Closure slam pass-pass and fail-fail correlation using the duty cycle approach for closing and opening efforts

ECS Simulation Conference 2021

Author – Srikrishna Koduri , Durga Mohapatra & Suhas Kangde

Mahindra & Mahindra Ltd.,
Mahindra Research Valley-Chennai, India

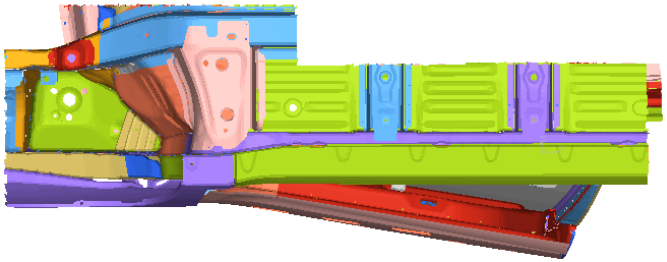
May 19th 2021

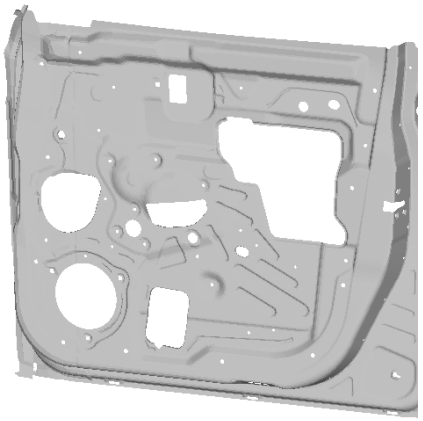
Company Overview

- Mahindra & Mahindra is $21 billion multinational group with a presence in more than 100 countries and employing over 250,000 people.
- Operation expanded to 22 key industries that form the foundation of every modern economy.

Automotive Closure Slam Test

- Passenger car closures experiences extreme slam loads repeatedly depending upon customer usage pattern.
- Closure panels experiences (1) impact and inertial loads, and (2) check arm mount regions are loaded depending upon check arm design.
- In CAE, explicit transient simulation was done to predict impact and inertial load affects. Check arm is not considered in this analysis due to the following reasons
  - complexity of modelling snapping behavior between check arm components.
  - Limitation of considering preload affects in explicit analysis.





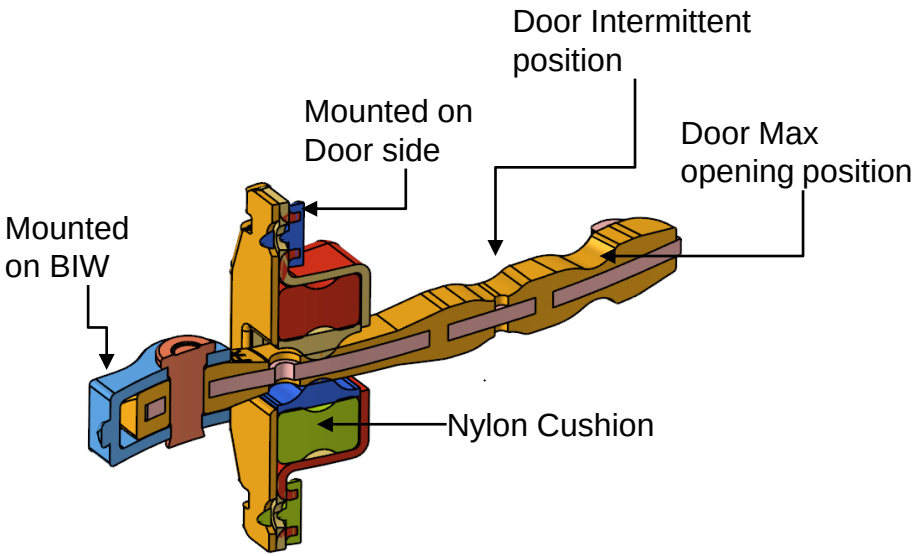
Stress Plot

Door Slam event

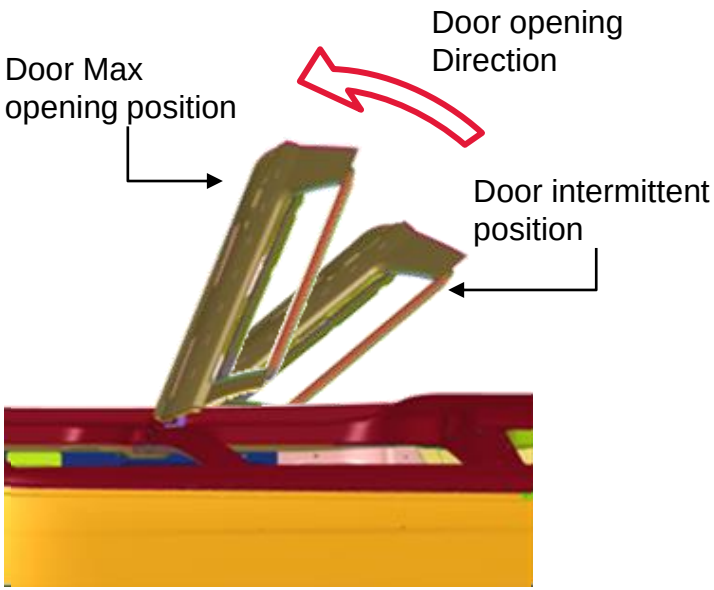
Problem statement

- Check arm helps in holding the door at the desired position.
- Excessive loads are generated at check arm mounting region while door is opened and closed from door max opening position with considerable velocity.
- Due to the limitations in explicit analysis and complexity in check arm mechanism modelling, existing explicit transient simulation cannot evaluate check arm are mounting region.

A New method is developed for durability evaluation of check arm mounting regions



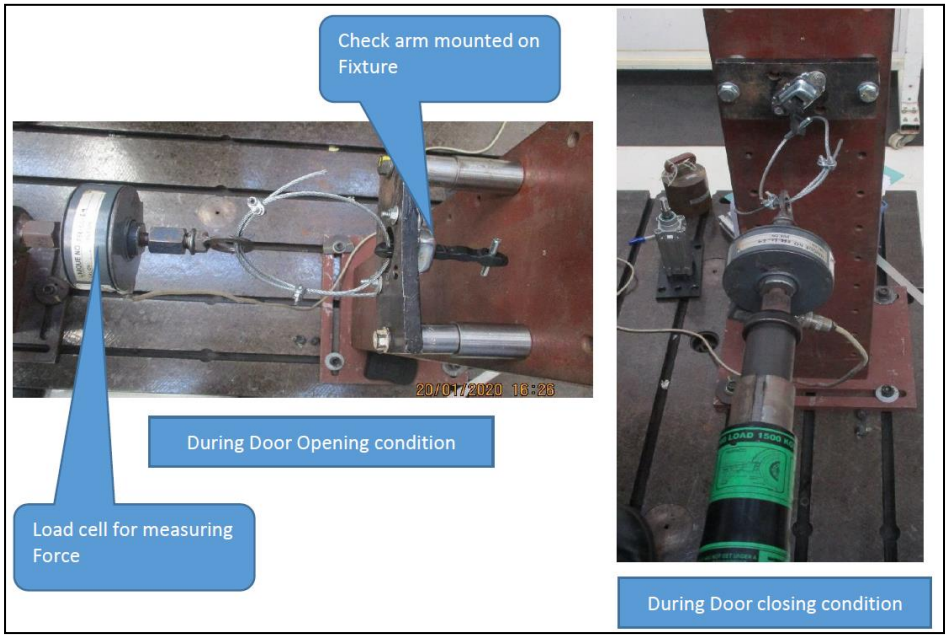
Cut Section of Check arm Assembly in door closed position



Top View of vehicle with two door opening positions

Load Measurement

- Load required to move the check arm slider from one position to another position is measured.
- It is observed that 10x times load is experienced by check arm mounts when compared to door handle loads to open and close the door.



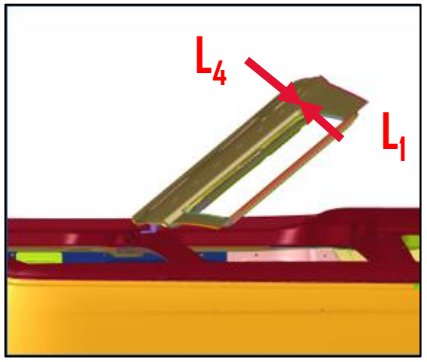
Condition	Check Arm Position	Load at Door handle (N)	Load at Check arm (N)
During Door Opening Condition	0 To 1	L_1	L_1 x 9.5
	1 To 2	L_2	L_2 x 10.2
During Door Closing Condition	2 To 1	L_3	L_3 x 10.2
	1 To 0	L_4	L_4 x 9.5

0 – Door closed position
1 – Door intermittent position
2 – Door max opening position

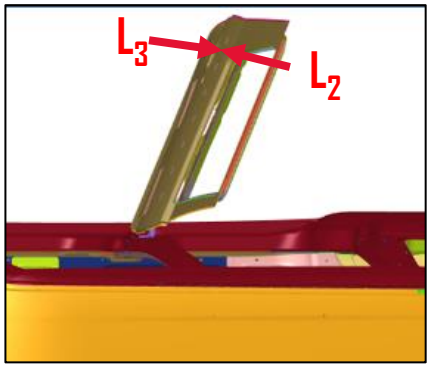
Stress Analysis

- Door opening and closing loads are applied at the door handle region.
- Stress analysis is done at all four-loading condition separately, i.e., L1, L2, L3 & L4.
- Due to leverage affect, considerable stresses are observed at the check arm mounting region on Door side.

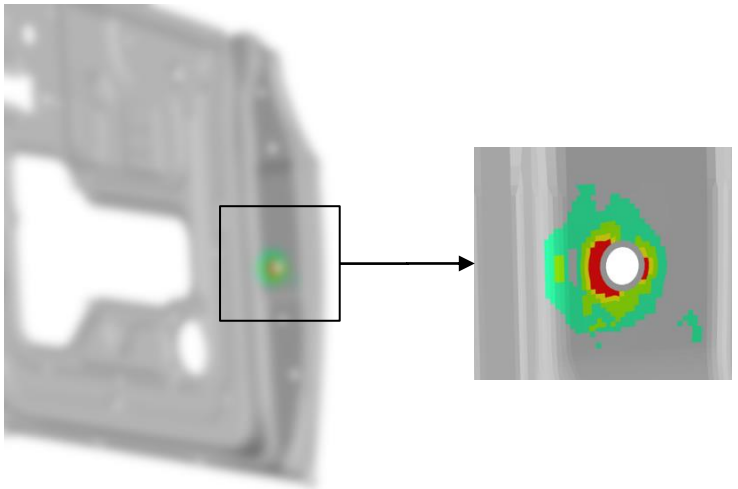
Door Position 1



Door Position 2



Condition	Check Arm Position	Force at door handle (N)
During Door Opening Condition	0 To 1	L1
	1 To 2	L2
During Door Closing Condition	2 To 1	L3
	1 To 0	L4

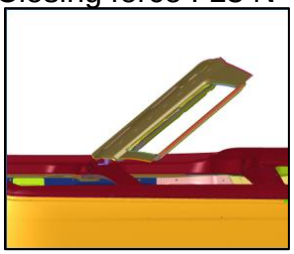


Stress plot at check arm mount for L2 loading event

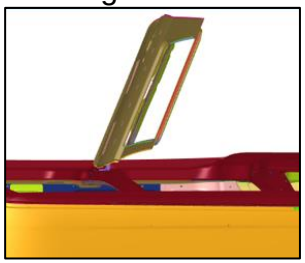
Duty Cycle Approach using FEMFAT – channel Max

- Duty cycle is derived to represent the one door opening and closing event
- Damage is calculated using equivalent stress history considering duty cycle defined in channel definition..

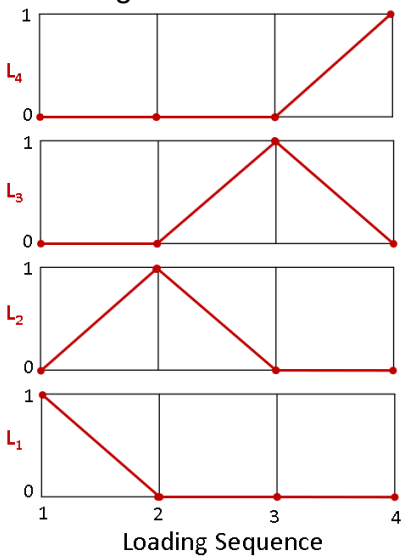
Door Position 1
Opening force : L1 N
Closing force : L3 N



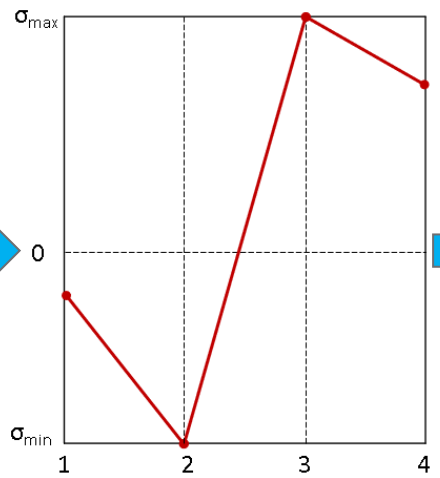
Door Position 2
Opening force : L2 N
Closing force : L4 N



Channel history for one complete door open and closing event



Equivalent stress for one cycle



$\Sigma d_{(i)}$

Cumulative damage calculation

Lbl	Format	Stress File	LC	Factor	L.HIST	Load History File	Row	Col	SCR	Scratch File
1	ODB ABA...	Door_Position1.odb	1	1.00000	RPC ASCII	dutyCycle.txt	1	1	ASC	cgh_1.fms
2	ODB ABA...	Door_Position2.odb	1	1.00000	RPC ASCII	dutyCycle.txt	1	2	ASC	cgh_2.fms
3	ODB ABA...	Door_Position3.odb	1	1.00000	RPC ASCII	dutyCycle.txt	1	3	ASC	cgh_3.fms
4	ODB ABA...	Door_Position4.odb	1	1.00000	RPC ASCII	dutyCycle.txt	1	4	ASC	cgh_4.fms

Stress results

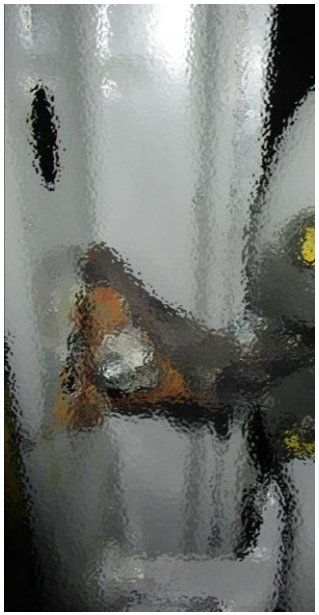
Identity matrix

Test-CAE Correlation:

- Initial design has durability concern at FEMFAT analysis predicted region.
- In Initial design, 1.49 times factor is observed between Test to CAE fatigue life.
- In Improved design, CAE fatigue life is improved by 95 times when compared to initial design.
- Improved design based on FEMFAT analysis has cleared the target cycles in physical test.

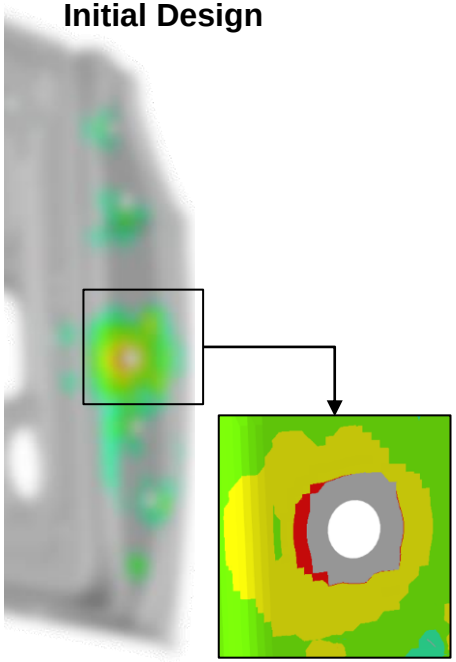
Closure Slam Test in Lab

Initial Design

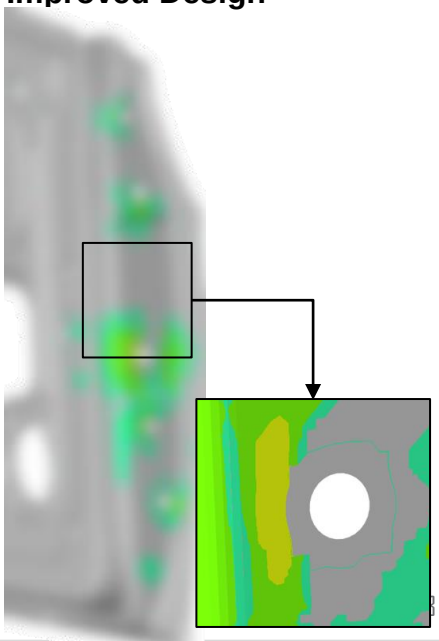


Fatigue Analysis Result

Initial Design



Improved Design



Conclusions:

- Computationally less expensive CAE method is developed to evaluate check arm mounting region on BIW and Closure side for opening and closing efforts.
- FEMFAT channel max module is used to predict the fatigue life and its results are inline with the physical test results.
- In Initial design, 1.49 times factor is observed between Test to CAE fatigue life.
- In Improved design, CAE fatigue life is improved by 95 times when compared to initial design.
- Improved design has cleared the physical slam test without any concern.
- Fail-Fail and Pass-Pass correlation is achieved with new method.

Acknowledgement:

- Thanks to Mahindra & Mahindra Limited for providing opportunity to learn and develop new methods.
- Thanks to FEMFAT team for providing technical support and platform to showcase our work.

Thank you

Visit us at www.mahindra.com

Disclaimer

Mahindra & Mahindra herein referred to as M&M, and its subsidiary companies provide a wide array of presentations and reports, with the contributions of various professionals. These presentations and reports are for informational purposes and private circulation only and do not constitute an offer to buy or sell any securities mentioned therein. They do not purport to be a complete description of the markets conditions or developments referred to in the material. While utmost care has been taken in preparing the above, we claim no responsibility for their accuracy. We shall not be liable for any direct or indirect losses arising from the use thereof and the viewers are requested to use the information contained herein at their own risk. These presentations and reports should not be reproduced, re-circulated, published in any media, website or otherwise, in any form or manner, in part or as a whole, without the express consent in writing of M&M or its subsidiaries. Any unauthorized use, disclosure or public dissemination of information contained herein is prohibited. Unless specifically noted, M&M or any of its subsidiary companies is not responsible for the content of these presentations and/or the opinions of the presenters. Individual situations and local practices and standards may vary, so viewers and others utilizing information contained within a presentation are free to adopt differing standards and approaches as they see fit. You may not repackage or sell the presentation. Products and names mentioned in materials or presentations are the property of their respective owners and the mention of them does not constitute an endorsement by M&M or its subsidiary companies. Information contained in a presentation hosted or promoted by M&M is provided “as is” without warranty of any kind, either expressed or implied, including any warranty of merchantability or fitness for a particular purpose. M&M or its subsidiary companies assume no liability or responsibility for the contents of a presentation or the opinions expressed by the presenters. All expressions of opinion are subject to change without notice.