Cumulative Loading Methodology Development

Somnath Chavan[1], Shrikant Jagtap[1], Nikhilesh Wankhede[1], Amit Mandal[2], Krishna Kusupudi [3]

[1]*Lead Engineer, Whirlpool of India Ltd., Pune, India*

[2] *Senior Manager, Whirlpool of India Ltd., Pune, India*

[3] *Manager, Whirlpool of India Ltd., Pune, India*

Agenda

1. About Whirlpool
2. Introduction and Problem Statement
3. Simulation Objective
4. Experimental Work
5. Methodology
6. Correlation: Block analogy and standmixer
7. Conclusions and Future scope
8. Benefits to Organisation
9. Q & A

Whirlpool Corporation

- Committed to being the **best Global Kitchen and Laundry company,** in constant pursuit of improving life at home
- Founded over **111 years** ago in 1911
- **$22 billion revenue** in 2021
- Product sold in over **130 countries**
- **78,000 employees** worldwide
- 59 Manufacturing and Technology Centers

Our Brands

Whirlpool Corporation (NYSE: WHR) is committed to being the best global kitchen and laundry company, in constant pursuit of improving life at home. In an increasingly digital world, the company is driving purposeful innovation to meet the evolving needs of consumers through its iconic brand portfolio, including Whirlpool, KitchenAid, Maytag, Consul, Brastemp, Amana, Bauknecht, JennAir, Indesit and Yummly. In 2021, the company reported approximately $22 billion in annual sales, 78,000 employees and 59 manufacturing and technology research centers. Additional information about the company can be found on Facebook, Twitter, LinkedIn, Instagram and YouTube.

Whirlpool · KitchenAid · MAYTAG · INDESIT · AMANA · Hotpoint · Bauknecht · JENNAIR

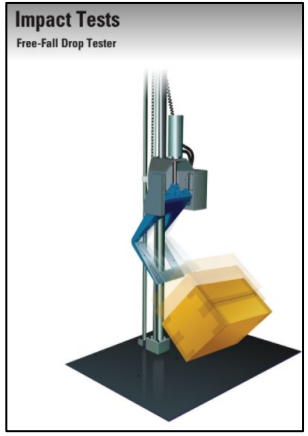
Whirlpool of India Ltd - Global Technology & Engineering Center (GTEC)

- Whirlpool Corporation's only **Integrated Global Technology & Engineering Center** outside US operating under Whirlpool of India Ltd (WOI).
- **19 years of Value Creation for Whirlpool**
- Comprising of product & technology teams of **900+ engineers**
- Innovation focussed with **250+ patents** filed till date
- Ranked consecutively 5 times in a row as **"One of the best places to work"** By AON Hewitt.

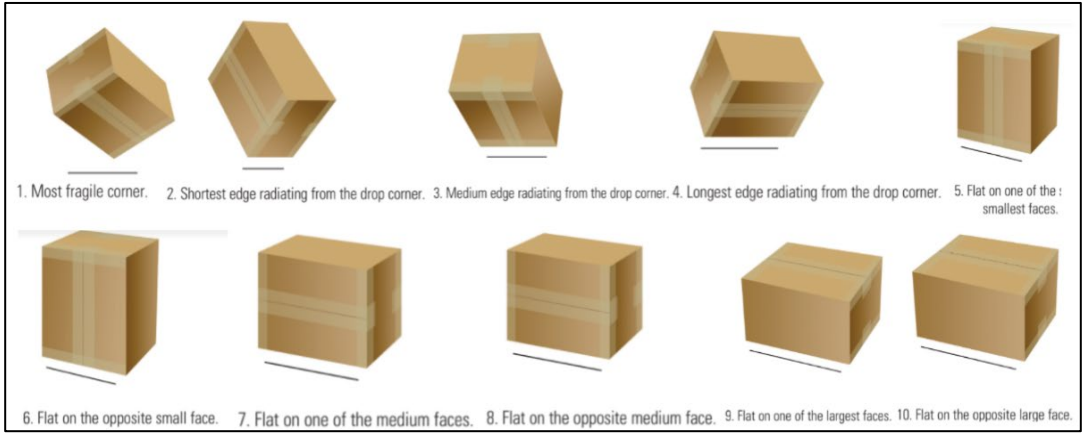
Introduction and Problem Statement

- Whirlpool Corporation designs and manufactures appliances that are intended for household and commercial purposes and Stand Mixer is one such appliance.
- These Stand mixers may undergo specific levels of dynamic stresses during transit.
- Whirlpool evaluates these transit conditions (eg. Sequential product drops) physically and virtually during the approval process.
- The current simulation methodologies are very mature to mimic the individual drops but simulating sequential drops is a bit challenging task.

Stand Mixer
(Source Whirlpool Proprietary)



Drop Tester
(Source ISTA-6-FedEx-A)

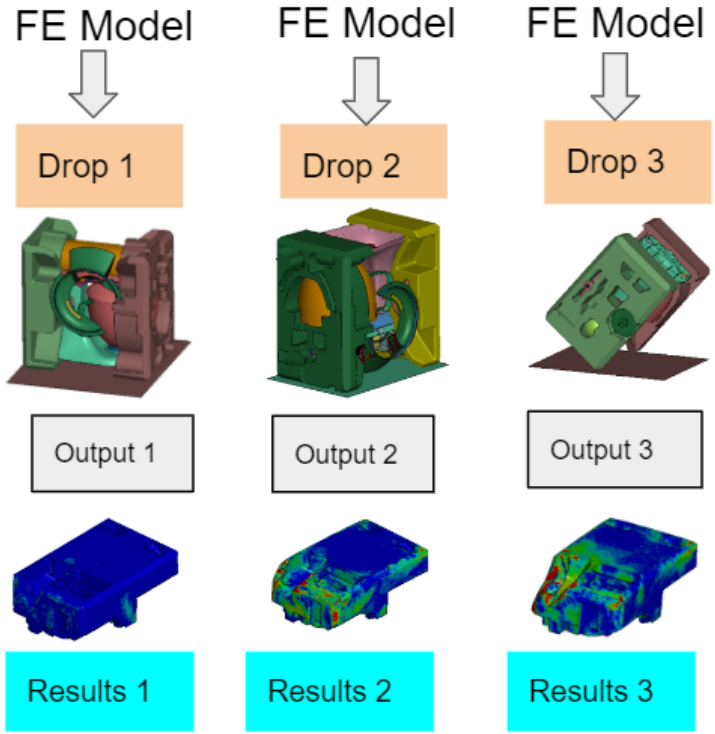


Sequence of Product Drops
(Source ISTA-6-FedEx-A)

Simulation Objective

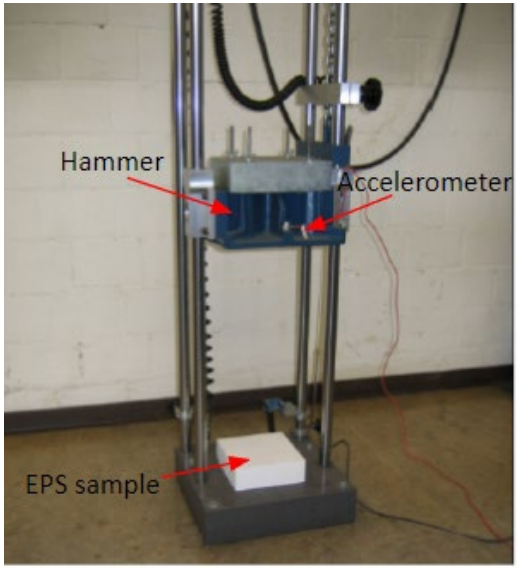
- **Simulation Objective:** Develop a methodology to replicate the cumulative effect of sequential tests in the physical world.

- **Current approach limitations**
  - Virgin FE models for each drop
  - No residuals stress/strains carried forward
  - Error during manual intervention
  - Time consuming process
  - Missing probable critical failure modes



Current Approach

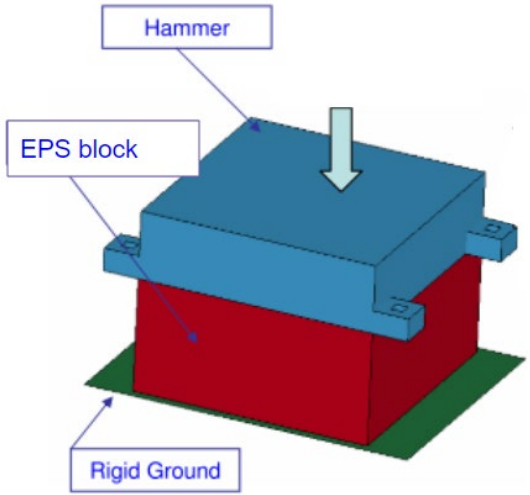
Experimental Work : Block Analogy



Before drop

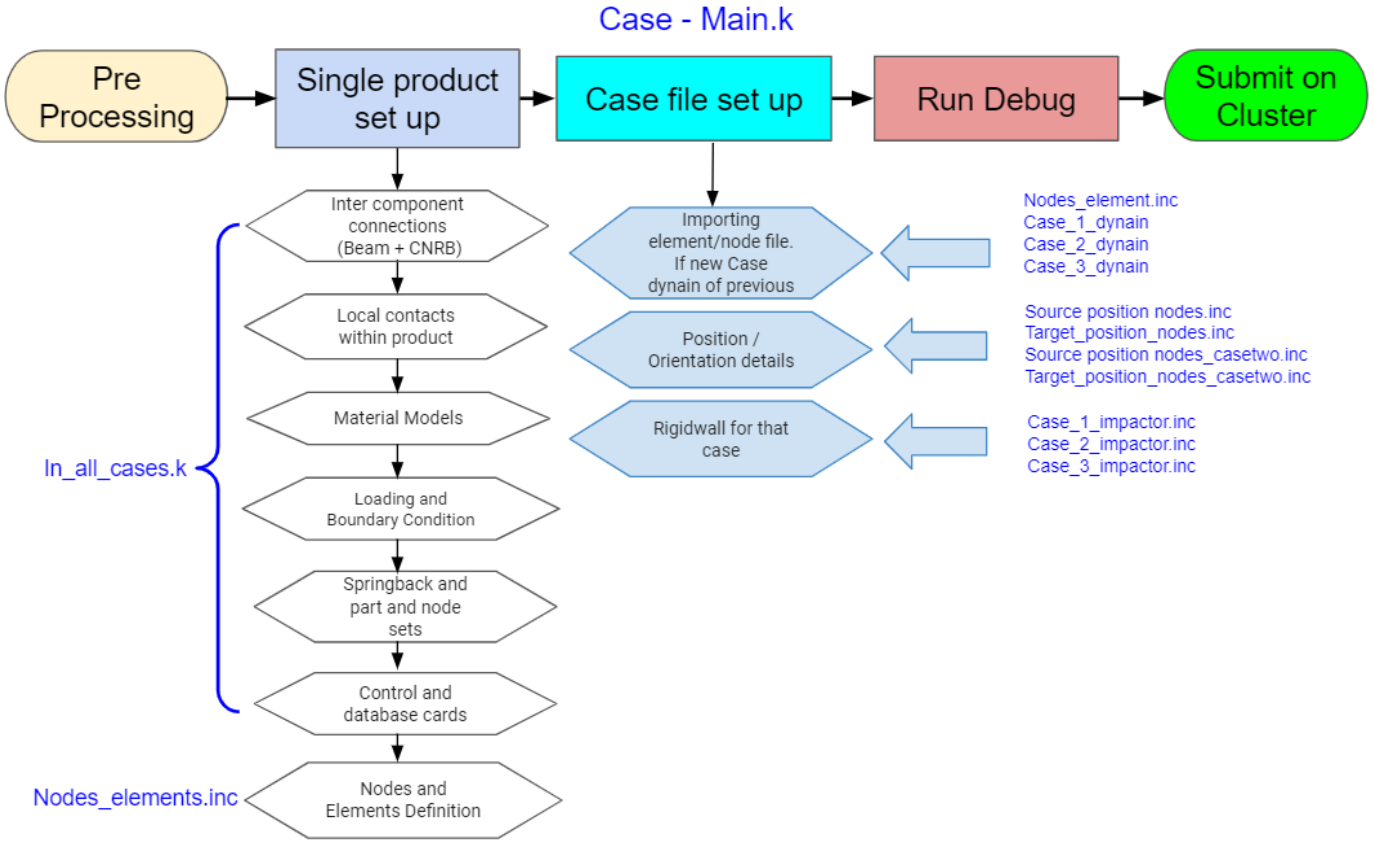
After drop

Experimental Setup



FEA Setup

Methodology : Flowchart



Flow Chart for 3 drop Sequence Loading

Methodology : Script Overview

```
*KEYWORD
*INCLUDE
In_all_Cases.inc
$
$----------------------< CASE-(ONE)-BEGINS-HERE >-----------------------|
*CASE_BEGIN_1
$
*INCLUDE
Case_1_Nodes_Elems.inc
*INCLUDE
Case_1_impactor.inc
$
*CASE_END_1
$----------------------< CASE-(ONE)-ENDS-HERE >-------------------------|
$
$----------------------< CASE-(TWO)-BEGINS-HERE >-----------------------|
*CASE_BEGIN_2
*INCLUDE
Case_2_impactor.inc
*INCLUDE
case1.dynain
*DEFINE_TRANSFORMATION
$:    label
          1
$:  option        a0        a1        a2        a3        a4        a5
POS6N       10000101  10000102  10000103  20000101  20000102  20000103
*NODE_TRANSFORM
$:    trsid      nsid
          1         9
*CASE_END_2
$----------------------< CASE-(TWO)-ENDS-HERE >-------------------------|
$
$--------------------< CASE-(THREE)-BEGINS-HERE >---------------------|
*CASE_BEGIN_3
*INCLUDE
Case_3_impactor.inc
*INCLUDE
case2.dynain
*INCLUDE
Source-Position-Nodes-new.inc
*CASE_END_3
$----------------------< CASE-(THREE)-ENDS-HERE >-----------------------|
*END
```

Common Includes

First Drop - Setup

Case 1 output is input to Case 2

Second Drop - Setup

Case2 output is input to Case3

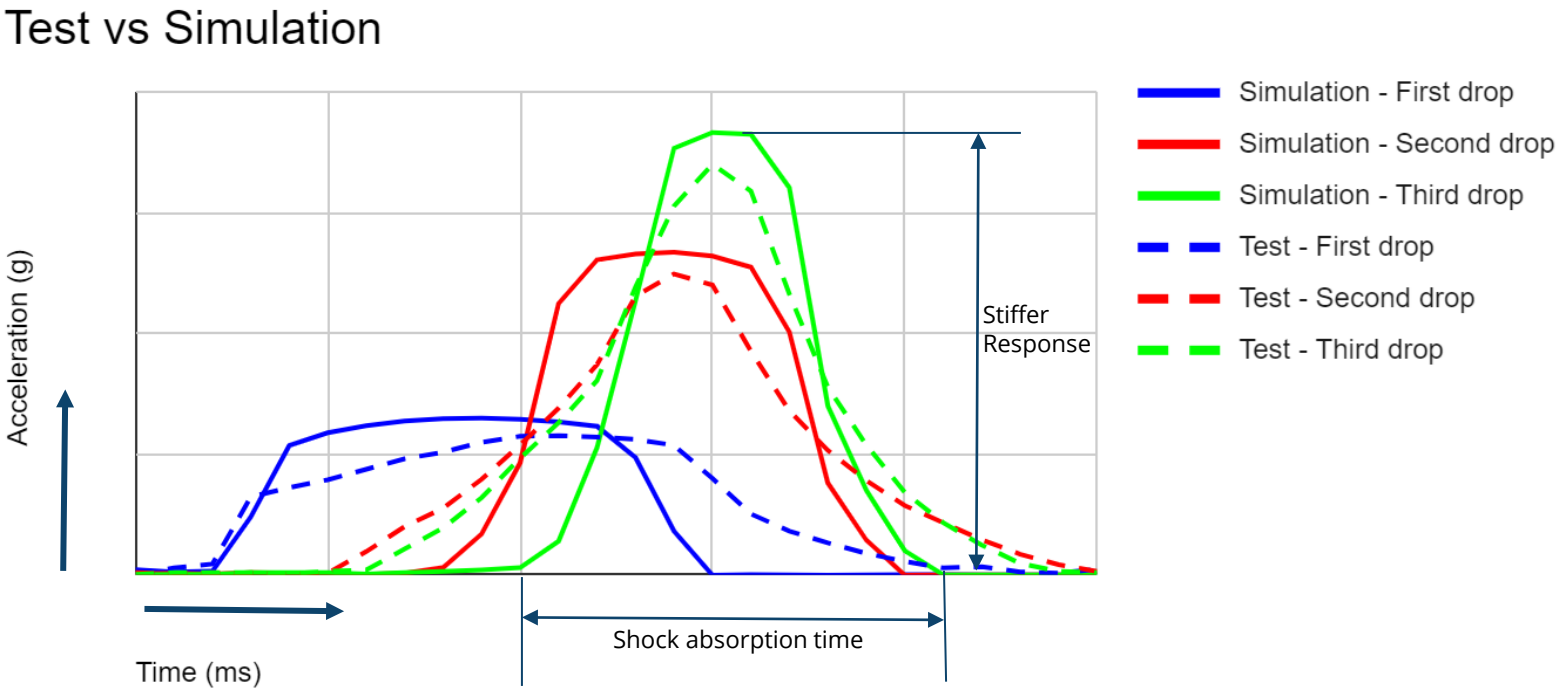
Third Drop - Setup

Final Cumulative Output

Main Master Include

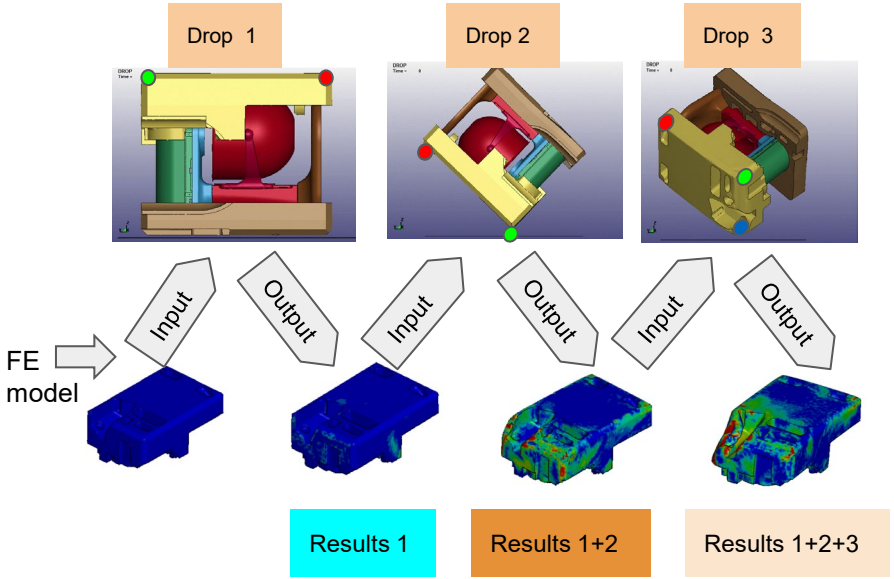
Script for 3 drop Sequence Loading

Correlation : Block Analogy

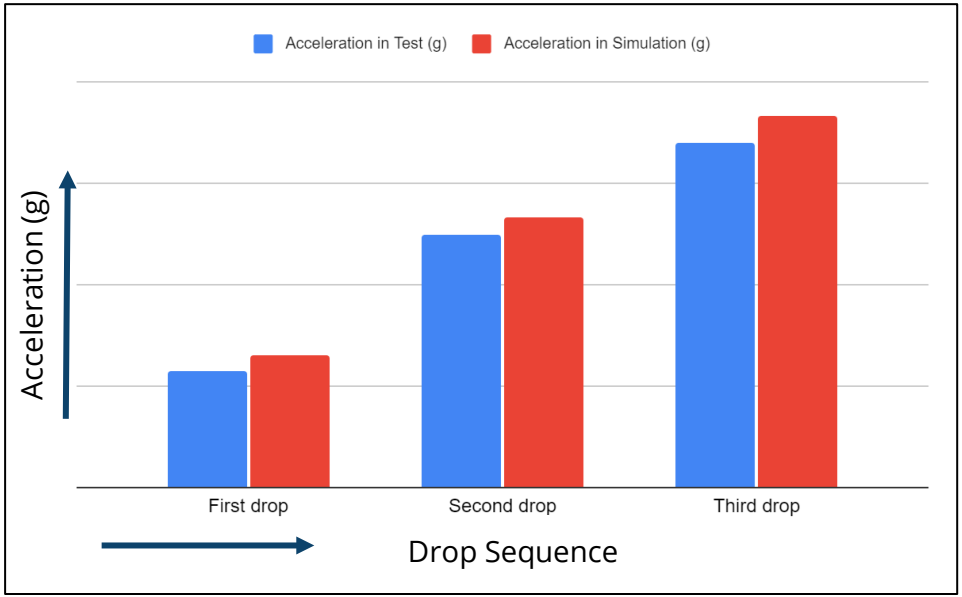


Graph: Block Test Acceleration Vs Time

Correlation : Full System



***Case file Approach**



Bar chart: Comparison Peak Accelerations

Conclusions and Future Scope

❑ Conclusions

- ❑ Case File Approach shows a strong correlation at component level
- ❑ Leveraged methodology to product level and replicated the behavior as in tests
- ❑ Avoided manual intervention and speed up the virtual process

❑ Future Scope

- ❑ Correlation studies on damages and failures of the structural and packaging components
- ❑ Leverage to repeated loading problems such as Door Slam, Impact problems, etc.
- ❑ Eliminate physical transit tests in Concept and Design Validation phases

Benefits to Organisation

- ❑ Improved virtual capability to replicate sequential tests
- ❑ Enables to drive Virtual Product Development
- ❑ Significant savings on prototypes and testing
- ❑ Predict the failures in advance and avoid the costly late design changes
- ❑ Quick turnaround in simulation report preparation
- ❑ Reduce the design development time
- ❑ Significant cost avoidance of service and repair costs
- ❑ Robust inventory management and warehouse utilization

References

1. Head Impact Evaluation onto Conventional Tempered Glass and Laminated Glass, N. Gupta, VJIT, Hyderabad, 2010.
2. Surrogate Crash Test Vehicle for Impacts with Roadside Objects: FHWA/ NHTSA National Crash Analysis Center, E. Azim, M. Dhafer, B. Nabih, 1997.
3. ASTM D -1621,Standard Test Method for Compressive Properties.

Thank You !

JOIN THE CONVERSATION

@WhirlpoolCorp #WhatMatters
LinkedIn.com/company/Whirlpool-Corporation
WhirlpoolCorp.com