EVS32 A world of E MOTION 2019 MAY 19 22
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EVS 50th anniversary 1969-2019

A Study on the Effect of Vibration and Nail Penetration on Lithium ion Battery and Its Material Characterization

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Forging Industry Division

Homologation and Technology Centre

- **Centre of Excellence - E Mobility**

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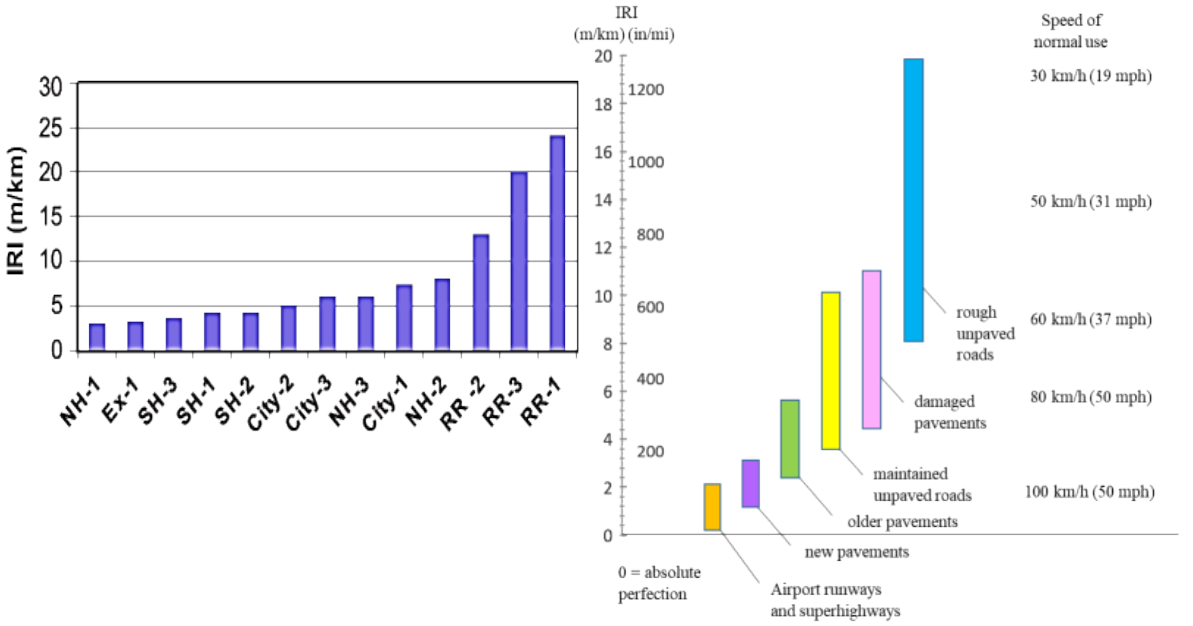


- Safety of Passenger in the electric vehicle is important.
- India signed Brasilia declaration and committed to reducing road accidents

Oct 2017
New Models

Oct 2018
New Models
AIS 100: Pedestrian Protection

Oct 2019
All Models
AIS 096: Full Frontal
AIS 099: Side Impact

Oct 2020
All Models
AIS 100: Pedestrian Protection

F A M E

Total Outlay INR 113 Mn Euro)

National Automotive Board
Under Department of Heavy Industry

To Promote

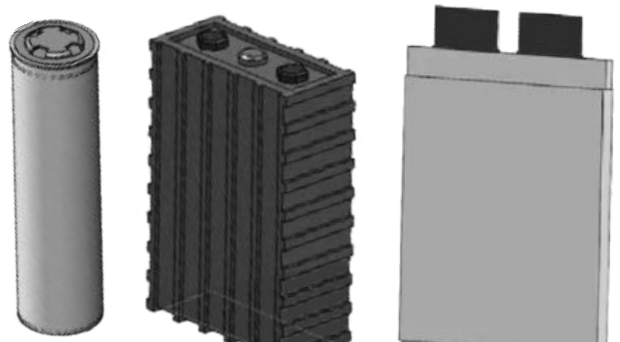
Good Response to Scheme

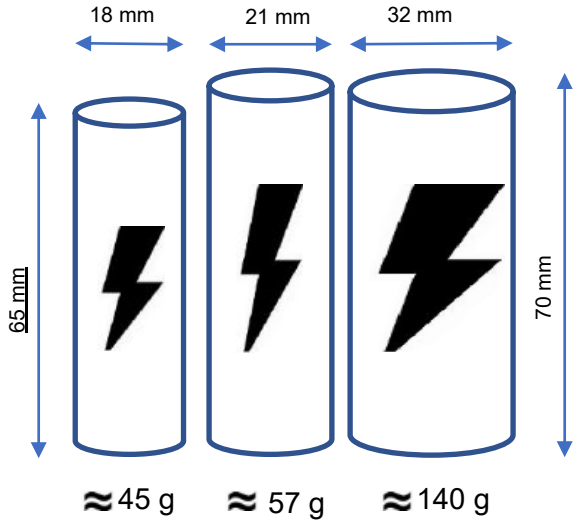
FAME-India
(National Mission on Electric Mobility)

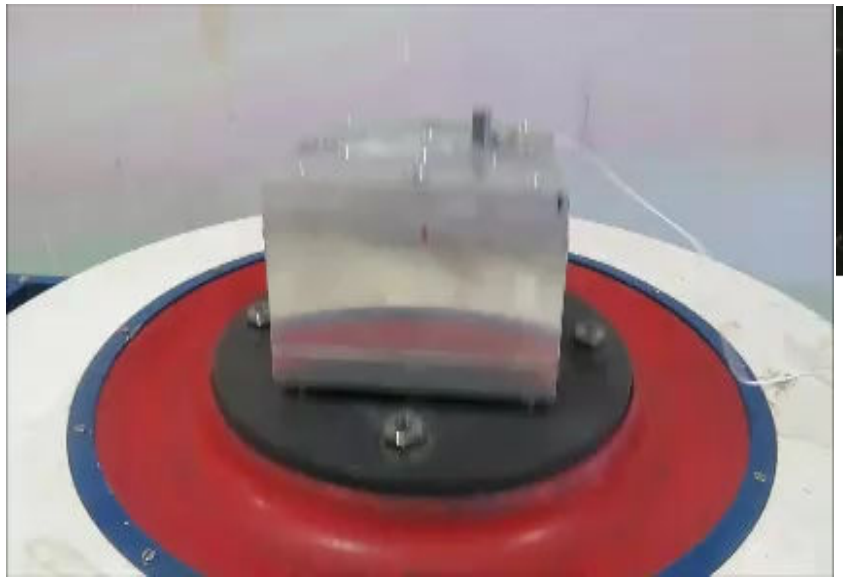
More info on https://www.fame-india.gov.in/

Introduction & Experimental Setup

- Structural stability of the cell need to be evaluated for different abuse conditions
- Nail Penetration at 100% & 50% SoC and Vibration at 100% SoC

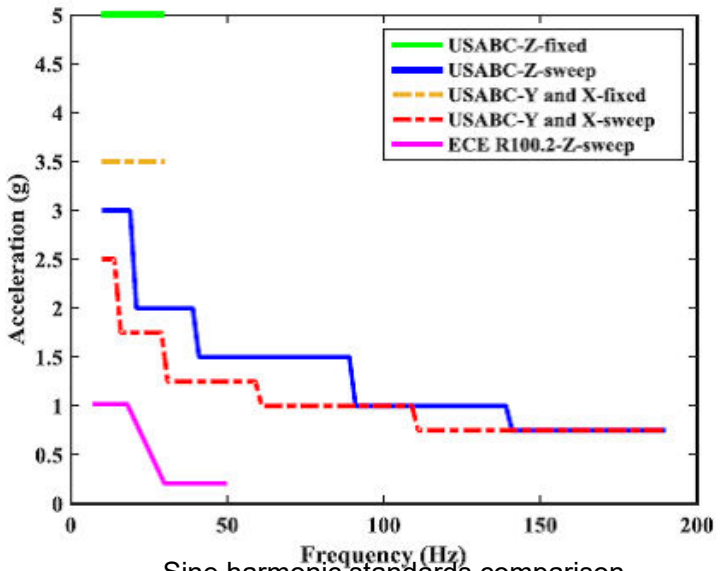






Vibration test fixture and Setup

Nail Penetration Test Setup



Sine harmonic standards comparison

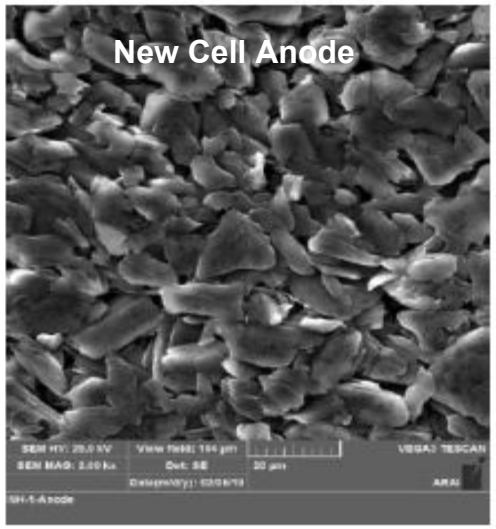
Morphology Analysis After Nail Penetration Test

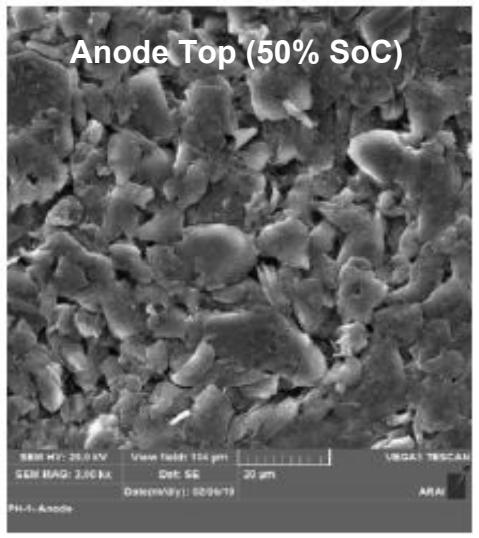
Anode

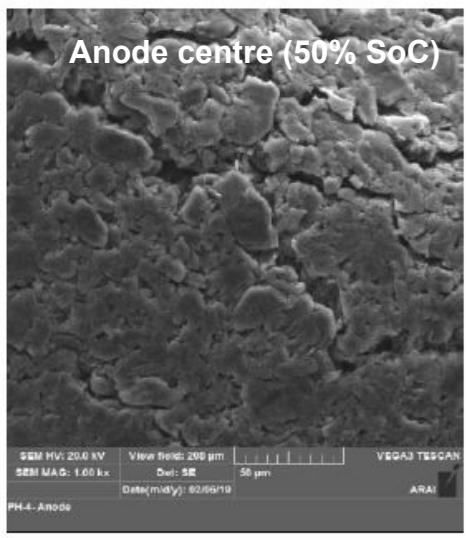
- 50% SoC : - The average grain size reduced from 12 µm to 7 µm.
- 100% SoC :- Inhomogeneity in structure and grain size.

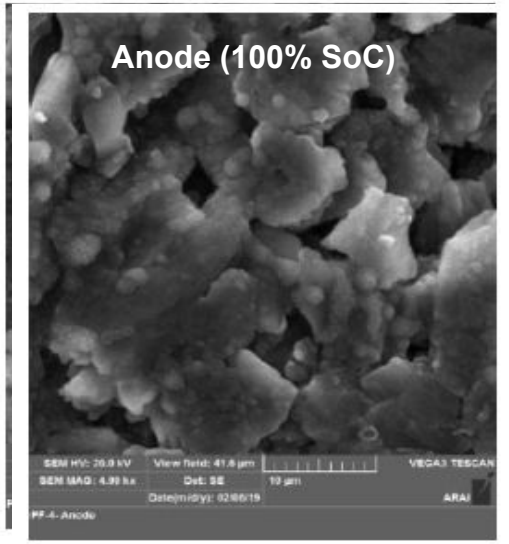
Cathode

- 50% SoC :- At top cracks were observed in the morphology but at the centre the grains were completely destroyed
- 100% SoC : - The average grain size increased from 0.56 µm to 1 µm.

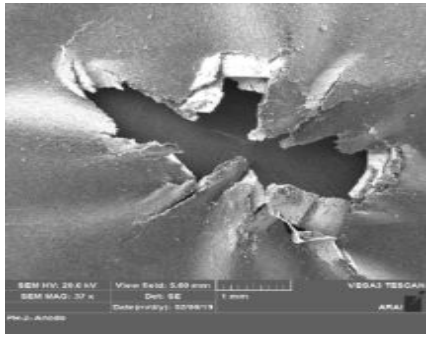








Top Region



Centre Region

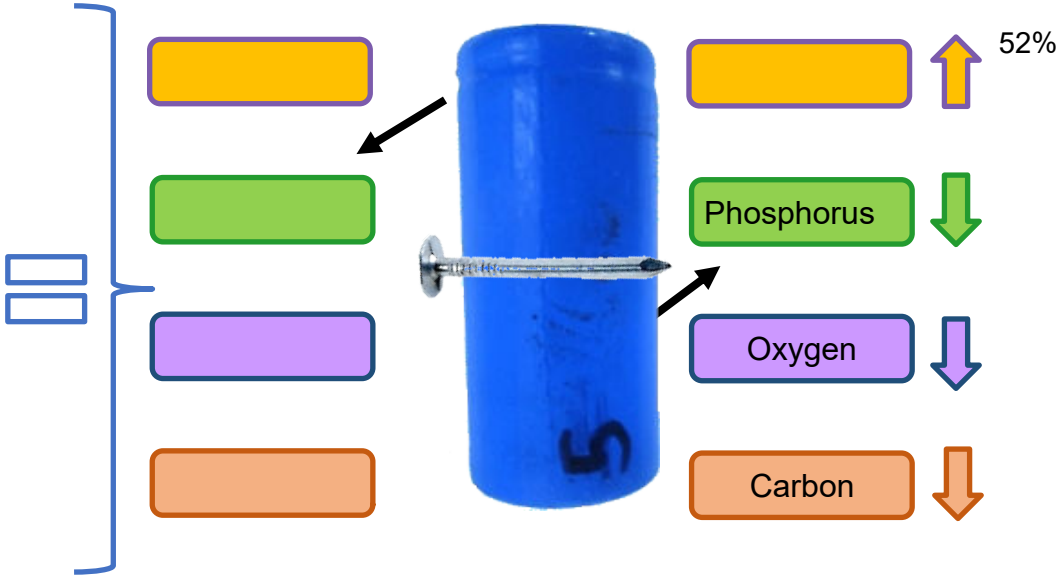
Composition Analysis After Nail Penetration Test

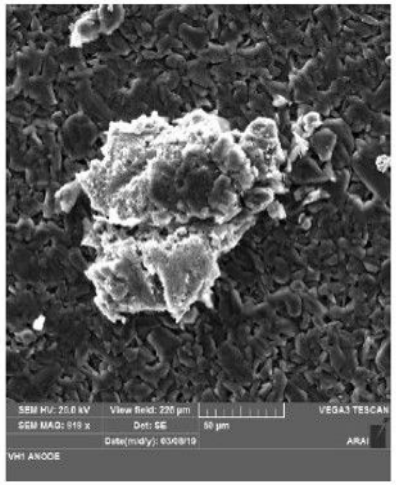
50% SoC

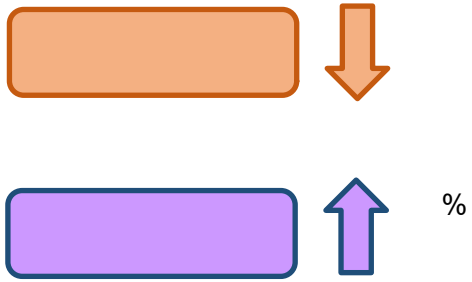
- With respect to anode, the elements such as C,O and P is found similar before and after penetration test at both the locations
- At Cathode, There is significant difference in the elements before and after penetration test at centre

100% SoC

- The elemental distribution of cathode was similar to new cell
- In Anode Traces of iron element is observed in the destroyed anode.

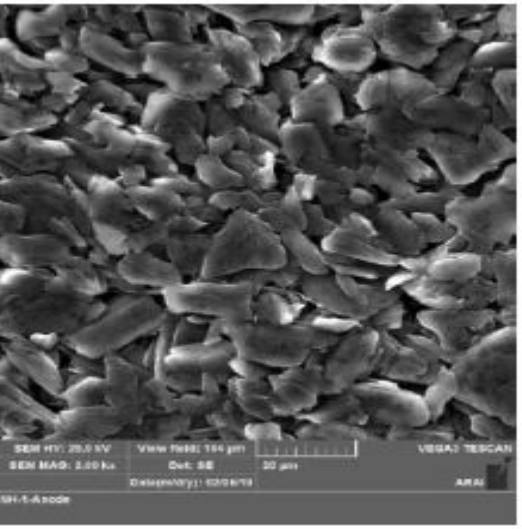


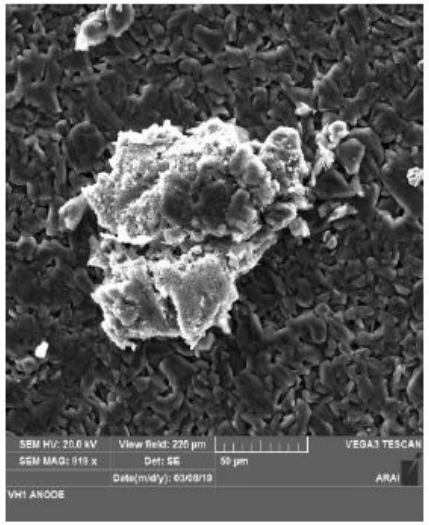


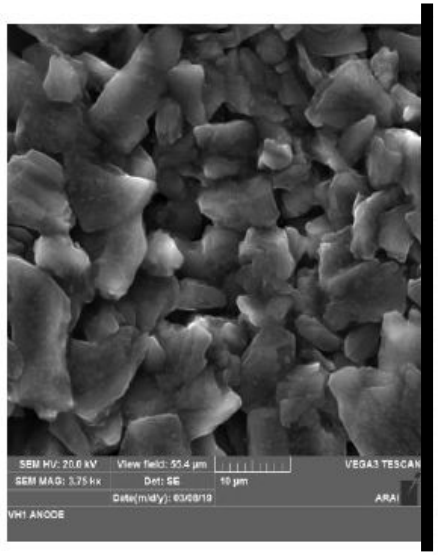


Morphology Analysis Of Electrodes After Vibrational Test

- The anode was found intact, but throughout the surface presence of tower like structure is observed, Which is due to transfer of material from the cathode.
- It is observed that the anode has additional deposition of oxygen, phosphorus and iron which has come from the cathode, as compared to the new cell anode.

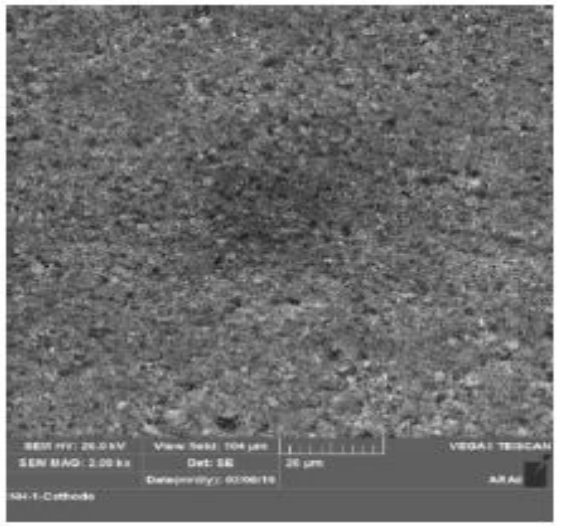


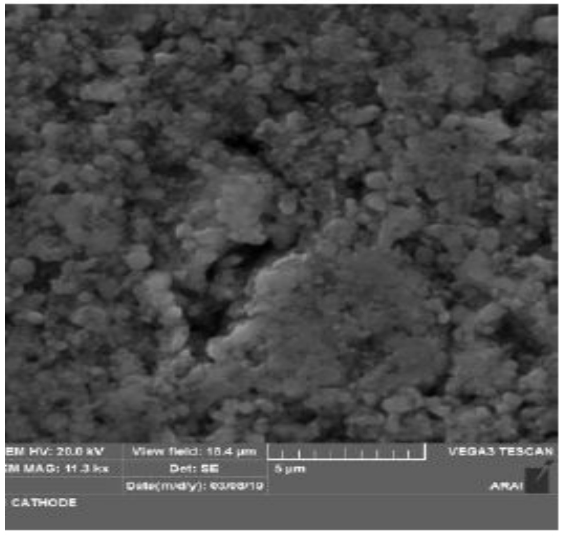




Anode after vibration test

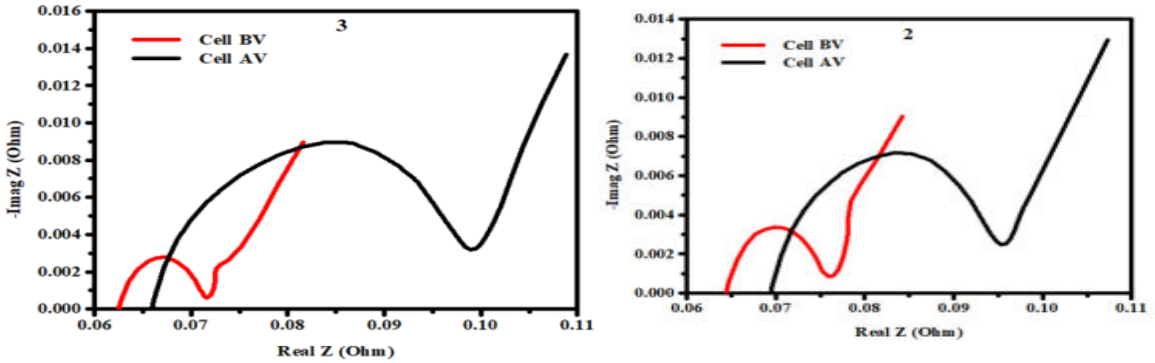
Cathode after vibration test



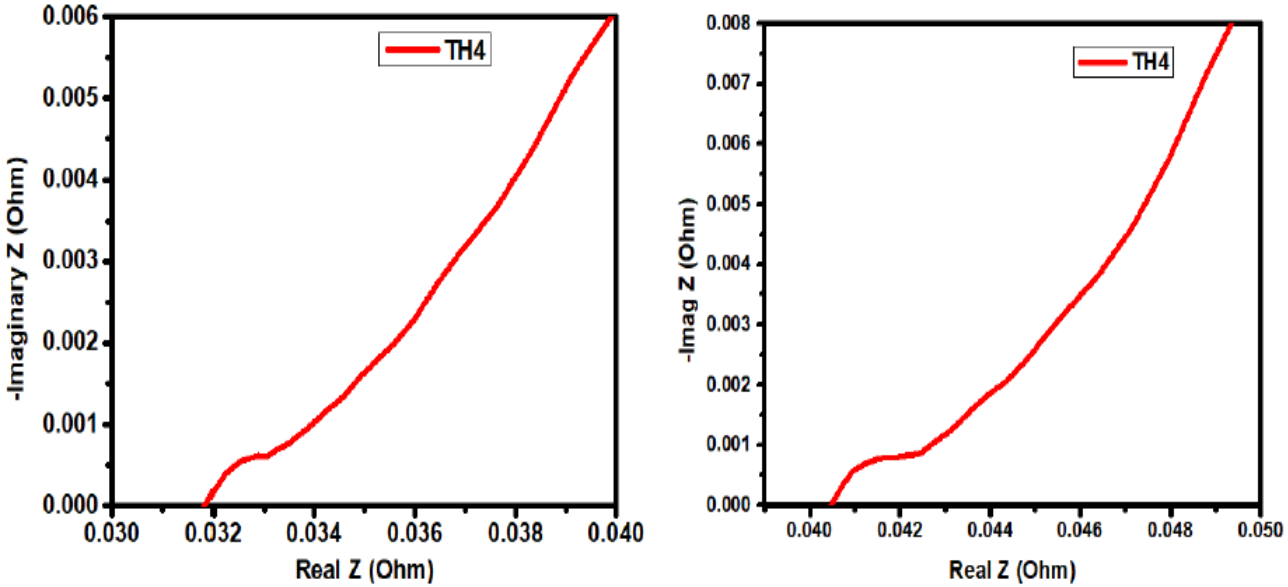


Internal Resistance Analysis After Vibration Test

- The resistance of the new cell at 50% SoC is found to 30-35 mΩ
- Voltage drops from 0.3 to 0.4 V
- Test showed increase in the internal resistance by 5-25%

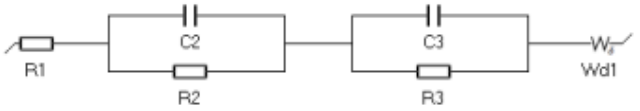


EIS on Another Commercial 18650 cell before (red) and after vibration (black).



Nyquist Plot for 32700 Cell tested before and after Vibration testing

Equivalent circuit *
R1+C2/R2+C3/R3+Wd1



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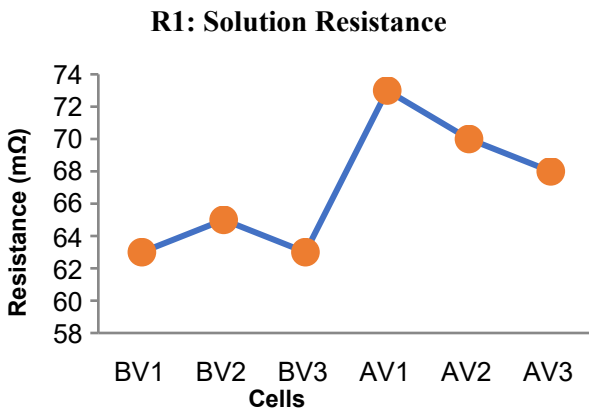
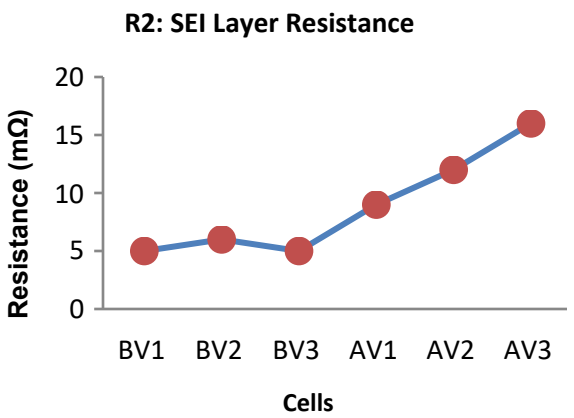
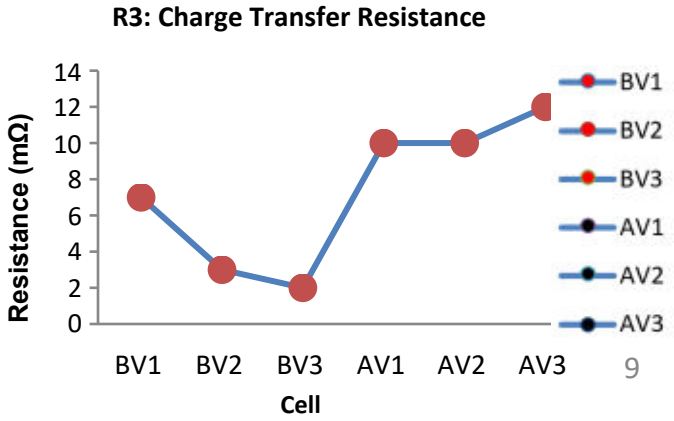
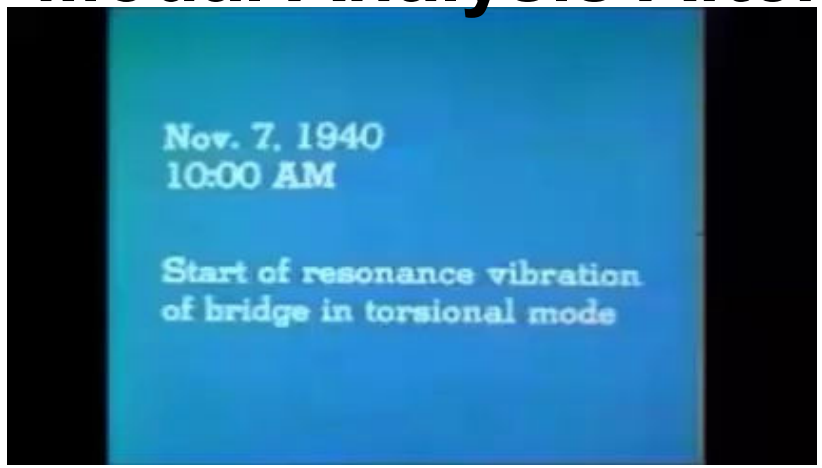
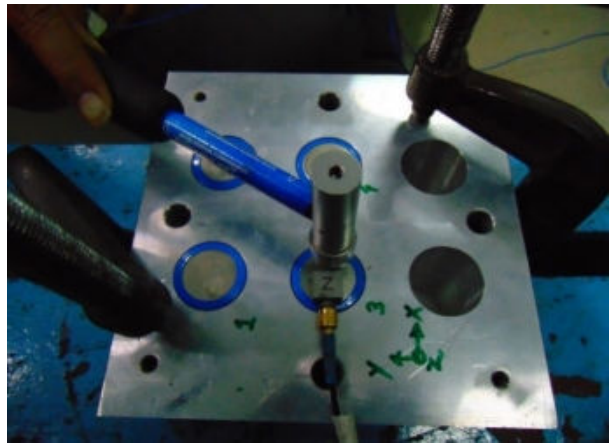






Modal Analysis After Vibration Test

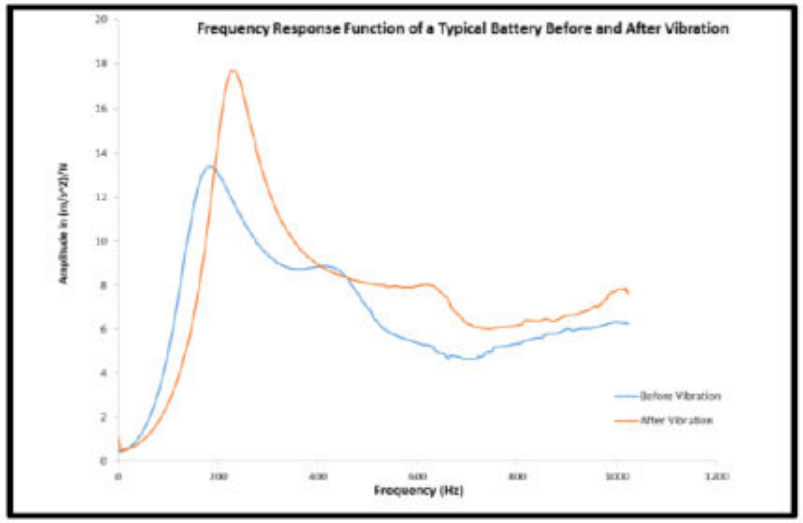




Videos Courtesy : YouTube

Cells	Max Amplitude (m/s^2)/N		Max Amplitude's Freq, Hz		Dynamic Stiffness at Max Amplitude Freq (N/mm)	
	Before Test	After Test	Before Test	After Test	Before Test	After Test
1	15.3	17.0	156	216	63	109
2	15.1	15.3	177	270	82	188
3	13.4	17.7	183	231	99	118
AVERAGE	**14.6**	**16.7**	**172**	**239**	**81**	**138**

14%



Summary

- It is **important to validate the performance of LiB for its application** and understanding of the vibrational load during the lifetime of cell is to be carefully considered while **designing the battery pack**.
- **Capacity fade happened** in the cells which were in 100% SoC to 50% SoC wherein cathode showed tower like structure
- In the **top side location there is no much effect** of abuse on the distribution of the elements and thus the material can be used further for recycling.

Conclusion

A Quick Quality Check Quantitative Methodology is developed which can be used for Cell Validation

Hybrid Vehicle

Vehicle

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