iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: X Month of publication: October 2023

DOI: https://doi.org/10.22214/ijraset.2023.55956

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

Crash Box Impact Energy Absorption

Mr. Sayed MD Junaid Khalil Ahmed[1], Dr. V.V. Mane[2]
[1]Student, [2]Principal & Guide, Department of Mechanical Engineering, TPCT, College of Engineering, Dharashiv

Abstract: Crashworthiness parameters like internal energy absorption and crush force efficiency are the key constants in evaluating the component crashworthiness and its safety in the design of automotive structures for crashworthiness, there is an immense requirement for null strain sub modules that provide a rigid room of survival area for the occupants and deformable sub modules. Which can dematerialize the kinetic energy effectively? The front crash box of an automotive car is one of the most important deformable components which dissipate kinetic energy while frontal crash, which is the most persistent crash situation, affects the entire automotive structural behavior. In this research, quasi-static axial loading response and crashworthiness characteristics of empty hollow tube have been investigated through experimental and numerical simulations. The axial quasi-static loading was executed at a feed rate to evaluate the crashworthiness constants of each sample against quasi-static loading. The supremacy of feed rate empty hallow structures were pursued. The numerical simulation of quasi-static test was performed in accordance with explicit finite element algorithm of LS-DYNA in order to investigate and justify the crashworthiness of each variety of specimens with experimental results.

I. OBJECTIVE

The objective of this thesis was to evaluate the crashworthiness and vehicle dynamics of a pre safety standard vehicle. Based on the evaluations, recommendation for improvements to the vehicles crashworthiness can be made. A full vehicle finite element model (FEM) was created of a 1965 Nissan Patrol G60. To validate the model it was compared to an already existing FEM model of a 1994 C1500 light pickup that has been validated with physical test data. This vehicle has similar frame construction and weight characteristics. The crashworthiness was then compared to existing physical test data of a 2007 Jeep Wrangler that has been manufactured with all safety standards and technology. These comparisons were made to evaluate the crashworthiness of the pre safety standard vehicle as compared to current vehicles manufactured to meet all relevant safety standards. A full vehicle Multi Body Dynamic (MBD) model was created to measure the ride steer suspension characteristic of the vehicle. The ride steer suspension characteristics of a vehicle are directly related to accident avoidance.

II. MATHEMATICAL /EXPERIMENTAL ANALYSIS

A. Basic Folding Mechanism

In the design of energy dispensing structures, the hypothesis of thin-walled columns has been rec-organized as very effective energy absorbing methodology. In this type of system, energy absorption will occur in a conjunction of progressive folding and bending collapse. Progressive crushing of a prismatic column involves subsequent deformation of a consecutive layer. Two potential buckling modes of a single layer are shown in Figure 2(a). The common buckling mode of a single super folding element is shown graphically in Figure 2(b) (Santosa & Wierzbicki, 1998).

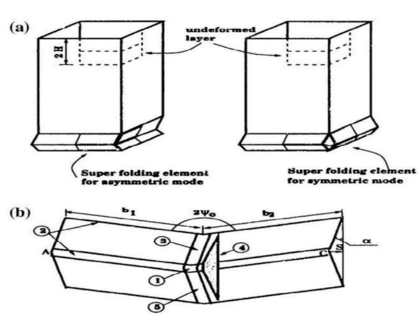


Figure2. (a) Deformation pattern and (b) basic folding mechanism

The 2D diagram of the test specimens was represented in the Figure 4(a c) respectively. As dis-cussed by Gomez and Elices (2003), the crack initiation and propagation will be stable and more control on displacement can achieved for the notch angle of 90°. Also, it was discussed that the relative depth should be minimal for maximum load absorption. Xu et al. (2016) showcased that the energy absorption and initial peak crushing force has a predominant influence on the groove depth value. In the current study, considering the thickness of the specimen the maximum possible groove depth of 1 mm was accounted. The basic peripheral dimension of the specimen is 50 × 50 × 250 mm (width × height × length) with a thickness of 2 mm. The typical automotive crash box width to thick-ness (W/T) ratio is MTS Insight 100 KN Universal Testing machine. The physical material properties of the alloy were determined and shown in the Table 2. The dimensions of the test specimen like width, thick-ness and area are detailed in the Table 2. Also, that the gauge length values like initial gauge length, final gauge length and the load at the offset yield were presented. The peak load and the tensile strength of the alloy were determined to study the physical properties. The engineering stress-strain curve has been constructed using the parameters like Load, extension, time and extensometer readings. 0.2% proof stress is considered to determine the yield strength of the specimen. The computed engineering stress-strain curve of Al6063 is shown in the Figure

Table 1. Physical material properties of High Strength Steel

Parameter	value	Units
width	40	mm
Thickness	1	mm
Area	40	mm2
Initial gauge length	50	mm
Final gauge length	57.54	mm
Load at offset field	2.536	KN
Peak load	60.17	KN
Tensile strength	150.5	MPa

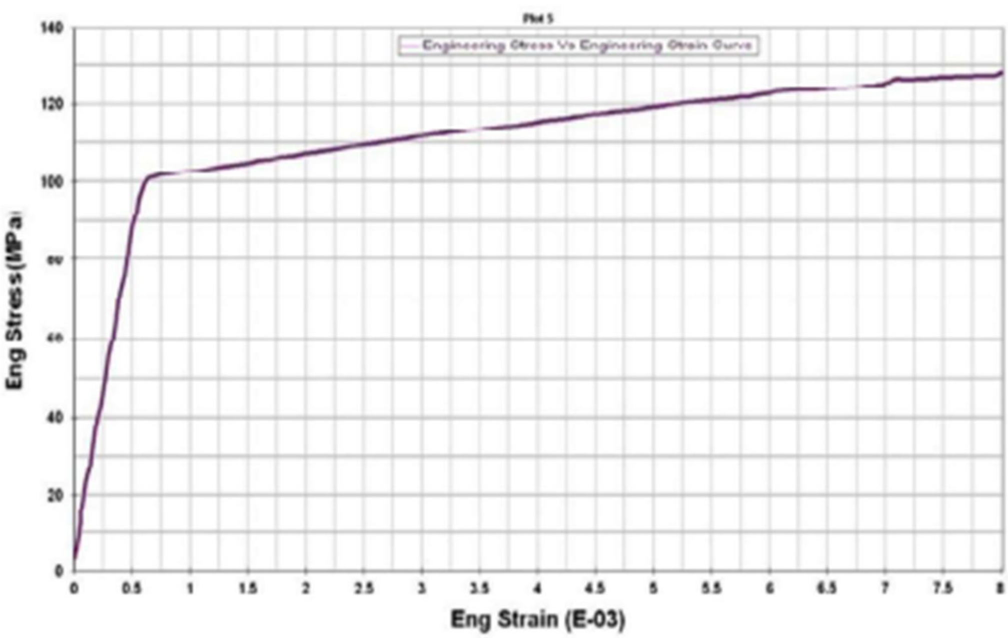


Figure3. Engineering tress strain curve

III. SOFTWARE ANALYSIS

This section reviews the various CAD, FEM and crash simulation tools used to develop the crash simulation model and interpret the results.

A. Geometry Development

This section reviews the tools used to develop the Computer Aided Design (CAD) model that is the basis to create a complex FEM model. Due to the age of the vehicle, no CAD data exists. To create the CAD, the vehicle was manually measured or existing drawings were scanned.

1) Raster to Vector

Raster to Vector is a stand-alone program that converts scanned drawings, maps and raster images into accurate vector files (such as DXF, HPGL, WMF, EMF, etc) for editing in any CAD application [8]

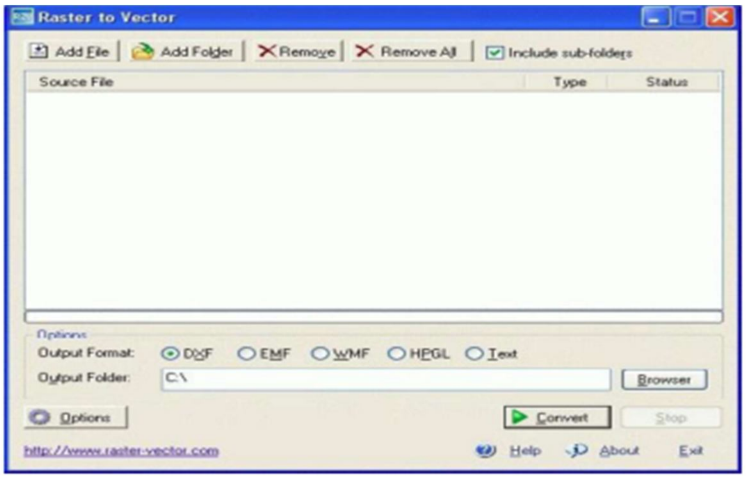


Figure 3.1 Raster to Vector screenshot

B. Finite Element Tool

1) Preprocessors

Altair Hypermesh Altair Hyper Mesh is a high-performance finite-element preprocessor for popular finite element solvers that allows engineers to analyze product design performance in a highly interactive and visual environment. Hyper Mesh's user interface is easy to learn and supports a number of CAD geometry and finite-element model file formats, thereby increasing interoperability and efficiency. Advanced functionality within Hyper Mesh allows users to efficiently manipulate geometry and mesh highly complex models. These functionalities include extensive meshing and model control, morphing technology to update existing meshes to new design proposals and automatic mid-surface generation for complex designs with varying wall thickness. Solid geometry enhances tetra-meshing and hex meshing by reducing interactive modeling times, while batch meshing enables large scale meshing of parts with no manual cleanup and minimal user input. Hyper Mesh provides direct access to a variety of industry-leading CAD data formats for generating finite-element models.

2) Solver Ls-Dyna

Ls-Dyna is a general-purpose, explicit and implicit finite element program used to analyze the nonlinear dynamic response of three-dimensional structures. Its fully automated contact analysis capability and error-checking features have enabled users worldwide to solve successfully many complex crash and forming problems. Ls-Dyna is one of the premier software’s to study automotive crawsh and has many default input parameters tailored for crash simulations. For crash simulations, the explicit time integration is used due to advantages over the implicit integration method. In the explicit integration method, the solution is advanced without computing the stiffness matrix thus dramatically reducing the time of the simulation. Due to these savings, complex geometries and large deformations can be simulated. 21 Ls-Dyna supports a very extensive library of material models. Over one hundred metallic and nonmetallic material models were able to be simulated which involves elastic, elasto-plastic, elasto-viscoplastic, Blatzko rubber, foams, glass and composites.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

Ls-Dyna supports a fully automated contact analysis that is simple to use, robust and has been validated. It uses the constraint and penalty method to simulate contact conditions. These methods have been shown to work particularly well in full vehicle crashworthiness studies, systems/component analysis and occupant safety studies. LsDyna supports over twenty-five contact formulations to treat contacts between deformable objects and rigid objects [12]. 3.2.3 Post processor Altair Hyper View Altair Hyper View is a complete post-processing and visualization environment for finite element analysis, multi-body system simulation, digital video, and engineering data. Hyper View combines advanced animation and XY plotting features with window synchronization to enhance results visualization. Amazingly fast 3D graphics and unparalleled functionality set a new standard for speed and integration of CAE results post-processing. Hyper View supports many popular CAE solver formats through direct readers, providing flexible and consistent high performance postprocessing environment. Hyper View's animation client provides a complete suite of interactive post-processing features that dramatically improve results visualization. Hyper View also supports an advanced toolset for model query and result comparisons for single and overlaid models. The video client in Hyper View introduces the unique capability to read digital video files and synchronize them to CAE animations and XY-plot information for enhanced simulation 22 post-processing and correlation. The video client directly reads and writes most standard movie file formats, including VI, BMP, JPEG, PNG and TIFF. Hyper View supports the following:

- Multi-body dynamics animations with flex-bodies
- Complex animations and complex stress calculations
- Deformed animations
- Linear animations
- Transient animations.

Hyper view's plotting client is a powerful data analysis and plotting tool with interfaces to a wide array of data file formats. Engineers can build, edit and manipulate 2D curves and 3Dplots (such as waterfall, surface and 3D line plots). A simple point-and-click environment provides easy access to curve expressions, axis labels, and legends, plot headers and footers. In addition, plots can be annotated with advanced notes using templex a built-in text and numeric processor. A sophisticated math engine is capable of processing even the most complex mathematical expressions. The publishing session export feature allows users to output reports to HTML or a PowerPoint XML of the active Hyper View session. Users can specify which pages are to be written out, as well as specify the format for each window exported. Hyper View supports many popular CAE solver formats through direct readers, providing a flexible and consistent high-performance post-processing environment. Additional solver formats can be supported through user-defined results translators that convert results into the Altair H3Dcompressed binary format. This functionality further increases the value proposition of Hyper View by broadening its ability to support other commercial and proprietary solver formats.

C. Finite Element Model Development

Due to the complexity of a full vehicle FEM, a systematic process of checks and validation needs to be followed to reduce rework and debugging of the final model. Certain guidelines have also been established to reduce the complexity of the final model in order to reduce the resource requirements of the final simulation. Figure 4.2 outlines the process followed to create the FEM model of the 1965 Nissan Patrol.

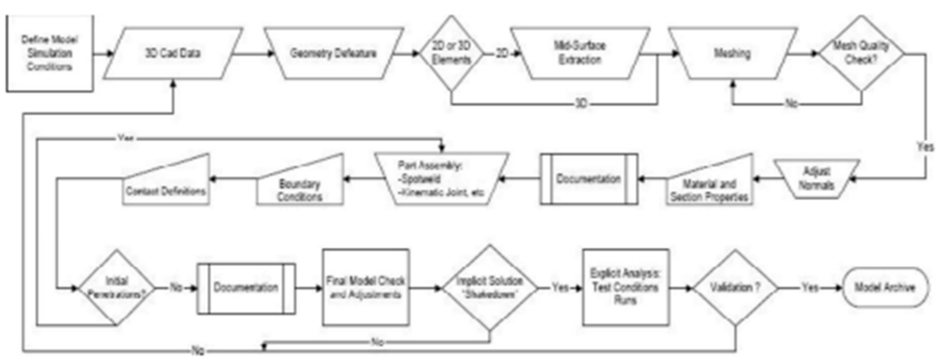
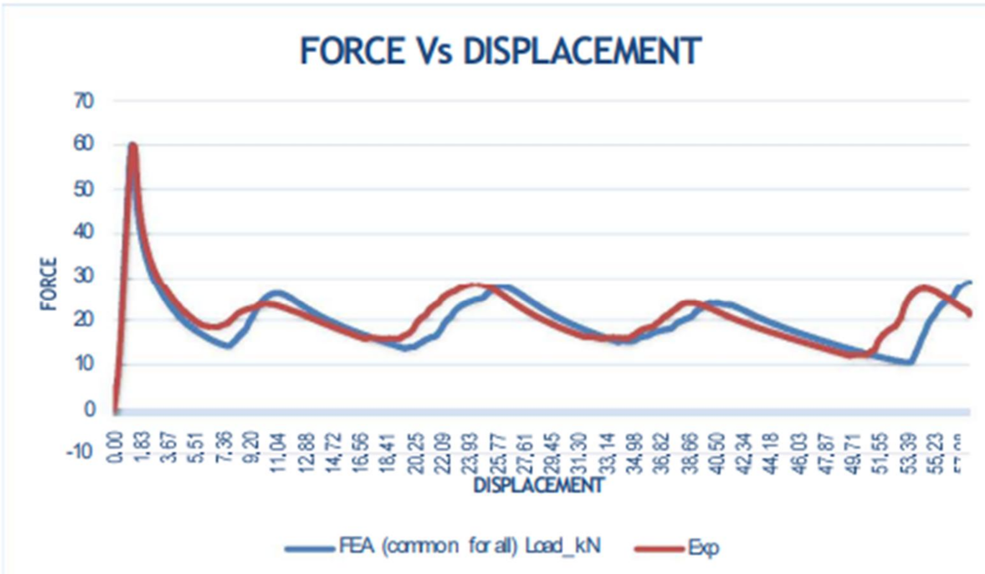


Figure 3.2 Finite Element Modeling Process

IV. RESULT AND DISCUSSION

Sr.no	First peak load (KN)	Avg crashing Load (KN)	Energy Absorption (J)
Experimental	60.17	20.04	1240
FEA (LS-DYNA)	60.07	19.99	1178
Error(%)	0.166	0.249	5



Exploration of force-displacement (F-S) mode

In experimental test, the extruded specimens of type empty hollow tube were subjected to an axial quasi-static loading and their toughness against crush force was plotted as force-displacement (F-S) curve.

The experimental results convey that the EHT type structures are recorded with higher level of Peak load (Pmax) The other crashworthiness parameters such as EA and ACF are derived from Pmax and Pm values of each specimen and the results are shown in Table The crush force efficiency (CFE) of EHT is recorded as lowest. This is because of the ratio between Pm and Pmax. It is bit inferior to that of EHT. The tendency of peak force (Pmax) and crush force efficiency (CFE) for EHT, sample was observed to be bit different for FEM when compared to test results. Whereas the biasing looks a like for other parameters like EA, Pm and EA for EHT, samples. The charts are plotted to compare the results as shown in the Figure 4.1. The value of peak force (Pmax) in Experimental showed as 5% more than FEM results. This could be because of some imperfections while fabricating the specimen. Some abrupt peaks were recorded in FEM results compare to Experimental results for EHT specimens. This could be because of the numerical assumptions in definition of self-contact. Also the friction value and contact thickness used in numerical simulation may have some adverse effects.

V. CONCLUSION AND FUTURE SCOPE

Crash box is introduced to vehicle design to improve the impact performance and reduce the damage of vehicle body at impact speed. Repair cost at collision accident can be cut down by use of this box. In this paper several numerical simulations have been performed on different crash-boxes models in order to obtain an optimized shape necessary to reduce the absorbed energy by the side-member. The impact velocity considered in these simulations was 10km/h, according to ENCAP standardization. The best behavior in case of low speed impact is obtained by the optimized shape of the caisson made from High strength steel. The most unfavorable caisson shape is the rectangular one due to the fact that this type of section induces large deformations in the side member structure which represents a total damage of the vehicle structure. The optimized shape made from steel should be another option, with a difference of 0.4% deformation of the side member.

The experimental results for empty hollow tube (EHT) with feed rate of 2mm/min were shown in the Table3. This data demonstrates that crashworthiness parameters behavior significantly changes with the effect of feed rate. The reason for this phenomenon could be that, as the feed rate is predominantly very less, there is a significant impact of reaction forces for quasi-static loading conditions. This result showcases that EHT specimens are much recommendable for energy absorption in desired situations.

REFERENCES

[1] Balaji & Annamalai, Cogent Engineering (2017), An experimental and numerical scrutiny of crashworthiness variables for square column with V-notch and groove initiators under quasistatic loading 4: 1364118 https://doi.org/10.1080/23311916.2017.1364118

[2] orina Popovicic (2016), Material and shape crash-box influence on the evaluation of the impact energy absorption capacity during a vehicle collision 28 (2016) 67 72 www.science direct.com.

[3] Bambach MR, Elchalakani M. Plastic mechanism analysis of steel SHS strengthened with CFRP under large axial deformation. Thin-Walled Struck 2007;45(2):159 70. www.science direct.co

[4] Abramowicz, W. (1983). The effective crushing distance in axially compressed thin-walled metal columns. International Journal of Impact Engineering, 1, 309 317. https://doi.org/10.1016/0734-743X(83)90025-8

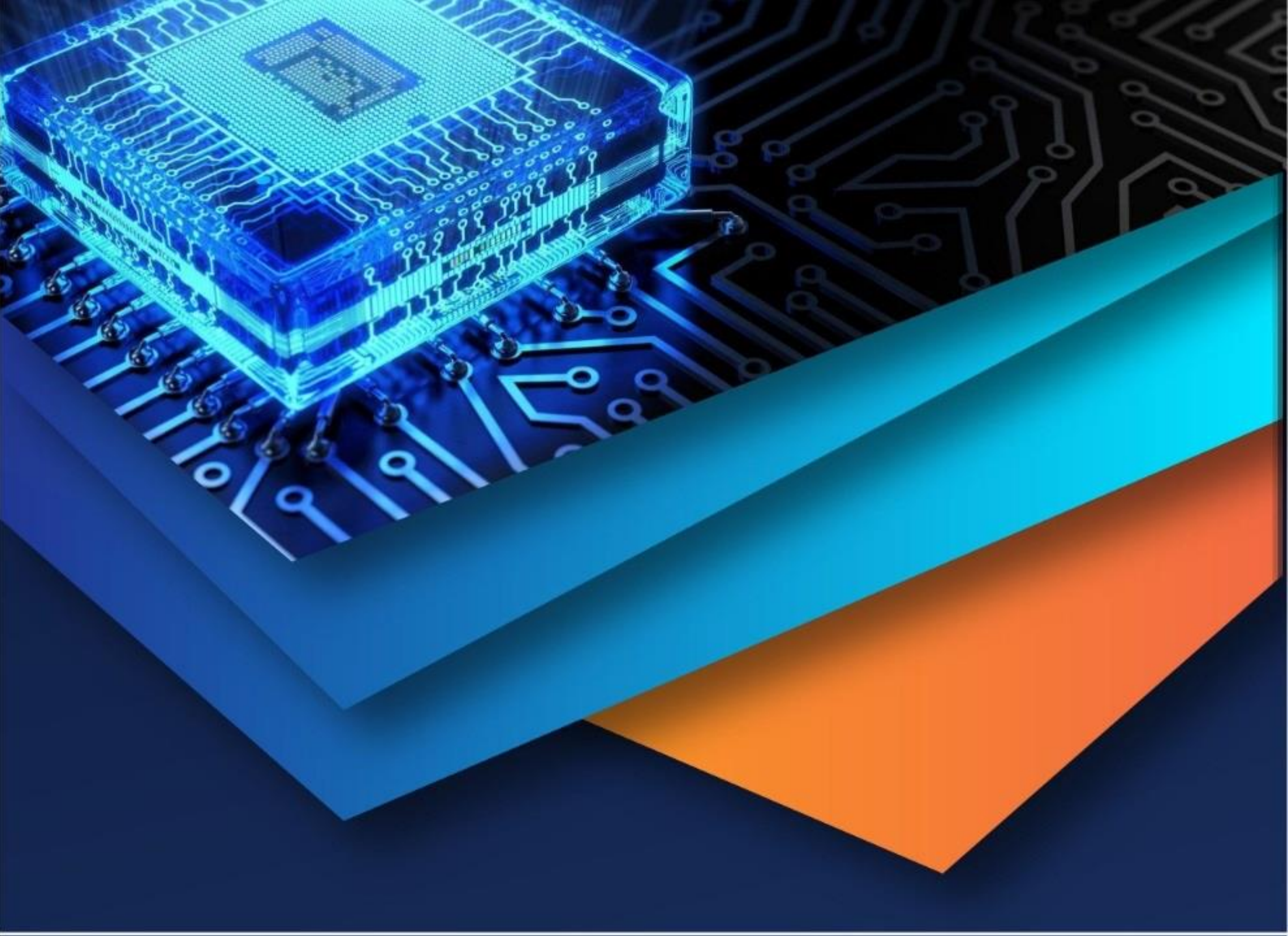
[5] Azimi, M. B., & Asgari, M. (2016). Energy absorption characteristics and a met model of miniature frusta under axial impact. International Journal of Crashworthiness, 21, 222 230. https://doi.org/10.1080/13588265.2016.1164445

[6] Dagdeviren, S., Yavuz, M., Kocabas, M. O., Unsal, E., & Esat, V. (2016). Structural crashworthiness analysis of a ladder frame chassis subjected to full frontal and pole side impacts. International Journal of Crashworthiness.

[7] Tanlak, N., & Sonmez, F. O. (2014). Optimal shape design of thin-walled tubes under high-velocity axial impact loads. Thin-Walled Structures, 84, 302 312. https://doi. org/10.1016/j.tws.2014.07.003

[8] Tarlochan, F., & Ramesh, S. (2012). Composite sandwich structures with nested inserts for energy absorption application. Composite Structures, 94, 904 916. https://doi.org/10.1016/j.compstruct.2011.10.010

[9] Toksoy, A. K., & Guden, M. (2010). Partial Al foam filling of commercial 1050H14 Al crash boxes: The effect of box column thickness and foam relative density on energy absorption. Thin-Walled Structures, 48, 482 494. https://doi.org/10.1016/j.tws.2010.02.002



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)