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ACOUSTICAL MODELLING AND EXPERIMENTAL MEASUREMENT OF CONCENTRIC RESONATOR REACTIVE MUFFLER

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1. INTRODUCTION

In the past, most attempts to predict the acoustic performance of reactive mufflers have been limited. However, in recent years, prediction of acoustic attenuation can be made with greater accuracy by numerical modelling using FEM and BEM.

In this paper concentric resonator reactive mufflers were investigated. This type of muffler consists basically of a perforated tube coaxial with an expansion chamber. No gas flow or temperature variation is considered. Four different configurations with different dimensions were investigated (see table 1 and figure 1).

The following evaluation methods are considered: Finite Element Method (FEM), Transfer Matrix Method (TMM) and experimental measurements with one microphone and a two channel FFT analyser. The results obtained for the transmission loss are then compared [1].

Configuration	dh (mm)	t (mm)	Total number of holes	porosity %	l (mm)	d (mm)	D (mm)	La (mm)	Lb (mm)
1	3	3.5	480	4.93	12	43	170	31	471
2	5	3.5	252	15.05	11	43	170	154	225
3	3	3.5	132	4.17	15	43	135.5	00	153
4	5	3.5	198	17.16	15	43	135.5	00	153

Table 1 : Dimensions of the four configurations

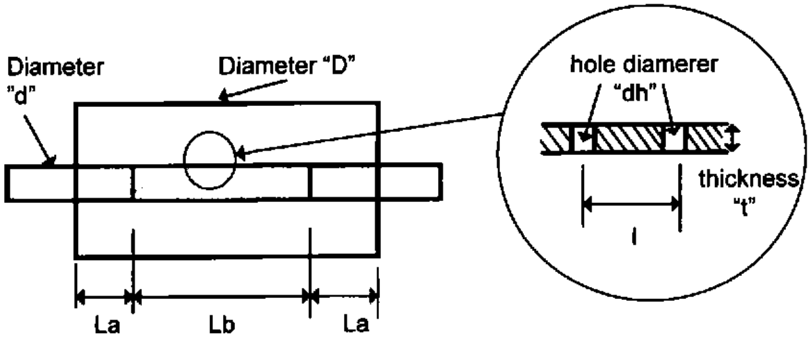

Figure 1: Concentric Resonator Reactive Muffler

2. MODELLING BY FINITE ELEMENT METHOD (FEM)

The FEM modelling consists of two independent meshes; one for the external expansion chamber duct and the other mesh for the internal perforated tube. There is no connection between the two meshes except through the transfer acoustic impedance imposed by the boundary conditions. ANSYS software was used to generate the mesh. The processing and post processing were carried out by SYSNOISE 5.2. Bauer[2] linear equation for transfer impedance was used for zero flow.

3. TRANSFER MATRIX METHOD (TMM)

In this method, the muffler is be divided into various elements, where analytical modelling of each element is performed [6]. For TMM, only plane wave propagation is possible. The relation between sound pressure and particular velocity on the input and output planes of the mufflers are given by :

$$\begin{bmatrix} p_1 \\ v_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} A_3 & B_3 \\ C_3 & D_3 \end{bmatrix} \begin{bmatrix} A_4 & B_4 \\ C_4 & D_4 \end{bmatrix} \begin{bmatrix} A_5 & B_5 \\ C_5 & D_5 \end{bmatrix} \begin{bmatrix} p_6 \\ v_6 \end{bmatrix}$$

Where;
p1 and p6 are the acoustic pressure at the entrance and exit of the tube;
v1 and v6 are the particle velocity at the entrance and exit of the tube;
A, B, C e D are available for each simple element such as; uniform tube section [3], extended element [4, 3], elements of expansion and contraction [3], perforated element [6].

4. TRANSMISSION LOSS MEASUREMENTS

Transmission loss measurements were carried out using a single microphone and a two channel FFT analyser. In this technique no anechoic termination is needed [6]. Measurements are carried out with microphone separation distance of 50 mm, which means that the results are valid for a frequency range from 343 Hz to 2744 Hz [6,7].

5. RESULTS AND COMMENTS

Figure 2 show a comparison of the TL obtained using FEM, TMM and Measurements for the four configurations considered on table 1.
The results obtained from the FEM and measurements, of the second and the third configuration are similar, while for the first and the third configuration where the "open area ratio" is lower, a small difference is obtained between FEM and Measurements. The TMM results give good approximation with experimental results up to 1600 Hz . At low frequencies, the transfer impedance tends to zero and numerical instability occurs, therefore there are opposing tendencies among the numerical, FEM and TMM results. Generally, the results obtained by FEM, TMM and experimentally looks very promising.

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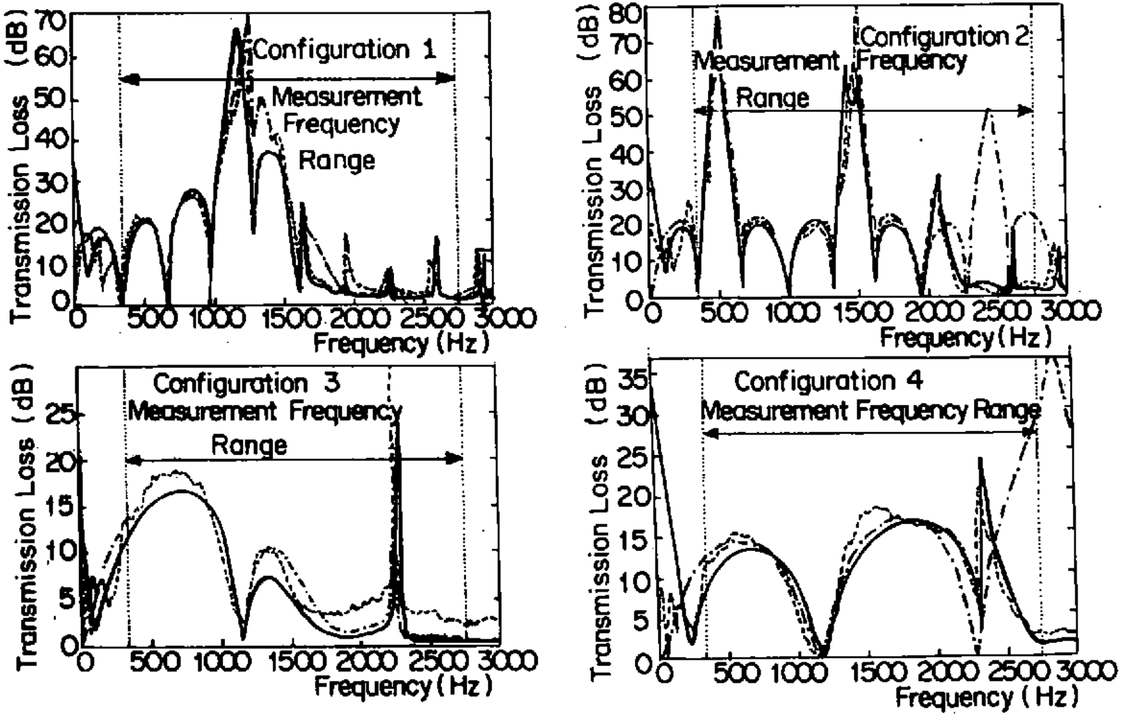

Figure 2: Transmission Loss for configuration 1, 2, 3 and 4 (see table 1), FEM (———), TMM (—·—·—) and Measurements (-------).