IMPACT TEST ANALYSIS ON A 2-WHEELER HELMET USING 3D MODELLING AND ANALYSING SOFTWARE FOR TWO DIFFERENT MATERIALS

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***Abstract*— A motorcycle helmet is a protective asset for the prevention of head injuries caused by different impact forces. In this project, a standard motorcycle helmet is designed using CATIA V5.0. Two materials i.e. Acrylonitrile butadiene styrene (ABS) and Poly vinyl chloride(PVC) are being used for dynamic analysis. The impact test analysis is performed on the helmet using ANSYS at different speeds ranging from 50-70 kmph. Peak acceleration and Head Injury Criterion values derived from the head form are used to assess the protective performance of the helmet. The stresses, strains and deformations formed are evaluated. Results are compared for the prediction of material that would be suitable for the preparation of helmet.**

***Index Terms*— Helmet , Impact analysis , Stress, Strain, Deformation, ABS (Acrylonitrile butadiene styrene) and PVC (Polyvinyl Chloride).**

I. INTRODUCTION

A helmet is a form of protective gear worn on the head to protect it from injuries. Every year in the construction industry and on the roads many people are killed and many others injured as a result of head injuries. Helmets are widely used by two wheeler riders to protect their head during the accidents or falls. The Motorcycle helmets have a hard outer shell that prevents penetration and distributes the impact force on a wider foam area, increasing the liner capacity to absorb energy and therefore reduce the load that reaches the head. The oldest known use of helmets was by Assyrian soldiers in 900BC, who wore thick leather or bronze helmets to protect the head from blunt object and sword blows and arrow strikes in combat. Soldiers still wear helmets, now often made from lightweight plastic materials. In civilian life, helmets are used for recreational activities and sports (e.g., jockeys in horse racing, American football, ice hockey, cricket, and rock climbing); dangerous work activities (e.g., construction, mining, riot police); and transportation (e.g. Motorcycle helmets and bicycle helmets). Since the1990s, most helmets are made from resin or plastic, which may be reinforced with fibers such as aramids.

II. MATERIALS USED

Types of synthetic fiber used to make some helmets:

- ABS
- PVC

In former times lightweight non-metallic protective materials and strong transparent materials for visors were not available.

Most helmets are made from resin or plastic, which may be reinforced with fibers as the above mentioned ones.

III. LITERATURE REVIEW

V. C. Sathish Gandhi, R. Kumaravelan, S. Ramesh, M. Venkatesan, M. Ponraj , carried the analysis of Motor Cycle Helmet under Static and Dynamic Loading. The Design and analysis of helmet were carried out in 'ANSYS' for static and dynamic conditions.

P. Viswanadha Raju, Vinod Banthia , Abdul Nassar , Designed a Streamlined Motorcycle Helmet with Enhanced Head Protection. Fluid flow analyses were carried out to study the flow behavior inside a helmet and modifications were proposed to improve the flow within the helmet to improve comfort of the rider. Impact analysis was done to check if the modified helmet meets the BIS impact absorption test specification.

S. Irfan Sadaq , Md. Abdul Raheem Junaidi , V. Suvarna Kumar , Joseph George. Konnully, Sirajuddin Qadiri , carried out Impact Test on Motor Cycle Helmet for Different Impact angles using FEA. A finite element model based on realistic geometric features of a motorcycle helmet is established, and explicit finite element, COSMOS, was employed to simulate dynamic responses at different impact velocities.

IV. UNITS

Mass: Kg
Volume: Cubic meter (m^3)
Density: Kg/m^3
Weight: Newtons
Result & Solution time: microseconds
Speed: kmph
Displacement: mm
Von misses stress (σ_{VM}) - N/mm^2

V. DESIGN AND ANALYSIS OF HELMET

In the present work impact analysis is performed on helmet by using ANSYS software. The model of helmet is prepared in CATIA software and it is imported in ANSYS software to perform analysis. Analysis is performed with two different materials i.e ABS and PVC in three different directions to predict the suitable material for making the helmet. The dimensions are taken from the predefined standards for the manufacturing of helmets. The shell portion of the helmet is taken into consideration during analysis as it is the part exposed to the outer environment. A set of estimated results are found out by using the analyzing softwares.

For designing a helmet model, the standard designing parameters are followed. These standards are defined by conducting several appropriate tests and analysis. The British, American standards as well as the IS are preferred mostly.

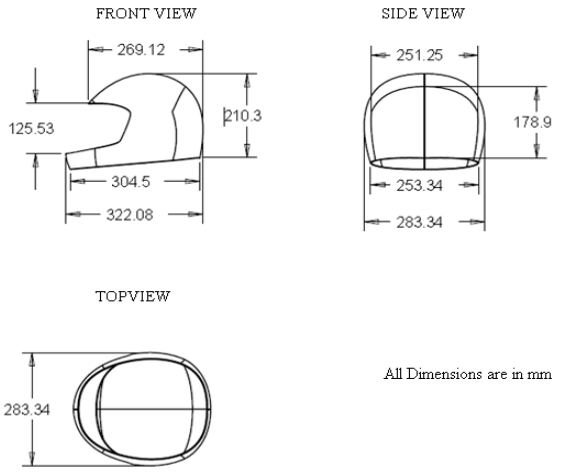

Fig 5.1: Designing dimensions

Properties of helmet:

Mass	2.802 kg
Volume	0.002524 m^3
Density	1110.14 kg/m^3
Weight	30.01 N

Model Information:

Body Name	ABS , PVC
Analysis	Impact test
Velocity Magnitude	12.75 m/sec
Solution time	35 microsecond
Result time	25 microsecond

The meshing and the impact analysis for the two materials are carried out in ANSYS. For the analysis to be done, the modeled helmet in CATIA is transferred to ANSYS. Here are some of the figures showing meshing and deformations at various speeds.

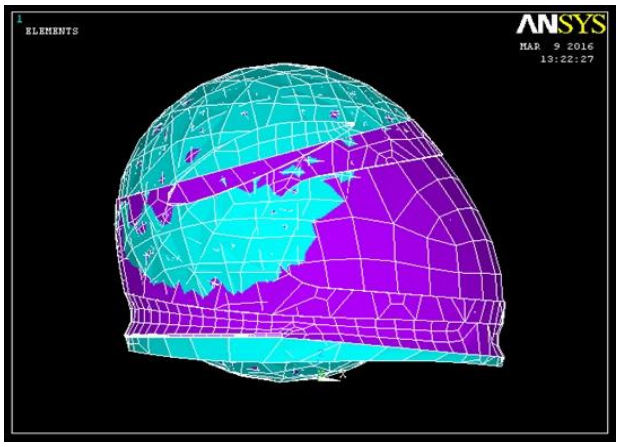

Fig 5.2: Meshing operation being carried out

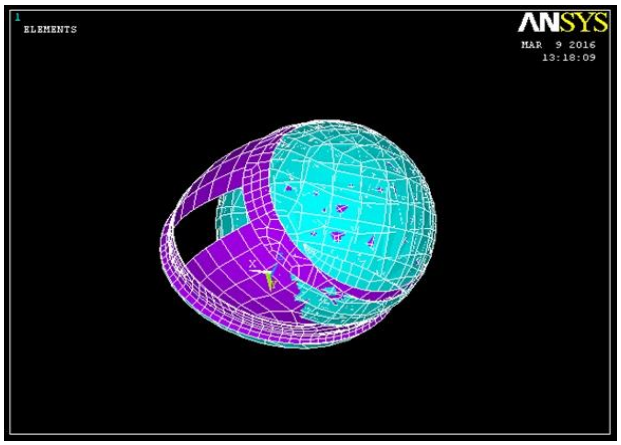

Fig 5.3: Meshing in the helmet using APDL

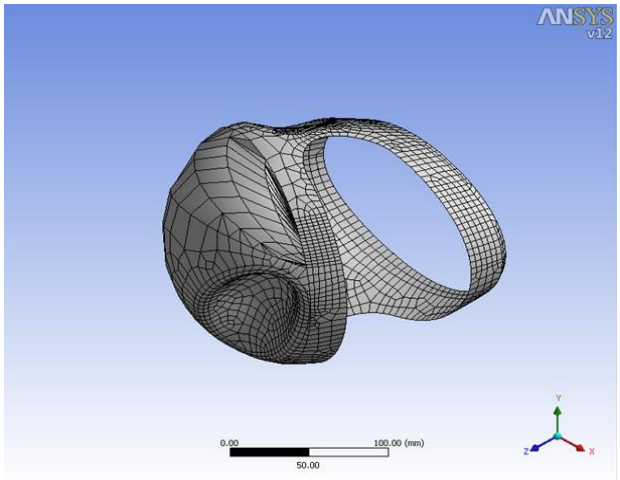

Fig 5.4: Deformations developed in front direction of helmet.

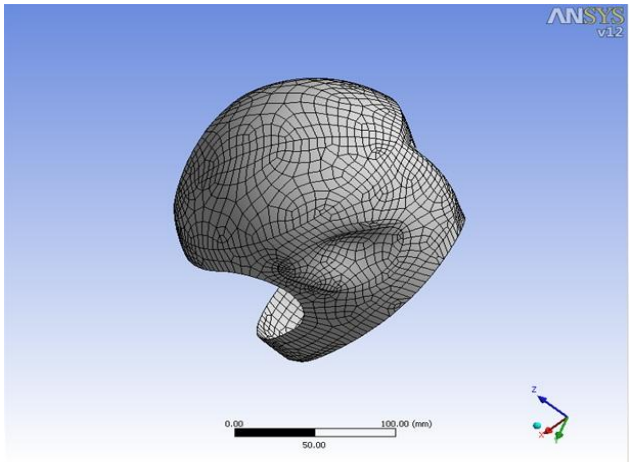

Fig 5.5: Deformation developed at sides of the helmet.

VI. RESULTS AND DISCUSSION

The most common injury in car and motorcycle accidents is head injury. Although in many countries using helmets on motorcycles are obligatory there is still a need to improve the helmet design to prevent head injury. The search for providing better materials for the manufacturing for the helmet never ends.

The comparison of von misses stresses, strain and deformations of ABS (Acrylonitrile Butadiene Styrene) and PVC (Poly Vinyl Chloride) at 50km/hr,60km/hr and 70km/hr in front right and back direction is presented.

Depending on the results, prediction of suitable material for helmet is made. This provides a rough estimation for the material properties and its impact resistant values. The comparison is based on analysis done using ANSYS software.

The Ansys Parametric Design Language (APDL) is used to do the meshing. The constants, material properties are defined in this stage. Also the application of loads and the boundary conditions are properly checked to get effective results.

ABS Plastic:

Table 6.1: Consolidated result of helmet in all directions

Hitting at 50 km/hr

	FRONT	RIGHT	BACK
STRESS	31.2728	38.3062	43.2435
DEFORMATION	0.44952	0.48752	0.45920
STRAIN	0.008201	0.009421	0.00991

Hitting at 60 km/hr

	FRONT	RIGHT	BACK
STRESS	34.2267	42.8764	49.2147
DEFORMATION	0.549887	0.585864	0.54782
STRAIN	0.009512	0.009548	0.02144

Hitting at 70 km/hr

	FRONT	RIGHT	BACK
STRESS	39.281	44.1295	52.0684
DEFORMATION	0.647630	0.699132	0.63889
STRAIN	0.008560	0.009058	0.01210

PVC Plastic:

Table 6.2: Consolidated result of helmet in all directions

Hitting at 50 km/hr

	FRONT	RIGHT	BACK
STRESS	36.0129	40.5314	46.0577
DEFORMATION	0.459251	0.494876	0.44981
STRAIN	0.008094	0.01069	0.01095

Hitting at 60 km/hr

	FRONT	RIGHT	BACK
STRESS	42.2738	47.5802	52.7399
DEFORMATION	0.548546	0.583436	0.55876
STRAIN	0.007862	0.010157	0.12235

Hitting at 70 km/hr

	FRONT	RIGHT	BACK
STRESS	48.591	49.4815	55.9121
DEFORMATION	0.63649	0.681212	0.640283
STRAIN	0.00912	0.009462	0.057121

VII. GRAPHS

The consolidated results obtained in the previous stage is plotted in the form of a graph. This gives a clear idea about the development of von misses stresses from different directions.

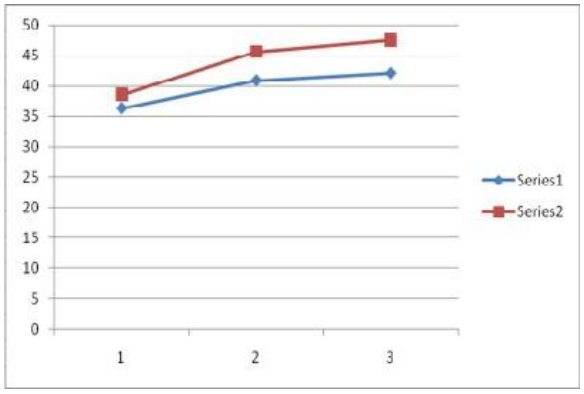

Fig 7.1 - Graph of ABS and PVC material for Von Misses Stresses from right direction.

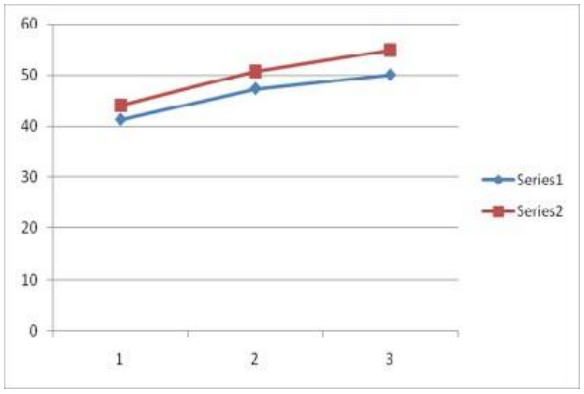

Fig 7.2 - Graph of ABS and PVC material for Von Misses Stresses from Back direction.

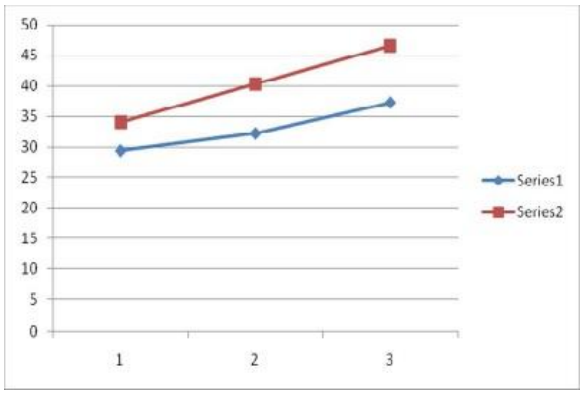

Fig 7.3 - Graph of ABS and PVC material for Von Misses Stresses from front direction.

VIII. CONCLUSION

In this present work motorcycle helmet is modeled in 3D modeling software CATIA V5 and analysis is performed in ANSYS software.
From the results it is stated that:

1. PVC (Poly Vinyl Chloride) plastic material is better when compared to ABS (Acrylonitrile Butadiene Styrene) in terms of stresses developed. Hence, the shell part if manufactured with PVC will be able to withstand large stresses.

2. ABS material is better than PVC in terms of strain and deformations occurred during colliding. Hence this material can be employed to provide lesser deformations during accidents.

IX. LIMITATIONS

1.Since this work is solely based on designing, it only gives a prediction as to which could be a better material for the manufacturing of shell of a helmet.
2. For the materials to be put into use, the real mechanical impact tests such as Izod-charpy exp has to be performed before proceeding to further applications.
3. The analyzing software i.e. ANSYS provides an approximated value for the stresses, strains and deformations developed. The designs used in this work are taken from standard helmet designs, however new and innovative designs are always given a greater edge and preference over existing designs.

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