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A Durability Investigation on Automotive Front Bumper Guard

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자동차의 프런트 범퍼 가드에 관한 내구성 연구

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ABSTRACT

In this study, three models on the installation of automotive additional front bumper guard were designed and the structural analysis was carried out. The additional front bumper models B and C appears to be safer on stability instead of the basic front bumper model A. Model A with a simple structure is shown to have the safe region overall except in the area where the load is applied directly. Models B and C are shown to have the shortest lives at the regions where the bumpers are connected with each other. By comparing with the least fatigue lives at models A, B and C, Model B has the longest life with the best durability.

Key Words : Front Bumper Guard(프런트 범퍼 가드), Structural Analysis(구조해석), Total Deformation(전변형량), Equivalent Stress(등가 응력), Fatigue Life(피로 수명)

1. Introduction

The accidents of collision occur frequently during driving on a busy road. In order to increase the durability in the front bumper of the car, the front bumper guard has been installed additionally. When the impact is applied to the car body, It can be seen that the collision patterns become different between the basic front bumper and the bumper installed with additional bumper. When installing a bumper guard at the car body, it is necessary to examine which parts of the body are more damaged and less durable. The fundamental vehicle bumper is released from an automotive factory. And the additional bumper can be sold in the market. In this study, these models are designed[1-4] and the structural analysis was carried out[5-10]. By the utilization of this study result, it is thought to be available to increase the durability[11-14] of car body by installing the additional car front bumper.

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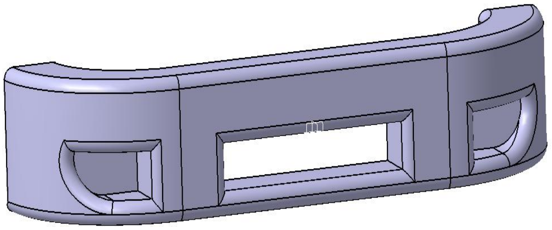
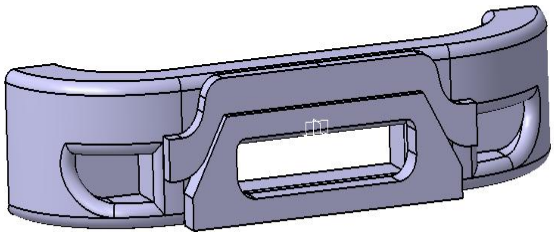
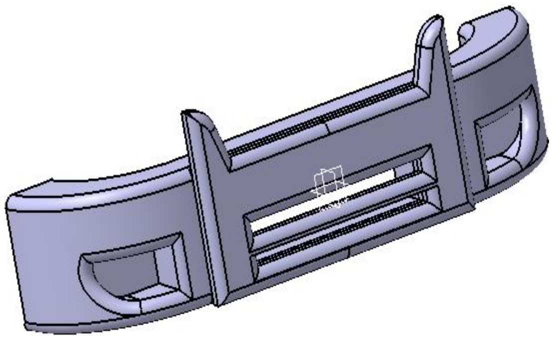
2. Study Models and Analysis Conditions



(a) Model A



(b) Model B



(c) Model C

Fig. 1 Bumper guard model A, B and model C

2.1 Study Models

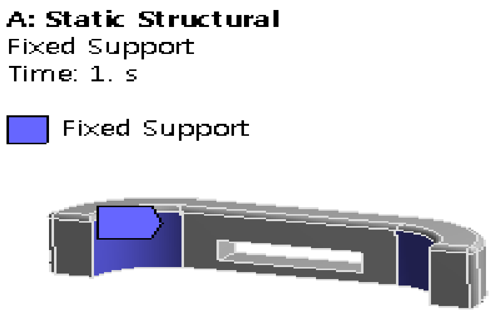
In this study, all three models were designed by using CATIA program. As shown by Fig. 1, model A is the fundamental model. Also, models B and C are designed differently as the additional bumpers installed on the fundamental model A. Table 1 shows the material property and Table 2 shows the information on the meshes of models A, B and C in order to carry out the structural analysis.

Table 1 Material property

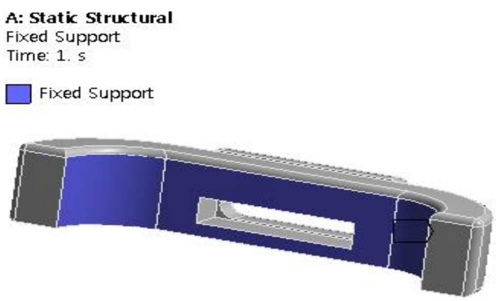
Young's Modulus (GPa)	200
Poisson's Ratio	0.3
Density (kg/m^3)	7850
Tensile Yield Strength (MPa)	250
Tensile Ultimate Strength (MPa)	460
Compressive Yield Strength (MPa)	250

Table 2 Number of nodes and at models 1, 2 and 3

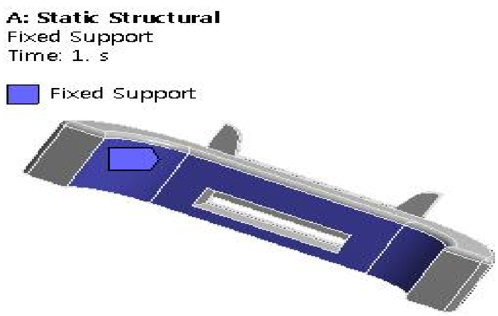
Model	Nodes	Elements
Model A	52634	30043
Model B	23087	23103
Model C	31272	31299



(a) Model A



(b) Model B

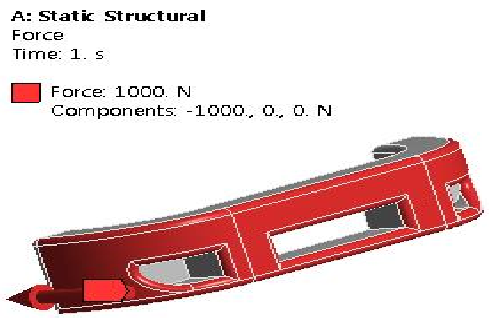


(c) Model C

Fig. 2 Fixed supports of models

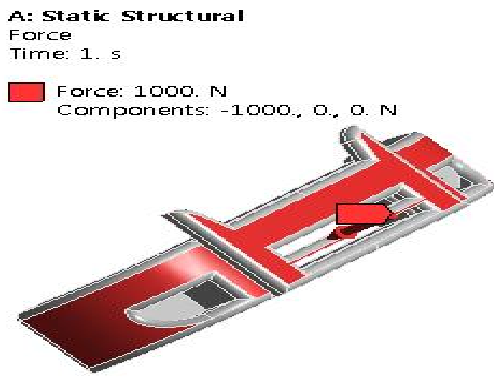
2.2 Analysis Conditions

Fig. 2 shows the fixed conditions of models 1, 2 and 3. By being connected in front of the vehicle body, the parts are fixed at models 1, 2 and 3. Fig. 3 shows the forced conditions of models 1, 2 and 3. All three models are applied with the same load of 1000 N.



(a) Model A

(b) Model B

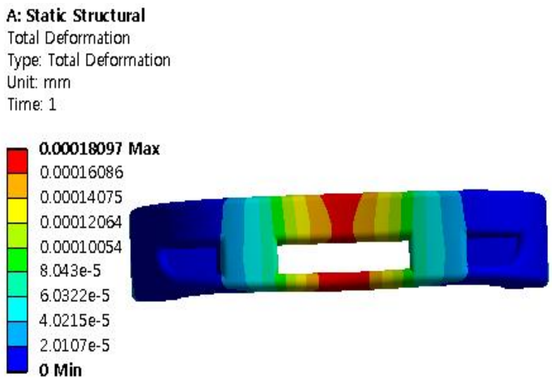


(c) Model C

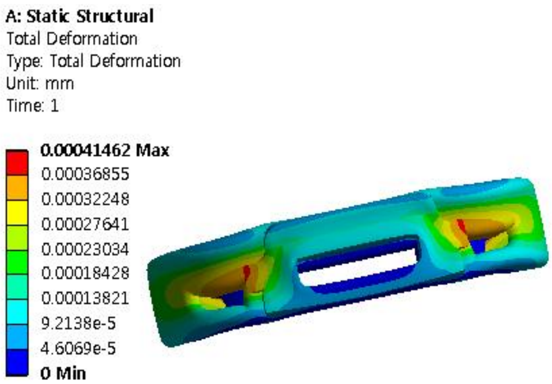
Fig. 3 Applied forces at models

3. Study Results

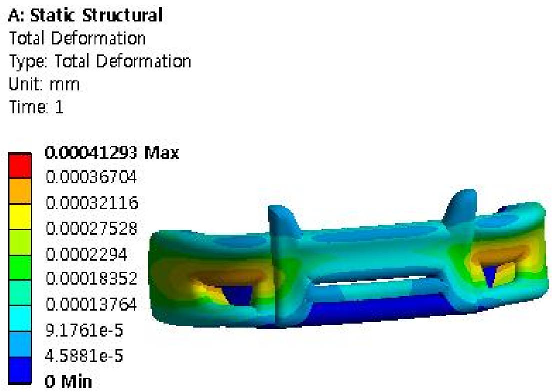
3.1 Structural Analysis Result



(a) Model A

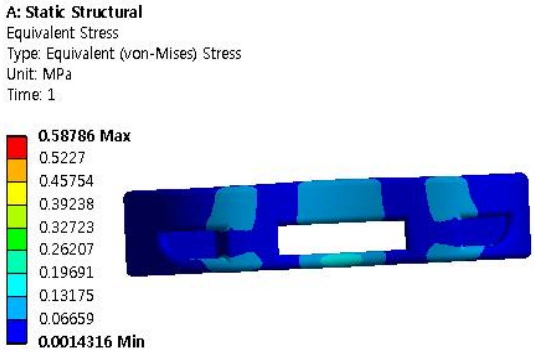


(b) Model B

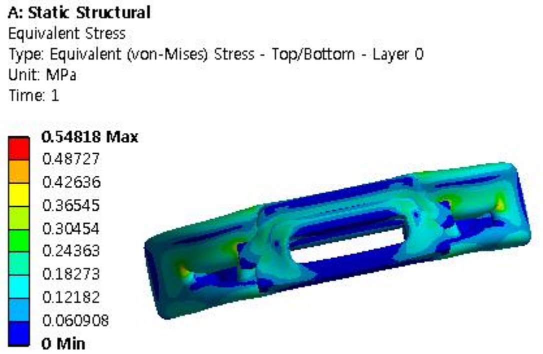


(c) Model C

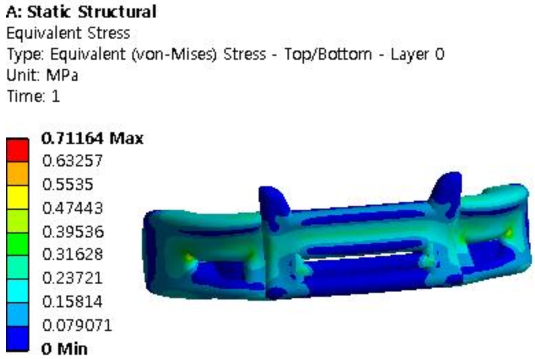
Fig. 4 Contours of total deformations



(a) Model A



(b) Model B



(c) Model C

Fig. 5 Contours of equivalent stresses

Fig. 4 shows the contours of total deformations at models A, B and C. Also, Fig. 5 shows the contours of equivalent stresses at models A, B and C. At Fig. 4, model A has the maximum deformation of 0.00018097 mm at the center of the forced area and model B has the maximum deformation of 0.00041462 mm. Model C has the maximum deformation of 0.00041293 mm. Model B is shown to have the most deformation among three models. At models B and C shown by Fig. 4, the maximum deformations take place, not the front part but the connection part. So, the additional front bumper models of B and C appear to be safer on stability instead of the basic front bumper model A. At Fig. 5, the maximum equivalent stresses of models A, B, and C become 0.58786 MPa, 0.54818 MPa, and 0.71164 MPa, respectively. Among three models, the maximum stress is seen as the greatest value at model C.

3.2 Fatigue Analysis Result

At the fatigue analysis result, the boundary conditions of three model are the same as the structural analysis conditions of Figs. 2 and 3. Fig. 6 shows the alternating stress(S) due to fatigue cycles(N) until the fatigue damage of material used in this study.

Fig. 7 shows the fatigue loading history which is applied to the model of automotive front bumper guard. As seen by Fig. 7, two kinds of fatigue loading conditions are ‘SAE transmission’ and ‘Sample history’. The unit of one fatigue cycle is

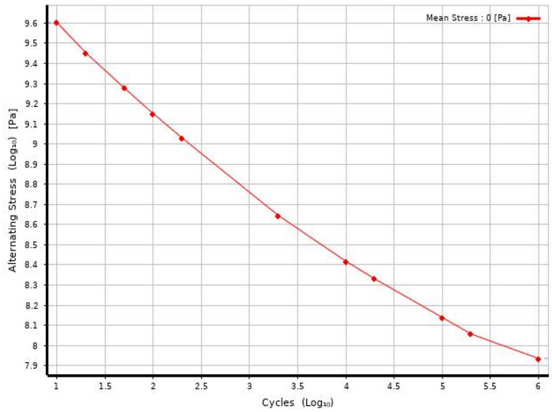
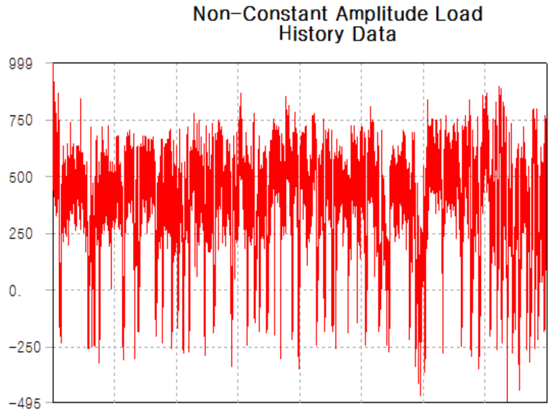
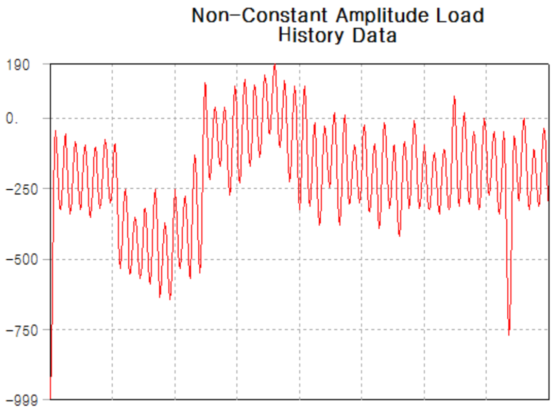


Fig. 6 Alternating stress due to fatigue cycles

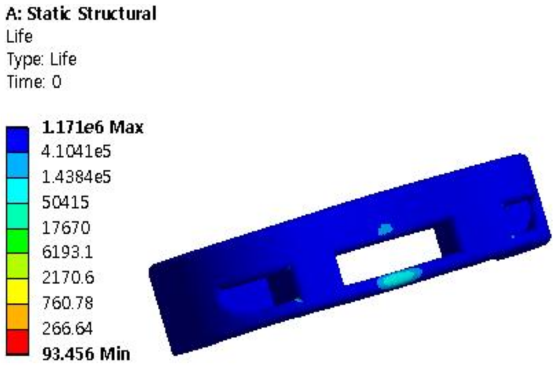


(a) SAE transmission

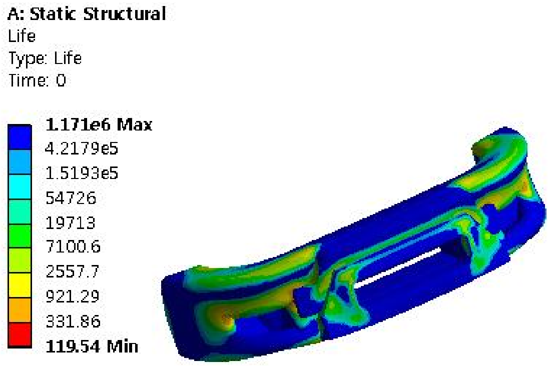


(b) Sample history

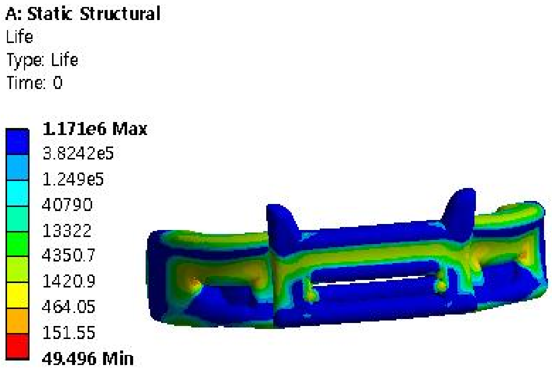
Fig. 7 Fatigue loading history on one cycle



(a) Model A



(b) Model B

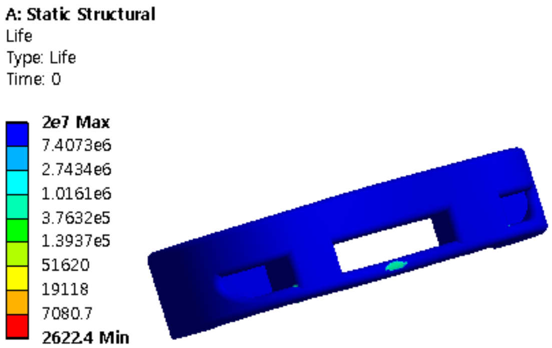


(c) Model C

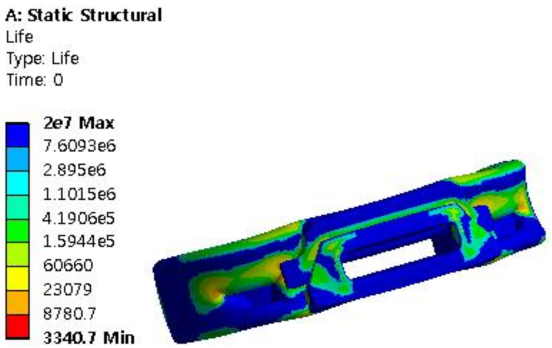
Fig. 8 Contour plots of fatigue lives at 'SAE transmission'

shown on the horizontal axis and the fatigue load with a varying magnification of the mean load is also shown on the vertical axis. The fatigue load of 'SAE transmission' is applied in case that the car is driven on the uniform road like asphalt road. 'Sample history' is also applied to in case that the car is driven on the unpaved road.

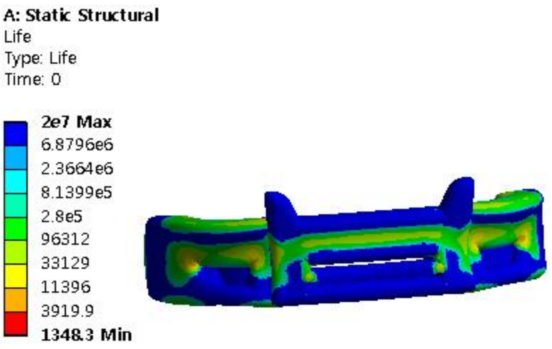
Fig. 8 shows the contour plots of fatigue lives at 'SAE transmission' at models A, B and C. As the value of fatigue life, the unit of 1 cycle means the entire fatigue loading history on the horizontal axis as shown by Fig. 7. The maximum fatigue life becomes 1.171 $\times$ 10^6 at models A, B and C. The minimum fatigue lives become 93.456, 119.54 and 49.496 at models A, B and C. Fig. 9 shows the contour plots of fatigue lives at 'Sample history' at models A, B and C. The maximum fatigue life becomes 2 $\times$ 10^7 at models A, B, C. The minimum



(a) Model A



(b) Model B



(c) Model C

Fig. 9 Contour plots of fatigue lives at 'Sample history'

fatigue lives become 2622.4, 3340.7 and 1348.3 at models A, B and C.

By comparing with the least fatigue lives at models A, B and C, model B has the longest life with the best durability. Model A with a simple structure is shown to have the safe region overall except in the area where the load is applied directly. Models B and C are shown to have the shortest lives at the regions where the bumpers are connected with each other.

4. Conclusion

In this study, the models on the installation of automotive additional front bumper guard were designed and the structural analysis was carried out. The study results are as follows;

1. Model B is shown to have the most deformation among three models. At models B and C, the maximum deformations take place, not the front part but the connection part. So, the additional front bumper models of B and C appear to be safer on stability instead of the basic front bumper model A.
2. The fatigue lives at 'SAE transmission' and 'Sample history' are applied to the model in this study. By comparing with the least fatigue lives at models A, B and C, model B has the longest life with the best durability.
3. Model A with a simple structure is shown to have the safe region overall except in the area where the load is applied directly. Models B and C are shown to have the shortest lives at the regions where the bumpers are connected with each other.

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