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On noise reduction of motorcycle helmets

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ABSTRACT

Motorcycle helmets are mandatory on the safe driving, in spite of that the helmet usage rate decreases by the reason of discomfort. One of the most common complaints of the drivers is noise in the helmet. The noise may be structural bourne or air bourne. In this paper, measurements were performed to determine the external noise reduction of the motorcycle helmets, which is a preliminary study to improve the sound quality. The measurements were carried out on a specially designed field to provide a controlled acoustic environment. A Head& Torso simulator was used to measure noise in the built cabinet that produced by an omnidirectional sound source. The in-cab calibration was provided by in-house microphones. The excitation sounds were generated by using special software on the computer and the output was transmitted to the speaker cabinet via a sound card connected to an amplifier. Two types of motorcycle helmets were tested and the sound reduction results were compared.

Keywords: Noise Reduction, Insertion Loss, Noise Measurement I-INCE Classification of Subjects Number(s): 70, 72, 78

1. INTRODUCTION

In literature, there are several studies about the helmets, but the pioneer studies on helmet acoustics have emerged in the 70s. The study of Moorhem et.al. (1), in which the effects of motorcycle helmets on hearing and the detection of warning signals were investigated, can be accepted among the first studies in this field. Młyński et. al. (2) measured insertion loss of motorcycle helmets by using microphone-inreal-ear technique and sound attenuation by using the real-ear-at-threshold method. By the lights of the measurements, it is mentioned that helmets showed essentially no protection against external noise below 250 Hz and attenuation increases linearly at a rate of 8–9 dB per octave, to ~30 dB at 8 kHz above 500 Hz. Kennedy et.al. (3) analyzed sound transmission characteristics of a motorcycle helmet by using a combination of insertion loss measurements and loudness matching in their study. The effect of helmet on riders' perceptions of loudness was examined by generated equiloudness curves. It is concluded that helmets behave as frequency dependent filters for the human auditory system. Carrilho and Silva (4) studied the aerodynamic noise in motorcycle helmets. In their study, aerodynamic measurements were carried out in a wind tunnel. The data were collected by using a head-torso acoustic mannequin. It was found that the velocity of the motorcycle and usage of windscreen in motorcycle effect the noise levels in the helmets. In another study by Kennedy et. al. (5), an investigation about the temporary hearing loss in motorcyclists is performed. The helmet noise transmission characteristics have been analyzed in their study. The effects of motorcycle noise exposure on THTS were investigated by conducting pure-tone audiometry before and after listeners were exposed to white noise. Liu et. al. (6) presented an active noise control system for motorcycle helmets to reduce noise. After analyzing the motorcycle noise, researchers measured transfer functions for computer simulations and conducted real-time experiments. As a result, the performance and feasibility of the ANC algorithm was evaluated.

In this study, external noise reduction of the motorcycle helmets was determined by using a Head& Torso simulator and a sound source in a built acoustical cabinet. Two types of motorcycle helmets were tested and their insertion loss coefficients were calculated by using measured sound

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pressure levels. The insertion loss (IL) is defined as the difference between levels before and after an alteration (7). In this study, the alteration is the helmet usage. In this case, introducing the subscripts to indicates sound pressure levels 1 (without helmet) and 2 (with helmet) the insertion loss is formulated as:

$$IL = L_{p_1} - L_{p_2} \tag{1}$$

2. EXPERIMENTS

The tests were conducted at the Istanbul Technical University Vibration and Acoustics Laboratory. The measurements were performed in a cabinet which is designed to supply an acoustic environment for the sound pressure measurements. The dimensions of the test cabinet are 70x160x180 cm. A Brüel & Kjaer head-torso simulator, which has 4189-A-002 type microphones at the entrance of both ear, was used for obtaining the acoustic pressure inside the helmet. In order to determine the effect of the background noise, a 4189-A-021 type Brüel & Kjaer microphone was conducted close to the mouth of the head-torso mannequin. Brüel & Kjaer omnidirectional sound source was used to generate the noise. It was located 1 meter in front of the head-torso mannequin. The cabinet, the head-torso simulator, the 4189-A-021 type microphone and the sound source can be seen in Figure 1.

Figure 1 - Experimental setup; the cabinet, the head-torso simulator, the 4189-A-021 type microphone and the omnidirectional sound source.

All microphones used in experimental setup were connected to the 16 channel 3560 D type analyzer to record the sound pressure data. And this analyzer was connected to a personal computer to process the signals. White noise generated by personal computer was used for all measurements in this study. The 2416C type amplifier was used as a module without gain adjustment. Measurements were carried out between 20 Hz and 10000 Hz. 10 seconds time averaging was subjected for all measurements.

Two types motorcycle helmets were used for determining the effect of the helmets on the noise reduction. One of the helmets has a modular design and the other one is full face. The helmets used in the measurements were depicted in Figure 2.

(a) (b) (c)

Figure 2 - The helmet models: (a) full face, (b) modular and (c) modular (open face).

3. RESULTS

Figure 3-6 show the results of insertion loss measurements on 1/3 octave band for two types of motorcycle helmets in variation of visor conditions. The curves obtained have similar characteristics within themselves and in other studies (3, 4, 5). This is in agreement with previous observations that helmets supply no protection for the exterior noise for lower frequencies. Attenuation gradually increased in the 800-5000 Hz frequency range. The rate of the increment was approximately 5 dB per octave in that frequency range and reached a maximum ~25-35 dB. From 5000 Hz upwards, attenuation was in tendency to decrease.

Figure 3 shows insertion loss of the full face helmet for open and closed visor conditions. As it can be seen in the plot, closed and open visor have similar insertion loss characteristics, but attenuation of closed visor was ~3-8 dB higher than attenuation of open visor, especially in higher frequencies.

Figure 4 shows insertion loss of the modular helmet for open, closed visor and open face conditions. From the graph, it is clear that the change of insertion loss was similar for visor open and open face conditions. By comparison, the spectra of different types of conditions, the closed visor condition shown by blue dashed line has greater insertion loss in the high frequency range at 1250 Hz and above.

Figure 5 shows insertion loss comparison of the visor closed helmet models; full face and modular. Once the results given in the figure are examined, it can be easily noted that the curves obtained were very similar for both types of helmets in closed visor condition.

The insertion loss comparison of the visor open helmet models; full face and modular was illustrated in Figure 6. It can be observed by looking at the resulting curves that they show the similar attenuation for both types of helmets in open visor condition up to 5000 Hz. Above 5000 Hz, they have the same characteristic behavior but with ~3-10 dB difference.

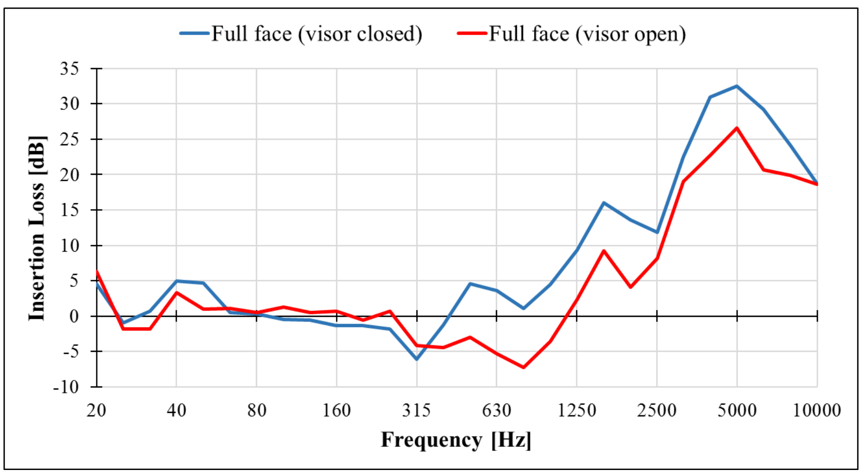

Figure 3 - Insertion loss of the full face helmet; visor closed and visor open.

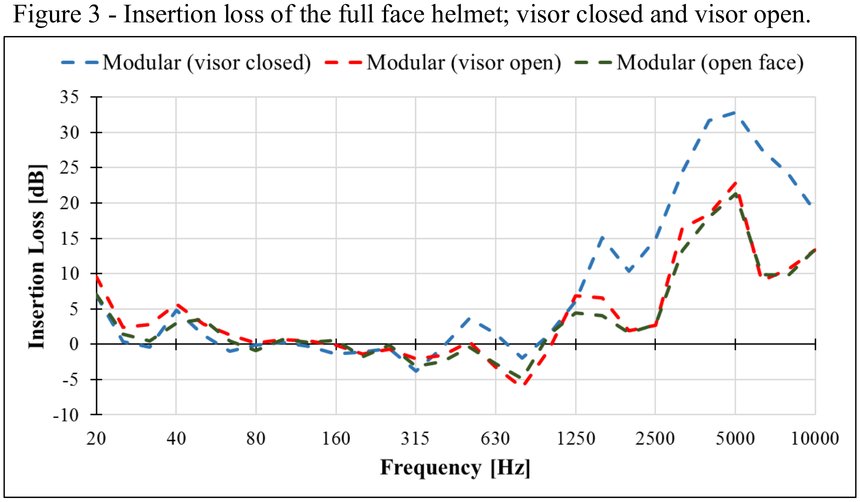

Figure 4 - Insertion loss of the modular helmet; visor closed, visor open and open face.

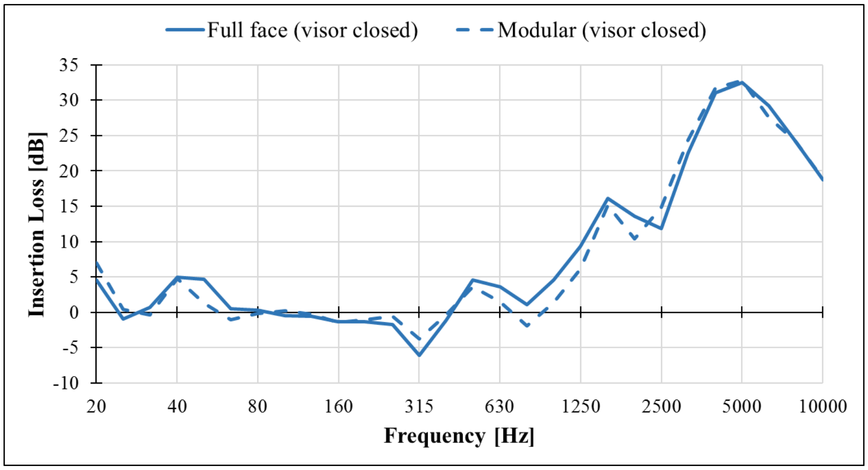

Figure 5 - Insertion loss comparison of the visor closed helmet models; full face and modular.

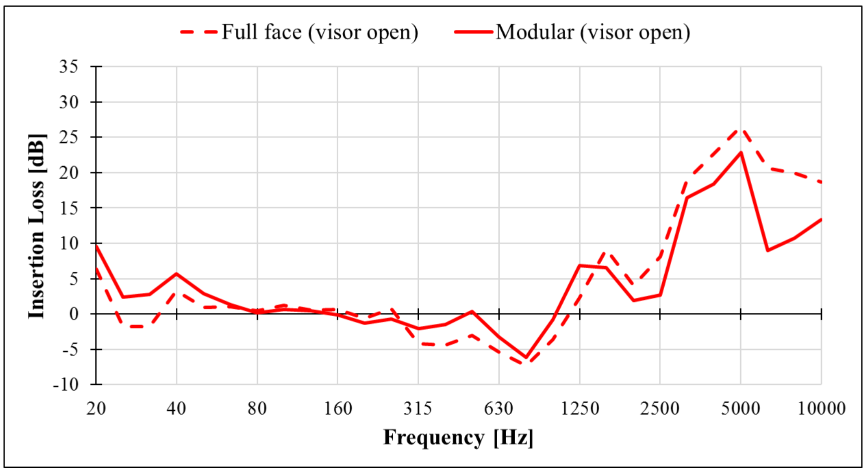

Figure 6 - Insertion loss comparison of the visor open helmet models; full face and modular.

4. CONCLUSIONS

In order to determine the effect of helmets on the noise reduction for various conditions, insertion loss measurements were performed in this study. Two types motorcycle helmets were used with their open and closed visor options for the measurements. Noise reduction of the open face condition of the modular helmet was also examined. All measurements were conducted in the cabinet for both elimination of the background noise and avoiding the reflected noise in the present work. One may say that the helmets are successful to decrease the noise level at higher frequencies although they are not capable for attenuation at lower frequencies in every case. Insertion loss measurements for visor closed form of both helmets show that they almost have same attenuation in every frequency band. However, visor open conditions of the helmets have difference between their insertion loss values, especially at higher frequencies. It can also be noted that the difference between insertion loss spectrum of open face and visor open form of the modular helmet can be negligible.

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