Sequential Drop Analysis - Front Loader Washing Machine

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05/06/2014
About IFB

IFB AUTOMOTIVE
- Seating Systems
- Door Systems
- Motors
- Latches

IFB INDUSTRIES
- Fine Blanking Tools
- Fine Blanking Components

IFB HOME APPLIANCES
- Washing machine
- Refrigerator
- Dryer
- Air conditions
- Micro-wave
- Dish washer

IFB AGRO
- Packed Sea Food
- Country spirit

Overall Turn over in Crore: Rs.3000 Crores
IFB Test Facilities at IFB Goa(1)

Environmental Test Rooms
EMI/EMC testing Lab
Safety Test Lab

Mechanical Testing Lab
IFB Test Facilities at IFB Goa(2)

Semi Anechoic Chamber

Vibration Shaker Test

Bevel Hitting

Side Clamping test

Compressive Resist test

Drop test

Investment in Test Lab (Only Applinace): ~ Rs.20 Crores
Objective

The objectives of the Sequential Drop Analysis is to ensure that the product is safe in Drop test and perform without any malfunction, by predicting the failure and solving the same in design phase itself.
Product Description

Front Load washing machine is also called Horizontal axis washing machine. Front load washing machine contains Drum & tub assembly which are suspended on Springs and Dampers.
Product Specification

Following Test/FE analysis are conducted on Front Load Washing Machine.
Foam Material Testing at IFB

Quasi-static Compression Test results

[Images of test setup and graphs showing force vs. displacement and stress-strain curve]
Virtual Validation of Foam Material

Foam Compression Test

Material Parameters Calibrations

Simplified Drop Test

High Speed Camera
Finite Element Mesh Model

**Number of elements:**

- 2D elements: 504033
- 3D elements: 175534
- 1D/0D elements: 210
**Initial Velocity:**

In order to reduce the solution time, Initial velocity is applied to the model with reduced drop height.

**Gravity:**

Simulation is done under gravitational acceleration of 9810 mm/sec$^2$.

**Rigid wall:**
Considering the floor as rigid.
Sequential Drop test
Analysis Results

Results are captured in form of Stress/Strain for all the drop sequences.
Correlation study

Cabinet Deformation

EPS Foam Failure
Conclusion

- FE Results are well correlated with physical test results.

- The Designers should be able to create a Robust Design by considering the correlation report and shall ensure the Time-to-Market target.
IFB CAE Capabilities

**FE Simulation**
1. Linear Static, Quasi-Static & Non-linear Static Analysis
2. Crashworthiness & Safety
3. Sequential Drop Analysis
4. Fatigue & Fracture Analysis
5. Buckling Analysis

**CFD Simulation**
1. Fluid Flow Simulation
2. Multiphase Flow Simulation
3. Thermal Analysis
4. Rotating (Domain) Simulation

**NVH Simulation**
1. Vibration Analysis (All Types)
2. Noise Analysis (All Types)
3. Harshness Analysis

**Manufacturing Simulation**
1. Mold Flow Analysis (Plastic)
2. Sheet Metal Stamping & Spring-back Simulation
3. Fine Blanking Tool Simulation

**Optimization**
1. Topology (Space & Size)
2. Topography (Geometry)
3. Geometry & Size

**MBD Simulation (Rigid & Flexible)**
1. Kinematic Simulation
2. Dynamic Simulation
Fine Blank & Conventional Blank

Fine Blanking: Characterization of the process
Difference between Shearing and Fine Blanking

- **Shearing**
  - $F_S$ – punch force
  - 1 – cutting die
  - 2 – guiding plate
  - 3 – punch

- **Fine Blanking**
  - $F_S$ – punch force
  - $F_R$ – vee ring and blank holder force
  - $F_G$ – counter punch force
  - 1 – cutting die
  - 2 – vee ring and blank holder
  - 3 – punch
  - 4 – counter punch

*Die clearance*
- 5% for shearing
- 0.5% for fine blanking
## Optimization of Design

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Alternative Raw Material</td>
</tr>
<tr>
<td>2</td>
<td>Change of Tolerance in RM Thickness - if possible</td>
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<tr>
<td>3</td>
<td>Reduction in Thickness of the Part</td>
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<tr>
<td>4</td>
<td>Size reduction using software (FormingSuite, etc.)</td>
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<tr>
<td>5</td>
<td>Shape (Geometry) Change - if possible</td>
</tr>
<tr>
<td>6</td>
<td>Part Commonization</td>
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<td>7</td>
<td>Part Count Reduction</td>
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<td>8</td>
<td>Weight Reduction</td>
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<td>Yield Improvement</td>
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<tr>
<td>10</td>
<td>Benchmarking</td>
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</tbody>
</table>

**Option - 1**: Topology Optimization: Generates an optimized material distribution for a set of loads and constraints within a given design space / size.

**Option - 2**: Topography Optimization: Generates an optimized distribution of shape based reinforcements.

**Option - 3**: Shape & Size Optimization: General size and shape optimization problems can be solved. Variables can be assigned to properties, which control the thickness, area, moments of inertia, stiffness, and non-structural mass of elements in the model.
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Thank You