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Static And Free Vibration Analysis Of A Car Bonnet

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Abstract

Car bonnet consist of the outer panel and inner stiffener panels and reinforcement members placed there between to increase the strength of said panel in localized area. The outer panel and inner stiffener panel are connected by hemming. Bonnet is a main component of front portion of the car which is used for many purposes. Bonnet is made aerodynamic in shape to reduce air effect. Also bonnet is used to decorate car and add luxurious look. 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 gives minimum hindrance to aerodynamic flow. While car is in running condition it experiences a resisting forces of air, hence bonnet of car must be aerodynamic.

For analysis, car bonnet of well known manufacturer have been selected. Static load on the bonnet is identified. Finite element analysis of existing bonnet revealed the stress distribution on the bonnet. So an effort is made to modify the structure of existing bonnet so that the advantages of weight reduction along with safe stress can be obtained.

Introduction

Automotive industry is the fastest growing industry today. In the competitive business the automotive companies have to take care of prize of vehicle, its efficiency and service. Research work is in progress in this direction making light weight cars such as electric cars but these cars are less efficient for carrying heavy load and cannot be used in long distance. Same objective may be achieved by making light weight parts of vehicle.

Bonnet is a main component of front portion of a car one which is used for many purposes. Bonnet is made aerodynamic in shape to reduce air effect. Also bonnet is used to decorate car and add luxurious look. Bonnet generally used to cover car engine. Therefore bonnet must be designed in such a way that all the maintenance part should be easily accessible and it gives minimum hindrance to aerodynamic flow. Car bonnet consist of the upper panel and inner stiffener panel and reinforcement members placed there between to increase the strength of said panel in localized area. The reinforcements consist of a structure made up of a base material of plastic or aluminum and an insert material of hard metal. Loads are transferred to the panel through the metal insert material and dissipated to the panel members through the base structure. The inner stiffener panel provides strength and the outer panel is just a metal cover or skin the underneath of the bonnet is covered with sound absorbing material. The upper and inner stiffener panels are connected by hemming. Some High performance cars have opening in the bonnet to aloe the engine breathe easier. 'Hood Scoops' are used to channel air directly to the air filter, which gives improved performance and efficiency. Outer panel and inner stiffener panel of bonnet are connected by adhesive called 'mastic'.

Syyad Shafik R. [3] in 2010 analyzed the pedestrian kinematics in pedestrian-cars accident scenarios and determined the Head Injury Criteria (HIC) from the head resultant acceleration, for head impacts at various locations on the vehicle hood. M. Hamacher, R. Wohlecker and L. Ickert [4] in 2008 emphasised on the use and development of hybrid bonnet hence to reduce weight. Instead of only steel hood has been made with the use of both steel and aluminum. By applying boundary conditions i.e. all degrees of freedom fix and load of 481 N at different positions, analysis is carried out and compare with the original steel hood. . A remarkable weight reduction in hood about 38.46% is found by using aluminum. D. Costi, E. Torricelli, L. Splendi and M. Pettazzoni [5] in 2011 discussed an optimization procedure for mass optimization through various processes. For optimization he used hood of Ferrari without breaking the performance target an aerodynamic shape of an vehicle. Four types of optimization processes namely topology, topometry, topography and size optimization has been discussed to reduce the weight.

MODELLING AND ANALYSIS OF EXISTING BONNET

Upper panel and inner stiffener panel are made up of sheet metal hence surface modeling environment is used. Upper, inner and assembly of bonnet is shown in figure 1.1, 1.2 and 1.3 respectively.

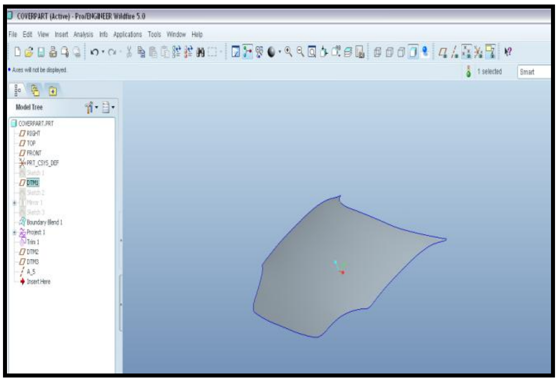

Figure 1.1 Upper Panel of Bonnet

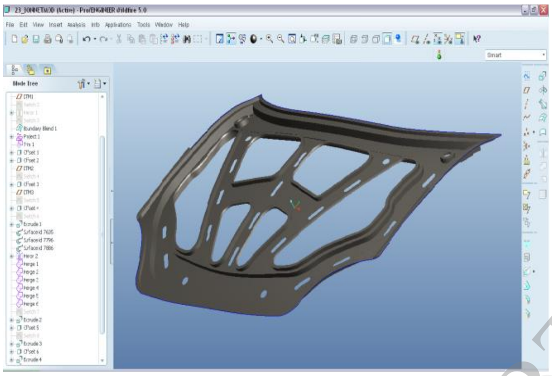

Figure 1.2 Inner Stiffener panel of Bonnet

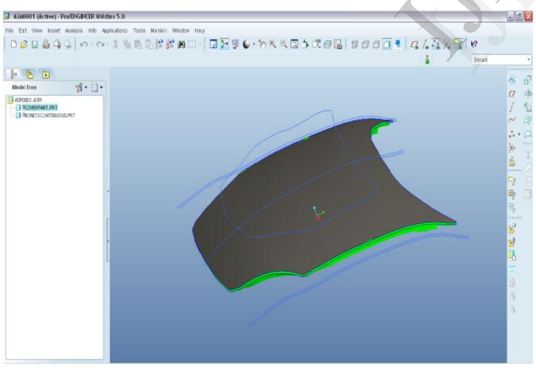

Figure 1.3 Assembly of Bonnet

Material property of a bonnet is considered as structural steel. Thickness of upper panel and inner stiffener panel of bonnet is considered as 1 mm. SHELL element is selected for discretizing the model into elements and nodes. The bonnet is meshed into elements count 9484 and nodes count 7895. Boundary conditions are applied to the back and front portion of a bonnet. End corners of back portion of bonnet are fixed, while end corners of front portions of bonnet are supported by rubber bushes so displacement in z- direction is not constrained. For these purpose four contact areas are provided. A uniform pressure of 8175 N/m^2 is applied normally on entire portion of upper panel of bonnet.

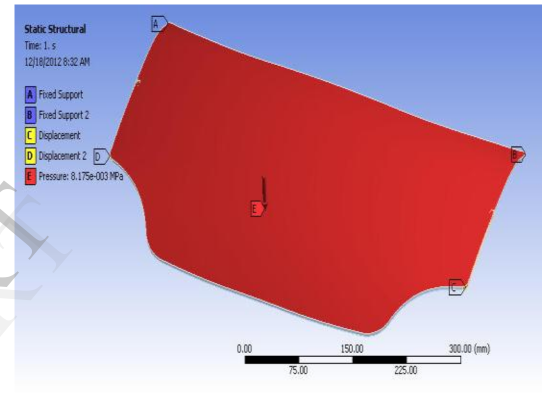

Figure 1.4 Static Structural Model of the Bonnet

Finite element analysis of the bonnet yielded the solution for static structural analysis and the stress distribution in the form of stress contours is obtained. Stress contours in the form of Von-mises stresses are shown separately on upper panel and inner stiffener panel in Figure 1.5 and 1.6 respectively.

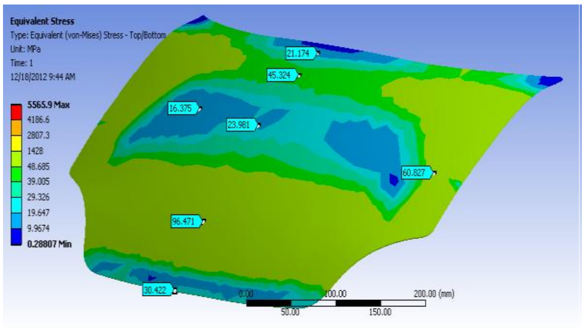

Figure 1.5 Von-mises Stress Distribution of Upper Panel (Existing Bonnet)

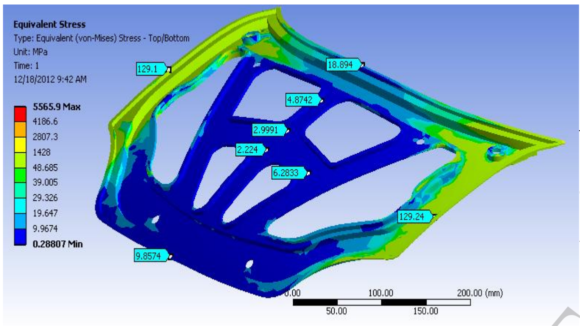

Figure 1.6 Von-mises Stress Distribution of Inner Stiffener Panel (Existing Bonnet)

Finite element analysis of the bonnet yielded the solution for the static structural analysis and deformation contours is obtained. Deformation contours are shown separately on upper panel and inner stiffener panel in the Figure 1.7and 1.8 respectively.

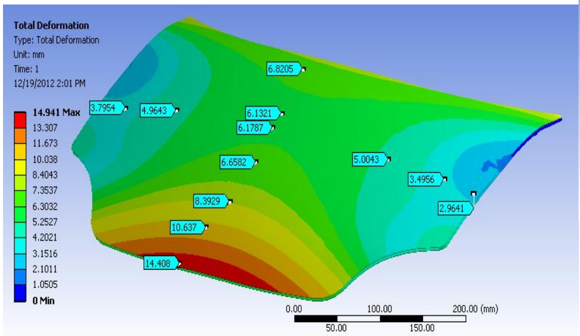

Figure 1.7 Deformation Contours for the Upper Panel (Existing Bonnet)

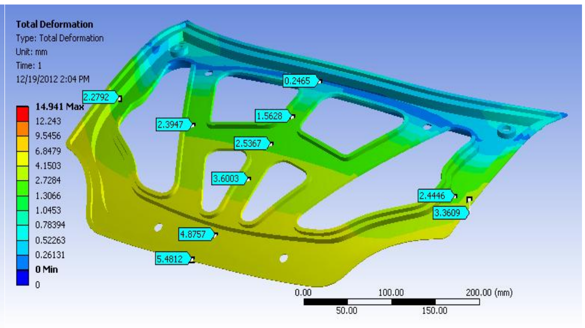

Figure 1.8 Deformation Contours for the Inner Stiffener Panel (Existing Bonnet)

The first three natural frequencies of the existing bonnet are evaluated for the free vibration case. The total deformation contours with natural frequencies for three mode shapes are shown in figures 1.9 to 1.11 respectively.

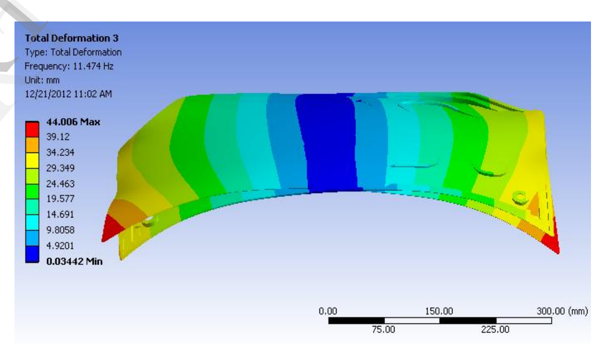

Figure 1.9 Mode Shapes for First Natural frequency (Existing Bonnet)

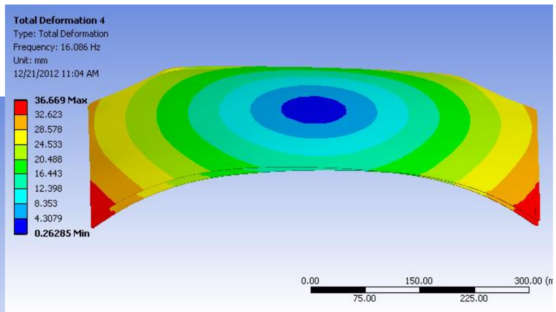

Figure 1.10 Mode Shape for Second Natural Frequency (Existing Bonnet)

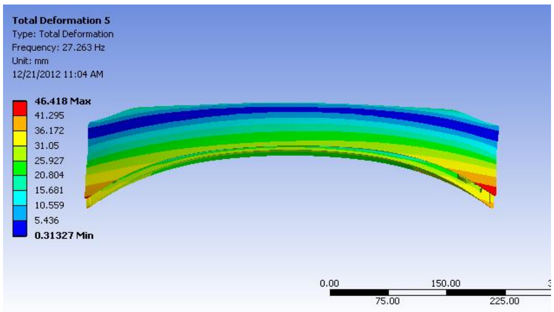

Figure 1.11 Mode Shape for Third Natural Frequency (Existing Bonnet)

ANALYSIS OF MODIFIED BONNET

Finite element analysis of existing bonnet revealed that the stress over inner stiffener panel of a bonnet is small in comparison with upper panel of bonnet so effort has been taken to reduce the weight of inner stiffener panel by changing its design. Different cases considered during the modification of existing bonnet are given as follows.

Case I: Conversion of small slots present at the centre of the inner stiffener panel into a continuous single slot

Case II: Conversion of small slots present at the bottom side of the inner stiffener panel into continuous single slots

Case III: Conversion of all small slots present at the end side of inner stiffener panel into continuous series of slots

Case IV: Conversion of small slots present at the end side of inner stiffener panel along with the inner rib into series of continuous slots

Case V: Conversion of all small slots present at inner stiffener panel into series of continuous slots.

Stress contours of various cases in the form of Von-mises stresses are calculated and shown in figures from 1.12 to 1.21.

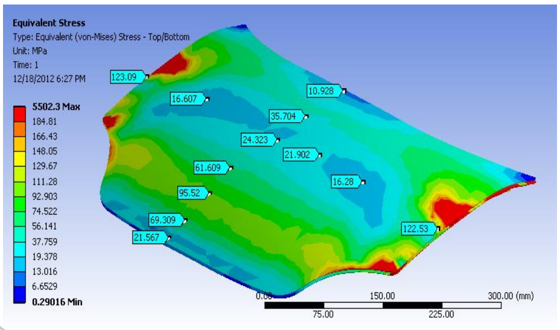

Figure 1.12 Von-mises Stress Distribution of Upper Panel (Case I)

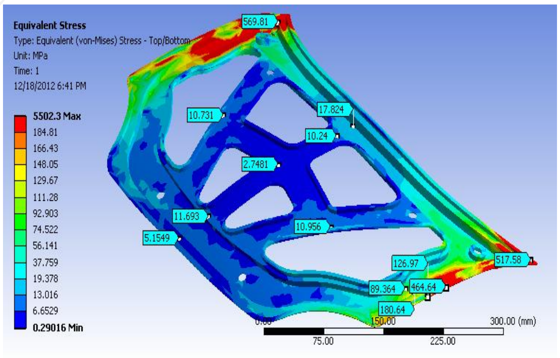

Figure 1.13 Von-mises Stress Distribution of the Inner panel (Case I)

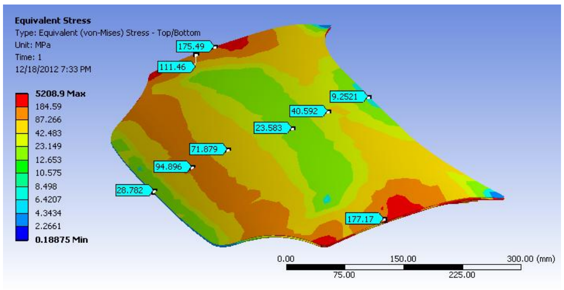

Figure 1.14 Von-mises Stress Distribution of Upper Panel (Case II)

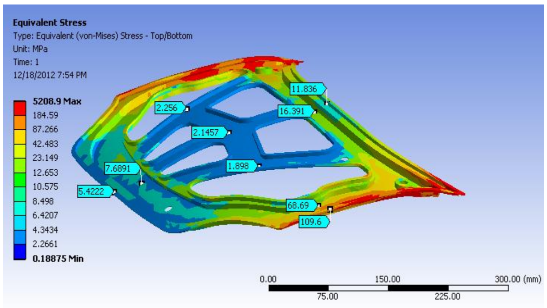

Figure 1.15 Von-mises Stress Distribution of Inner stiffener Panel (Case II)

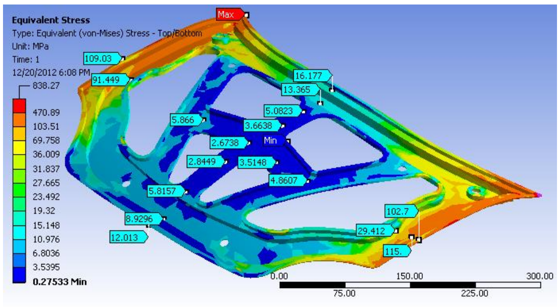

Figure 1.19 Von-mises Stress Distribution on Inner Stiffener Panel (Case IV)

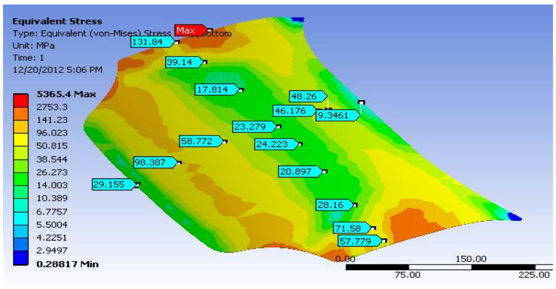

Figure 1.16 Von-mises Stress Distribution on the Upper Panel (Case III)

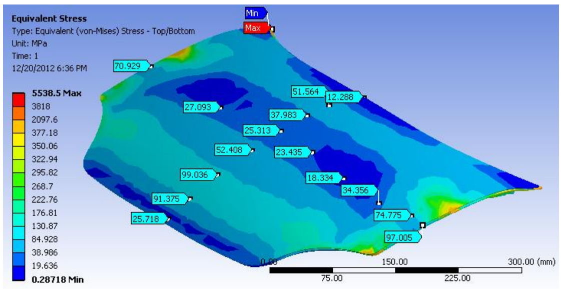

Figure 1.20 Von-mises Stress Distribution on Upper Panel (Case V)

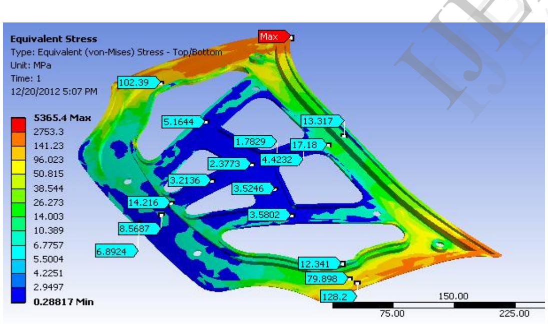

Figure 1.17 Von-mises Stress Distribution of the Inner Stiffener panel (Case III)

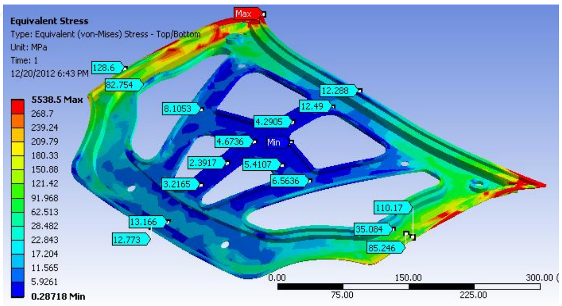

Figure 1.21 Von-mises Stress Distribution on Inner Stiffener panel (Case V)

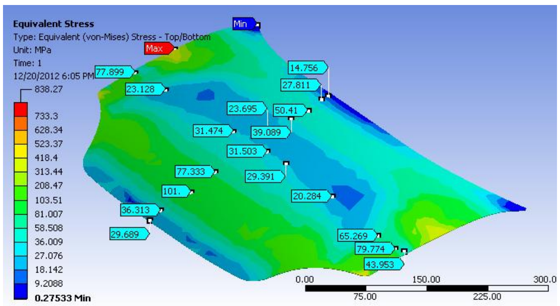

Figure 1.18 Von-mises Stress Distribution on Upper Panel (Case IV)

RESULTS, DISCUSSION AND CONCLUSION

In stress analysis of existing car bonnet, Von-mises stress distribution of upper panel of bonnet stresses are found between 16.5 MPa to 150 MPa while on inner panel of the bonnet it is 3 MPa to 40 MPa. Maximum deformation of upper panel of existing bonnet is found to be 14.94 mm and that of inner panel is approximatel 6 mm. Stresses larger than 150 MPa are found at the corner region of the bonnet.

Modification in the bonnet is carried out by changing design of inner stiffener panel. Comparative table 1 shows, the results of existing bonnet and various cases for modified bonnet.

It is observed from the Table1, deformation in the existing bonnet is 14.94 mm and stresses in the range of 25 MPa to 150 MPa. It is also seen that for all the cases except third case deformation increases. In the third case, deformation is found to be 13.54 mm whereas stresses are in the range of 13 MPa to 181 MPa. In all the cases, there is little variation in stress distribution. It is observed that from various cases weight can be reduced by 0.01 Kg to 0.03 Kg.

It is also observed from above table that natural frequencies for all cases are lesser than the excitation frequency due to engine rotation.

It is seen that case no III or case no. IV are better for reduction in the weight of bonnet and also for safe stresses and defection levels.

Table 1 Comparison between various cases

Sr. No.	Case/ Type	Deformation in mm	Equivalent stresses in MPa	Natural frequencies in Hz		
				First	Second	Third
1	Existing Bonnet	14.94	25 to 150	11.47	16.08	27.26
2	Case I	15.98	13 to 130	11.59	13.29	21.80
3	Case II	13.54	13 to 184	13.26	16.29	36.37
4	Case III	14.24	14 to 141	11.44	14.88	28.67
5	Case IV	15.57	27 to 130	10.79	14.57	25.34
6	Case V	19.11	25 to 176	10.07	13.47	24.99

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