Title:

Linear source identification for I.C. engine exhaust noise prediction

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Abstract:

Considerable efforts have been devoted to the development of predictive models that, from a certain set of data related to an engine, and making use of an adequate representation of the effect of the silencing elements, provide an estimate of the exhaust noise emitted. Aside from the effect of the silencers, such models should allow for the consideration of the engine, its interaction with the exhaust system and the radiation process. While gas-dynamic models are becoming the standard, linear models solved in the frequency domain may still play a role in exhaust system design, as the engine is treated as a black box. Such a representation is very attractive for engine manufacturers, since it gives the possibility to provide data on the engine without being possible to trace back to its real characteristics.

Procedures for the identification of these black-box source magnitudes are based on the assumption that source characteristics are independent of the exhaust system considered (the "load", in the usual terminology of acoustical-electrical analogies), so that they may be obtained from measurements (or simulations) considering a certain set of "independent" loads.

Here, a multi-load method, in which an extended set of loads is considered, and the resulting over-determined system is solved by fitting the values of the source parameters in a least-squares sense, has been developed in order to extract source characteristics from gas-dynamic simulation results.

The details of the method are described, and different approaches are used in order to check the internal consistency of the source representation obtained and the suitability of the assumed representation for its application to the exhaust of an internal combustion engine: the identification of pressure and velocity sources, and the application of the least-squares criterion to the modulus or to the real and imaginary parts separately. In particular, four different results for the source impedance are obtained, which should be strictly identical when one deals with a linear time-invariant system. Considering the application of this formalism to an engine exhaust, one may only expect that the system is approximately linear and time-invariant, and therefore the differences observed provide a simple criterion for the evaluation of the suitability of the representation and of the particular set of loads chosen.