Fluid Acoustic Properties of Improved Hydraulic Mufflers with Extended Necks

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The acoustic properties of three improved hydraulic mufflers with extended necks are investigated theoretically and experimentally. The effect of length and slope of the conical tube, and the perforations on the extended tube is studied on the resonance frequency and the insertion loss. The plane wave approach is used for the constant and the variable area tubes, while Sullivan and Peat’s method is applied for the perforation tube unit. Theoretical predictions are compared with experiments for these three different hydraulic noise suppressors, which are fabricated. It is shown that the resonance frequency and the insertion loss characteristics may be controlled by the length and the slope of the conical tube and perforation porosity of the extended tube without changing the expansion chamber volume. Finally, the effect of the cross-sectional shape of the expansion chamber is investigated.

NOMENCLATURE

Subscripts
0 Equilibrium state
s Isentropic process

Superscripts
\( \sim \) Perturbed quantity

1. INTRODUCTION

The fundamental assumptions used in the formulation of the governing equations of motion for the resonators were as follows:

1. The Reynolds number in the tube was low (smaller than 2000), which was called the laminar flow
2. The amplitude of pressure pulsation and related density in either tube or cavity was small, compared with the mean flow values
3. Gradients of temperature of the medium in the resonator were neglected;
4. In the case of a rigid-walled tube filled with a stationary ideal fluid, inviscid waves travel as plane waves.

The basic equations for this case were:

\[ \dot{\rho} + \vec{\nabla} \cdot \rho \vec{u} = 0; \quad (1) \]

\[ \dot{\rho} + \vec{\nabla} \cdot \rho \vec{p} = 0; \quad (2) \]

\[ c_0^2 \approx \frac{dp}{d\rho} \mid_{s,0} = \frac{1}{\beta_s \rho_0} = \frac{p}{\rho}; \quad (3) \]

Using the basic linearized form of Eq. (1), (2) and (3) yielded:

\[ \Delta p - \frac{1}{c_0^2} \frac{\partial^2 p}{\partial t^2} = 0; \quad (4) \]