

# Abstract

The main objective of this Thesis is the development, design and implementation of an experimental test rig to obtain the acoustic characterization of mufflers and other elements of the exhaust line of internal combustion engines in the presence of mean flow.

It has also been carried out a review of the models typically found in the literature for characterizing absorbent materials and perforated surfaces. Next, it has been studied the different indices representing the acoustic response of mufflers, and has been selected as most suitable index the transmission loss.

First, a theoretical study of the governing equations of the acoustic phenomenon in ducts in the presence of mean flow has been carried out. Also, a review of the typical models found in the literature for characterizing absorbent materials and perforated surfaces has been achieved. Next, several indexes that represent the acoustic behavior of exhausts mufflers has been studied and the transmission loss has been selected as the most suitable.

The matrix representation has been introduced through the plane wave model. It provides the acoustic characterization of the devices on the exhaust line. This representation allows obtaining the acoustic characterization of the complete exhaust line by multiplying the matrices that represent each element.

Due to the limitation on frequency range of the one-dimensional theory, the numerical solution of the classical convective wave equation, that governs the acoustic phenomenon, has been obtained by means of the finite element method. The method has been particularized for axisymmetric geometries as the prototypes used. It has also been studied how to apply different boundary conditions to force acoustic velocity, the modeling of a perforated surface or an anechoic termination. The numerical solution obtained by the finite element method has been used to compare with experimental measurements.

Furthermore, a detailed study of experimental techniques frequently used in the measurement of acoustic parameters has been carried out and an assessment of each indicating its suitability has been done for its use in the presence of mean flow analyzing advantages and disadvantages. As conclusion of the analysis it has been determined that the most interesting technique is the two microphones method. The original procedure contains some aspects associated which imply difficulties in the implementation in the presence of mean flow, such as the installation of an anechoic termination for the direct determination of the transmission loss and the excess time requirement for obtaining the same parameter using the alternative procedure which involves performing two separate tests.

The experimental technique developed, based on the two microphones method, allows to carry out the two independent tests required simultaneously

removing the need of an anechoic termination and reducing test time significantly. This aspect is especially critical in the presence mean flow because the environmental variables can change quickly.

Finally, it has been implemented the experimental set-up designed and equipped it of the required instrumentation to measure environmental parameters and the acoustical signals. The validation of the developed technique has been carried out by obtaining the poles of the transfer matrix of a straight duct with uniform cross section that are available in the bibliography, with different values of mean flow. It has obtained the transmission loss for different types of exhaust mufflers, achieving in all cases satisfactory results.

**Keywords:** experimental measurement, transmission loss, exhaust muffler, mean flow, simultaneous excitation, finite element