STUDY OF INFLUENCE OF THE SHOCK ABSORBER IN BATTERY PACK'S HOUSING OF AN ELECTRIC VEHICLE USING FEA AND UTM

[1]S. NARESH, [2]Prof. AMOL B. GAIKWAD, [3]Prof. VINOD G. PATIL

[1,2,3]Dr.D.Y.Patil School of Engg. Pune, Maharashtra India

Abstract: crash simulation analysis of the battery pack so as to extend the stiffness once the electrical vehicle is concerned in traffic accident. In project the study presents the steps needed to form the crash analysis of the battery pack. The CAD style of the assembly model is generated victimization advanced modelling techniques for 2 simulations battery pack models. the primary model features a basic form pure mathematics and therefore the second model features a shock absorber mounted on the external faces to scale back the crash impact. The crash analysis of the battery pack is set for 3 velocity load cases: seven m/s, fourteen m/s and twenty-one m/s. the ultimate a part of the paper presents the simulation results and totally different benefits of the battery pack geometry with the shock absorber. Testing of battery pack specimen was done on UTM using three point bending test.

Index terms: Design optimization, battery pack, 3 Point bending test, UTM.

I. INTRODUCTION

An electrical-vehicle battery (EVB) (also called a traction battery) could be a battery accustomed power {the electrical the electrical} motors of A battery electric vehicle (BEV) or hybrid electric vehicle (HEV). These batteries are sometimes reversible (secondary) batteries, and area units generally lithium-ion batteries. These batteries are specifically designed for a high quantity unit (or kilowatt-hour) capability. Electric-vehicle batteries disagree from beginning, lighting, and ignition (SLI) batteries as {they are they're} designed to administer power over sustained periods of your time and are deep-cycle batteries. Batteries for electrical vehicles are unit characterized by their comparatively high power-to-weight quantitative relation, specific energy and energy density; smaller, lighter batteries are fascinating as a result of the scale back the load of the vehicle and thus improve its performance. Compared to liquid fuels, most current battery technologies have a lot of lower specific energy, and this typically impacts the most all-electric variety of the vehicles.

The most common battery kind in trendy electrical vehicles are unit atomic number 3-ion and lithium compound, due to their high energy density compared to their weight. different sorts of reversible batteries utilized in electrical vehicles embrace lead–acid ("flooded", deep-cycle, and valve regulated lead acid), nickel-cadmium, nickel–metal binary compound, and, less ordinarily, zinc–air, and Na nickel chloride batteries.[1] the number of electricity (i.e. electric charge) stored in batteries is measured in ampere hours or in coulombs, with the full energy typically measured in kilowatt-hours.

The current market for electrical vehicles (EV) isn't any longer a matter of speculation and analysis predictions. The introduction in the market in 2017 of the provoke Bolt and Tesla Model three models (with a mean vary of over 250 kilometers on one charging of energy source) was the event that marked a brand-new era for the automotive business. The newest trends from the Scandinavian countries (Sweden, Scandinavian nation and Denmark) are regarding the ban on the sale of vehicles equipped with combustion engines, underlining all over again the utilization of EVs as a future property suggests that of transport.

Together, automotive makers, battery/energetic sources producers, restrictive agencies and therefore the automobile insurance domain ought to be ready to deal with this growing drawback resulting from the increased range of EVs in circulation. This suggests the need of completing studies and research geared toward distinguishing the constructive solutions (both at the micro-level of the chemistry cell and at the macro level of the battery pack in its entirety) that offer the protection needed for the battery pack (the energy source) within the case of impact or road accident.

II. LITERATURE REVIEW

Hongshen SSZhang, Gan Huang and Dali Yu. et.al [1], In this examination, the casing construction of a van-type electric truck was taken as an exploration object. Stress, strain, and modular examinations of this edge structure were performed utilizing Abaqus, a limited component programming, to confirm the sanity and wellbeing of the underlying model. The casing structure was streamlined by mathematical examination. The fourth shaft was pushed 524 mm ahead between the establishment points of the force battery pack and the back lifting drag of the front leaf spring. Results showed that the upgraded outline bowing, the full-load slowing down condition, and the full-load torsional working condition stresses diminished by 44.499%, 23.364%, and 31.303%, individually. The twisting solidness of a streamlined edge expanded by 4.026%, while the front and back torsional stiffnesses expanded by 4.442% and 4.092%, individually.

Hartmut Popp, Markus Kollera , Marcus Jahna , Alexander Bergmann. et.al [2], This audit means to introduce the present status of this promising subject for both research facility uses and applications on non-ruinous in-situ and in-operando strategies for estimation of mechanical battery boundaries like extension, strain and power, exploratory modular examination, ultrasonic testing and acoustic outflow innovations. The goal of this synopsis is to give bits of knowledge in this arising point by showing benefits, disadvantages, conceivable outcomes and utilizations of every procedure and contrast those with one another, hence giving the pursuers a profound understanding into the subject. The examination showed that dilatometric techniques are broadly utilized for examination of LIB cells. One extremely well-known methodology is the estimation with 1-D contact sensors. With this, a wide assortment of marvels like Li-arranging of graphite, warm extension and unwinding, full cell development, and Li plating have been explored, and techniques were created for situations like quick accusing of limited damage to the terminals.

Golriz Kermani and Elham Sahraei. et.al [3], In this audit we talked about and examined different methodologies of mechanical testing, material portrayal, limited component demonstrating, and approval strategies utilized in researching the mechanical respectability of Li-particle batteries at the cell level. This paper is a far-reaching audit of progressions in exploratory and computational strategies for portrayal of Li-particle batteries under mechanical maltreatment stacking situations. Various ongoing examinations have utilized trial techniques to portray disfigurement and disappointment of batteries and their segments under different ductile and compressive stacking conditions. A few creators have utilized the test information to propose material laws and foster limited component (FE) models. Then, at that point the models have been approved against tests at various levels from examination of shapes to foreseeing disappointment and beginning to short out. In the current audit primary parts of each investigation have been examined and their methodology in mechanical testing, material portrayal, FE displaying, and approval is breaking down. The primary focal point of this audit is on mechanical properties at the level of a solitary battery.

Shashank Arora, Ajay Kapoor and Weixiang Shen. et.al [4], This paper presents a deliberate structure that empowers battery pack creators to theoretically break down components of this pool, foster a reasonable comprehension of client needs, and recognize factors that can be ideally changed in accordance with assemble a dependable battery pack that meets different client necessities in whole. A worth-based item advancement procedure, ordinarily known as hearty plan strategy (RDM), is applied for assessment of plan perspectives identified with battery cell type and size, bundling engineering, warm administration arrangement and so on of measured EV battery pack. Through the use of RDM a significant mechanical impediment of battery packs' plan is uncovered. It is found that the mechanical plan and the warm plan of battery packs are basically interrelated; implying that disregarding both of the two would think twice about the battery pack. Likewise, mechanical/underlying associations in battery bundling go about as warmth moves ways. Warm ways in a module-level plan should thus be segregated subsequent to thinking about all mechanical hard focuses and associations. All the more significantly, it is discovered that funneling/plumbing alongside the assistants utilized in ordinary fluid cooling or constrained air-cooling frameworks limit configurability and adaptability of the battery pack.

Na Yang, Rui Fang, Hongliang Li and Hui Xie. et.al [5], As a significant gadget to secure batteries in electric vehicles, the dynamic and static presentation of the battery box is firmly identified with the wellbeing of the entire vehicle. In this way, study the pressure and uprooting dispersion of the battery box under explicit working conditions to upgrade the plan of the feeble pieces of the battery box's solidness and strength. The outcomes show that the altered model has a decent improvement impact and has fundamentally arrived at the set-up plan necessities, which checks the sanity of the primary improvement scheme. Domestic and unfamiliar exploration organizations and auto endeavors have completed a great deal of examination work on the foundational layout and enhancement of battery boxes, dynamic and static qualities investigation, and so on.

III. PROBLEM STATEMENT

Generally, if the battery (pack) is damaged during a road accident, it has the potential to cause a fire and/or explosion hazard. This immediate danger is amplified by the increasing capacity of energy storage for lithium-ion cells used in the construction of the battery pack of an EV, and thus the stored large energy can be released suddenly during a vehicle accident.

IV. OBJECTIVES

- Modelling of battery pack’s housing of an electric vehicle in CATIA V5R20 software.
- crash analysis of the battery pack is determined for three velocity cases: 7 m/s, 14 m/s and 21 m/s.
- Obtain effect of shock absorber in battery pack’s housing of an electric vehicle during crash analysis.
- manufacturing of battery pack’s housing.
- Experimental validation of battery pack’s housing with shock absorber done using UTM.

3D Cad model prepared in Catia R20 battery pack’s housing model. modeling of battery pack’s housing model done using surfacing tool.

V. GEOMETRY

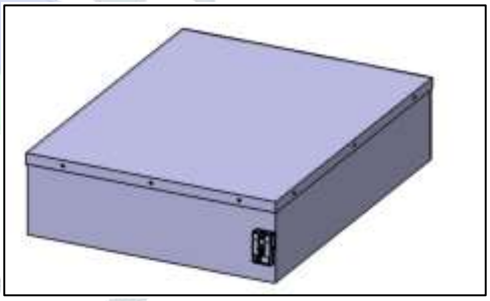


Figure 1: Battery housing

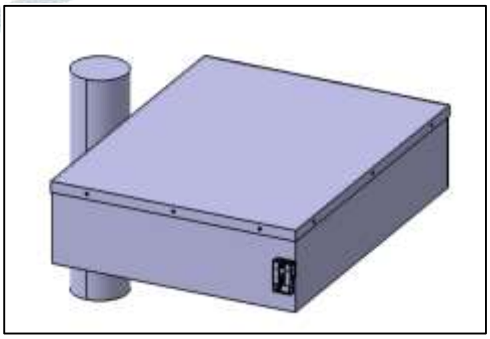


Figure 2: Cad model with striking body

VI. FEA ANALYSIS

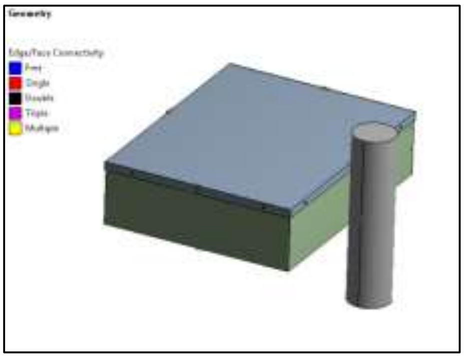
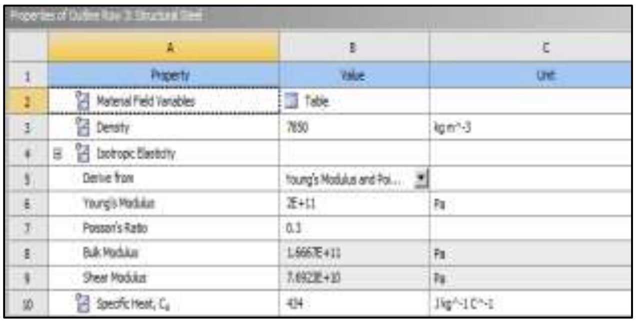


Figure 3: Geometry



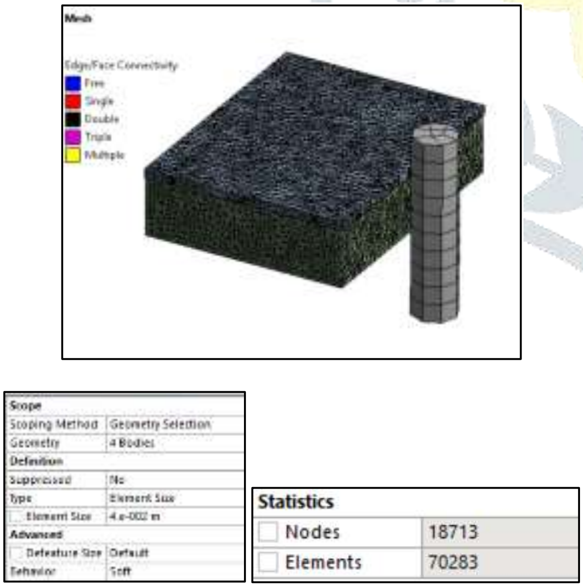
Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Poi...	
6	Young's Modulus	2E+11	Pa
7	Poisson's Ratio	0.3	
8	Bulk Modulus	1.6667E+11	Pa
9	Shear Modulus	7.6923E+10	Pa
10	Specific Heat, C_p	434	J kg^-1 C^-1

Figure 4: Material properties

Meshing:

Meshing is an integral part of the computer-aided engineering simulation process. The mesh influences the accuracy, convergence and speed of the solution. Furthermore, the time it takes to create and mesh a model is often a significant portion of the time it takes to get results from a CAE solution. Therefore, the better and more automated the meshing tools, the better the solution.



Scope	
Scoping Method	Geometry Selection
Geometry	4 Bodies
Definition	
Suppressed	No
Type	Element Size
Element Size	4.e-002 m
Advanced	
Defeature Size	Default
Behavior	Soft

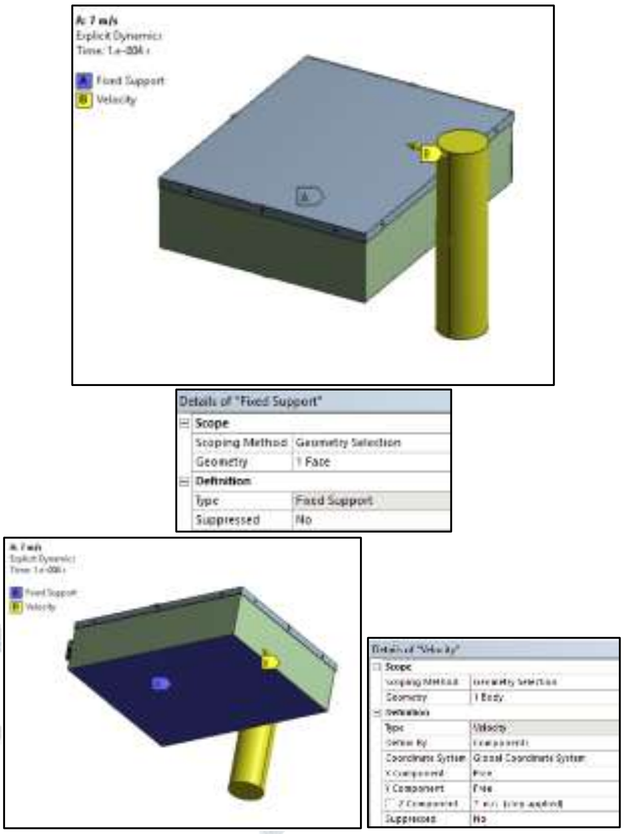
Statistics	
☐ Nodes	18713
☐ Elements	70283

Figure 5: Meshing details

ANALYSIS OF EXISTING BATTERY PACK WITH 7 m/s VELOCITY:

Boundary Condition:

A boundary condition for the model is the setting of a known value for a displacement or an associated load. For a particular node you can set either the load or the displacement but not both.



Details of "Fixed Support"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Type	Fixed Support
Suppressed	No

Details of "Velocity"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Type	Velocity
Define By	Components
Coordinate System	Global Coordinate System
X Component	Free
Y Component	Free
Z Component	7 m/s (step applied)
Suppressed	No

Figure 6: Boundary condition

Results:

Total deformation:

The total deformation & directional deformation are general terms in finite element methods irrespective of software being used. Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. total deformation is the vector sum all directional displacements of the systems.

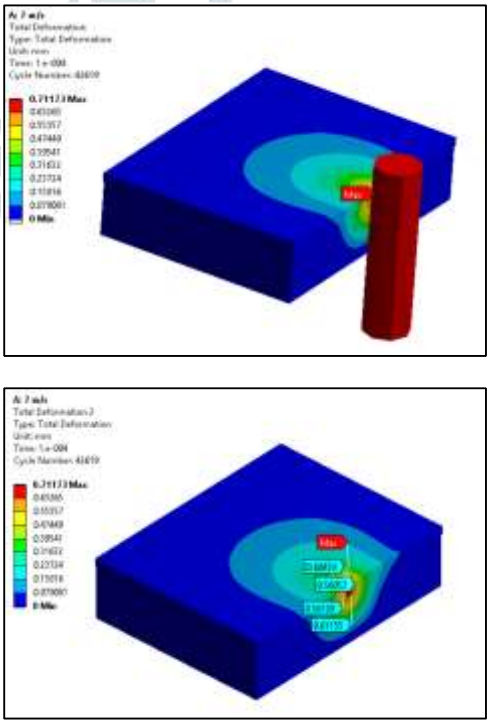


Figure 7: Total deformation

Equivalent Stress:

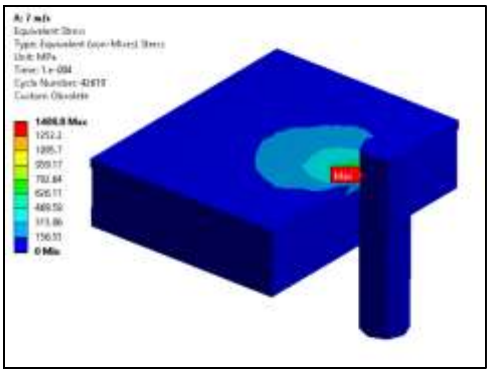


Figure 8: Equivalent stress

ANALYSIS OF EXISTING BATTERY PACK WITH 14 m/s VELOCITY:

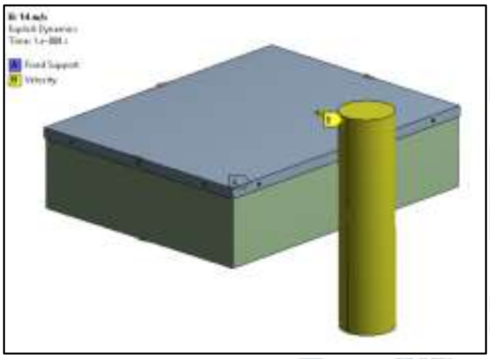


Figure 9: Boundary condition

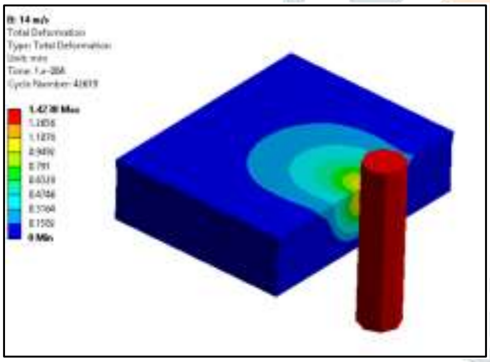


Figure 10: Total deformation

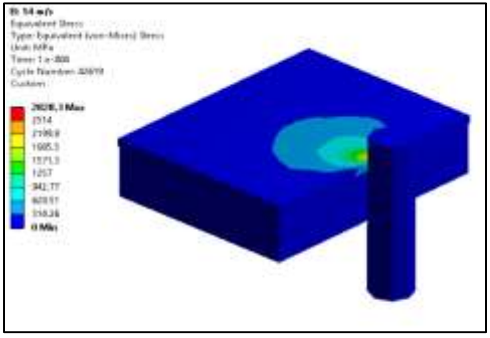


Figure 11: Equivalent stress

ANALYSIS OF EXISTING BATTERY PACK WITH 21 m/s VELOCITY:

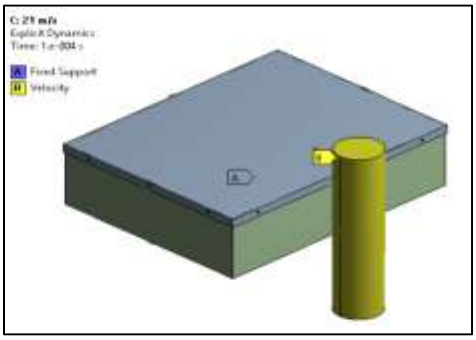


Figure 12: Boundary condition

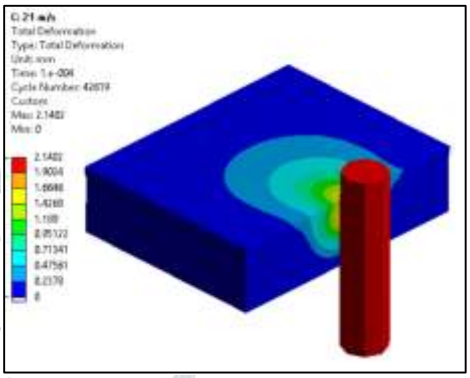


Figure 13: Total deformation

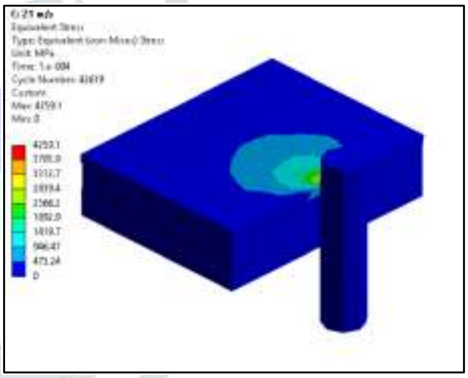


Figure 14: Equivalent stress

OPTIMIZED CAD MODEL:

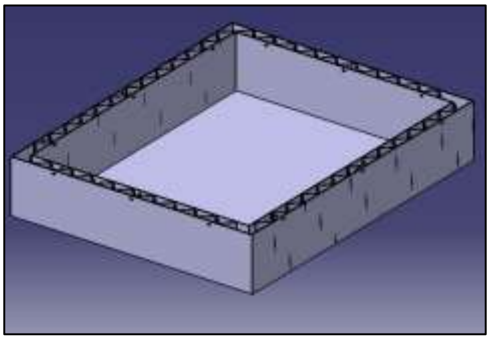


Figure 15: Cad model

ANALYSIS OF OPTIMIZED MODEL WITH 7 m/s VELOCITY:

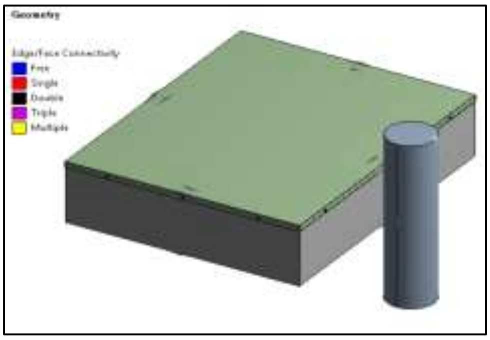


Figure 16: Imported geometry

Statistics	
☐ Nodes	50418
☐ Elements	175668

Figure 17: Meshing detail

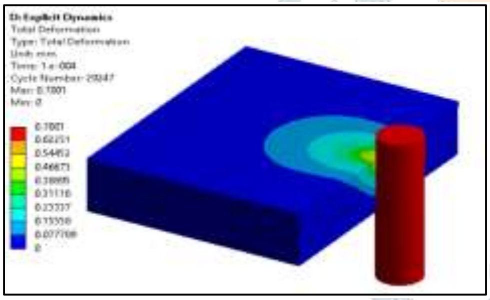


Figure 18: Total deformation

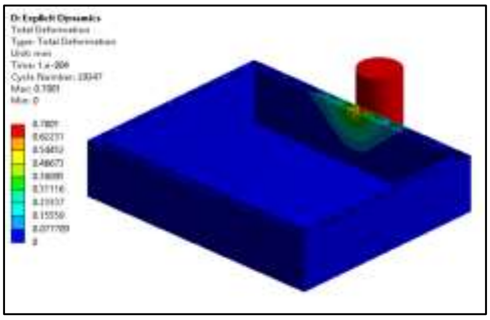


Figure 19: Internal deformation

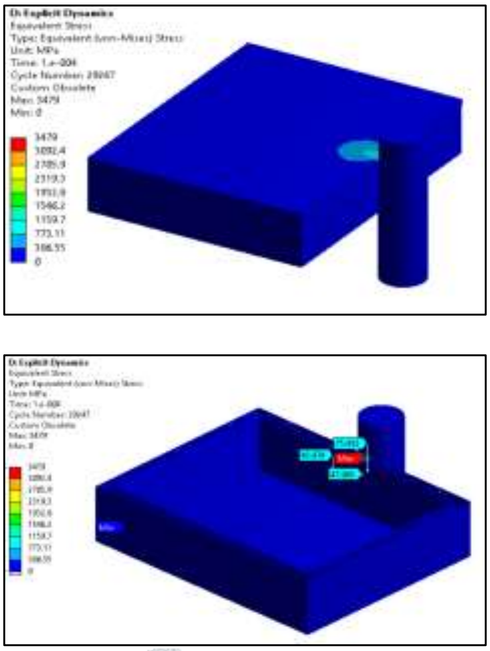


Figure 20: Equivalent stress

ANALYSIS OF OPTIMIZED MODEL WITH 14 m/s VELOCITY:

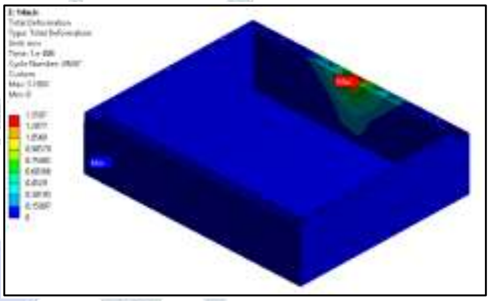


Figure 21: Total deformation

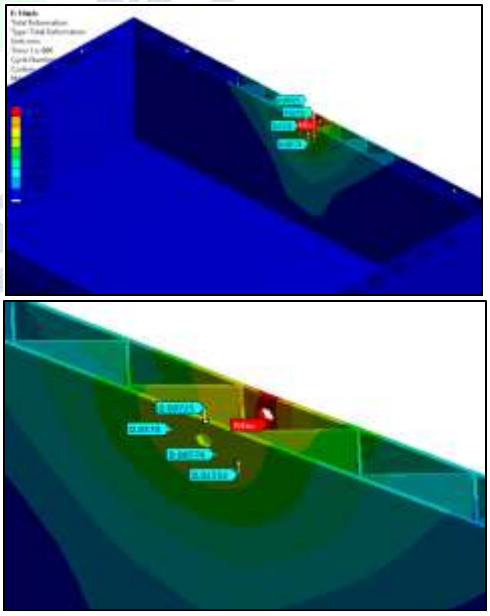


Figure 22: Maximum deformation in inside body

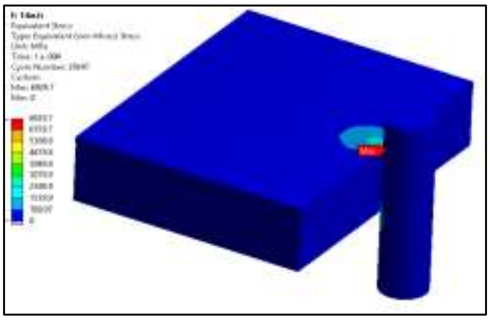


Figure 23: Equivalent stress generated on overall body

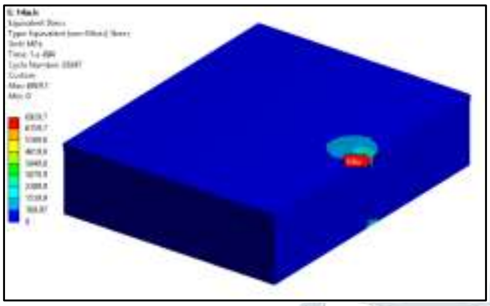


Figure 24: Equivalent stress

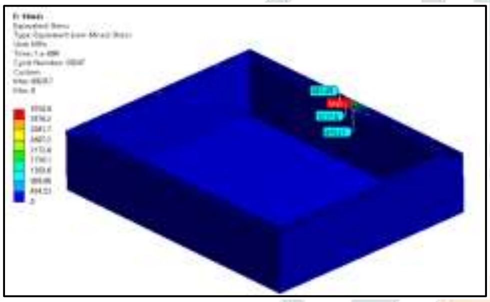


Figure 25: Max equivalent stress generated on inner body

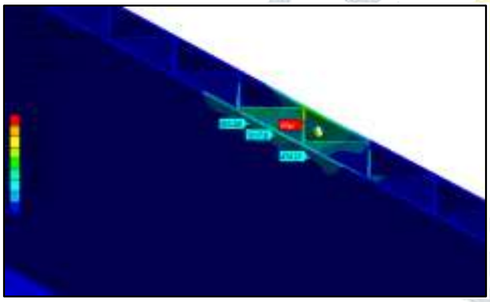


Figure 26: Stress distribution on ribs

ANALYSIS OF OPTIMIZED MODEL WITH 21 m/s VELOCITY:

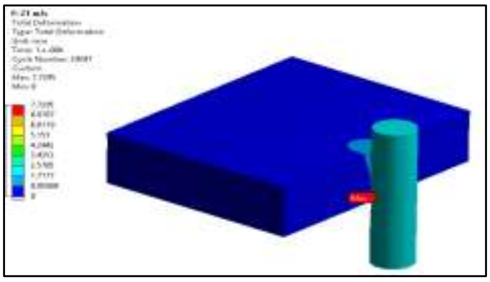


Figure 27: Total deformation

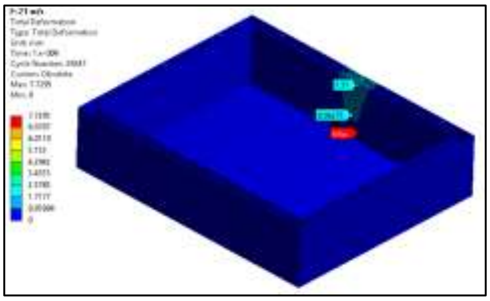
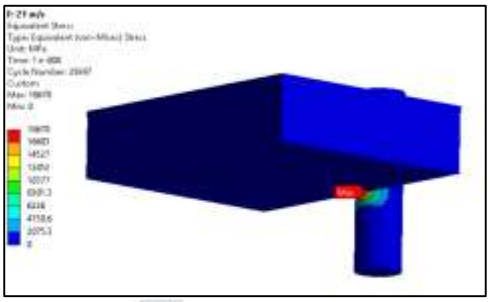


Figure 28: Total deformation in internal housing



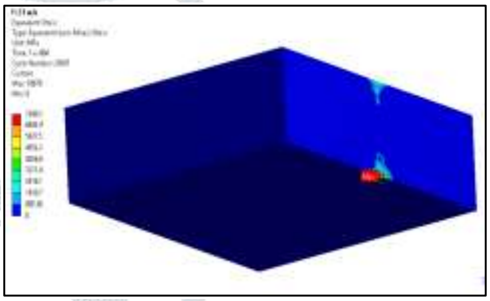


Figure 29: Equivalent stress

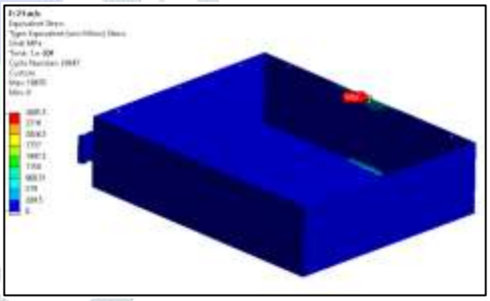


Figure 30: Equivalent stress in internal housing

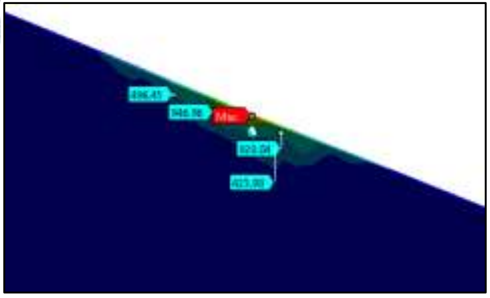


Figure 31: Stress distribution in internal housing

VII. EXPERIMENTAL TESTING FEA

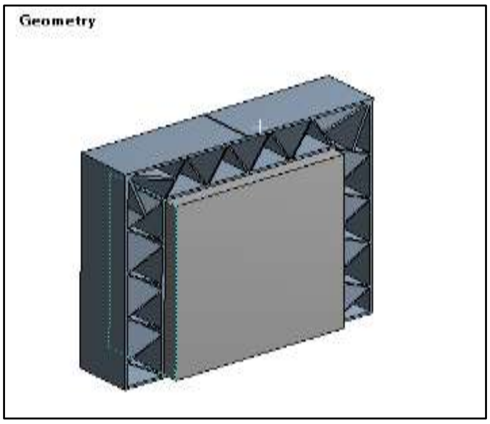


Figure 32: CAD model

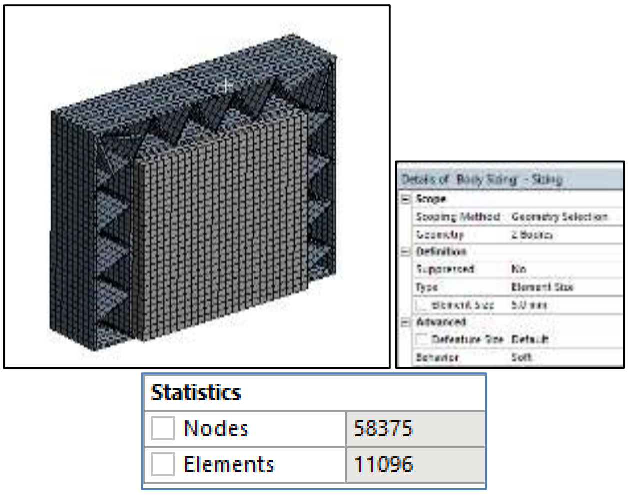
Properties of Outline Row 3: polypropylene

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	0.92	g cm^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and...	
6	Young's Modulus	1070	MPa
7	Poisson's Ratio	0.45	
8	Bulk Modulus	3.5667E+09	Pa
9	Shear Modulus	3.6897E+08	Pa
10	Bilinear Isotropic Hardening		
11	Yield Strength	44.5	MPa
12	Tangent Modulus	356.6	MPa

Properties of Outline Row 3: Structural Steel NL

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Elasticity		
5	Derive from	Young's Modulus and...	
6	Young's Modulus	1.8E+05	MPa
7	Poisson's Ratio	0.29	
8	Bulk Modulus	1.4286E+11	Pa
9	Shear Modulus	6.9767E+10	Pa
10	Bilinear Isotropic Hardening		
11	Yield Strength	240	MPa
12	Tangent Modulus	1100	MPa

Figure 33: Material properties



Details of "Body Sizing" - Sizing

Scope	
Scoping Method	Geometry Selection
Geometry	2 Bodies
Definition	
Suppressed	No
Type	Element Size
Element Size	5.0 mm
Advanced	
Defeature Size	Default
Behavior	Soft

Statistics	
☐ Nodes	58375
☐ Elements	11096

Figure 34: Meshing details

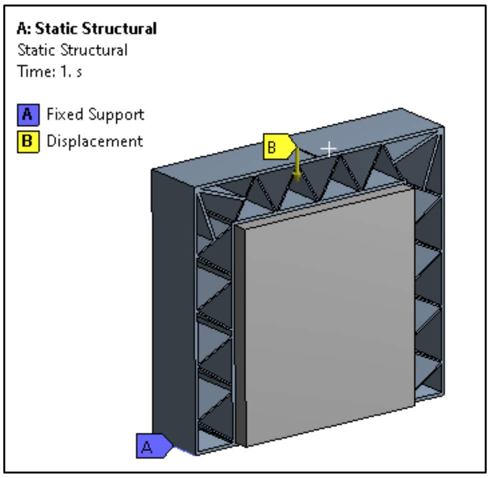


Figure 35: Boundary condition

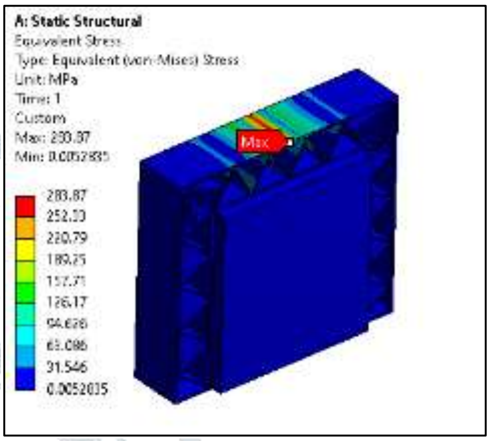


Figure 36: Equivalent stress

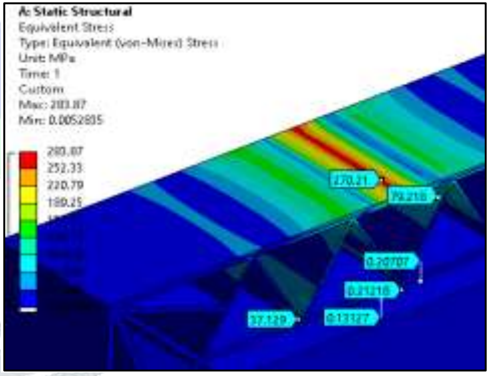
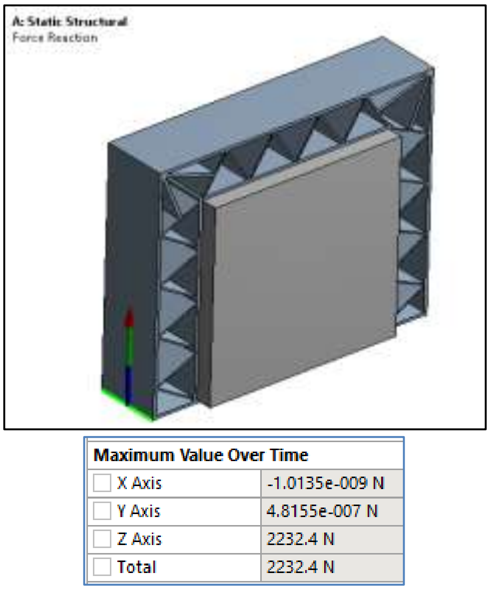


Figure 37: Stress observed on battery



Maximum Value Over Time	
☐ X Axis	-1.0135e-009 N
☐ Y Axis	4.8155e-007 N
☐ Z Axis	2232.4 N
☐ Total	2232.4 N

Figure 38: Reaction force

Reaction force observed is 2232.4 N.

VIII. EXPERIMENTAL VALIDATION

A Universal Testing Machine (UTM) is used to test both the tensile and compressive strength of materials. Universal Testing Machines are named as such because they can perform many different varieties of tests on an equally diverse range of materials, components, and structures.

Universal Testing Machines can accommodate many kinds of materials, ranging from hard samples, such as metals and concrete, to flexible samples, such as rubber and textiles. This diversity makes the Universal Testing Machine equally applicable to virtually any manufacturing industry.

The UTM is a versatile and valuable piece of testing equipment that can evaluate materials properties such as tensile strength, elasticity, compression, yield strength, elastic and plastic deformation, bend compression, and strain hardening. Different models of Universal Testing Machines have different load capacities, some as low as 5kN and others as high as 2,000kN.

Table 1
Specifications of UTM

1	Max Capacity	400KN
2	Measuring range	0-400KN
3	Least Count	0.04KN
4	Clearance for Tensile Test	50-700 mm
5	Clearance for Compression Test	0- 700 mm
6	Clearance Between column	500 mm
7	Ram stroke	200 mm
8	Power supply	3 Phase, 440Volts, 50 cycles. A.C
9	Overall dimension of machine (L*W*H)	2100*800*2060
10	Weight	2300Kg

Figure 39: Battery housing prototype

Figure 40: Experimental testing setup

Praj Metallurgical Lab. Pune 38

Machine No.:STS-248

COMPRESSION TEST GRAPH
(Load vs Deformation)

Remark :
Tested By :
Checked / Witnessed By :

Figure 41: Experimental testing result

- As per FEA testing, applied 2 mm displacement and find out reaction force and compare that reaction force with FEA result.
- The reaction force observed in experimental testing is 2119.74 N.

CONCLUSION

Completed dynamic analysis on existing battery housing by applying velocity with 7, 14 and 21 m/s. And find out stress and maximum deformation generated on the housing. Then redesign the battery housing with the help of stiffeners.

Reanalysis is performed for optimized model with 7, 14 and 21 m/s velocity and find out total deformation and stress generated on the optimized battery housing.

The prototype of battery housing is manufactured for the experimental testing. And analysis also performed to compare the reaction force generated by the battery housing. The reaction force generated by the FEA result with 2 mm displacement is 2232.4 N. And the reaction force calculated by the UTM testing after 2 mm displacement is 2119.74 N.

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