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The Noise Characteristics of Reduction Gear for Moving Device of Automotive Seat

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Abstract. This study analyzed that the noise characteristics for the reduction gear of automotive power seat. First, the operating noise of the slide mechanism was measured using a microphone and then we found the gear mesh frequency. From this, the noise characteristics for the reduction gear assembly was analyzed by deriving the noise level for each frequency order from the time domain. Thus, it was found that the rotation direction of the reduction gear affects the characteristics of the operating noise.

Keywords: Reduction gear, Gear mesh frequency, Operating noise.

1 Introduction

Today, studies on reduction of noise is being actively conducted throughout the entire automotive industry. Among them, the noise from automotive seat accounts for an important factor in consumers' selection of a vehicle [1,2].

Automotive seat is equipped with various convenient components such as slide mechanism, recliner, height, lumbar support, tilt, and most of them are controlled by electric motor [3]. Among these components, the slide mechanism is a device that moves seat back and forth. It consists of DC motor, flexible shaft, reduction gear, bearing, track, etc. Above of things, reduction gear is made up of a set of rotating worm gear connected to a wheel work [4]. And gear mesh frequency is occurred by each gear's teeth and mate together in a gearbox. The reduction gear assembly used in this study are three start thread worm and 18 tooth worm wheel. For this reason, the gear mesh frequency 1st order is occurred the same as motor 3rd order. These frequencies appear as operating noise when slide mechanism moves back and forth [5].

So, this study focused on noise characteristics for the reduction gear of slide mechanism. First, the operating noise of the slide mechanism was measured using the microphone and then we found the reduction gear mesh frequency and harmonic orders.

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2 Method

2.1 Environment and Equipment

The working noise of seat slide mechanism was measured in a semi-anechoic room that had ordinary temperature in 20±5°C, the 40±20% of room humidity, and the background noise was under 25dB.

Experimental equipment was LMS Test lab 32 channel that was used for noise data collection and analysis. The sensor for noise measurement was microphone it was ICP type and 1/2inch size. DC motor drove by power supply that applied voltage was 13.5V. Motor rpm was measured by tachometer. Semi-anechoic room and equipment for experiment are shown in Fig. 1.

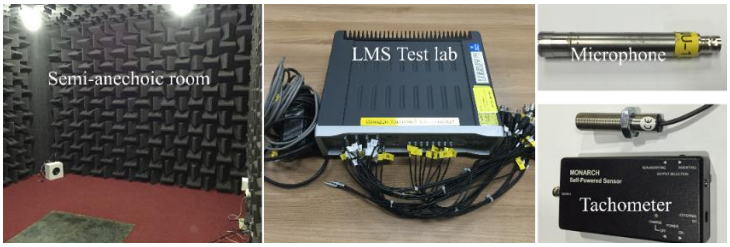


Fig. 1. Experiment environment and equipment

2.2 Experiment Method

To obtain noise data from operating experiment of slide mechanism, recliner angle set 100°. Slide rail mounts are inclined at 5° slope due to the difference in height between front and rear. Load condition on the top of seat cushion gave 75kgf with dummy. The temperature of the DC motor was maintained approximately 25±3°C to prevent overload.

Microphone position for noise measurement located as shown in Fig. 2 that was perpendicular to the seat bite line and facing forward in car position. And it was recorded the noise while operating the slide mechanism in each mode of operation. One was Mode 1 which means that move from full rearward to full forward, the other was Mode 2 that is opposite of Mode 1.

The total moving distance of slide mechanism is 280mm. The seat track consists of upper and lower, each were 380mm and 355mm in length. Fig. 2 shows the vehicle seat used in the operating experiment.

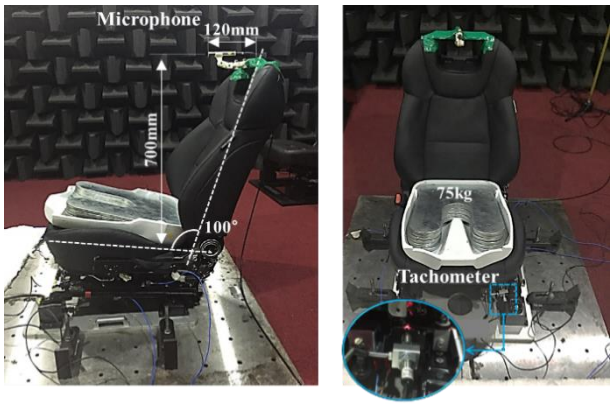


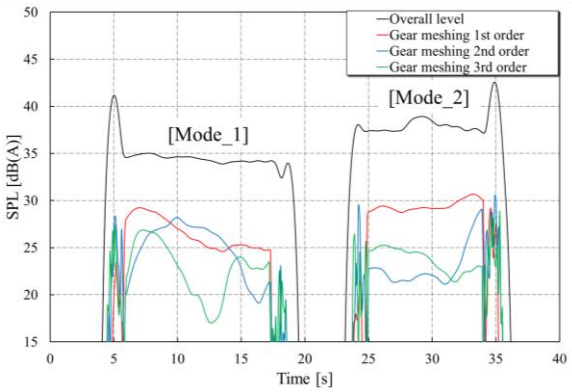
Fig. 2. Automotive power seat

3 Result and Analysis

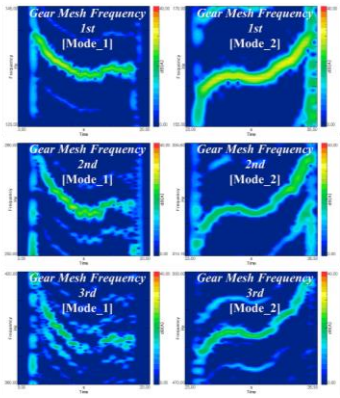
Fig. 3 shows the noise level and color map data with respect to operating noise of slide mechanism. The noise caused by reduction gear assembly occurred in the frequency range below 500Hz. Among the gear mesh frequencies of reduction gear assembly, 1st to 3rd order affected the operating noise in all operating modes.

In mode 1, the amplified noise was different depending on the position of the slide mechanism, especially 1st and 2nd orders were confirmed high level between 6 and 12 seconds.

In case of Mode 2, it was similar to Mode 1 but the noise level of 1st order was higher than Mode 1. In other words, operating noise was analyzed that it is sensitive to change of rotation direction of reduction gear due to reverse rotation of DC motor.



(a) Overall level and gear meshing orders



(b) Color map of the gear noise

Fig. 3. Calculated data for working noise

4 Conclusion

In this paper confirmed that the noise characteristics of reduction gear assembly when slide mechanism of automotive power seat was operating, and results were as follows.

The Gear mesh frequency of the reduction gear assembly occurred below 500Hz, which was 1st to 3rd order and it has been observed that the noise level of gear mesh frequencies was changed depending on the position of seat. The reason for this was determined that the dynamic characteristics of the structure according to the position of the seat is changing continuously. In addition, we were found that the rotation direction of the reduction gear affects the characteristics of the operating noise, especially the 1st order noise was very amplified in Mode 2. In conclusion, the noise level of reduction gear assembly was determined by the load acting on gear and rotational speed of worm gear.

This study is an experimental research for vehicle power seat, and it will be used as a basic data to study the sound quality of the moving device in the future.

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