INVESTIGATION OF VIBRATION DAMPING IN THE PASSENGER SEAT

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Abstract: In this study, it was aimed to decrease the vibration reaching to passenger from the legs of vehicle seats. For this purpose, seat legs were manufactured from aluminum foam material by utilizing vacuum casting method. The aim of this study is to provide a comfortable and healthy to travel by decreasing the vibration coming from the chassis of the intercity buses. In experimental study, 2 seats having different legs were placed into the same type of vehicles. It was performed in two different experimental studies. In the first, modal analysis was used and Freguency Response Function (FRF) graphs were obtained. The second acceleration measurement was made and acceleration graphs were obtained. Both graphs obtained by this method were compared to two legs. It was observed that legs made of foam material shows better damping propertiesin vibration than 2 mm thick sheet metal original legs. Besides, it was observed that the foam material improved the comfort and delayed the tiredness threshold.

Keywords: modal analysis, acceleration, vibration, aluminum foam, damping, car seat

Introduction

In current century, one of the most important efforts of scientists is on finding the solutions of health problems triggered by negativities depending on developing technology use. One of the most important negativities is the vibrations with which we always face at any point during our daily lives. Under the lights of scientific studies, it is known that the vibration has significant effects on living creatures and non-living things. Human body faces with many different vibrations daily.
In that study, the vibration has been classified as whole-body vibration and hand-arm vibration (Griffin, 1997). Scientists have worked on modeling the human body-seat system within a vibration medium, and it has been determined that it is required in order for model of a human sitting on a seat to be established to evaluate the factors such as seat cushion, suspension system and seat surface geometry and the general human dynamics together (Rosen and Arcan, 2003). Estimating the response of integrated human body-seat structure to vibration signal is very hard nowadays. That's because of the complex dynamic behavior of the human body seating on seat in response to the vibration (Leo, Fard, Subic and Jazar, 2013). In theoretical analysis of vehicle vibrations and a computer modeling study, the vibrations occurring in a vehicle were examined theoretically, and particularly the responses of the vehicle to signals coming from the road were taken as base (Er, Orak and Par, 2006). The medical and biological effect of the vibration depends mostly on the amplitude and the duration of exposure. The frequency of the vibration having significant effect on human body is between 1 Hz and 100 Hz (Candır, 2012). In general, the dynamic response of the seats is examined in tests, where the acceleration is measured at the ground and seat-bottom while there is a passenger on the seat (Corbridge and Griffin, 1986). It has been emphasized that the roughness and the velocity on road is a factor increasing the vibration value (Eaton, 2003).The standards of seat test require the use of human objects for measuring vibration isolation of the seats (Lewis, Griffin, 2002). In porous material, the damping coefficient depends on the pours. As the number of pours increases, then the damping also increases (Dahil, Baspinar and Karabulut, 2011). In vehicles, the effect of vibration firstly emerges as tiredness. Tiredness gradually increases the muscle tension of driver, and leads to increase in hormonal secretion by affecting nervous, blood circulation and digestive systems (Babalık and Orak, 1992). The reason of spinal failures has been, in many studies, found to be the vibrations transmitted from the vehicle to driver. In a clinic study carried on a person spending more than half of his working hours on driving a motor vehicle, it has been determined that he was more compliant about the back ache than other people do (Bovenzi and Zadini 1992, Dupuis and Zerlett 1987, Troup, 1988).

The aim of this study is to ensure the comfortable and healthy journeys of passengers. In order to do it, the seat legs made of porous material have been manufactured via vacuum method. These legs have improved the damping, and decreased the vibration reaching to the feet of passengers.

Materials and Methods

First of all, the mold to be used in production of porous material via vacuum method was designed. In order to cast the open-porous aluminum foam material that will be used in seat legs, the mold made of SAE1040 material with dimensions of 50 x 30 x 500 mm to be used in leg manufacture was prepared. After the mold production, the casting process of the foam material to be used in seat construction was started. 4 seat legs at dimensions of 25 x 40 x 250 mm were produced from porous aluminum material by using vacuum casting method. The foam Legs as seen in Figure 1.

Figure 1 The foam legs

The most important measurement value required for modal analysis is the Frequency Response Function (FRF). By comparing the obtained FRF, the information about the dynamic behaviors between the leg types was obtained. Since the stimulation effects to come to the seat will occur at the point of connection of the seat with floor, these points were selected to be the points where the stimulation will be implemented during measurement. The points where the vibrations coming from the floor will be transmitted directly to the passenger (connection points between the legs and seat structure) were determined to be the response points. The free-free conditions were ensures as well as possible before the tests. The data was gathered from the seat via 2 accelerometers having 3 axes. The stimulation is provided from the bolt holes where the legs are mounted on the floor.
In order to determine the levels of vibrations reaching at passengers, a test pad placed under the passenger seat was used, and HVM100 device was used for digitizing the information obtained. By transferring the vibration data to system by using HVM100 device, the acceleration graphics were prepared with Blaze software.

Figure 2 Acceleration measurement test work

The vehicle had pass over the speed bump at speeds of 25 km/h, 50 km/h and 75 km/h. The accelerations occurring as a result of vibrations reaching to passenger from original leg and foam leg were compared through these graphics.

In order to determine the levels of vibrations reaching at passenger seat, as seen in Figure 2, the passenger was sit on 3 directional acceleration receiver – test pad placed on the seat. In order to prevent any weight change throughout the study, the person sitting on the seat during the study was the same person in all the measurements. The acceleration in 3 directions was recorded HVM 100 device during 2 minutes of vehicle travel

Results and Discussion

The changes in stimulation and response points lead to changes in frequencies and amplitude values in FRF graphics. From the change in amplitude values, it is seen that the actual mode frequency overstrains the part. In order to obtain a FRF graphic, 5 hammer impacts have been applied on each of stimulation points, and the mean of these 5 FRF graphics were taken.

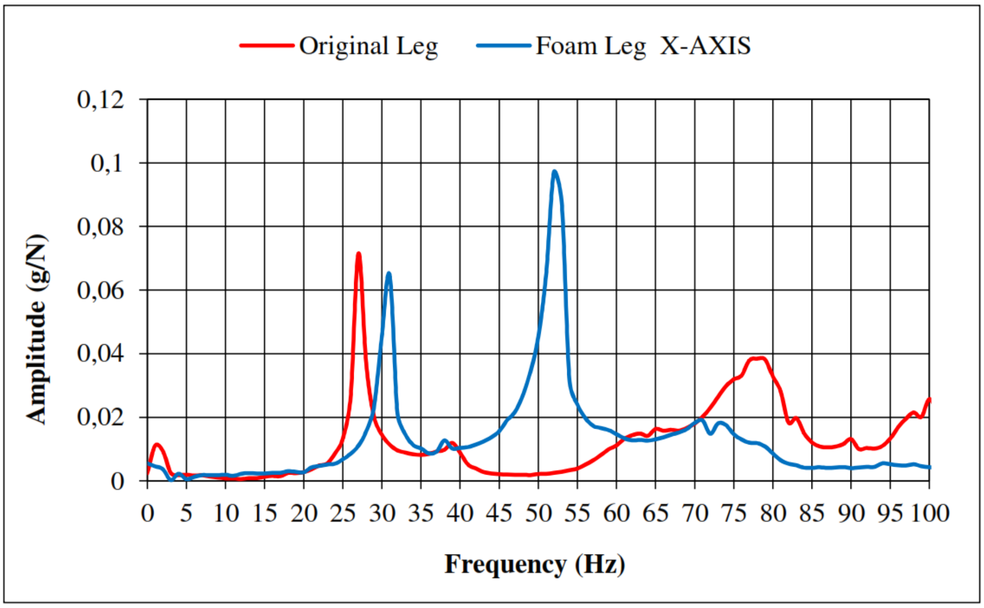

Figure 3 FRF graphic in direction of x-axis in 0-100 range

It is seen in Figure 3 that it has postponed the 1st mode of original leg to higher frequencies, that it has increased the damping rates for 1st mode, and that it has led to improvement from this aspect. It has also been observed that it hasn't led to any improvement useful for 2nd mode of original leg, that it has made damping worse, and that it has postponed the mode to slightly lower frequencies. It has been seen in original leg that the decreases occurred in modes in high frequencies and there occurred improvements from this aspect.

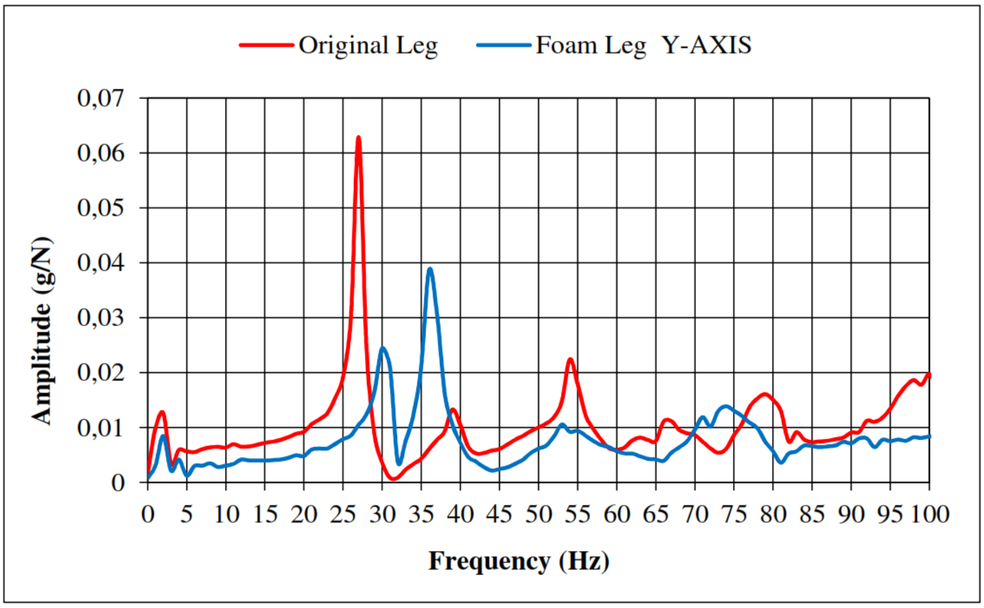

Figure 4 FRF graphic in direction of y-axis in 0-100 range

As seen in Figure 4, it has been observed that it postponed the 1st mode in original band to higher frequencies, and that it led to a little increase in damping rates for 1st mode. In proportion to original leg, the improvements were observed in damping rates, and there occurred the improvements from this aspect.

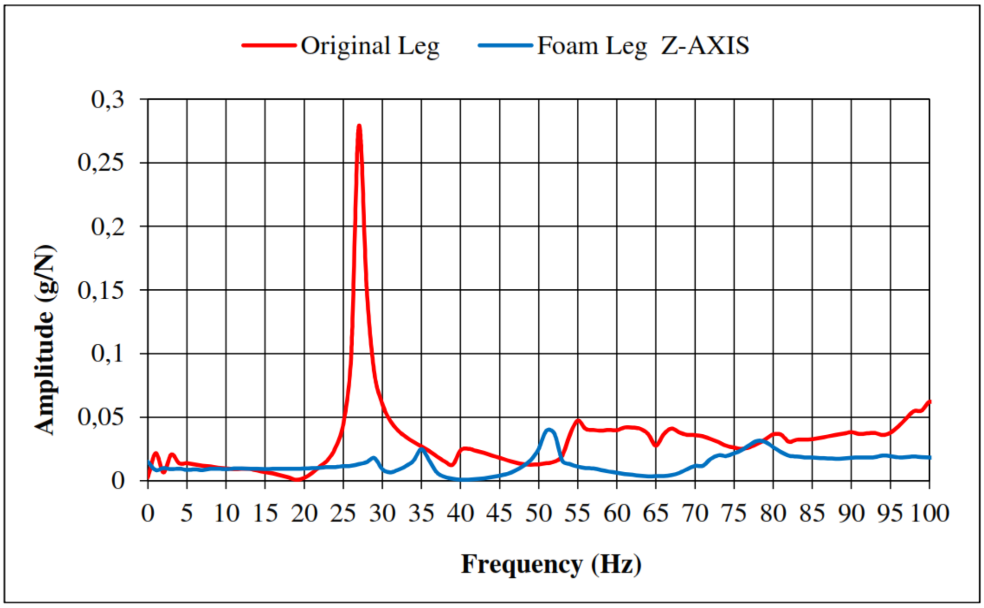

Figure 5 FRF graphic in direction of z-axis in 0-100 range

As seen in Figure 5, it has led to an improvement by postponing the 1st mode in the original leg at 20-45 Hz higher frequencies, but it hasn't created any improvement for 2nd mode but made the damping worse.

As the level of acceleration increases, the duration of tiredness decreases. In other words, as the acceleration gets higher, the patient reaches at the tiredness threshold sooner. The accelerations of both of seat legs were measured at 3 speed levels. While the vehicle passes over the speed bump, the acceleration in vehicle is higher than it is on a normal road.

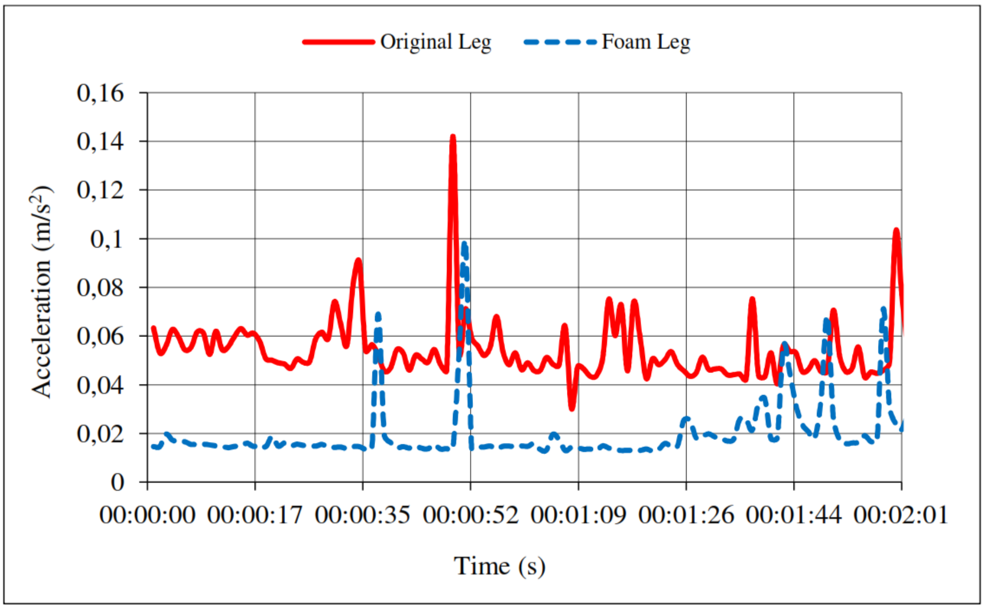

Figure 6 Acceleration-time graphic of original and foam legs at 25 km/h

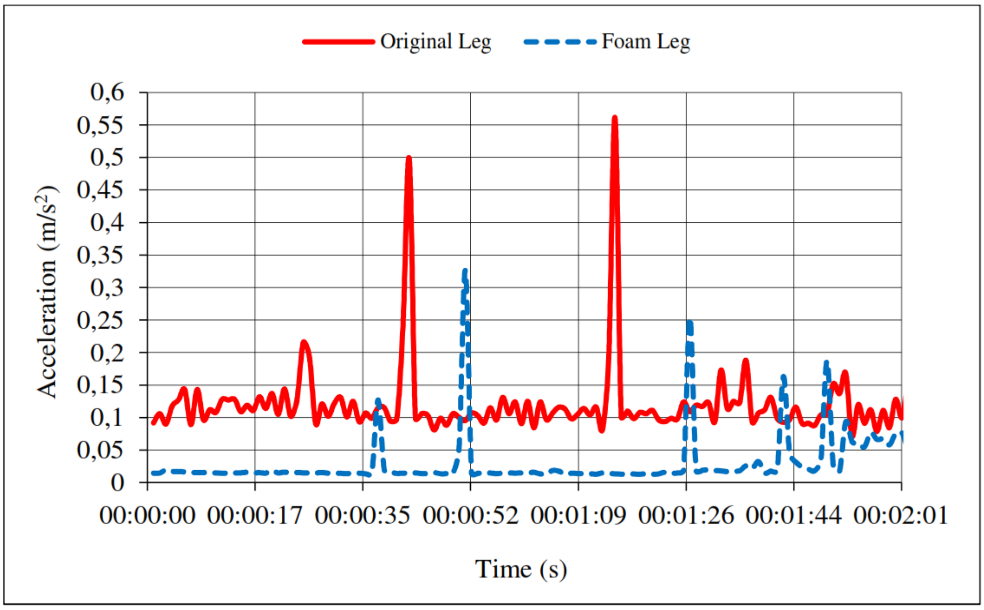

Figure 7 Acceleration-time graphic of original and foam legs at 50 km/h

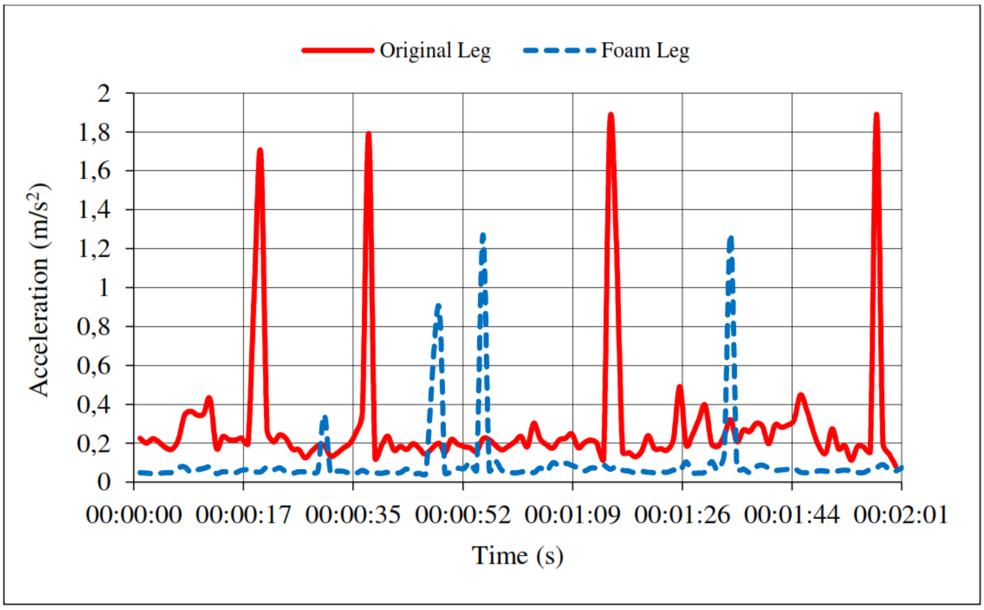

Figure 8 Acceleration-time graphic of original and foam legs at 75 km/h

As seen in graphics, whole of the vehicle passing over the speed bump showed vertical rigidity. On the other hand, both of speed and acceleration of the vehicle reached maximum. The graphics prepared are the graphics of vertical acceleration. It was observed that acceleration values increased as the speed increased.

Conclusions

As seen in FRF graphics; while the amplitude levels are low in certain frequencies, they reach very high amplitudes (peak points) at certain frequencies. The force implemented at these special frequency points, where the amplitudes peak, transforms more into vibration within the structure.

Considering the lower frequencies, it is seen in the graphics that the foam leg would work better, while it is seen that the original leg would work better while considering the higher frequencies.
As seen in acceleration graphics that acceleration has increased in both of legs as the speed increased. Acceleration measured at seat with aluminum foam leg was found to be lower than the acceleration measured at the seat with original leg.

Acceleration levels of the seat with original leg increased before the seat with foam leg did. It was observed that the foam material improved the comfort and delayed the tiredness threshold. Accordingly, the seat with foam leg damped the stimuli forces better than original legs did. Faster movement of vehicles decreases the tiredness threshold. Thus, passengers get tired sooner.

As a result of both experimental studies, foam leg foot was observed that better than the original leg vibration damping.

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