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MEASUREMENT OF NOISE EMISSION BY TYRE OF PASSENGER'S CAR

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ABSTRACT

In this research, the noise emission level for two types of speed reducers (bump & cushions) with different dimensions and different speeds of vehicle (20, 40 and 60 km/h) has been numerically and experimentally investigated. The numerical analysis has been performed using an FEM method with Ansys software. The exerted force to tyre has been exploited by half-car model; furthermore, the modeling of vehicle has been accomplished by Simulink software. The experimental results show that for bump with the height of 0.04 m, the peak noise level increases between 1 to 14 dB (A) and for bump with the height of 0.055 m, the peak noise level increases between 1 to 19 dB (A). The results represent that there is an excellent agreement between the numerical and experimental results.

1. INTRODUCTION

Undoubtedly, the most important source of noise pollution in urban areas is related to vehicles commutating the streets. Focusing on vehicles, the engine and road-tire contact, generates the maximum portion of noise emitting to the environment. Kuziume (2003) investigated the level of noise emitted from the vehicle driving the plain road with the speed of 50 km/h and zero acceleration. He used the boundary element method (BEM) to accomplish his numerical attempt and his experimental result had good compatibility with the numerical results [1]. Lelong (2000) showed that the vehicle acceleration also affects the noise level while in lower vehicle speeds; the emitted noise has more sensitivity to accelerations compared with higher vehicle speeds [2]. Rylender (2000) experimentally investigated the noise level of vehicles crossing the speed limiters (bumps) especially for passenger cars and Lories. He showed that in both types of vehicles, the emitted noise will increase while passing bumpers [3]. According to Lelong research, although the emitted noise of engine in lower engaged gears are prominent in upper engaged gears the tire/road noise level is more important. The sound radiated from tires is generally classified into three components. The first component is from whole- tire vibration produced by road roughness. It is most remarkable in the frequency band to 500 HZ. The second one is the tread block vibration and the third one is the tread air groove resonance. The second and third components are remarkable in the frequency band to 1000 HZ. Vibration noise mainly radiates from the tire side wall; whereas the other two components are due to the tread pattern [4-5]. Kuziume investigated smooth tire vibration noise generated by rolling on roads. Kuziume measured the vibration and sound radiation characteristics of smooth tires, and analyzed the radiated sound field. Kuziume employed an operational analysis method to clarify vibration behavior in a rolling tire, and studied sound intensity distributions to determine the sound radiation characteristics. He also uses the Boundary Elements Method (BEM), which is suitable for analyzing sound radiation problems. Their BEM result is close to the experimental data [1].

1.1. Tire/road noise

Air Resonance: The first, pipe resonance is due to standing waves, which occur in the groove of the tire tread. The resonant sound will have a wavelength of twice the pipe length if the pipe is open in either ends, or four times the pipe length if it is open in one end only. The second Helmholtz resonance - the volume of air in a cavity will act as a spring resonating with the mass of air in the "throat" between the cavity and the external air. The third air pumping in the tire rolling process, air is trapped and compressed in small voids between the tread and pavement. Noise is generated when this high pressure air is ejected to the atmosphere at the exit of the contact patch. Because of the high velocity of the air jets created by this process, air pumping can be a major contributor to radiated noise. The Helmholtz resonance might amplify the noise. Tire Body Vibration: Tread element vibration is produced by the collision between the tread blocks and road or the roughness of road. Getting in contact with and leaving the pavement generate tread vibration, which is a major source of tire noise radiation. Track and side wall vibrations are the other sources of vibration. Experiments: The test has been done in a road according to EEC1standard as shown in Figure 4. The test accomplished with one passenger car and two different bumps. Characteristics of bump1 are, width and height respectively 0.9, 0.055 m and bump2, width and height respectively 0.6, 0.04 m. Air temperature and background noise level were about 30˚C and 45dB (A) respectively. The wind speed was measured less than 5km/h and there was no noise reflection within a 50 m radius of road selected for test according to the standard. The maximum noise level from the passing vehicle was manually recorded using a Bruel

[1] European Economic Community

and Kjaer noise level analyzer (B & K 2060) and the tests were carried out for the speeds of 20, 40, and 60 km/h.

1.2. Figures

To calculate the transmitted force the vehicle half model is used as shown in Figure1.

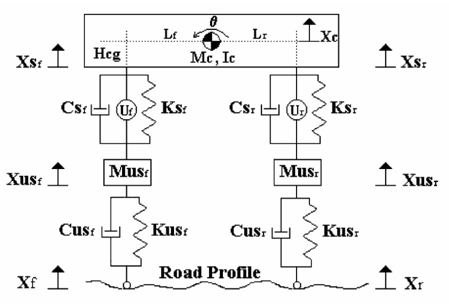

Figure 1. Half car model

The element used in finite element analysis for modeling the tire is 181 nonlinear shells illustrated in Figure 2.

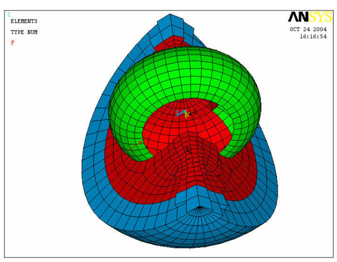

Figure 2. Model sections

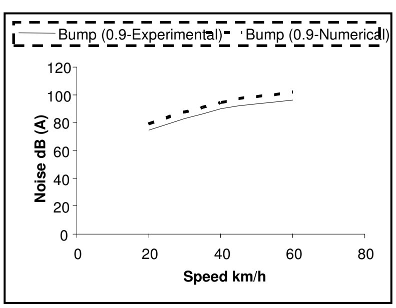

Figure 3. Comparing the numerical and experimental results for bump 0.9.

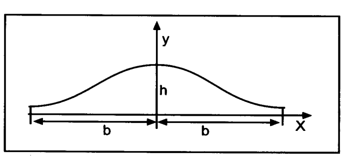

Figure 4. Bump dimensions

1.3. Equations

The relation between the height of bumps and its width as shown in Figure 4 and vehicle speed can be given by the following equations:

$$y = \frac{h}{2}(1 + Cos\frac{\pi x}{b}) \Rightarrow \dot{y} = -(\frac{h\pi\dot{x}}{2b})Sin\frac{\pi x}{b} \quad (1)$$

In half-car model, K_{US} , C_{US} , K_S and C_S are respectively tire stiffness, tire damping coefficient, suspension stiffness and suspension damping coefficient.

$$F_f = K_{S_f}\left(X_{S_f} - X_{US_f}\right) + C_{S_f}(\dot{X}_{S_f} - \dot{X}_{US_f}) - U_f \quad (2)$$

$$F_r = K_{S_r}\left(X_{S_r} - X_{US_r}\right) + C_{S_r}(\dot{X}_{S_r} - \dot{X}_{US_r}) - U_r \quad (3)$$

$$F_{US_f} = K_{US_f}\left(X_{US_f} - X_f\right) + C_{US_f}(\dot{X}_{US_f} - \dot{X}_f) \quad (4)$$

$$F_{US_r} = K_{US_r}\left(X_{US_r} - X_r\right) + C_{US_r}(\dot{X}_{US_r} - \dot{X}_r) \quad (5)$$

$$F_f R_f - F_r R_r = I_c \ddot{\theta} \quad (6)$$

$$-F_f - F_r = M_C \ddot{X}_C \quad (7)$$

2. CONCLUSIONS

Car noise emission level has been experimentally and numerically investigated in this research. Two types of speed reducers are used for experimental purposes. The experimental results show that the peak noise level increases 1 to 19 dB (A) when the car passes the bump with the height of 0.055 m. ANSYS environment has been used for the numerical investigation. There is an excellent correlation between the numerical and experimental results. The results obtained by numerical simulation express the geometry of bump is an important factor in emitted noise from vehicle.

3. REFERENCES

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