Development of Car Hood for Stiffness Improvement using FEA System

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Abstract— In the competitive business the automobile companies have to update for the aesthetic look of vehicle with its efficiency, service and cost of vehicle. When car come across any accident from the front portion most of the time Hood system gets damaged. So there is a need for analysis of Hood system. For every new car project, updated vehicle's style is coming from styling department. The engineering feasibility data is prepared as per updated styling with the provided surrounding space. In this paper, new hood design is prepared for better stiffness than the existing hood design. The torsion stiffness and cross member bending durability load cases are considered for stiffness calculation in this work. The primary data of hood assembly has created as per design consideration and development has done as per Computer Aided Engineering results. This paper deals with development for better stiffness of new hood assembly design compare to the existing design.

Key words: Stiffness, FEA System

I. Introduction

Automotive industry is the fastest growing industry today. In the competitive business, the automotive companies have to take care the market demand. The customer choice is change from day to day, hence the vehicle must be upgrade as per requirement. Now a day the sport utility vehicle is in demand. Every vehicle manufacturing company like Mahindra, Tata, Honda, Hyundai, VW, etc are upgrading the vehicles as per customer demand. The theme of vehicle is mostly change as per market requirement. Theme is mainly depending upon the hood assembly, bumper assembly, fender, side panel and front light assembly of vehicle. Vehicle manufacturer changed theme of car by changing the closer style. Customers demanding the luxuries look of car with high efficiency and low prize. Hence the research work is in the progress of making light weight vehicle with better stiffness. The major challenge for automotive industry is to make light weight components and improving the other efficiency parameter. This work is focus on the design and development of new hood assembly for better in stiffness of hood assembly. Hood is a main component of front portion of a car which is used for many purposes. [1]

Mainly four parts in hood assembly, like outer panel, inner panel, latch system and Hinge system in hood assembly design. The outer panel skin surface from style department with proper aesthetic look, gap and falseness, as shown in Fig. 1. Outer hood panel follow the aerodynamic criteria. Hood inner is main functional part in hood design. It's most complicated and weight consuming part in hood assembly. In the vehicle development, the hood inner was designed to meet the standard load cases. The hood latch system is vital to all cars, trucks or other vehicles. This system is the attachment of hood assembly and vehicle body. The hinges also guide and hold the hood when open & close. Their kinematics analysis had done to ensure that the hood does not contact other components.

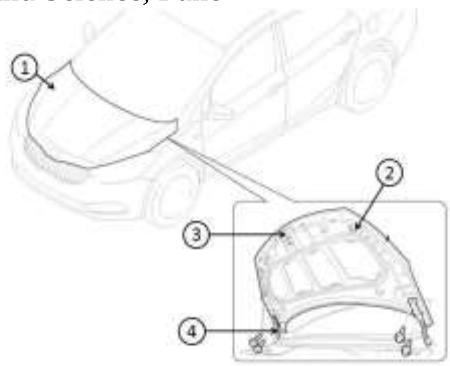

Fig. 1: Hood assembly explored view.
(1. Outer Hood Panel, 2.Inner Hood Panel,
2. Latch Reinforcement and 4. Hinge Reinforcement)

This paper focuses on analysis and techniques used for development of hood assembly with the help of CAD and FEA tools. The hood development for new project is based on two durability load cases, i.e Torsion stiffness and Cross member bending. As per initial design consideration created the primary data of hood assembly and development has done as per Computer-Aided Engineering (CAE) results. Numbers of iterations are done to satisfy the acceptance criteria of durability tests. Computer-Aided Design (CAD) tools used for design and development of hood assembly. In the static analysis part was carried on Nastran and Hypermesh. The paper described the brief information about efficient hood design and development.

II. Design and Development

In this work, Computer Aided Surface (CAS) as a input and available packaging space as constrain. Styling surface means the outer panel skin surface. The package space means all existing surrounding parts of hood assembly, like Bumper, Head lamp, Fender, Engine and radiator assembly, Short Gun, Latch Mounding Bracket, widescreen, wiper location. Bump stop and stay rod design with location has gives as constrain. [2]

Styling surface quality, homologation criteria, gap and flushness, manufacturability, and other consideration are checked in first step of hood design. After the study highlight the problem to styling department and start the packaging study on existing CAS surface.

For initial design of hood assembly, benchmarking the same class of vehicle and studied basic design considerations. Benchmarking is the process used in automotive industry for comparing products and performance. In the process of best vehicle benchmarking, management identifies the best in another industry where similar vehicle exist, and compares the results and processes. Benchmarking on that class of vehicles, Study the all basic design consideration for hood assembly. This is mainly divided in following type.

- Ergonomical considerations.
- Manufacturing aspects.
- Check points.

– Regulations.

A. Ergonomical Considerations

Automotive ergonomic is the study of human comfort for automotive design. The human comfort factor for automobile design is first consideration. It is a method to safeguard and protect space for the human user and necessary components that make up the vehicle being designed. Other purposes are provided by alternative solutions and proposals. Ensure the all safety regulation requirements are meeting. The following aspect considered during primary hood assembly design. [3]

– Head Clearance
– Hood opening angle and Location of stay rod
– Latch Operation

Full opening angle is mainly depending on the head clearance criteria, geometry of hood assembly and hinge assembly. As per benchmarking study the angle is 60 to 65 degree shown in Fig. 2.

B. Manufacturing Aspects

The most important design consideration of any component is manufacturing aspect. In sheet metal, the component is manufactured by press tool dies. The Press tool is stamping which includes cutting operations like shearing, blanking, piercing etc. and forming operations like bending, drawing etc. The main focus of manufacturing aspect is to manufacture hood assembly with minimum operation sequence and process time. Following aspect are considered for the primary design of hood assembly.

– Tooling Considerations
– Welding Consideration
– Hemming Considerations.
– Assembly Considerations.

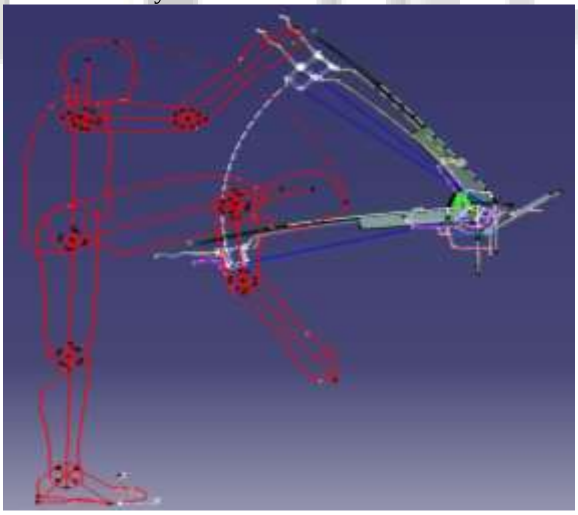

Fig. 2: Head Clearance with Hood Assembly Study.

C. Check Points

In hood assembly, design has done as per the styling and given constraint surrounding data. Checking of hood assembly is necessary for conformation the design to satisfying all functional requirements. Following points are consider during checking the hood assembly.

– Swing study with nearby body parts
– Over samming considerations.

Main objective of this study is maintained the proper clearance during working. The swing study of hood assembly is mainly focus on rear side clearance. There is more overhang area on rear side of hood assembly, i.e reason for chance for clash or close clearance with other part.

Due to over slamming of component may be sagging and rattling in feature. It may be causes car of shutoff. This study has done for overcome of this problem. The more distance from bump-stop to outer edge is main reason for this problem.

D. Regulations

Regulations are the requirement of any industry to sell the product in market. In automobile industry regulations are flexible as per market to market. They are usually mandatory by New Car Assessment Program (NCAP) and Electronics and Communication Engineering (ECE) of a government rules. The regulation aspects such as vision zone, crash test, environment protection and theft protection are to be considered. In hood design there are two tests are mandatory on part level as shown in below. [4]

– Forward vision regulation
– External projection regulation, is 13942 -1994

The scope of forward vision regulation is 180° forward field of vision the driver. The purpose is to ensure an adequate field of vision when the windscreen and other glazed surfaces are dry and clean. The requirements of this Regulation are so worded for vehicles. This submitted by the vehicle manufacturer or by his authorized representative. The Forward vision regulation knows as ECE- R125. [4]

The external surface of vehicles has not exhibit, direct outwards, any pointed, sharp parts or any projections. This type of shape, dimension, direction or hardness has to increases the risk or seriousness injury. The external surface of vehicles shall not exhibit, direct outwards, any parts likely to catch on pedestrians, cyclists ond motorcyclists. No protruding part of the external surface other than wiper blades and supporting members have a radius of curvature less than 2’5 mm. [5]

III. Finite Element Analysis

Every automotive part must be check on three tests, 1) Durability tests, 2) NVH tests and 3) Crash tests. In durability test, stress and strain are checked with all related parameters of component. NVH tests conducting for check the natural frequency of component. To ensure the frequency of other component is not match with the engine frequency zone. Crash tests are on the vehicle level tests are on the basis of vehicles safety regulation. Two durability tests are considered for work.

A. Torsional Stiffness Test

This test determines torsional rigidity of hood system. Results requested after the test is without damage of the bonding or joining points, without visible permanent deformations and elastically deformation under maximum load is allowed in linear area only.

Four bump stops used for this project, two is inner side and two is outer side. So force is applied on two bump stop on one side simultaneously and other bump stop is fixed. Two readings are taken for torsional test i.e. inner bump stop (Case 1) and outer bump stop (Case 2) location.

B. Cross Member Bending

In this simulation determine the bending rigidity of hood subsystem. Its ensures robustness of Hood under its own weight. It prevents hood from sagging or bending when in the open position. It's also prevents for sagging when customer pulls/ pushes bonnet edge down to close. Hood is mounted in horizontal position and its held fixed hinges. Lift cylinder attachment points on both the side i.e RH and LH are constrained in Z direction. One of bump stop location is constrained in Z direction and at other end point load is applied.

A finite element analysis (FEA) was carried out on primary data of hood assembly. The finite element model has been prepared by using pre-processor Hypermesh and the post processor has done on Nestran Software. The first run of FEA analysis has done on primary data. As per the CAE feedback, the hood assembly has modified. Number of CAE iteration are done and as per that development of hood assembly are done. Modification are described as per parts, as shown in below.

1) Hinge Reinforcement

Hinge reinforcement has modified on following points as shown below.

- Thickness of hinge reinforcement reduced from 1.6 to 1.4 for Weight reduction.
- Form shape changed (i.e. Flanges & beads added) for increasing the stiffness and to meet CAE target.
- Shape of reinforcement changed to increase the contact area of latest outer panel and inner panel face.
- Spot weld points between inner and hinge reinforcement reduce from 10 spot to 6 spot weld points.
- Hinge mounting holes diameter changed for better bearing surface.
- Hinge reinforcement locating holes position has changed to maintain 10 mm clearance from grommet.

2) Lock Reinforcement

Lock reinforcement has modified on following points as shown below.

- Rear flange angle changed to meet CAE criteria and for better stiffness.
- Side flanges removed for weight optimization.
- Shape changed to match latest bonnet inner.
- To maintain 5 mm clearance from inner panel to reduce risk of Corrosion.
- Welding Spots between inner and lock reinforcement reduced form 6 spots to 4 spots. Slot dimension changed for weight reduction.

3) Hood Inner assembly

Hood inner assembly has modified on following points as shown below.

- Weld spot reduced from 26 to 16 spots.
- This assembly and Drawing modified to change in part form.
- Flange modify for mastic area reduction.
- As per new Style, boundary flange on inner assembly has modified.

The focus of all the modification are enhancing the components strength, reduced weight of assembly, easy for manufacturability and joining. Assembly loading and reloading of component, process time and cost like weld spot and mastic area as reduces are consider during modification.

IV. EXPERIMENTAL DETAILS

The torsional stiffness and bending stiffness of existing hood structure has done by experimentally. Hood assembly is tested in the cured states. The overall dimension of existing hood assembly and distance from bump-stop is same as new assembly. Test process is described as shown below.

A. Torsional Stiffness

Torsional stiffness of hood assembly has checked by experimental test. The following steps are follows during the operation test.

- Measure and record hood dimensions reading on the Data Sheet.
- Remove the support from the front corner of the hood assembly to determine the exhibit maximum sag.
- The load is applied on negative Z direction at unsupported front corner. The load is 20 N increments to a maximum of 80 N.
- Measured and recorded the deflection reading on the Data Sheet.
- Deflection readings should be taken within one to two minutes after the load has stabilized.

B. Bending Stiffness

Bending stiffness of hood assembly has calculated by experimentally. Positive Z direction of force has applied in this test.

The Following steps are done during the operation testing.

- Dimensions is measured and recorded on the Data Sheet.
- The support from the front corner of the hood assembly is removed to determine the exhibit maximum sag.
- The load is applied at unsupported front corner in a 20 N increments to a maximum of 120 N.
- Measured and recorded the deflection reading on the Data Sheet.
- Deflection readings should be taken within one to two minutes after the load has stabilized.

Fig. 3: Experimental Setup of Existed Hood.

Experimental test of existing design has done on bench. It provides product engineering, research, testing, information and certification services to the automotive sector. The experimental setup has existing hood assembly as shown in Fig. 3.

V. RESULT AND DISCUSSION

Existing design of hood assembly means those are in current working condition. The physical validation had done on existing design of hood assembly. The physical validation of existing design and modified final design of hood assembly are Compare.

The stiffness comparison of existing design and new design of hood assembly is as shown in Table 1.

Test	Case	Existing Design	New Design	% Growth
Torsional Stiffness	1	115.15 Nm/mm	125.23 Nm/mm	+8.05%
	2	223.42 Nm/mm	231.98 Nm/mm	+3.68%
Bending Stiffness	1	32.55 Nm/mm	31.25 Nm/mm	- 4.00%
	2	34.45 Nm/mm	35.32 Nm/mm	+2.46%

Table 1: Stiffness comparison of hood assemblies

Stiffness of final hood assembly design is better than existing hood assembly design as measured in Table 1. Torsional stiffness of new design is 8.05 % for case 1 and 3.68 % for case 2 better than existing design. Bending stiffness of new design for case 2 is 2.46% more than existing design of hood assembly. But bending stiffness of new design for case 1 is 4% less than existing design of hood assembly.

The torsional stiffness of new hood assembly design is improved than the existing hood assembly design. The cross member bending stiffness of new hood assembly design is for the case 1 in less than the existing design. The cross member bending stiffness of new hood assembly design is for the case 2 in more than the existing design.

VI. CONCLUSIONS

In this paper, the development of hood assembly is discussed with the help of two durability cases. Based on the paper work, the following aims and object of the research have been achieved.

- New hood assembly design satisfies the all functional as well as safety criteria.
- Final design of hood assembly satisfies the torsional stiffness and cross member bending durability load cases.
- The torsional stiffness of new design is improved by 8.05% for inboard (case 1) condition and by 3.68% in outboard (case 2) condition than the existing design.
- The bending stiffness of new design is decreased by 4.00 % for inboard (case 1) condition and improved by 2.46 % for outboard (case 2) condition, which improved than existing design of hood assembly.
- New design of hood assembly gives better stiffness than that of the existing design of hood assembly.

The future scope of this work is,

- The development can be performed considering different material of hood assembly.
- Development can be carried out using easy manufacturing and assembly for mass production.

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