"Impact Test on Motor Cycle Helmet for Different Impact angles using FEA"

S. Irfan Sadaq [#1], Md. Abdul Raheem Junaidi [*2], V. Suvarna Kumar [#3], Joseph George. Konnully [#4], Syed Sirajuddin Qadiri [#5]

[#1, 2, 3, 4] Assistant Professor, [#5] Student Scholar Mechanical Engineering Department, Muffakham Jah College of Engineering & Technology, Hyderabad, Telangana, India.

***Abstract*— A motorcycle helmet is the best protective head gear for the prevention of head injuries caused by different carnial impact. A finite element model based on realistic geometric features of a motorcycle helmet is established, and explicit finite element, COSMOS, is employed to simulate dynamic responses at different impact velocities. Peak acceleration and Head Injury Criterion values derived from the head form are used to assess the protective performance of the helmet. In this present work motor cycle helmet is designed and modelled in 3D modelling software Pro/Engineer. The impact analysis is performed on the helmet when colliding to a target at different speeds of 50 Km/hr, 60 Km/hr and 70 km/hr that faces the helmet on the front, right and back directions using COSMOS software. The materials used for the helmet is ABS and PVC.**

***Keywords*— Impact Analysis, Helmet, Impact angles, COSMOS, 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. Ceremonial or symbolic helmets (e.g., English policeman's helmet) without protective function are sometimes used. 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 the 1990s, most helmets are made from resin or plastic, which may be reinforced with fibres such as aramids.

1.1 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. In Greece in ancient times helmets were sometimes strengthened by covering the surface with boars' tusks (= their canine teeth) laid flat.

In Britain in the 18th and 19th centuries gamekeepers, for head protection in fights against poachers, sometimes wore helmets (perhaps more describable as thick bump caps) made of straw bound together with cut bramble.

1.2 SAFETY HELMETS

Every year, in the construction industry and on roads many people are killed and many others injured as a result of head injuries. If you wear a safety helmet your chances of being seriously hurt are greatly reduced. Wearing one could save your life.

Personal Protective Equipment (PPE) is always the last line of defence. Wherever possible, other measures should first be taken to reduce or control the risk, e.g.:

- Provide brick guards and toe boards to stop objects falling from the scaffold.
- Keep scaffolds free of loose materials.
- Tie suspended loads securely.

II. FINITE ELEMENT ANALYSIS OF HELMET

In the present work impact analysis is performed on helmet by using cosmos software. The model of helmet is prepared in Pro/E software and it is imported in cosmos software to perform analysis. Analysis is performed with two different materials in three different directions to predict the suitable material for making helmet. The models of helmet is as shown in Fig. 2.1, 2.2 & 2.3 respectively.

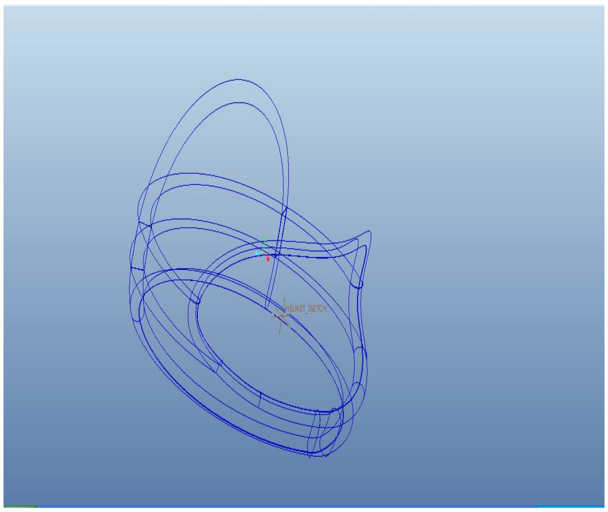

Fig 2.1: Wireframe Model of Helmet

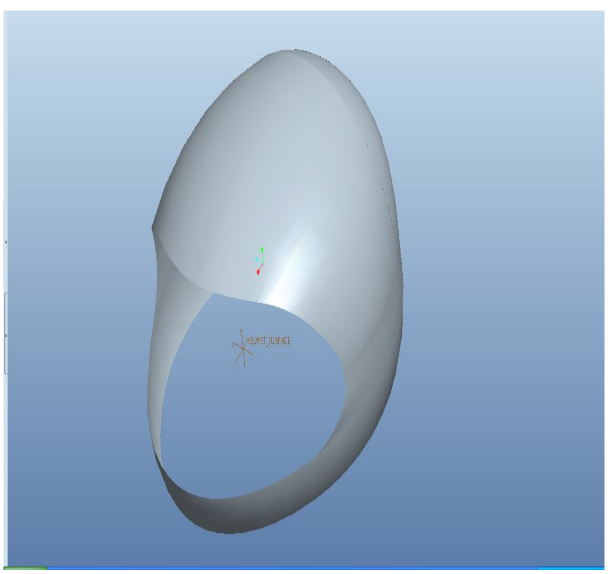

Fig 2.2: Surface Model of Hemlet

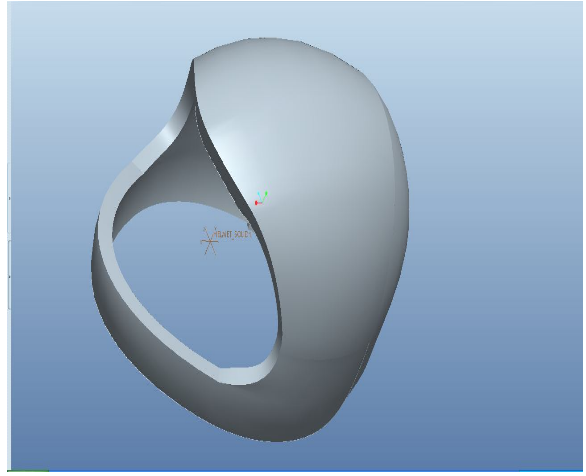

Fig 2.3: Solid Model of Helmet

Mass Properties of Helmet

Mass	3.0628 Kg
Volume	0.00286243m3
Density	1070kg/m3
Weight	30.0154N

Model information

Body Name	ABS Helmet
Analysis	Drop Test (Impact Analysis)
Mesh Type	Solid Mesh
Velocity Magnitude	13.8889m/sec
Solution Time	30 microsecond
Result Time	20 microsecond

Table 2.1: Von Mises Stresses of Helmet for different speeds in from front direction

Material	Hitting Direction	Speed (KM)	Von Mises Stress (N/mm2)
ABS	Front	50	29.378
ABS	Front	60	32.196
ABS	Front	70	37.291

Table 2.2: Strain of Helmet for different speeds in from front direction

Material	Hitting Direction	Speed (KM)	Strain
ABS	Front	50	0.0062
ABS	Front	60	0.0075
ABS	Front	70	0.0083

Table 2.3: Deformation of Helmet for different speeds in from front direction

Material	Hitting Direction	Speed (KM)	Deformation (mm)
ABS	Front	50	0.439
ABS	Front	60	0.529
ABS	Front	70	0.617

Table 2.4: Von Mises Stresses of Helmet for different speeds in from Right direction

Material	Hitting Direction	Speed (KM)	Von Mises Stress (N/mm2)
ABS	Right	50	36.306
ABS	Right	60	40.89
ABS	Right	70	42.11

Table 2.5: Strain of Helmet for different speeds in from Right direction

Material	Hitting Direction	Speed (KM)	Strain
ABS	Right	50	0.0074
ABS	Right	60	0.0085
ABS	Right	70	0.008

Table 2.6: Deformation of Helmet for different speeds in from Right direction

Material	Hitting Direction	Speed (KM)	Deformation (mm)
ABS	Right	50	0.4677
ABS	Right	60	0.5658
ABS	Right	70	0.6795

Table 2.7: Von Mises Stresses of Helmet for different speeds in from Back direction

Material	Hitting Direction	Speed (KM)	Von Mises Stress (N/mm2)
ABS	Back	50	44.05
ABS	Back	60	50.72
ABS	Back	70	54.91

Table 2.8: Strain of Helmet for different speeds in from Back direction

Material	Hitting Direction	Speed (KM)	Strain
ABS	Back	50	0.0094
ABS	Back	60	0.0106
ABS	Back	70	0.011

Table 2.9: Deformation of Helmet for different speeds in from Back direction

Material	Hitting Direction	Speed (KM)	Deformation (mm)
ABS	Back	50	0.439
ABS	Back	60	0.527
ABS	Back	70	0.618

III. RESULTS AND DISCUSSION

In this chapter comparison of von mises stresses, strain and deformations of ABC (Acrylonitrile butadiene styrene) and PVC (Polyvinyl Chloride) at 50 Km/hr, 60 Km/hr and 70 km/hr in front, right and back direction is presented. Results are compared for prediction of suitable material for the preparation of helmet. The comparison is based on analysis performed using COSMOS software.

3.1 ABS PLASTIC

Table 3.1: Consolidate result of Helmet in all the direction

50 Km/hr			
	FRONT	RIGHT	BACK
STRESS (N/mm^2)	29.3798	36.3069	41.2434
DISPLACEMENT (mm)	0.439729	0.467714	0.439527
STRAIN	0.00622059	0.00740194	0.00946212
60 Km/hr			
STRESS (N/mm^2)	32.1967	40.8984	47.3157
DISPLACEMENT (mm)	0.529667	0.565874	0.527806
STRAIN	0.00755202	0.0085388	0.0106471
70 Km/hr			
STRESS (N/mm^2)	37.291	42.1145	50.0664
DISPLACEMENT (mm)	0.617629	0.679562	0.618944
STRAIN	0.00836089	0.0088595	0.0111311

3.2 PVC

Table 3.2: Consolidate result of Helmet in all the direction

50 Km/hr			
	FRONT	RIGHT	BACK
STRESS (N/mm^2)	34.0279	38.5241	44.0557
DISPLACE MENT (mm)	0.438851	0.474886	0.439866
STRAIN	0.00708422	0.0087992 9	0.00995353
60 Km/hr			
STRESS (N/mm^2)	40.2728	45..5702	50.7299
DISPLACE MENT (mm)	0.528446	0.573636	0.528703
STRAIN	0.00776274	0.0091571	0.0112338

		7	
70 Km/hr			
STRESS (N/mm^2)	46.591	47.4865	54.9131
DISPLACE MENT (mm)	0.616493	0.671212	0.620283

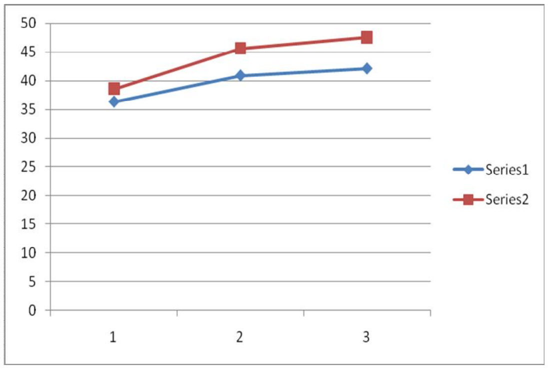

Fig 3.1: Graph of ABS and PVC material Von Mises Stresses at 60KM Speed from right direction

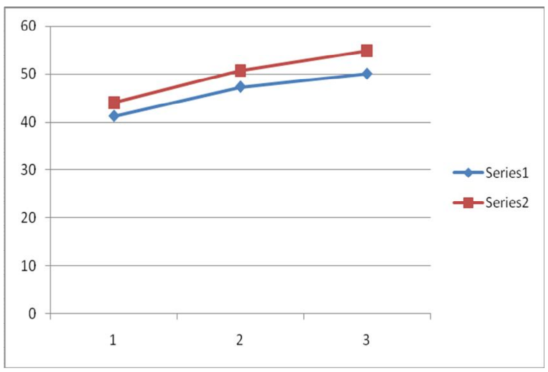

Fig 3.2: Graph of ABS and PVC material Von Mises Stresses at 60KM Speed from the back

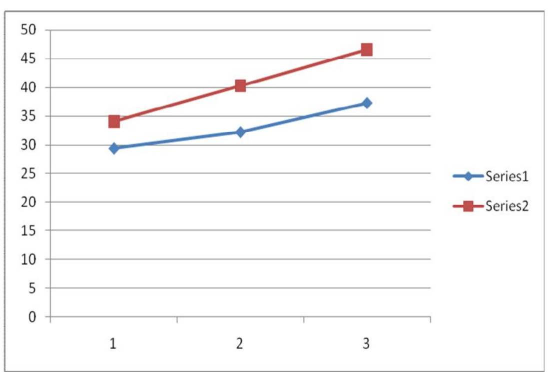

Fig 3.3: Graph of ABS and PVC material Von Mises Stresses at 60KM Speed from the Front direction

IV. CONCLUSION

In this present work motorcycle helmet is modelled in 3D modelling software Pro/Engineer and analysis is performed in COSMOS software. From the results it is stated that helmet made of PVC material is better when compare to ABC materials in terms of stresses and ABC material is better than PVC material in terms of deformation and strains.

V. REFERENCES

[1] Aare, M.; Kleiven, S.: Evaluation of head response to ballistic helmet impacts, using FEM, International Journal of Impact Engineering, 34, 2007, 596–608.

[2] Barnes, F.: Skinner, Stan. ed. Cartridges of the World. 11th Edition. Cartridges of the World. GunDigest Books, 2006, p. 295, ISBN 978-0-89689-297-2.

[3] Baumgartner, D.; Willinger, R.: Finite element modeling of human head injuries caused by ballistic projectiles, Proc. RTO Specialist Meeting, the NATO, Koblenz, Germany, 2003.

[4] Carroll, A.; Soderstrom, C.: A new non-penetrating ballistic injury, Ann Surg., 188, 1978, 753–7.

[5] Chang, F. K.; Chang, K. Y.: Post-Failure Analysis of Bolted Composite Joints in Tension or Shear-Out Mode Failure, J of composite material, 21, 1987, 809-833.

[6] Chang, F. K.; Chang, K. Y.: A Progressive Damage Model for Laminated Composites Containing Stress Concentrations, Journal of Composite Materials, 21, 1987, 834-55.

[7] Fox, D. M.: Energy Absorber for Vehicle Occupant Safety and Survivability. USA TACOM 6501 E 11Mile Road Warren, MI 48397-5000, 2006.

[8] N.J. Mills & A. Gilchrist, Finite element analysis of bicycle helmet oblique impacts, Int. J. Impact Engng.35, (2008) 1087-1101.

[9] COST 327: Motorcycle Safety Helmets (2001) Final report, Chapter 8. Directorate General for Energy and Transport, European Commission.

[10] MAGICS 12 software, Materialise NV, Leuven, Belgium

[11] Holbourn AHS. Mechanics of head injury. Lancet 1943;2:438–41.

[12] Rhinoceros 3 software, Robert McNeel and associates, Seattle, USA.

[13] D. Hull, Introduction to composite materials, Cambridge Univ. Press, 1981.

[14] A. Gilchrist & N.J. Mills, Impact deformation of rigid polymeric foams: experiments and FEA modelling, Int. J. Impact Engng., 25 (2001) 767-786.

[15] A.F. Elragi at www.softoria.com/institute/geofoam

[16] D.H. Glaister & P. Mortimer, A test for the sliding resistance of protective helmets, RAF Institute of Aviation Medicine, Farnborough, Hants, Div. Record 28 (1982).