Design of a Vehicle Door Structure Based on Finite Element Method

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Abstract: Finite element analysis is the key issue in determining the strength of a material. The door of a car was analysed in this research and von Mises was used to determine the weakest points where failure might occur. Red zones show the weakest points and green areas are safe and can last for long. The hinges where maximum force is applied are affected as well and where heat is more fail more as well. Solid works was the software used in research.

Keywords: Vehicle Door, Strength, Modal characteristic, Finite Element Method, Structure, Stiffness, Anti-extrusion.

I. INTRODUCTION

Door assembly is a very important part of vehicle design. Performance as stiffness, strength and modal state of door structure shall be taken into consideration of door design, meanwhile, there is also a homologation requirement for door’s anti extrusion aspect. This article is focused on researching the application on finite element analysis method during door assembly development, and elaborates how to evaluate door assembly from each aspect by using commanding finite element scrutiny software and improves the structures to have a new design proposal which meets all design targets. A common 3-D nonlinear vibrant overt finite element (FE) code with cutting-edge interaction algorithms and physical mock-ups was efficaciously used to mimic several types of armours exposed in the direction of the effect of missiles poignant at numerous speeds.

The author Augusto Cesar worked out this idea with 6-Sigma apparatuses to improve an investigational model that defines the arrangement and he concentrated that the shaking experiential at the highest of hindmost door throughout normal original operation, instigating the brand of a brittle arrangement. Tuncer N, 2001; constructed an assessment structure to copy the automobile door in addition to the body and obtained the normal frequencies of the construction done in an experiment with and without stoppers lying amongst the binary frames. The researchers in this study, came up with a methodology in the design of vehicle door.

The vehicle door model is established by hyper mesh. Then it is imported into Nastran for defining the boundary condition. Because of this reason, a determinate element archetypal of the vehicle door is assembled and the component coefficients of the prototype are resolute through the designed toolbox in Nastran. Nastran101 are used in linear static issues and Nastran103 for structural mode. Finally, the FEM model is solved by Ls dyna after defining the boundary condition.

II. AIM

The purpose of research is to forecast the recital of the door structured by commanding fixed element investigation using Solidworks, and improve the construction to encounter the intention targets.

A. OBJECTIVES

1. Designing of the vehicle door structure by the use of drawing software e.g. AutoCAD

2. Analyse the door and see if the areas under study are affected by force application.

III. LITERATURE SURVEY

Lately in technology, it has been identified that there are two methods in plummeting vehicle weightiness. The first one is by means of material way agiler than steel and the second one is by reformatting the steel organisation (Sandeep and Bindu, 1999). Although the former seems very effective, it is very expensive and not biodegradable. This is currently use in countries like Sri Lanka and modification in the machined parts is important for long last.

2) The second solution as well is to integrate parts as a method. In the integration method, the part is stamped out of a single blank. This lessens the amount of tools wanted; the assemblage cost, and excludes any suitable capability problem. Nevertheless, the proposed design engineer is enforced to work with similar grade, thickness, and corrosion resistance throughout the entire part. Since the most demanding of all these conditions must be satisfied for the entire blank, this would increase the cost and weightiness of the part significantly.

3) An explanation to the complications itemized above is the deployment of tailor-welded gaps. The tailor-welded blank is the one that is encompassed of two detached portions of area under the metal that has been welded together previous to stamping. Tailor welded blanks allow the welding of the different grades, different thickness or different corrosion coatings together in order give the properties needed in different areas, without increasing the number of tools needed to form the part and eliminating the fit ability.
concerns. They also allow a high degree of flexibility in designing parts and large blanks can be formed from much smaller sheets. The use of tailor-welded blanks would reduce the weight of the car. Having the ability to selectively place different thickness of material would result in weight reductions. An example of this used in production is the door inner panel. The only strength requirement on a door inner is in the region where the hinges attach to the panel.

3) Anticipated beltline external stiffness of door with stiff pad interiors (CAE Proposed design) is correspondent to existing front door design

IV. METHODOLOGY

In this study, the author developed a methodology in the design of vehicle door. Firstly, the vehicle door model is established by hyper mesh. Then it is imported into Nastran for defining the boundary condition. For this purpose, a finite element model of the vehicle door is constructed and the material coefficients of the model are determined through the optimisation toolbox in Nastran. Nastran101 are used in linear static issues and Nastran103 for structural mode. Finally, the FEM model is solved by Ls-dyna after defining the boundary condition. For every door configuration a number of simulations and analysis are performed.

V. DOOR STRUCTURE FINITE ELEMENT ANALYSIS

After the completion of the first version of door structure design proposal (B2), CAD data shall be firstly transferred into the data which could be capsulated by finite element mode, including mesh dispersion, material definition and boundary condition setup etc. Then analyze and calculate the first edition finite element model, including four performance targets, which are model state, static stiffness, strength, and anti-extrusion. During the pre-process process, the requirement of mesh shape is as follows: In finite element model, spot welds whose diameter is 6mm is processed by connectors in Hyper mesh which is created according to spot weld coordinates in CAD 3D model with quantity of welding layers set up and connectors of all spot welds uniformly recognized as Cweld element. Glue can be done by Area function in Connector. Eight-node element is adopted as glue element finally. The connecting element between glue and panel is RBE3. In finite element model calculated in NASTRAN, four nodes Cquad4 element is used as shell element, Cweld element is used as spot-weld. In the LS-dyna computing model, Belytschko-Tsay element type is used as shell element, Beam element is used as spot-weld.

A. Static vertical stiffness analysis

The freedom of the installation hole where one end of the upper and lower door hinge fixed with the door frame is constrained at six directions, doors vertical deformation and stress distribution is calculated under two loading case using Nastran 101 solver. Nastran is controlled by the keyword to generate *. Op 2 file which can be transferred in Hyper view to gain the stress and displacement results. Max Vomires stress of door shall be less than 0.23(σs+σb) [1] in order to guarantee the durability of door under gravity. Max Von Mises stress of door shall be less than maximum yield strength of material in order to prevent permanent deformation of door from happening with 385N loading on lock.
1) With 1g acceleration of gravity, calculate the maximum vertical displacement of the door and the stress generated on door sheet metal. See figure 3.

2) With vertical force of 385N on door lock, calculate the maximum vertical displacement of the door and the stress generated on door sheet metal, see figure 4.

B. Door torsion stiffness analysis

The freedom of the installation hole where one end of the upper and lower door hinge fixed with the door frame is constrained at six directions and centre of lock hole is constrained at Y direction. Torque M is applied to the centre hole in the door lock, and then calculates deflection angle \( \theta_1 \) and \( \theta_2 \) of highest and lowest nodes around the X-axis of the globe coordinates, the door torsion stiffness:

\[
T = \frac{2M}{(\theta_1 + \theta_2)} \text{ Nm} / ^\circ.
\]
Based on FEA result from proposal B2, strength, stiffness and modal performance all meet design requirements in this proposal. However, lateral extrusion performance is far behind the design requirement since the counterforce of rigid column hasn’t met the legal requirement (red curve is lower than target line). In consequence, door structure needs to be Revised. According to research on rigid column’s counterforce curve during the process of lateral extrusion, the original collision beam bends in the beginning of extrusion, which means stiffness of collision beam is too weak to resist the load like above. Moreover it is quite hard to improve structure stiffness of interior and exterior door panel. For these reasons, the key point of optimizing door structure is to design a new collision beam structure with Better stiffness under the condition of guaranteeing manufacture and assembly feasibility.

The thickness of collision beam and reinforcement plate is 3mm, height of upper collision beam reinforcement rib is 16mm, lower is 20mm, and lengths of upper and lower reinforcement plate are 700mm and 600mm, respectively. Same 4 types of FEA have been adopted on B25 proposal, see Fig 9.

From the finite element analysis shows, the rigid column counterforce curve with triangle mark in B25 proposal not only exceeds the curve with rectangle mark in B2, but also above both of the green solid line and the dashed line, which meets the regulation requirements. And mean while the structural strength, stiffness and modal performance also achieves the target value.

VI. DOOR STRUCTURE IMPROVEMENT AND ANALYSIS

Fig 7: B2 rigid column counterforce-displacement curve

In order to improve the stiffness of collision beam, Original horizontal collision beam has been moved upward with a new collision beam sideling supported underneath. Section of upper and lower collision beam has been changed into W shape with reinforcement plate welded inside, all of which formed a closed section (Please see the Fig. 8).

Fig 8: B25 proposal introduction (outside & inside view)

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VII. SUMMARY

There is no physical test in the development process of this new vehicle door product, just using the finite element method to the discovery of design problems and be able to make targeted recommendations for improvement are very effective, quick guide engineer to improve the product quality. This method can reduce prototype parts’ producing and the number of physical tests to shorten the development cycle and reduce the development investment.

VIII. REFERENCES

Fig 9: B25 Rigid column counterforce-displacement curve