Experimental Research of Aerodynamic Noise Induced by Condenser of Drying Machine

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In this paper analyse the noise of aerodynamic sources induced by a drying machine condenser. Two condenser versions of identical external geometry that differ in the form of the flow channel in the direction of the secondary flow, were studied. We analysed the integral and local aerodynamic and acoustic characteristics of both condenser types. The measured far-field sound frequency spectra show essential differences between the two cases, discernible in the form and location of specific peaks superimposed on a generic power-law frequency spectrum. Recent theoretical advances in the Lighthill acoustic analogy were used to identify the generic part of the spectrum due to isotropic turbulence. The specific peaks in the spectrum are apparently due to different structural characteristics of the two studied versions of the condenser types. The measured characteristics of the power spectra were used to propose optimisation strategies in the design of the acoustic properties of the drying machine condensers.

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1. INTRODUCTION

Energy consumption and noise emission are the most important functional characteristics of household clothes drying machines on the basis of which customers make their purchase decisions.[1] The condenser, whose energy characteristics make a particularly important imprint in the overall product evaluation, is one of the most important components of clothes drying machine. During the drying process, the primary airflow passes through the clothes drum and condenser, while the secondary airflow is used in cooling down the condenser and for driving the condensation process. In the design of clothes drying machines, the most important concerns are the energy efficient design of primary and secondary flow channels, are the proper selection of fans and condenser types. In assessing these production parameters, the sound power level and power frequency spectra are of primary importance. Thus, we set out to establish an approximate measure of the acceptance based on these measurable acoustic quantities that can be used in the evaluation and design of various condenser types.

In this work, we present a method to measure the sound power level and power frequency spectra of the noise of aerodynamic sources induced by the drying machine condenser. Our aim is to provide the condenser manufacturers with reliable parameters concerning the acoustic properties of condensers. Results of these measurements provide an insight into the strategy for the reduction of energy consumption of the drying machine.

The difference between various types of condensers can exceed 5 dB in A-weighted sound power level, when installed in the appliance, resulting in typical deviations in drying machine classifications that need to be considered in further development and optimisation. The noise level produced depends on the geometry of the channels and the aerodynamic characteristics of the airflow in the condenser flow channels. The most pronounced noise source of the condenser is the airflow at the outlet side of the secondary circuit, which is discharged directly into the environment. Another source of the difference between condensers can be determined by measuring their far-field sound power frequency spectrum that also shows pronounced variation with respect to the condenser type. We will show that for the two types of condensers investigated, their specificity can be ascertained by the presence and form of peaks in the sound power frequency spectrum.

In accordance with the Lighthill acoustic analogy,[2] the far-field sound intensity and sound spectrum are determined by different velocity correlators in the turbulent part of the airflow at the outlet side of the secondary circuit. Lighthill's acoustic analogy is based on a certain reformulation of the standard Navier-Stokes equations for the fluid flow that leads to an inhomogeneous wave equation for the fluctuating fluid density with quadrupole acoustic sources.[3] The complete flow problem in the far field approximation is thus substituted by a solution of an inhomogeneous wave equation with localised quadrupolar sources in the ambient flow at rest. These sources are described by the Lighthill's instantaneous applied acoustic strength tensor, T_{ij}. The central step in Lighthill's theory is the assumption that the applied acoustic strength tensor is spatially localised, thus, the far-field solution of the inhomogeneous wave equation is essentially reduced to the