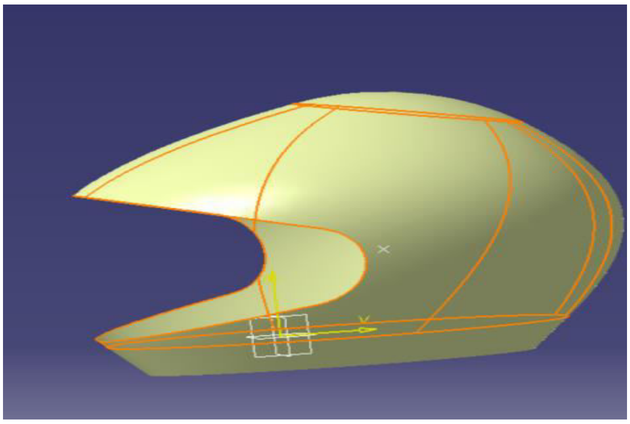

Fig. 1 Helmet CAD model

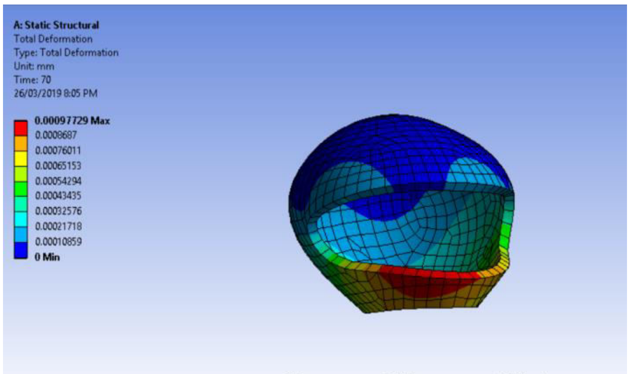


Fig. 2 Total Deformation of helmet due to compression

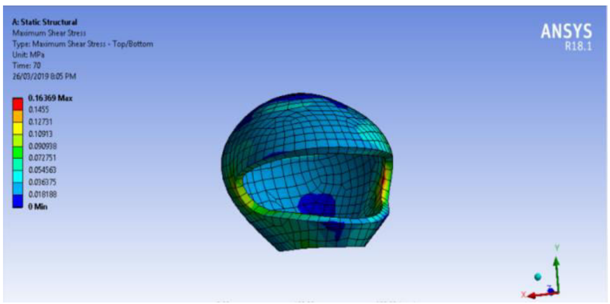


Fig. 3 Equivalent Von-Mises stress

Fig. 4 Total deformation (Compression)

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## V. Conclusion

Since both the geometries are same and same load is applied; the equivalent stress distribution is same in both the cases. But the equivalent max strain in polycarbonate composite is 0.00056 mm/mm which is less than the max strain 0.0019mm/mm in HDPE. Max total deformation in polycarbonate composite is 0.059mm which is less than total deformation 0.207mm in HDPE.Hence in the preliminary ANSYS test show that the polycarbonate composite with 10% glass reinforcement possess better mechanical strength than the traditional HDPEmaterial.

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