INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

A Review: Analysis and Optimization of Car Bonnet

Rupesh Y. Bhagat
M. Tech, CAD/CAM, G. H. Raisoni College of Engineering, Nagpur, India
Amol P. More
Asst. Prof (Mechanical Department), G. H. Raisoni College of Engineering, Nagpur, India

Abstract:
Bonnet is an important component of the front portion of the car which is used for many purposes. Bonnet is used to decorate the car and add luxurious look. Bonnet is made aerodynamic in shape to reduce air effect. Bonnet generally used to cover car engine, radiator and many other parts, therefore bonnet must be designed in such a way that all the maintenance parts should be easily accessible and it should give a minimum impact of external disturbance on the engine. When car come across any accident from the front portion most of the time bonnet system gets damaged. So there is a need for analysis of bonnet system. For that research has been done on the existing design with its limitation. This paper focuses on Analysis and techniques used for optimization of Bonnet.

Key words: *Optimization, Analysis, Car Bonnet*

1. Introduction

Automobile industry is the fastest growing industry today. In the competitive business the automobile companies have to take care of the cost of vehicle, its efficiency and service. In recent years, work has been done on the vehicle front end design which includes bumper and hood to reduce the injuries to the pedestrians in the event of a pedestrian vehicle collision. Because many accidents occurs in India. And mostly a front portion of the vehicle gets damaged including bonnet. So there is need of optimization of existing design of bonnet. The hood or bonnet is the hinged cover over the engine of motor vehicles that allows access to the engine compartment for maintenance and repair.Bonnet usually do not directly open onto the passenger cell which greatly reduces the importance (weighting) of certain of the functional requirements normally associated with closures such as air tightness, passenger safety, low cycle fatigue strength etc.The objective of these measures is to reduce the number of road accident fatalities and the severity of injuries sustained by pedestrians involved in a collision with a vehicle in urban traffic. Impact frequency and seriousness of injury has been studied for many years, resulting in rating systems and improved design.

2. Purpose of a Bonnet system

The bonnet system is an access panel to the engine compartment to enable maintenance of power train, drive belts, battery, fluid levels and lamp units. It is fundamentally a reinforced skin panel with many safety and quality requirements.

3. General Design of Bonnet System

The bonnet top is divided in two portions; a forward portion is for a child headform impact and a rearward portion (i.e. near to the windscreen) for an adult headform impact. Wrap around distances of 1000-1500 mm and 1500-2100 mm are defined for the boundaries of these two bonnet top test areas. The windscreen and A-pillars were not part of the mandate of WG10 and therefore not included as a test area (the lower windscreen frame however is included). The width of each test area is divided into 3 equal parts; a left and right outer part and a middle part The side of the test area's is also defined by means of the 'comers' of the bumper and the leading-edge, and the 'side' of the bonnet top.

Figure 1: Inner Panel of Bonnet

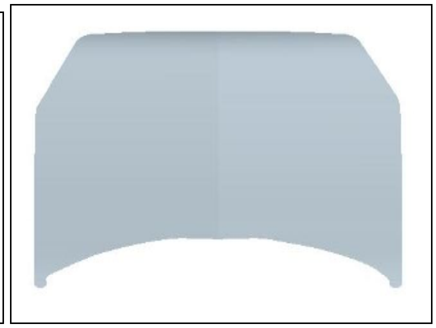

Figure 2: Outer Panel of Bonnet

4. Problem Statement

“To study the existing optimization methods available and to find the drawbacks in those methods. Select optimize technique for car bonnet analysis”.

5. Optimization Process

In this article, an optimization process based on different type of structural optimization with different techniques is presented. The optimization techniques are used, which are provided by the Altair Engineering software Optistruct. In particular, the process includes topology, topography, topometry and size optimizations.

First process starts from a topology optimization which applies to a design space: as a consequence, it is necessary to define a suitable preliminary architecture of the structure. The second process is Topography optimization which is an advanced form of shape optimization in which a design region for a part is defined and a pattern of shape variable-based reinforcements within that region is generated using OptiStruct. And in size optimization, the properties of structural elements such as beam cross-sectional properties, shell thickness, spring stiffness and mass are modified to solve the optimization problem.

At last, the model can be manufactured. Mounting it on cars, can assure remarkable benefits in terms of weight without damaging the performances. The requirements of the lateral stiffness are meant to assure that the side beams of the hood should have a sufficient bending stiffness. The hood is fixed at four positions in the test configuration as shown in Figure 3[4].

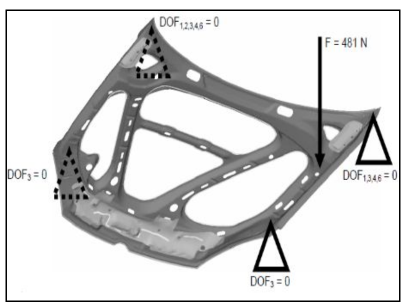

Figure 3: Load Case Lateral stiffness [5]

The finite element model has been prepared by using the pre-processor MSC/PATRAN with CAD PTC direct interface. First of all the bonnet analytical model has been validated by comparing the torsional stiffness calculation by MSC/NASTRAN Solution101 with the results obtained by the Pininfarina Testing Laboratory. After that an analytical modal analysis has been carried out by SOLUTION 103 of MSC/NASTRAN with the modal shape definition and frequency. Then by a pre-test analysis, a very less number of nodes are required to form an analytical model than the complete analytical mode,but able to make the dynamic behaviour completely approximate, by using the MAC as control index, a modal experimental analysis has been carried out on the bonnet on the reduced set of points. A considerable importance is given to the methodologies by which the modal parameters are drawn by the frequency response functions (FRF) experimentally obtained by the software LMS Cada-X. At the end a bonnet frame topological optimization has been carried out by MSC/CONSTRUCT.It is a powerful tool of design and to produce good results either in the predesign phase and also when we have to act in some phases of the manufacturing process [6].

A sandwich hood design that has a potential to improve the hood’s ability to absorb the impact energy of a pedestrian’s head with a relatively small Underhood clearance has been shown. Using EEVC headforming factor models and nonlinear finite element,a design analysis was conducted for the adult head impact area and the child head impact area, a design analysis was conducted with an Underhood clearance target of 75 mm and 60 mm, respectively. A set of design parameters was optimized for a sandwich hood. At the end analysis shows, out of the 12 impact points covering the main hood area, about half of the impact points achieved.Head Injury Criterion (HIC) values less than 800 and the others yielded HIC values between 800 and 1000[2].

The head impact analysis on the present hood of the car has been carried out at two different locations to study the response of the adult head form.Modal and structural analysis of the same present hood assembly has been done to observe the local and global stiffness. The local stiffness over the area of head impact has been reduced, thus the new design of the hood inner panel has been focused on that and the modal and structural analysis have been done for the new design.The design with similar global stiffness and lesser local stiffness compared to the existing hood has been finalized. The head impact analysis for the new design of the hood inner panel has been performed. The HIC values of the adult head form for two different locations are found to be 706 and 948 which meets the safety limitations of the adult head acceleration during impact as proposed by Euro NCAP regulations and EEVC WG17. Finally the new design of the hood is pedestrian friendly, considerably maintaining the overall global stiffness of the hood [7].

In Another case focus has been given on the work done on the passenger vehicle hood subsystem. The Optimized mass of the hood is in multi structural durability, NVH and pedestrian protection, which have conflicting requirements. The durability requirements need higher stiffness whereas the pedestrian protection calls for lesser stiffness, which might affect the NVH requirements. Both static and dynamic load cases are considered for the study using optimization studies of hyper works products. The main aim of this work is to find a lightweight solution, without compromising the static stiffness and pedestrian protection requirements [3].

In this paper [8] Author studied three basic concepts of hood. The first one is Requirements: Pedestrian protection-related requirements for head impact and its conflicting requirements for the vehicle handling and driving.

Second one Hood Concepts: The impacts of the hood design parameters on the head impact performance are shown and different conceptual solutions are presented. And the third one Hood Hinge Concepts: Examines the hinge performance for pedestrian protection in detail.Different hinge- concepts and their impact on the head impact performance are shown.

In this research paper[9], a method, which uses an experiment and simulation simultaneously, is developed. To link the two methods orthogonal arrays are employed. To some rows of an orthogonal array minimum number of experiments is allocated and the simulations are allocated to the rest of the rows. In the cases of the experiments orthogonal experiments should be allocated. Mathematical error analysis is conducted. A hood and a bumper are designed to protect pedestrians based on the proposed methods. For the rows of orthogonal arrays real experiments and computer simulations are conducted. The results show that the errors are distributed uniformly and a precise design is obtained.

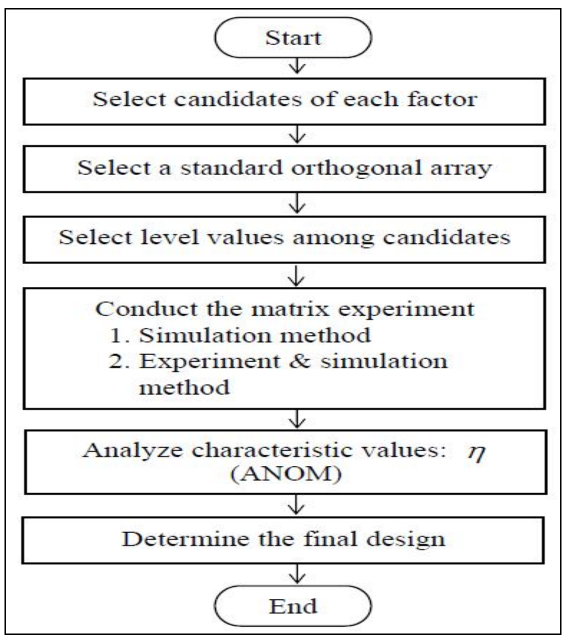

Figure 4: Flow of the Design Process [9]

This paper reports Finite Element (FE) based simulations of the frontal impacts for Motorcycle (MC) the Opposing Vehicle (OV) and their detailed analysis. The simulations have been carried out in PAMCRASH^{TM}.The crash simulation kinetics have been matched with the Full Scale Test (FST) conducted at Japan Automobile Research Institute (JARI).The simulations indicate the sensitivity of the different parameters in the various MC – OV impact configurations.

In this paper stress has been given upon establishing the importance of detailed geometry and properties of the components in the impact situation, have shown their relevance for MC - the OV frontal impact configuration and have highlighted the need of repeatability / reproducibility in the FST.It also demonstrated the importance of FE simulations as a tool to study the impact behaviour of vehicles at the design stage [10]. Hood lifting is a new technology which can improve the pedestrian head protection performance of vehicles before pedestrian head impact with vehicle lifting up the hood, but the pop-up hoods available are most of the time irreversible, causing high maintenance costs. Therefore a new reversible pop-up hood was designed. At the beginning the FE model of the frontal body of the researched car was built and validated with test carried out according to the requirements of Directive 20031102/EC phase I. The head protection performance of the hood areas near windscreen and A-pillars are very poor, that was found by performing the simulation analysis of Euro NCAP head assessment, so the structural redesign itself can't improve the score of head protection of those areas efficiently. For that, a new pop-up hood was designed, which can be lifted about 0.4 second upwards and backwards before the collision between pedestrian and car, to increase the free space beneath the hood and cover the bottom areas of the windscreen and A-pillar. This system can be reset if the detection system makes false alarms to cut maintenance costs. This pop-up hood can efficiently improve the pedestrian head protection performance of the researched car, in accordance with the requirements of Directive 20031102/EC and Euro- NCAP showed by simulation results [11].

6. Conclusion

From the review of the Research papers it is concluded that in most of the cases, an accident occurs with the pedestrian, and work has been done on the design of front head and rear head panel. For those techniques such as topometry, topology and different software's are used to analyze the design. And for the safety of the bonnet, work should be done on the stiffness of the material. Hybrid materials can be suggested for better performance of the bonnet. In most of the cases steel and aluminium are used. With the help of orthogonal array the results are more efficient. So such techniques can be used extensively for Optimization of bonnet structure. But more Optimization techniques need to find for a better structure of Bonnet system.

7. References

1. Ramesh C. K, Dr. Srikari S, Suman M. L. J, "Design of Hood Stiffener of a Sedan Car for Pedestrian Safety", SASTECH Journal, Volume 11, Issue 2, Sep 2012
2. Qi Liu, Yong Xia, Qing Zhou, Jenne-Tai Wang," Design Analysis of a Sandwich Hood Structure for Pedestrian Protection", General Motors Research & Development, Warren, Michigan, USAPaper No 09-0356
3. Chetan Patre, Prashant Kulkarni, Umesh Nayaka, "Multi-Disciplinary Optimization of Passenger Car Hood Subsystem", Altair user conference, 2012.
4. D. Costi, E. Torricelli, L. Splendi and M. Pettazzoni,"Optimization Methodology for an Automotive Hood substructure (Inner Panel)'',Proceedings of the World Congress on Engineering 2011, Vol III.
5. M. Hamacher, R. Wohlecker and L.Ickert fka," Simulation of a Vehicle hood in Aluminum and Steel", Abaqus user's conference, 2008.
6. D. Col, F. Furini, O. Mueller, R. Trivero, "Static-Vibrational Design of A Bonnet WithFrame Topological Optimization",
7. T. L. Teng, V. L. Ngo," Optimization of Bonnet thickness with respect to pedestrian safety", Journal of Automobile Engineering, 2010.
8. Christoph Kerkeling, Joachim Schäfer, Dr. Grace-Mary Thompson, "Structural Hood and Hinge Concepts For Pedestrian Protection", Paper No: 05-0304
9. Jae-Wan Lee, Kyong-Han Yoon, Youn-Soo Kang, Gyung-Jin Park, "Vehicle Hood and Bumper Structure Design to Mitigate Casualties ofPedestrian Accidents", Paper No 05-0105.
10. Chawla, S.Mukherjee, D.Mohan, Dipan Bose, Prakash Rawat, M. Sakurai, T. Nakatani, "Fe Simulations Of Motorcycle – Car Frontal Crashes, Validation And Observations".
11. Dang Xut, XichanZhut,Qiang Miao, Zhixiong Mat, Bin Wu, "The Research of Reversible Pop-up Hood for Pedestrian Protection", IEEE Conference