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Fabrication and Impact Behaviour Study of Industrial Safety Helmet

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Abstract: ***The skin that covers the head (scalp) plays a vital role in the protection of head from various impact threats. Scalp is an only sliding interface between helmet and skull, also it is a first tissue of the head which undergoes impact in both with and without helmet conditions. Helmets are universally endorsed by all industrialists and motorcyclists as effective head protection system. It is very important to analyse and observe the overall impact behaviour (Ballistic behaviour) of the industrial helmet in order to prevent accidental defects. In recent times there is huge helmet awareness (material and maximum impact energy resisting or dissipating capacity) among the people of emerging countries like India and China. In this present investigation, the industrial helmet of standard dimension reinforced with E-Glass fiber / Epoxy matrix is fabricated by resin infusion moulding (RIM) and analysed for obtaining its maximum impact resistance. The proposed outcome of this project is an alternate for present industry helmets which provides ultimate impact resistance and protection to human head.***
Keywords: Ballistic Load, Industrial Helmet, Impact Behaviour, E-Glass Fiber, Epoxy Matrix, Head Protection, Resin Infusion Moulding.

I. INTRODUCTION

Presently composites which made up of polymer matrix plays major role in the fabrication of all commercial products like daily needs, industrial goods and household applications due to its lightweight, improved mechanical properties, handling mode and easy fabrication methods. Helmets are one of the most important protection casing for motorcycle drivers and industrial machine operators, which is economical safety method too.

The deliberate need of industrial and vehicle safety helmets all over the world attracts researchers to work and analyse on safety behaviour of head armours. Its increasing demand pushes industrialists and companies to commercialize economical and high strength helmets.

A. Industrial Safety Helmets

Even after the reasonable implementation of artificial intelligence and robotic techniques still in most of the industrial environments like mining, building and tunnel constructions, military, power plants, and production industries human intervention is inevitable and there is a possibility of head injuries, threats are constantly presents. The industrial helmets quietly protects the worker from physical injuries that occurs by collision or falling objects.

The design and development of safety helmets for specific work environment is fully depends on two important things, nature of working environment and materials that the employee deals. Initially these phenomena is called safety assessment. The more harmful material the employee deals, the more consideration should be on the helmet design and material. The motorcycle and industrial safety helmets are designed in such a way that it should withstand or dissipate high-velocity impact loads, low or zero thermal and electrical conductivity, penetration resistant and proper adjustment, easy handling.

B. E-Glass Fiber

E-Glass fiber is one of the significant and economical reinforcement used worldwide to fabricate various fiber reinforced commercial and industrial products. Its ultimate mechanical properties, low cost, lightweight, dimensional stability, fire resistance, durability, and electrical resistance nature E-Glass became a crucial substitute for various conventional metals and wood products.

The present investigation focuses on following aspects,

1) Fabrication of standard industrial helmet by resin infusion moulding process reinforced with E-Glass fiber Epoxy matrix.
2) Izod and Charpy testing for predicting ultimate impact strength.

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II. EXPERIMENTAL

A. Materials

The matrix material epoxy LY 556 and resin hardener W152 LR is supplied by Aishwarya polymers ltd, Coimbatore, Tamilnadu, India. The properties of epoxy polymer resin is mentioned in Table1.

Table 1 Properties of Epoxy Resin

S. No	Parameter	Specific Value
1	Colour	Pale Yellow, Clear White
2	Specific Gravity at RT	1.10-1.20
3	Viscosity in cPS	8000-12000
4	Volatile Content in wt.	0.75%

E-Glass fabrics were supplied by KM polymers, Maharashtra, India. The properties of glass fibers are depicted in Table 2

Table 2 Properties of E-Glass Fiber Material

S. No	Parameter	Specific Value
1	Tensile Strength (MPa)	3100-3800
2	Elastic Modulus (GPa)	72.5-75.5
3	Specific Gravity	2.5-2.62

B. Helmet Fabrication

Resin infusion moulding (RIM) technique is well known for its surface finish and improved product quality. RIM method preferably suitable and used by industries, researchers to fabricate advanced composites having very precise and curved surfaces such as automobile bonnets, panels, casings and mountings.

In this proposed work helmet mould with the dimension as per ISO 3873 standard is prepared. Proper allowance is provided to mould for easy removal and finishing works. The helmet dimensions were mentioned in Table 3.

Table 3 Dimensions of Helmet

Preferred Model	D A 4-8
Weight	380 g
Size	54-65
Length	295 mm
Width	235 mm
Height	175 mm
Colour	Yellow

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Helmet with above mentioned dimension were fabricated by RIM – Vacuum pump setup and surface smoothened by using emery sheets and grinder. The helmet model as per ISO 3873 standard and fabricated helmet are shown in Figure 1.

Fig. 1 Standard and Fabricated Helmets

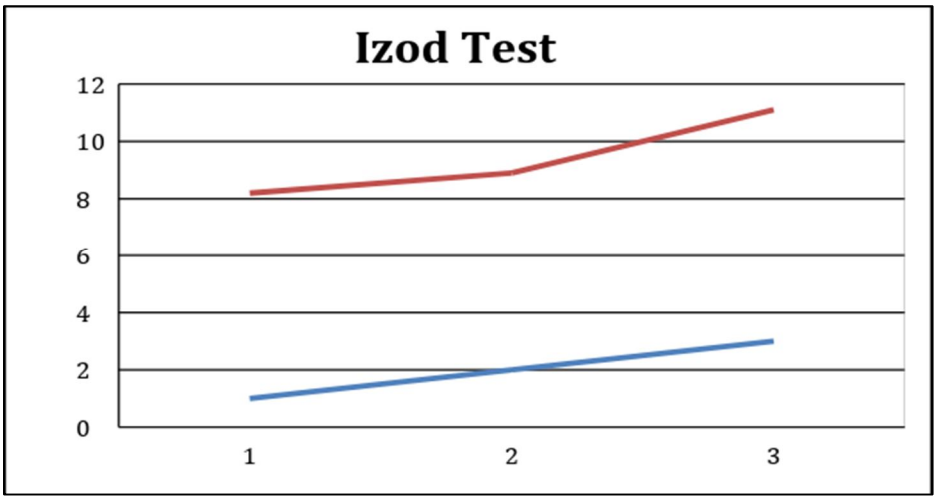
C. Impact and Flexural Tests

The prepared test specimens that made similar material of helmet (E-Glass- Epoxy) is impact tested to obtain maximum impact resisting capacity. Izod and charpy impact tests were performed by using AIT-300N impact tests having striking hammer weight of 18.7 kg, striking velocity of 5.6 m/sec, and 1600 mm of pendulum swing diameter. The test specimens are prepared as per ASTM D256 (Izod test), ASTM D6110 (Charpy Test) standards. Flexural tests done by Instron 4486 universal testing machine to grasp stress strain properties of prepared samples.

III. RESULTS AND DISCUSSIONS

A. Impact Test

Izod and charpy impact test results were shown in Figure 2 and 3. The results portrays that the reinforcement of glass fiber significantly improves the energy absorption nature of prepared samples. The higher reinforcement (70% E-Glass fiber) improves impact resistance of helmet considerably.



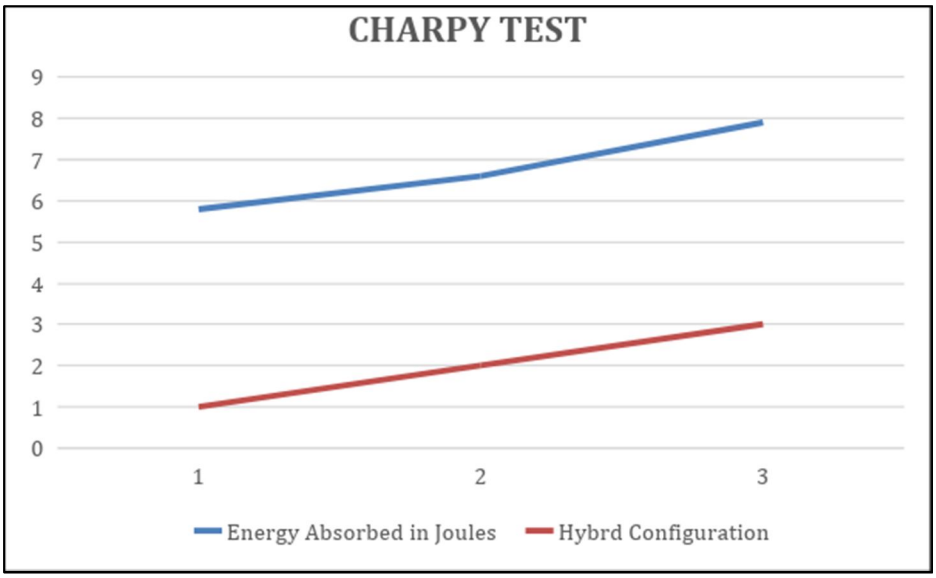


Fig. 2 & 3 Izod and Charpy Impact Test Results

B. Flexural Test

Stress strain Relationship curve obtained from three point bending flexural test is depicted in figure 4. It shows that higher volume of glass fiber reinforcement enhances flexural property and mechanical stability as well.

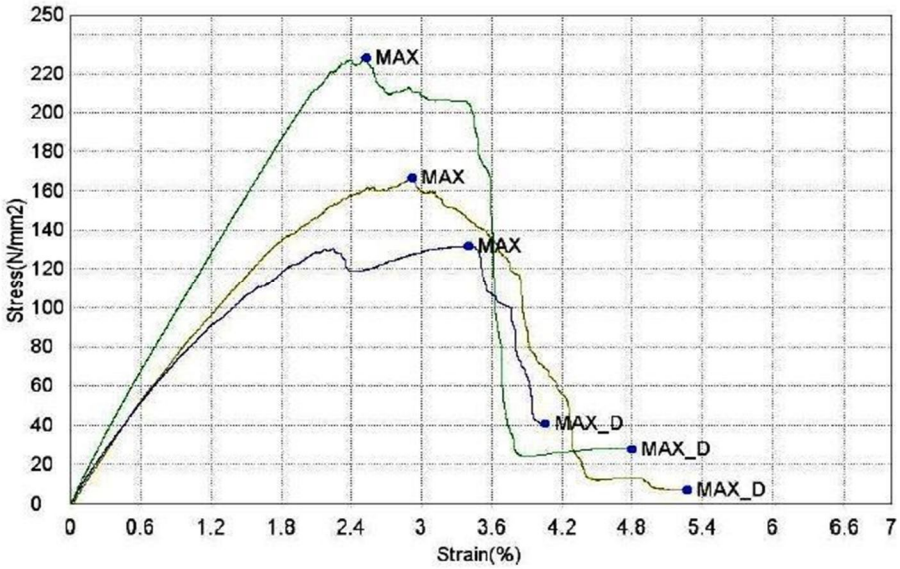


Fig. 4 Stress - Strain Relationship Curve

IV. CONCLUSIONS

The industrial safety helmet reinforced with E-Glass and epoxy polymer matrix as per ISO 3873 standard were fabricated by using resin infusion moulding and impact (Izod and Charpy) tests, flexural tests were carried out to predict maximum energy absorption of safety helmets. From the investigation the following results are concluded.

A. Resin Infusion moulding possess enhanced surface finish to the products.
B. Reinforcement of E-Glass significantly improves the mechanical properties.

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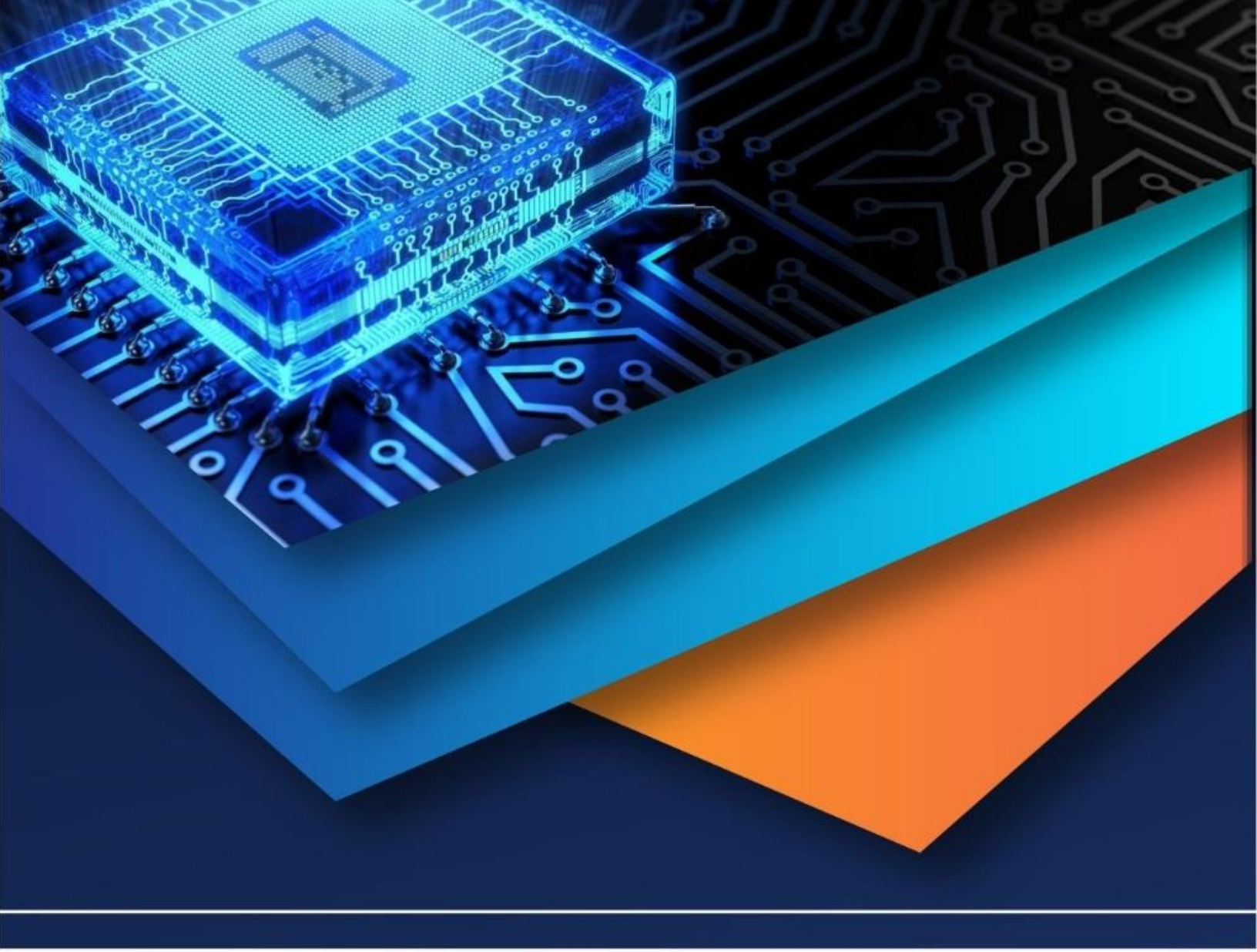

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