"Multiple density liner helmet versus single density liner helmet its application and scope"

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Abstract

Recently bio composite materials are EPP materials as reinforcements together with matrix, which have attracted the attention of researchers due to their low density or single density with high specific mechanical strengths, availability, renewability, degradable and being environmental-friendly. The present work attempts to make an improvement in the current existing helmet manufacturing methodology and materials used to have better mechanical properties as well as to enhance the compatibility between EPP materials. The bio-composite are prepared with the epoxy resin matrix and fibbers such as jute, sisal, coconut, areca and banana using hand lay-up method with appropriate proportions to result in helmet shell structure. The fabricated bio-composite are evaluated for mechanical properties such as impact strength and flexural strength. The bio-composite helmet was evaluated for drop weight impact test. The results show that bio-composite could be a potential application for helmet with further optimisation of volume fraction of natural fibbers of single density helmet liner and multiple density helmet liner materials.

Keywords: Traumatic brain injury (TBI); Polymeric foams; Mechanical properties; Helmet; Head form;

1. Introduction

In recent years, sport injuries have attracted more and more interest, not only because of the short-term impact on athletes' performance but also because of the costs of possibly long rehabilitation periods and difficulties to fully recover. One striking example in this sense is represented by the Head Health Initiative of National Football League.
Focusing on traumatic brain injuries (TBIs) only, the Centre for Disease Control and Prevention (CPSC) estimated that around 450,000 sports-related head injuries were treated in U.S. hospital emergency rooms in 2009. Among the most impressive data is that children in the range of 10 to 14 years old show the highest rate of emergency visits associated with such sports-related TBIs. The actual incidence of head injuries may be potentially higher, as not-severe cases are typically self-treated. In Italy, a survey conducted by the Institutor Superior di Sanità also revealed that every year around 30,000 accidents occur in ski areas, of which 25% involve underage children and 10% lead to mild TBIs.
In case of impacts, helmets have to prevent or reduce the outcome of mild TBIs thanks to a kind of cushioning effect, mainly linked to the mechanical behaviour of their inner liner. The level of the impact-induced acceleration hitting the athlete brain is reduced by mechanisms of energy dissipation occurring while the mentioned liner deforms and possibly locally fails. Accordingly, international standards like provide requirements for the shock absorbing capacity in terms of acceleration peaks in the range of 137-167 g. depending on country and sport, all measured in case of (guided) falls of head forms wearing the protective helmet. Not much care is usually devoted to the impact duration and to rotational accelerations, which were instead highlighted as further important parameters to classify the severity of the impact in, In this work, the focus is on bike and ski helmets that are basically made of a hard outer shell of polycarbonate, and a soft inner liner of polymeric foam, typically expanded polystyrene. With the goal of either enhancing the protection level, or reducing size and weight of the helmet to improve the athlete's comfort at the same safety level, the study was developed following three main research lines. First of all, tensile and compressive properties of polymeric foams were characterized in relation to their density and strain rate, the foam being the helmet constituent whom is mainly responsible for cushioning. These data then allowed finite element numerical modelling of the whole helmet to be performed in order to describe its response to impacts. In parallel, a novel monitoring system based on micro electromechanical systems (MEMS) was designed and realized to perform measurements on existing helmets and new prototypes helmet these are divided into main different - different parts shown in the figure 1.

Figure 1.

2. Motorcycle helmets

Helmets usually made of a rigid fibber glass or plastic shell, a foam liner, and a chinstrap, have been the principal countermeasure for preventing or reducing head injuries from motorcycle crashes. Based on police reports, helmets reduced the risk of motorcycle deaths by 29% during and their effectiveness increased to 37% during 1993–2002 possibly due to improvements in helmet design and materials. After adjusting for age and crash characteristics, non helmeted riders were 2.4-times more likely than those wearing a helmet to sustain brain injuries or skull fractures. After adjusting for collision type, posted speed limits, and environmental factors, non helmeted riders had a 3.1-fold increased risk of head injuries or death compared with helmeted riders). Moreover, after stratification by crash severity measured by the Injury Severity Score (ISS) for other than head injuries or repair costs of motorcycle damage, the protective effect of helmets on head injuries remained significant .Summarizes results of helmet studies in the US from different sources of emergency room records, hospital discharge data, police reports, and trauma registries. The outcomes included are percentages of head injuries, deaths, and hospitalization as well as the average length of hospital stay and average hospital charge per patient for helmeted and non helmeted riders. As a whole, the results consistently indicate that non helmeted riders are more likely to have head injuries, die, require longer hospitalization, and have higher medical costs compared to helmeted riders.

While three types of helmets (full-face, full-coverage, and half coverage) are effective in reducing head injuries differences in the effectiveness among various types of helmets have not been well examined. In addition, detachment of helmets during motorcycle crashes is not uncommon and head injuries seem to occur more frequently and are more severe for riders who wear a nonstandard helmet than those who wear a standard helmet. These findings reflect the importance of helmet fixation for maximal protection against head injuries during motorcycle crashes; nevertheless, the use of nonstandard helmets in terms of preventing head injuries or increasing potential side effects has not been examined.

3. Characterisation

Expanded Poly-Propylene (EPP) and Expanded Poly-Styrene (EPS) foams with varying relative densities were considered; materials nominal densities are reported in these foams were produced from pre-expanded beads which were subsequently moulded into blocks. Of helmet they are helmet in to main parts inner shell and outer shell they are inner is inner liner we study on inner liner Unix- axial compression and tensile tests were run on screw-driven dynamometer under crosshead displacement control conditions. All the tests were performed at 23°C temperature and 50% relative humidity. Five samples per density were tested. EPS compression specimens were cut having nominal dimension of single density liner helmet 208.59x283.06x260.56mm, and multiple density liner helmet 240 x287.60 x332.37mm. Strain rate dependence was investigated at three nominal values: 3×10^{-3}, 3×10^{-2} and 3×10^{-1} s^{-1}. A 10MPixel camera was used for the measurement of Poisson's ratio in 0.3 compressions. Tensile tests were performed on dumbbell specimens having gauge length of 70 mm, width of 13 mm and thickness of about 12 mm; a fixed strain rate of 3×10^{-3} $s^{-}1$was adopted. To investigate foam morphology, samples were broken by bending a notched bar immersed in liquid nitrogen. Fracture surface were then metalized with palladium for scanning electron microscopy (SEM) observation.

4. Methodology

The methodology followed in this study is shown in the First, in order to model the helmet components, the material properties for each component needs to collect. Then helmet model can be built using hyper mesh pre-processor. After model translation to solid work, the helmet model impact is simulated using finite element solver; the output is displayed using both ANSYS Finite Element Model builder (FEMB) for the basic results visualization and the Hyper mesh post-processor for more detailed display features. The simulation results are categorized to two types. The first is the helmet design very frication simulations while the second is the response surface DOE simulations. In the former the model is checked against the Malaysian helmet standard which quotes the 300*g* peak acceleration limit of the head form center of gravity. However, this limit is the same for other international helmet standards such as the British standards. In the later simulations, the impact anvil is kept to the flat type and the helmet design parameters are varied according to the response surface method requirements. The peak linear acceleration, which is the predicted response in the DOE, is recorded in each case. The simulation data are inserted in the response surface design matrix, and then the response surface is created. After the response surface creation, the surface can be analyzed, and the 3 D response surface and contours can be plotted. Also optimization process can be performed. In this research work both tasks are performed to have a comprehensive helmet design analysis and optimization of helmet liner in single density and multiple density they are good performance in multiple density bike helmet inner liner. Results are then discussed, and conclusions with the after study in helmet liner.

5. Material properties

Modeling of the complete helmet requires the input data of the constituent's materials of the helmet liner. As mentioned previously, the two main components of the helmet are the shell and the liner. As the target in this study is the energy absorption of the new foam candidate, the shell material is selected to be the current market dominant shell material which is the ABS or EPP. This material has good impact properties, and possesses a cost elective manufacturing method. It has some draw back which is discussed elsewhere under the same research program. The use of this material allows for comparing results with single density liner helmets v/s multiple density liner helmets made from the same shell material and the current EPS foam liner with more accurate judgment than composite shell. The liner is the material under investigation which is the EPP foam. The EPP foam can be manufactured with the bead molding process as for the EPS. Therefore, the most crucial liner design constraint which is the manufacturability is eliminated from the comparison, and more realistic judgment can be made on the mechanical performance.

6. Liner design

They are liner design in different - different density are different face in black colours area FRONT Face, TOP Face, Both side Face and REAR Face. It is good response and high energy absorption bike helmet inner liner.

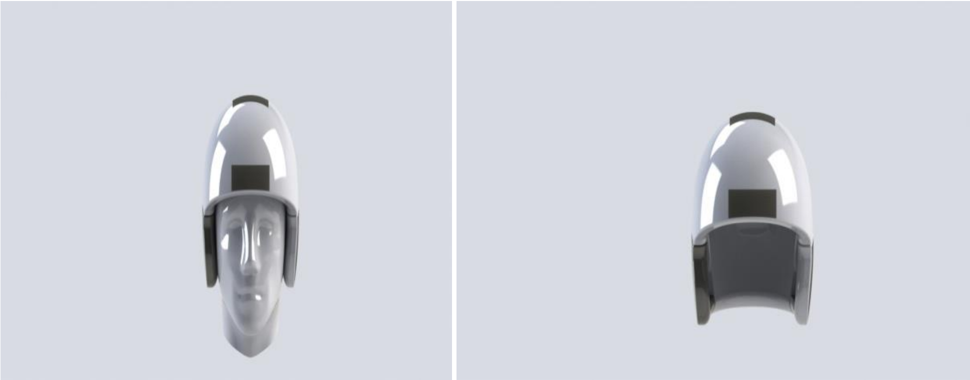

Figure 2. Different - different EPS Foam Liner

7. Mechanical properties of EPP foam

The quasi-static mechanical properties of the EPP foams are reasonably available in recent publications, whereas impact properties are very limited. This might be attributed to the fact that low density EPP foam type is newly developed and not much literature is published on its characteristics. As the required data of this type of foam is not sufficiently available in the literature, more detailed investigation and analysis is necessary. Accordingly the experimental data quoted by various references is described in foam mathematical modelling theoretical review is also included in this work.

Theoretical modelling the mathematical approaches to model the static and dynamic behaviour of the closed cell semi-rigid EPP foam are described. Typically, the EPP foam stress–strain behaviour can be divided into three regions. The first region is the linear elasticity, the second is the non-linear or long plateau elasticity, and the third is the densification. Mathematical modelling of the first two regions is the most essential requirement for the foam finite element modelling. Therefore it will be descried in more details here after.

The elasticity region theoretical modelling of the highly non-linear polymeric foams is still a wide area for further studies. Most of the previous work was carried out for the static behaviour of foams. Many empirical and semi-empirical equations have been developed, and some of which are applicable for certain foams and under specific conditions is a simple and widely used relation which predicts the elastic mechanical properties of EPP foam. This equation correlates the mechanical properties of the foam to the density. For mechanical properties (strength, modulus, etc.) a power law relationship has been found to apply in most cases. The non-linear elasticity region- Linear elasticity is limited to small strains, typically 5% or less. The EPP foam can be compressed much larger than this. The deformation is still recoverable (and thus elastic), but it is non-linear. In compression the stress strain curve shows an extensive plateau stress starting from the elastic collapse stress. This elastic collapse is caused by buckling of cell walls. For the closed cell EPP foam the compression of the gas within the cells, together with the membrane stresses, which appears in the cell faces, gives a curve of stress which rises with the strain. At present a general model, which predicts all the effects for the EPP mechanical behaviour does not exist. This may be due to the complex nature of the foam behaviour and the large number of factors, which affect its behaviour. Factors such as density, temperature, strain rate, and manufacturing process are found to have a greater effect than others. A theoretical expression for the yield stress increase based on cell was initially developed by foams and then verified by several researchers greater than atmospheric.

8. ADVANTAGES, APPLICATION AND FUTURE SCOPE

8.1 Advantages:

- Detection of accident in remote area can be easily detected and medical services provided in short time.
- Simply avoiding drunken drive by using alcohol detector. it will reduces the probability of accident
- Operates on solar as well as battery supply.
- If helmet was stolen then we can start the bike by the password

8.2 Application:

- It can be used in real time safety system.
- We can implement the whole circuit into small module later.
- Less power consuming safety system.
- This safety system technology can further be enhanced in car and also by replacing the helmet with seat belt.

8.3 Future Scope:

- We can implement various bioelectric sensors on the helmet to measure various activities.
- We can use small camera for the recording the drivers activity.
- It can be used for passing message from the one vehicle to another vehicle by using wireless transmitter.
- We have used solar panel for helmet power supply by using same power supply we can charge our mobile.

9. Result-

A good repeatability was observed in both tensile and compression tests, with exception of EPP compressive elastic modulus data, which presented a particularly high scatter. Poisson's ratio 0.3 in compression was measured to be zero within experimental accuracy for EPP and EPS foams -3.2769e-003 to 3.2767e-003(mm) strain. The foam compression behaviour is consistent with the expected behaviour a linear elastic region was followed by a collapse plateau and a final densification. Elastic modules were evaluated in the initial region and plateau stresses were defined at strain. In mechanical properties are plotted against density and compared to the predictions from the foam modulus ES stands for the solid material elastic modulus is the volume fraction of solid in the edges is the foam nominal density varying the 40 to 70 kg/m^3 is the base material densities the pressure inside the cells is the foam Poisson's ratio 0.3 is the stresses the solid material yield stress and the atmospheric pressure. EPS foam with different densities was examined for its compressive strength to be used as the helmet in racing. They are good performance of multiple densities than single density.

10. Conclusions

The main conclusions of this study can be summarized in the following points:

- Current helmet design using the EPS foam as a liner material is not optimum considering the multi-density performance, fitness and thermal comfort aspects.

- EPP foam material is suitable for multi-impact, and has ventilation system improvements potential due to its resilience nature. Therefore, based on the finite element simulation, this foam material is investigated for the motorcycle helmet application. This EPP foam is found to be suitable energy absorption helmet liner according to Malaysian Standards MS1: 1996 21 requirements.

- A method to investigate the effects of helmet design parameters including the interaction effects between these parameters, and also to optimize helmet design is successfully developed. This method is based on the response surface technique of the DOE statistical method. The philosophy is that by using the finite element simulation results as a response in the response surface model the helmet design can be analyzed and optimum design determined. Furthermore, this method can effectively be used in further investigation of helmet design studies.

- Based on the previous methodology solution, the foam thickness and the foam density are found to be the most contributing factors in preventing head injury represented by the peak linear acceleration limit of the 167g.

- The shell thickness is found to be of minor importance from the energy absorption consideration.

- The optimum helmet design using the EPP foam as a helmet liner is found to be a helmet with 70 kg/m^3 EPP foam density, 15 mm foam thickness, and 5 mm shell thickness. They are good performance of multiple densities.

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