FEA ANALYSIS OF PUMPKIN BALL IMPACT ON CONSOLE

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Abstract : ***Console of washing machine is one of the main important part of the machine that provides an interaction bridge between the human and the machine by human machine interface The console design should be such that it should be robust enough to pass the standard safety test during new product development. Ball impact is one of the test to check the robustness by impacting it on the console part at various locations. The ball is 25 cm in diameter and weighs about 10.5 kg after it is filled with sand to 75 percent of its volume. The main objective is to simulate the impact behaviour and correlate using the experimentation. The simulation is been done using the LS-Dyna and Hypermesh software and discrete elements are used inside the ball to replicate the sand particles. The experiment was performed on actual model and acceleration results are very close to that of simulation.***

Index Terms - Console, Pumpkin ball, Hypermesh, LS- Dyna, Accelerometer.

I. INTRODUCTION

The console is the part that creates an interaction bridge between human and machine. The Console assembly comprises of the HMI (Human machine interface) and the console shell. The Console shell is the part on which the HMI part gets mounted. The HMI (Human machine Interface) comprises of the all the electronic part which include LED bulbs, button, PCB etc.

The console of the washing machine is one of the important part when considering the safety of the user as it contains lot of electronics part and its breakage could result in safety issue which is given highest priority when designing any product. So, every console design made has to pass certain UL tests without which the product cannot be launched in market [1].

Out of many safety test performed on the console, one of the most important test is the ball impact test. The ball is actually a basketball filled with sand upto 1/3rd of it volume and impacted on the console. The test very much resembles with the pendulum impact test but the only difference between the two is that the pumpkin ball is deformable during the impact which makes it more dynamic and hard to study.

The need to perform the ball impact test on the console can be understood by an instance where there is a major impact on the console directly due to any unknown reason. So, the full impact can damage the console. The major concern is the access to the live wire after the damage.

The main objective of this paper was to correlate the simulation with the experimentation. During the new product development when a console is been designed, the only way to check whether the product would pass the UL standard safety test during the design stage is by simulation. So, the only way to understand the accuracy of simulation is to study the behaviour of the console when impacted with the ball and compare it with the actual experiment with the help of accelerometer.

II. LITERATURE REVIEW

Wherever S. Sridhar and Sushilkumar Vishwakarma worked on modeling the behaviour of dry sand with DEM for improved impact prediction with an objective to create a standard simulation model that would capture the behaviour of ball filled with sand particle when impacted on the concrete wall and validate it with the experimental model. The simulation results showed a close proximity with experimental results [2]. Hamidreza mahmoudi worked on the Modeling of Bonnet in LS-DYNA for Pedestrian Research with an attempt to come up with a finite element model for analysis of pedestrian kinematics with the help of LS Dyna and hypermesh software. The peak acceleration and the impact duration were used for the comparison with the experiment [3]. Edwin Fasanella and Karen Jackson worked on the describing the best practices for modeling aircraft impact using explicit nonlinear dynamic finite element codes such as LS- Dyna. In crash analysis, the most concern point is the magnitude and the duration of peak acceleration. Experimental data analysis, digital filtering is also discussed [4]. The report by SMP Svensk on requirement and test methods for impact from swing element for which the accelerometer is used during the experiment and results are compared in g units [5]. The Frank, Stefan and Marika worked on the material models for polymers under Crash loads giving an overview on existing material models for thermoplastic applicable on shell elements in LS-Dyna as there are still challenges in existing numerical tools for crash simulation [6].

III. EXPERIMENTATION

The pumpkin ball impact test setup had a ball filled with sand to its 3/4th of its volume and hook attached to the top of the ball using the tapes. The vertical height from the hinge point is 39.2”. Some counter weights were kept at the back of the pumpkin ball setup to avoid any misbalance during the swing motion of the ball. The Pumpkin ball’s height and location was adjusted such that the ball impact at the centre of the knob. The weight of the ball is about 10.5 kg. Two triaxial accelerometer were used to measure the acceleration on the console and pumpkin ball.

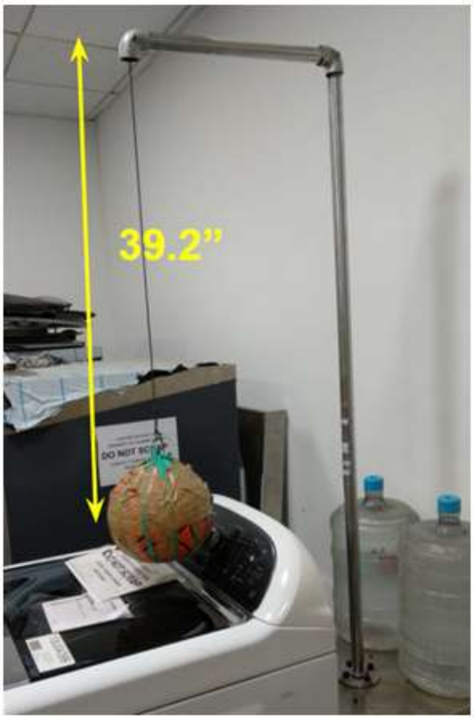

Fig.1: Experimental setup

3.1 Procedure

1. Secure the unit to avoid the movement along the floor or angular movement caused by the impact.
2. Secure the pumpkin ball to designated eye bolt location in lab which is 39.2" above the impact point.
3. Pull back the pumpkin ball to the calculated distance from the point of impact to the encoder, targeting the knob's centreline.
4. The ball will be hold immediately after the impact

3.2 Equipment

1. Washing machine
2. Pumpkin ball setup
3. Tool kit
4. DAQ setup
5. Measuring tape
6. Counter weights

Two accelerometers were used during the testing. One was attached to the console 76 mm away from the impact point and another was placed exactly behind the impact point of ball. The impact is maximum along the z direction which is normal to impact. The reading was taken for the horizontal distances of 5", 10" and 15".

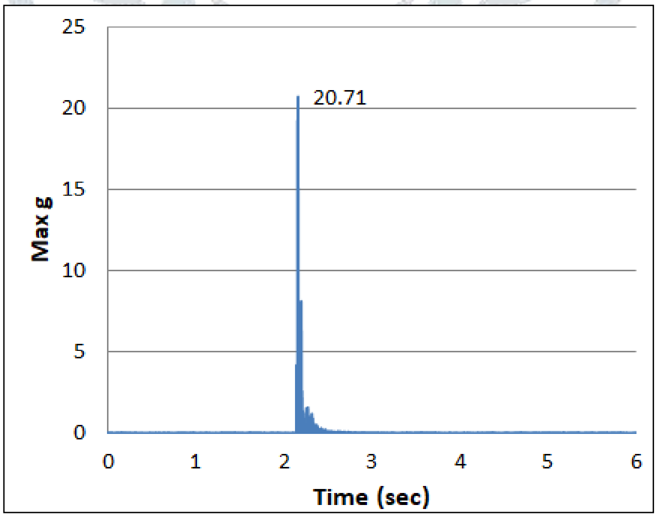

Fig.2: Acceleration plot

The Figure 2 shows the acceleration curve for the single run on the console.

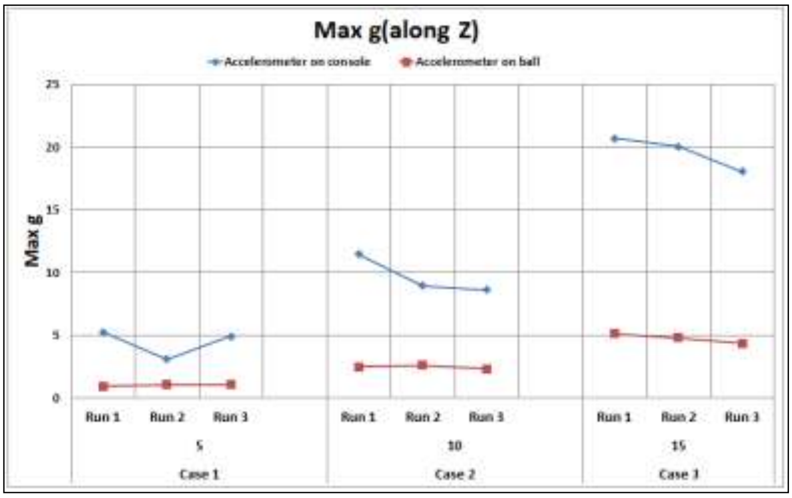

Fig. 3 : Experimental results

The Figure 3 shows the peak acceleration value of ball and console during each run. The maximum horizontal distance i.e. 15” is taken for correlation purpose.

IV. SIMULATION

The main target of the simulation is to check whether the stresses for Console are within allowable limit and there should not be any snap disengagement between Console and Fascia while ball impact. The simulation is been done using the LS- Dyna and hypermesh software and discrete elements are used inside the ball to replicate the sand particles.

4.1 Assumptions

1. Screw connections modeled using Rigid and Beam elements.

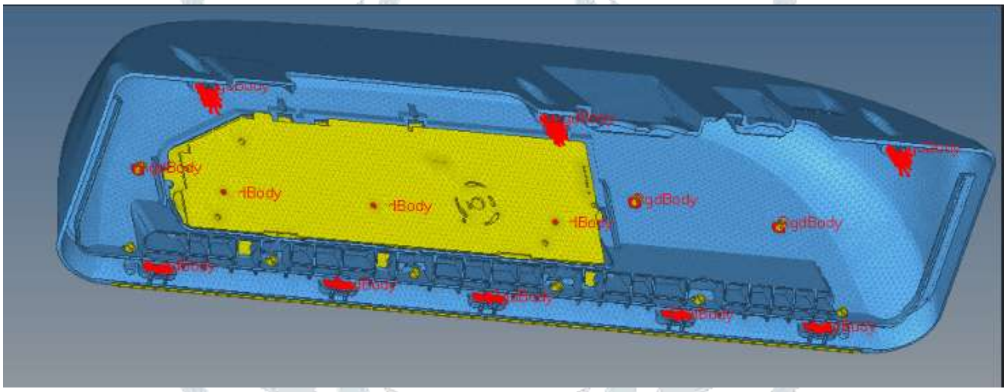

Fig. 4: Rigid connections

2. Plastic parts (console) modeled by tetrahedron elements
3. Sheet metal (Top panel) is modeled by shell elements.
4. Pumpkin ball of 500mm dia is used for simulation
5. Material properties assigned for ambient 23C (ambient temperature) condition. Temperature effects not included in simulation

4.2 Loading and Boundary condition

- Initial Velocity in Z-Direction is applied on the ball which would give the same impact energy.

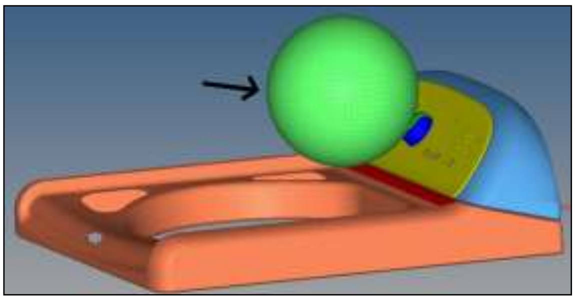

Fig. 5: Boundary condition

- 1G gravity load is applied on the complete model in Y-direction.
- Bottom face of the Top Panel is constrained in all DOF.

Dry sand particles are modeled using the discrete element method (DEM) technique and shell element is used to model rubber ball. [7]

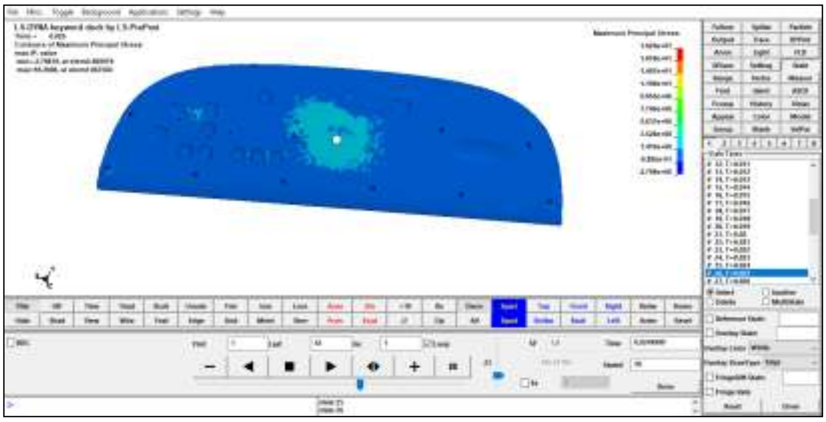

Fig. 6: LS Prepost

The LS- Prepost software is used for the post processing. Maximum stress levels during each run are within the allowable limit of the material and did not observe any risk in the assembly and snap disengagement in all load cases.

V. VALIDATION AND CONCLUSION

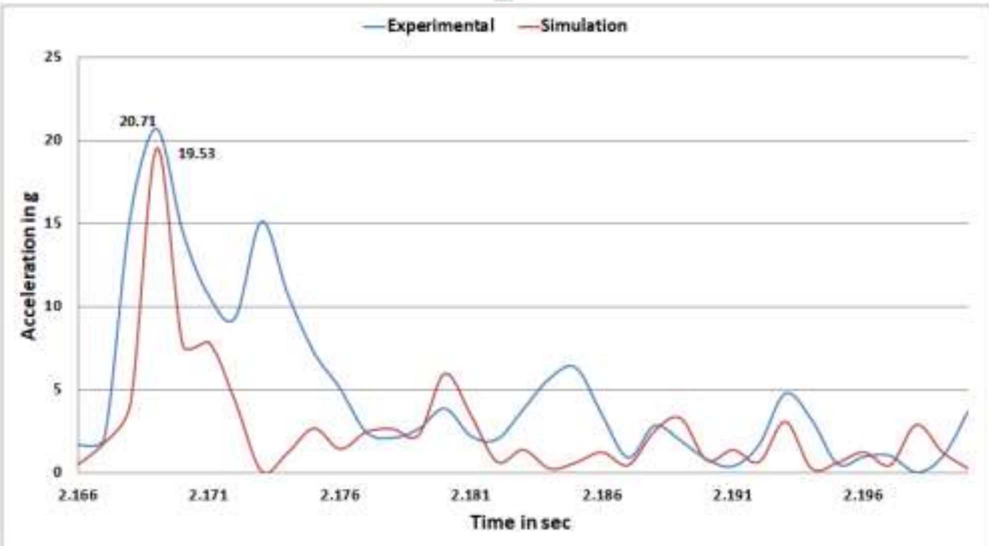

Fig.7: Acceleration plot

Since the correlation of the simulation was done by performing the experimentation on the same model, acceleration values for both the simulation and experimentation were being compared. The maximum acceleration value obtained in experimentation was 20.71g and in simulation 19.53g. The error between the simulation and experimentation maximum g value is of 5.69% which within the acceptable limit. Thus, results obtained from LS- Dyna presents a good correlation with the experimental test. This gives a forward step to the simulation process to approve the design at its early stage only.

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