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DISTROTION OF LID SIMULATION IN WASHING MACHINE

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ABSTRACT

In this paper, the developmental history and existing shortcomings of washing machine lids have been briefly described, the operating principle of the current washing machines lids has been analysed with reference to user requirements and the direction of industry development have been found out were the ABS lid material was introduced in washing machines which has been studied out through adoption w.r.t behaviour of glass lid structure, as well as high-efficiency lid materials and innovated the new design concept for ABS lids for washing machine. Thereby the problems with existing glass lid of washing machines such as breakage, slippage, crack formation and long washing time were solved in LG Model T8561AFET5.

Keywords: Lid impact / Washing machine / Lid / Glass / ABS materials.

I. INTRODUCTION

Acrylonitrile butadiene styrene (ABS) (chemical formula $(C_8H_8)_x\cdot(C_4H_6)_y\cdot(C_3H_3N)_z$ is a common thermoplastic polymer. Its glass transition temperature is approximately 105 °C (221 °F) .[2]. ABS is amorphous and therefore has no true melting point. The most important mechanical properties of ABS are impact resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. The impact resistance can be amplified by increasing the proportions of polybutadiene in relation to styrene and also acrylonitrile, although this causes changes in other properties. Impact resistance does not fall off rapidly at lower temperatures. Stability under load is excellent with limited loads. Thus, by changing the proportions of its components, ABS can be prepared in different grades. Two major categories could be ABS for extrusion and ABS for injection molding, then high and medium impact resistance. Generally ABS would have useful characteristics within a temperature range from −20 to 80 °C (−4 to 176 °F) .[3]. The final properties will be influenced to some extent by the conditions under which the material is processed to the final product. For example, molding at a high temperature improves the gloss and heat resistance of the product whereas the highest impact resistance and strength are obtained by molding at low temperature. The aging characteristics of the polymers are largely influenced by the polybutadiene content, and it is normal to include antioxidants in the composition. Other factors include exposure to ultraviolet radiation, for which additives are also available to protect against.

II. LITERATURE SURVEY

Enormous literature is available regarding the simulation of washing machine in distribution environment, packaging and clamp truck in the research papers and conference proceedings. Out of these a few noteworthy works are squeezed and briefly presented here.

Lu Peishi, Yang Lin [1] In this paper, the development history and existing shortcomings of washing machines have been briefly described, the operating principle of the current washing machines has been analysed, user requirements and the direction of industry development have been found out, and the even-drive washing technology has been studied out through adoption of hyperbolic impeller and suspended inner barrel structure, as well as high-efficiency drive and innovated control design. **David VanZoest** [2] A simulated washing machine with an integrated appliance control panel and intra-appliance Local Interconnect Network (LIN) bus capability has been designed and demonstrated. The control panel allows the integration of push-button and rotary controls into thin, low profile assembly with superior graphics and electrical circuit design flexibility. LIN is used as an intra-appliance network to replace bulky wire harnesses, improve manufacturability and reliability, and reduce costs. Only three wires are necessary for communication inside of the appliance. Appliance manufacturers must balance functionality, implementation cost, manufacturability and flexibility. This balance changes every generation and trends toward increased flexibility and improved communication. **Rajesh Kumar Garg, Vikram Singh** [3] This paper describes the use of simulation concept in scheduling of washing activities of a washing machine (dual tub)-an embedded system .The embedded systems contain programmed instruction running via processor chips. Embedded systems are programmable devices or systems which are generally used to control or monitor the devices. Simulation is used to observe the dynamic behaviour of model of a real or imaginary system. Indeed, by simulating the complex system we are able to understand its behaviour at low cost. Critical activities for washing process of dual tub washing machine are as obtained as output from simulator. Any failure in them will result in failure of washing process of washing machine. Experts must be employed for scheduling critical activities. In this way, the designed simulator will help in scheduling of washing activities of washing process of dual tub washing machine without practical implementation**. Sanjay Mohite, Narayan Pisharoty** [4] In this paper, multimode matrix converter is used to universal motor speed control system developed for proposed washing machine. Output voltage is synthesized by SPWM technique. In washing machines, the use of Induction motors wastes energy. To achieve speeds like tumbling operations at low speed and say drying at a spin cycle at a high speed, one needs to use a universal motor. Switching the voltage for achieving different speeds is again wasteful, so some companies have introduced 'variable frequency' drives. The simulation model on Multimode Matrix Converter for washing machine using MATLAB/Simulink Software Package has been presented. The Results are presented for both loads of operation. The multimode matrix converter topology for multiple AC-AC conversion using the single circuit has presented with SPWM strategy to synthesize the multiple AC output for a given AC input . The simulated Results are confirming the proposed methodology. **Doktor der Ernährungs and Haushaltswissenschaft** [5] Two opposing trends are observed in Europe: an increase in the washing machines' rated capacity and a decrease of the household size (hence a decrease of laundry that has to be washed). The basis for the virtual washing machine is the data gained by testing nine washing machines of different rated capacity (5 *kg*, 6 *kg*, 7 *kg*, 8 *kg* and 11 *kg*). All tests are conducted in accordance with EN60456:2005, with some modifications regarding the washing temperatures, load size and detergent dosage. Based on the data of different washing machines, a model of a virtual washing machine was developed and, despite the large differences among the tested washing machines, it shows a robust predicting power. The developed virtual washing household model offers a high range of possibility to simulate some of the consumers' behavioural patterns. Its dynamic development of the laundry stock course and possibility to vary household and washing machine parameters makes this model more advanced in comparison to the modeling solutions described in the literature. **International Standard IES 60335-2-7** [6] Household and similar electrical appliances – Safety Particular requirements for washing machines The International Electro technical Commission[1] (in French: Commission électrotechniue international) is a non-profit, non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies – collectively known as "electro technology". IEC standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology and marine energy as well as many others.

III. SIMULATION AND RESULTS

Simulation is the processes of product validation were the product is tested with defined boundary conditions and assumed parameters. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviours/functions of the selected physical system. The model represents the system itself, whereas the simulation represents the operation of the system over time. In this project we are implementing the composite materials for the lid in washing machines i.e., Glass and ABS materials were we are simulating the behaviour and strength of the lid in impact simulation.

3.1. Boundary Condition

Model was setup for two product clamping simulation as shown in the figure 3.1 which consists of cabinet top assembly of top load washing machine of 76kg.

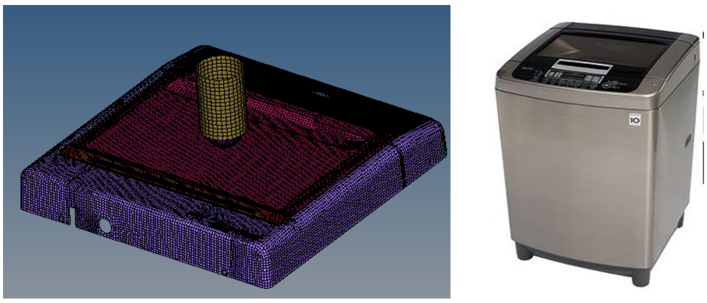

Figure 3.1: Boundary Condition & Model LG T8561AFET5

In the model setup, the velocity rate of 1400 mm/sec is given to impactor in global Y-direction and the Base frames are constrained to move in X, Y and Z direction. The time taken to reach the standard force is measured and at this time all the remaining results are plotted and measured. Some of the assumptions made in this project are as follows.

- Wash unit (Drum and motor assembly) has not considered as it has no influence on lid impact simulation.

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- Simulation is done only for loading condition was stress and deformations plotted are only for loaded condition.
- High Stresses near the sharp corner and bolt holes are neglected due to stress concentration effects.

3.2 Load Case

Simulation is performed to know the behaviour of top & lid assembly under impact of 20 kg impactor from 100 mm height for preliminary design concepts with glass lid assembly.

Option 1: Glass Lid.

Option 2: ABS Lid.

3.2.1 Counter Plots

- **Lid**

From the figure 3.2, we observe the maximum Von Mises stress of 47.54 Mpa in Option 1 and 46.58 Mpa in Option 2. The stress and strain are measured at max internal energy.

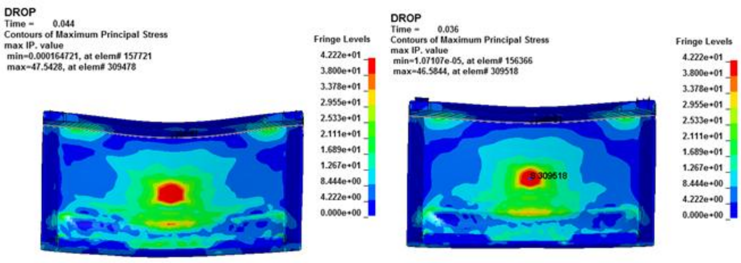

Figure 3.2: Option 1 & Option 2: Von Misses Stress

- **Base Frame**

From the figure 3.3, we observe the maximum Von Mises stress of 47.76 Mpa in Option 1 and 43.77 Mpa in Option 2. The stress and strain are measured at max internal energy.

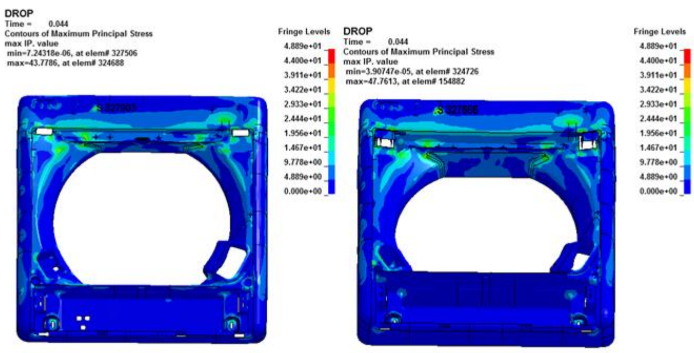

Figure 3.3: Base Frame Von Misses Stress

3.3 Summary of Results and Discussion

In this section we will discuss and compare the results such of contour plots of individual parts, obtained from the lid impact load cases.

- **Load Case**

  Option 1: Glass Lid.

  Option 2: ABS Glass Lid.

Table 3.1: Summary of Contour Plots

Option 1 & Option 2 (Flat Lid Assembly)					
		Lid	Base Frame	Hinge	Hinge Pin
Yield Strength (Mpa)		38	47.76	85	68
Principal Stress (Mpa)	Option 1	47.5	43.77	57.0	62.9
	Option 2	46.58	43.77	48.8	66.41
Threshold Strain (%)		2%	2%	2%	2%
Strain (%)	Option 1	2.8	1.9	2.6	2.6
	Option 2	1.3	1.1	2.4 (Localized)	5.0 (Localized)

Observations:

1. Decrease in strain by 47% in Option 2 to that of Option 1 model
2. High stress is observed on Lid for both the models but in Option 2 the stresses are neglected as their strain percentage is low which will shows it is in elastic region only.
3. No major risk is observed on top panel in both models.
4. High strain is observed on hinge and hinge pin at their assembly location.
5. Slippage of Lid at front side is observed due to less contact region between lid and top panel in Option 1 model.
6. No Slippage of Lid at front side is observed in Option 2 model.

IV. EXPERIMENTAL DETAILS

4.1 Experimental Setup

Figure 4.1 Experimental Setup

4.2 Displacement in Lid

The experimental test was conducted for both the cases i.e. ABS tinted glass and ABS tinted glass with extended base frame materials and their results of displacement is plotted as shown in figure 4.2 and 4.3.

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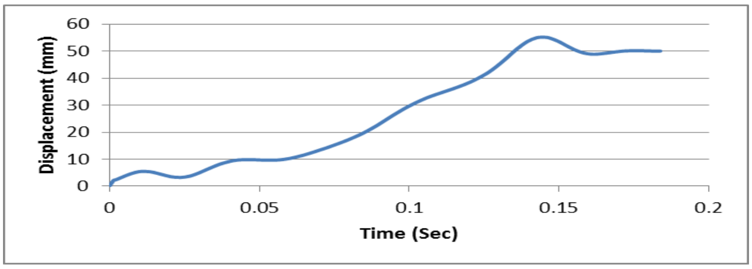

Figure 4.2: Experimental Displacement Plot for Glass Material

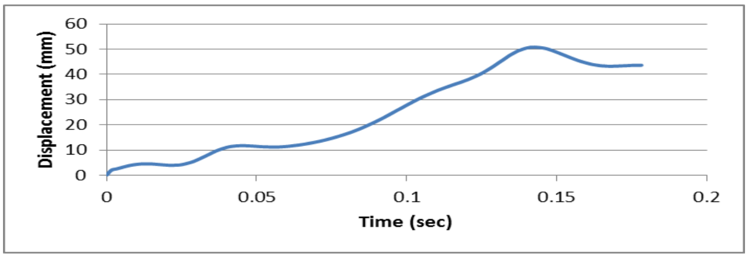

Figure 4.3: Experimental Displacement Plot for ABS Material

4.3 Simulation Test Data

Following figure 4.4 shows the displacement plot for the Load Case models i.e., (Glass Lid & ABS Lid) from the graph max displacement in option 1 model is 52.25 mm and max displacement in option 2 models is 48mm.

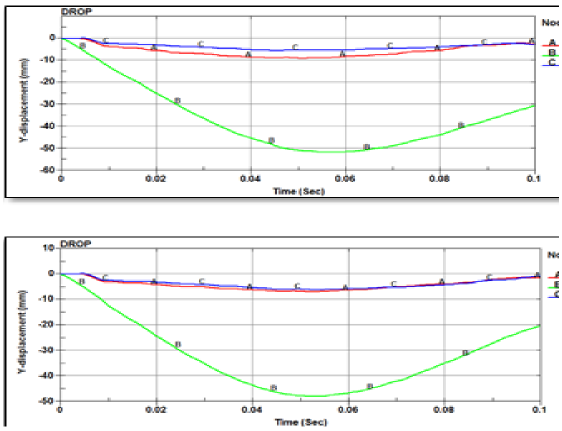

Figure 4.4: Displacement Plots (a) Option 1 (b) Option 2

V. COMPARISON OF EXPERIMENTAL AND SIMULATION RESULTS:

The table 5.1 shows the section forces of experimental and simulation at particular time steps.

Table 5.1: Displacement Plot Comparison

Model	Displacement (mm)		Error %
	Experimental	Simulation	
ABS Glass	54.50	52.25	4.2
ABS Glass (Modified Thickness)	51	48	5.8

VI. CONCLUSION

From the experiments conducted, the following conclusions were made

- There is considerable reduction in strain parameter is seen by 47% in Option 2 to that of Option 1 model in load case 2 .
- High stress is observed in Lid for both the models, stresses are neglected as their strain percentage is low which will shows it is in its elastic region only.
- High strain is observed on hinge and hinge pin at their assembly location but which are to be found safe as the strains are in localized regions only.
- Glass lid thk 4mm maximum stress on glass is 163 Mpa whereas in for 3.2 glass thk we are getting maximum stress of 181 Mpa assuming failure limit as 180 Mpa. 3.2 mm thk glass would fail while 4 mm glass thk will pass but in presence of crack marks on the top of the lid.
- The displacement plot tell from the graph max displacement in option 1 model is 52.25 mm and max displacement in option 2 model is 48mm.

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