Contemporary Engineering Sciences, Vol. 9, 2016, no. 20, 971 - 980
HIKARI Ltd, www.m-hikari.com
http://dx.doi.org/10.12988/ces.2016.66100

Structural Study through Investigation on the Pedals of Pendant Accelerator and Designed Accelerator

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Abstract

This research analyzed the differences in two accelerator types by analyzing equivalent stress and total deformation in relation to loads that are applied to each accelerator pedal. Also, by having used CATIA modeling, through structural and fatigue analysis of the accelerator pedal by using ANSYS, a new accelerator pedal was designed and a structural research was conducted by analyzing simulations. In this research, a more improved acceleration pedal is designed by modelling a new pendant type acceleration pedal with the advantages of an organ type acceleration pedal, and its structural analysis is conducted.

Keywords: Structural Analysis, Pedals, Pendant Accelerator, Designed Accelerator

1 Introduction

As recent demands for automobiles are being generalized, research that focuses more on the safety of drivers and vehicles, escaping from focusing on automotive performance, are being conducted. Especially, pedals, which are the parts of the automobile that play the key role in drivers controlling the speeds of their automobiles, can be specified into brake pedals, clutch pedals, and accelerator pedals, functioning to stop, control power, and increase or decrease speed, accordingly. Compared with devices that are controlled by hand, pedals, which are controlled by foot, are occasionally limited by the driver's posture. When analyzing research related to pedals, such research is usually focused on the performance of the clutch or brake. In the cases of automobiles or airplanes, when it comes to applying to the actual field a design with consideration of safety to prevent pedals from being damaged or destroyed, - that is, structural strength design – is important [1][2][3][4][5]. An accelerator pedal is an important device that directly influences the acceleration of the automotive as it is connected to a vehicle's throttle valve, and controls the rotation of the automotive's engine by controlling the amount of air and fuel. In this research, in relation to the influence of loads to the pendant type accelerator pedal and the organ type accelerator pedal, a newly shaped accelerator pedal will be modelled, analysed and compared to the design of a pendant type accelerator pedal with an improved shape. Also, by having used CATIA modelling, through structural and fatigue analysis of the accelerator pedal by using ANSYS, a new accelerator pedal was designed and a structural research was conducted by analyzing simulations. Aside from pendant type accelerator pedals, accelerator pedals that are fixed to the surface and operated by applying force with the ball of the foot, while having the heel fixed to the surface, are called organ type accelerator pedals. Organ pedals are frequently used in buses or new current vehicles. Since the operating method and shape are different for operating pendant type accelerator pedals and organ type accelerators, each type has different characteristics depending on the user's posture. Accelerator pedals with pendant type are common and are currently the mostly used type of accelerator pedals. They are pendant shaped and are pressed down by using the principle of levers. Because of this operation, the accelerator pedal is removed from the surface, and thus a driver must step on the pedal with the ball of the foot. When driving for a long period of time such a motion gives a lot of fatigue to the driver's knee and ankle. On the other hand, accelerator pedals with organ type which are frequently used in buses or newly current automobiles, are fixed to the surface. It operates by the foot's hill being fixed to the surface, and with its long shape that encircles the whole foot, a driver steps on the pedal with the ball of the foot. Compared with pendant type accelerator pedals, the fatigue of drivers' angle is reduced, thereby making them more effective for driving for a long period of time [6][7]. Also, accelerator pedals with pendant type are not attached to the surface of the automotive, and thus there is a higher possibility of accidents caused by the acceleration pedal not returning to its original position because the footing of the driver can be gotten stuck while operating the pedal. Therefore, organ type pedals are seen to be more effective. However, they are more expensive. In this research, a more improved acceleration pedal is designed by modelling a new pendant type acceleration pedal with the advantages of an organ type acceleration pedal, and its structural analysis is conducted [8].

2 Study Result

This research makes a comparison between a generally used pendant type accelerator pedal and that of a newly designed accelerator pedal (which is designed by a comparison between an organ type accelerator pedal and a pendant type accelerator pedal). The general pendant type accelerator pedal as shown by Figure 1 (a) was modeled by setting a width of 50mm and a length of 130mm. The newly designed accelerator pedal at Figure 1 (b) was modeled by setting a width of 54mm and a length of 180mm. The accelerator pedal of pendant type has 27,056 nodal points and is composed of 15,066 elements, and (b) the designed accelerator has 38,101 nodal points and is composed of 17,409 elements. Also, the material used for the two acceleration pedals in the analysis was assumed to be aluminum alloy.

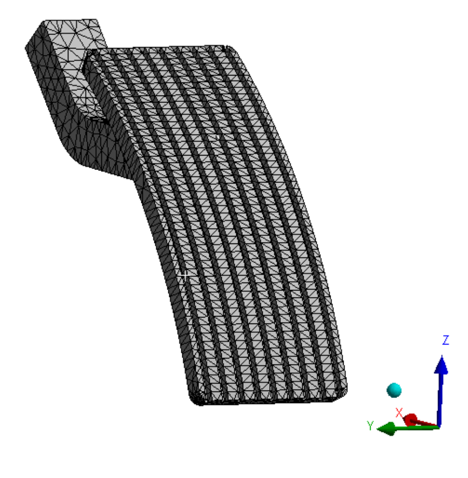
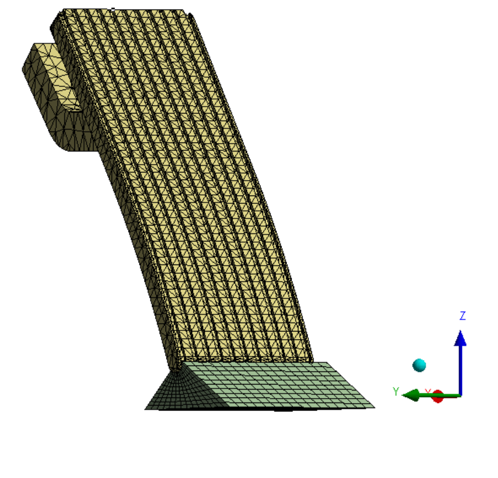
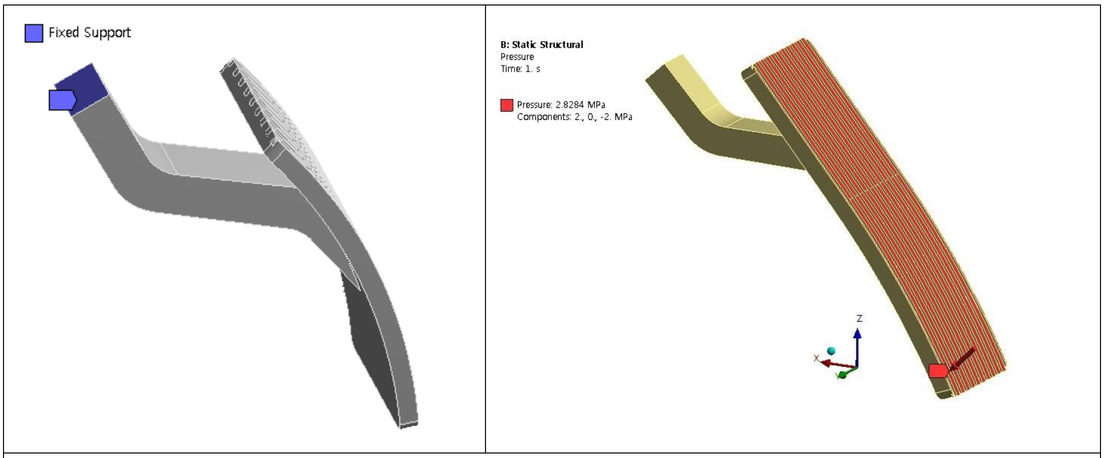
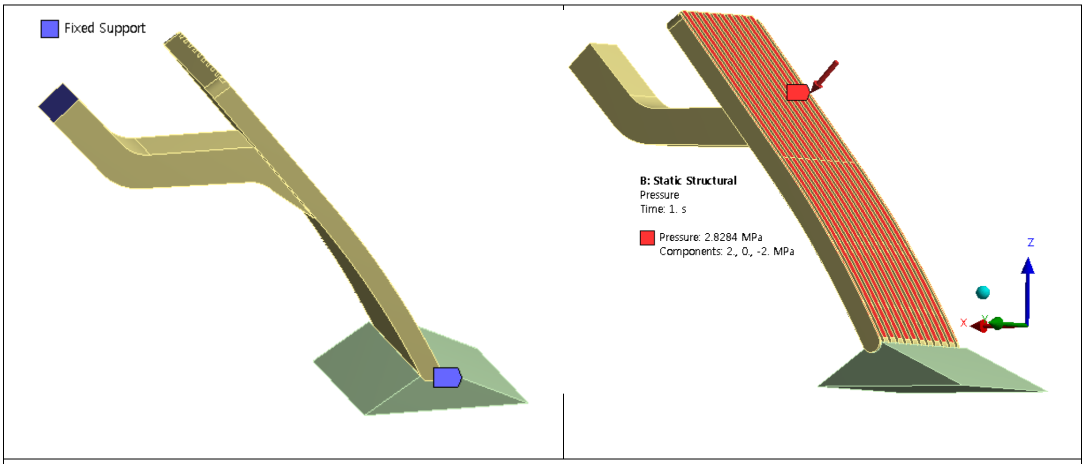
	
(a) Pendant type accelerator pedal	(b) Designed accelerator pedal

Fig 1. Meshes of accelerator pedals

As shown by Figure 2, to investigate the equivalent stress of accelerator when the force is applied to the accelerator pedal, each accelerator pedal is fixed and a force of 2.8284 MPa which is the assumed amount of force to be delivered from the tip of a human's foot is applied to the accelerator pedal's footplate on the same direction that the force is applied to the accelerator pedals.



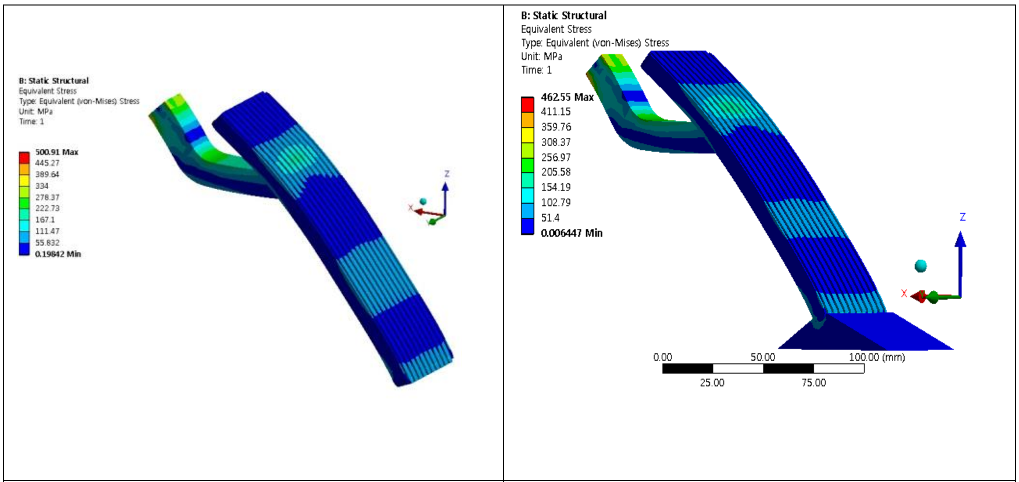
(a) Pendant type accelerator pedal



(b) Designed accelerator pedal

Fig 2. Fixed supports and forces of accelerator pedals

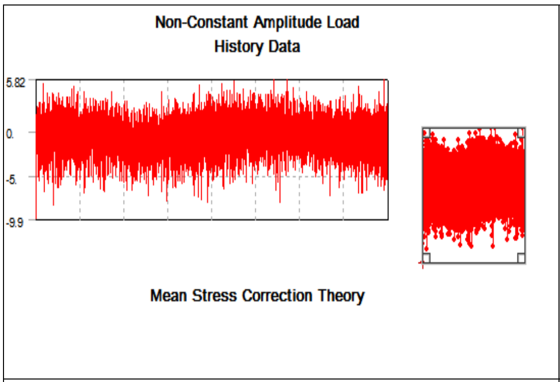
Figure 3 shows each accelerator pedal's equivalent stress in accordance with the loads applied to its footplate.



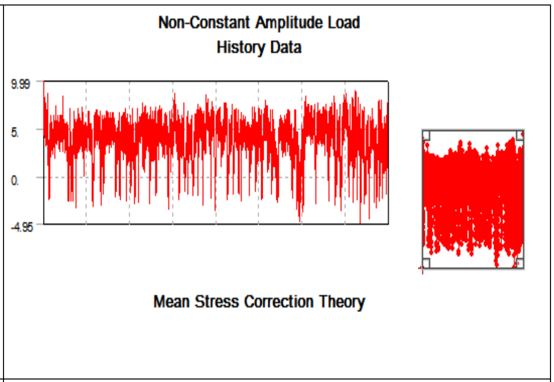
(a) Pendant type accelerator pedal	(b) Designed accelerator pedal

Fig 3. Equivalent stresses of acceleration pedals

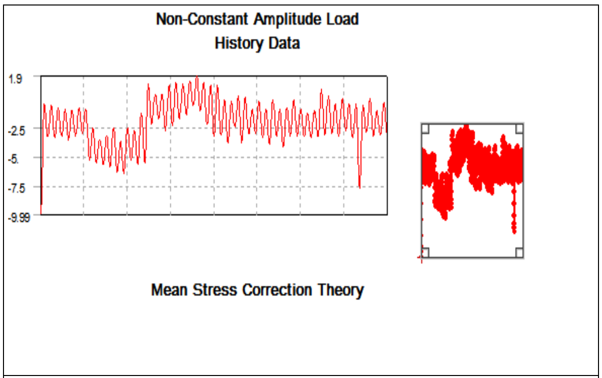
As in Figure 3, when considering the equivalent stress, (a)'s maximum equivalent stress is 500.91 MPa and its minimum equivalent stress is 0.19842 MPa. Also, (b)'s maximum equivalent stress is 462.55 MPa, and its minimum equivalent stress is 0.006447 MPa. Like this, when two accelerator pedals are compared, the equivalent stress of the newly designed shaped accelerator pedal was lower than that of the general pendant type accelerator pedal. Figure 4-1 below shows the types of nonuniform amplitude fatigue load conditions, which include SAE bracket history, SAE transmission, and sample history. This figure shows a list of constant average stress and stress amplitude of passes cycles. As seen at Figure 4, in the case of ‘(a) SAE bracket history’, it is a fatigue load condition that can be applied to extremely harsh mountain terrains. As the next case of '(b) SAE transmission', normally it can be applied to cases of unpaved roads. And for cases with roads that are well paved with asphalt, ‘(c) Sample history' can be applied.



(a) SAE bracket history



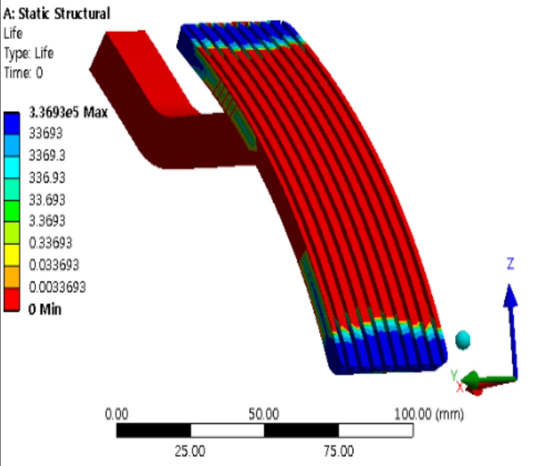
(b) SAE transmission



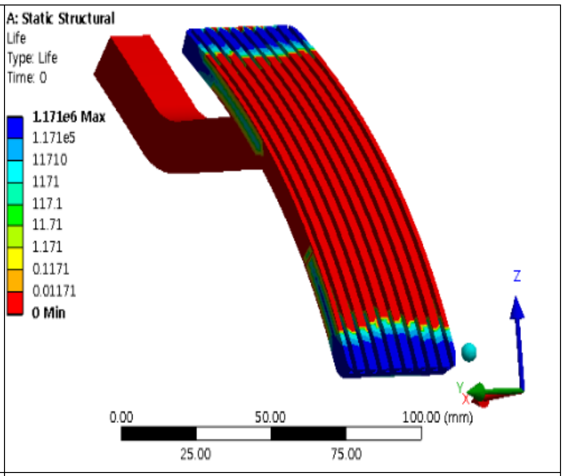
(c) Sample history

Fig 4. Load histories at nonuniform fatigue loads

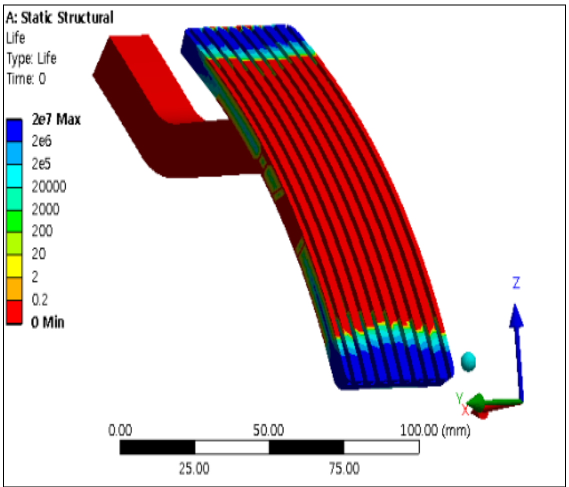
Outputs of the analysis result in relation to fatigue include fatigue life, damage, rainflow Matrix and damage matrices. Each output is the load of ‘SAE bracket history’, 'SAE transmission', and 'Simple history', which are nonuniform fatigue loads, and can thereby be compared with each other.



(a) SAE bracket history



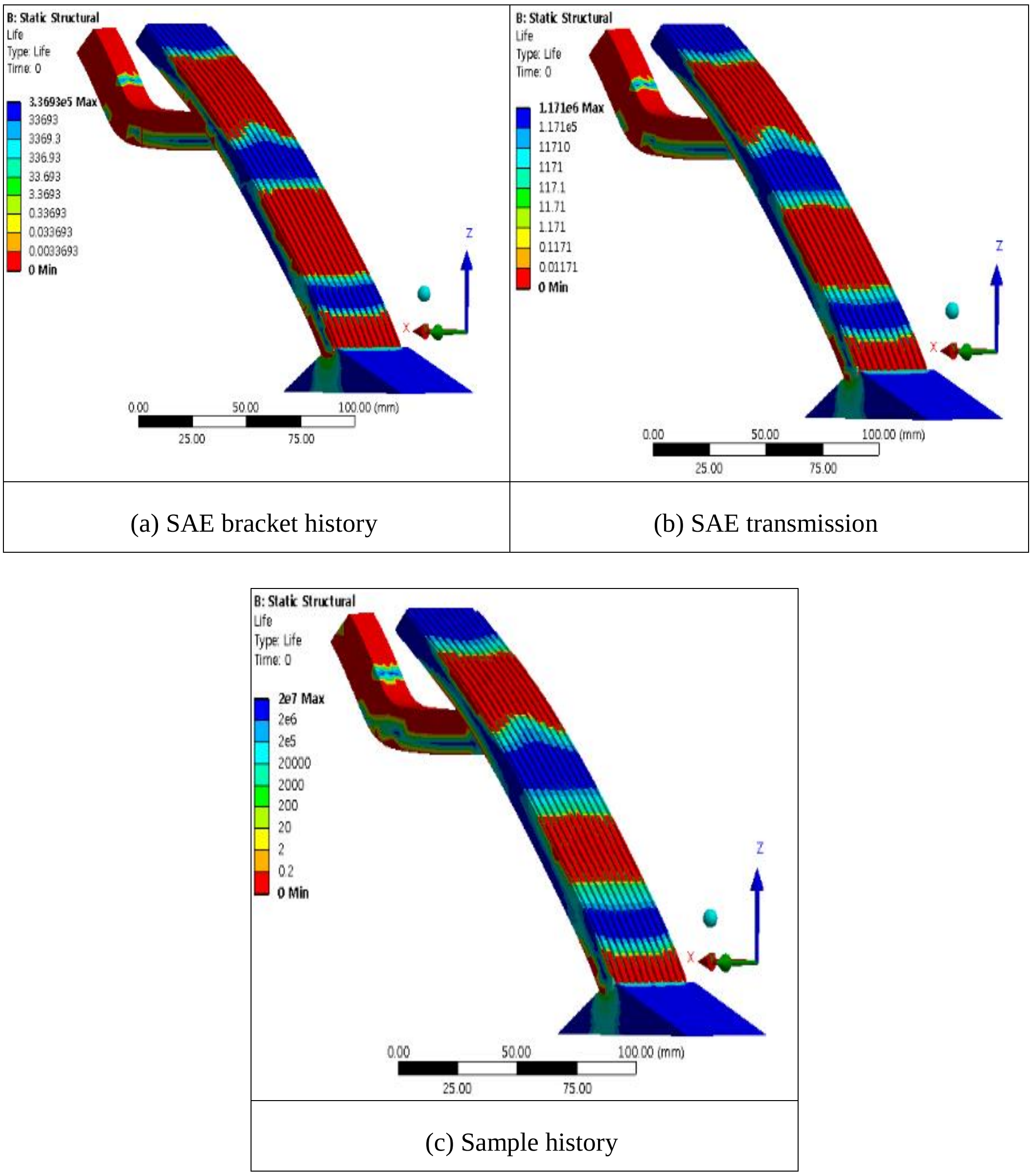
(b) SAE transmission



(c) Sample history

Fig 5. Pendant type acceleration pedal's contour plots of fatigue lives

Figure 5 shows contours of the general pendant type acceleration pedal's fatigue lives, which displays the pedal's useful life in relation to the given fatigue analysis.



(a) SAE bracket history

(b) SAE transmission

(c) Sample history

Fig 6. Designed accelerator pedal's contour plots of fatigue lives

Figure 6 like Figure 5 displays each contour of fatigue life of designed accelerator pedal, which shows it's useful life in relation to the given fatigue analysis. Both two types of accelerator pedals receive the same amount of fatigue loads, and contour plots of fatigue life for the cases when received 'SAE bracket history', 'SAE transmission', 'Sample history' are shown in Figures 5 and 6. The two accelerator pedals show the same trend, and in case of 'SAE bracket history', which have extreme changes in loads, have the shortest fatigue life with its maximum life of 3.3693×10^5 cycles. Meanwhile, in case of 'Sample history', which has smooth changes of loads, the pedals have the longest fatigue life with its maximum life of about 2×10^7 cycles. For the two types of accelerator pedals, in the case of ‘Sample history’ pedals, about a 60 times longer life was shown than those of ‘SAE bracket history’. In the case of ‘SAE transmission’, it is evident that the pedals have about 3.5 times longer life compared to that of the cases of ‘SAE bracket history’.

3 Conclusion

This research analyzed the differences in two accelerator types by analyzing equivalent stress and total deformation in relation to loads that are applied to each accelerator pedal. Also the research conducted a fatigue analysis according to the fatigue conditions. Such research resulted in the following findings. In the structural analysis, the maximum equivalent stress of the pendant type accelerator pedal was 500.91 MPa and its minimum equivalent stress was 0.19842 MPa. Also, the maximum equivalent stress of designed accelerator pedal was 462.55 MPa and its minimum equivalent stress was 0.006447 MPa. As such, in comparing the two accelerator pedals, the equivalent stress of newly designed accelerator pedal was proved to be smaller than that of the with the accelerator pedal with general pendant type. For the two accelerator pedals, in the case of 'Sample history', the fatigue life was about 60 times longer than for the case of ‘SAE bracket history’. In the case of ‘SAE transmission’, the fatigue life was about 3.5 times longer than for the case of ‘SAE bracket history’. Among the nonuniform fatigue loads, in case of ‘SAE bracket history’ having extreme changes of loads, the two accelerator pedals roughly showed the most unstable trend. In case of ‘Sample history’ having gentle changes of loads, the pedals showed the most stable trend.

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Received: May 1, 2016; Published: August 15, 2016