

Contributions of partial noise sources to overall noise of domestic appliance

M Bisták¹, Š Medvecký¹, I Gajdác¹ and J Ďungel²

¹University of Žilina, Faculty of Mechanical Engineering, Univerzitná 2, 01026 Žilina, Slovakia

²Ceit Engineering Services, s.r.o., Univerzitná 8413/6, 010 08 Žilina, Slovakia

E-mail: marek.bistak@fstroj.uniza.sk

Abstract. This article describes a method to identify partial sources of noise and their respective effects on the overall noise level of a clothes dryer. The focus is on the major sources of noise and options to control their noise levels so that the resulting declaration program produces as effective as possible acoustic improvement, while maintaining the desired drying performance, as indicated by the manufacturer in the rating plate. A rating plate is the main informative indicator allowing a consumer to compare performances of various competitor products.

1. Introduction

Comparing or analysing the acoustic performance of a clothes dryer during operation is a difficult assignment, which is particularly due to variations in operating conditions during a drying cycle. It is, therefore, important to identify all partial sources of noise and their individual contributions to the overall noise level of the domestic appliance generated during its operation.

2. Design of experiments for the objective assessment of effects of individual sources of noise

The measurements were performed in a certified acoustic laboratory and their aim was to assess noise emissions generated by the sources of noise in the dryer. In the first step, before the measurement itself, vibration sensors were attached to the independently driven electrical devices of the appliance to establish their operating states. Then, the declared measurement was made as an important basis for the assessment of both the overall noise level and the contributions of the various sources of noise [1].

Laboratory: Acoustic anechoic chamber

Measuring system: PULSE system, B & K 3053-B-120

Microphones: B&K 4190

Calibrator: B&K 4231

Accelerometers: B&K 4517

Acoustic camera: Noise Inspector

Declaration program: Cotton Eco

Weight of laundry: 9.00 kg





Figure 1. Appliance placed in an acoustic anechoic chamber.

Based on the measurement, the different sources of noise in the domestic appliance were identified and classified into two categories:

Primary, from motor operation:

- Motor
- Radial drying fan
- Drum rotation
- Laundry tumbling in the drum

Secondary, from other electrical devices with an independent drive:

- Compressor
- Pump
- Axial cooling fan

The first category comprises a combination of the various components of noise and noise from the motor, which is inherent to its drive. As this combined with the spinning of the drum, an increase in noise was observed due to the laundry tumbling in the drum.

The second category includes electrical devices operated by an independent drive that are integrated in the electric appliance. Such devices are operated by a control unit switching the devices according to the drying logics of the particular chosen dryer programme.

The declared measurement values served as the main state indicators for both categories and as a basis for the design of an external control unit and the measurement plan. [6, 7]

Table 1. Secondary noise source measurement plan.

Secondary sources of noise	Measurement #		
	1	2	3
Compressor	On	Off	Off
Axial fan	Off	On	Off
Pump	Off	Off	On

2.1. Preparation of the measurement exercise

The preparatory work involved adjustment of the electrical appliance and of its control and mechanical components to allow the measurement of each individual source as well as of the combinations of sources [4].

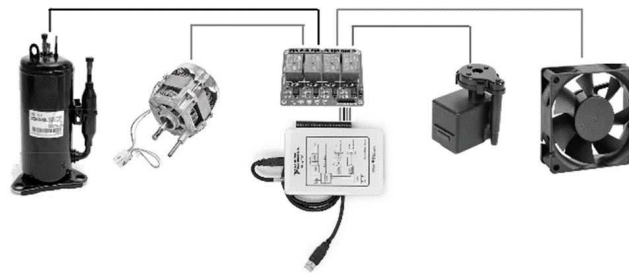


Figure 2. Simplified control diagram.

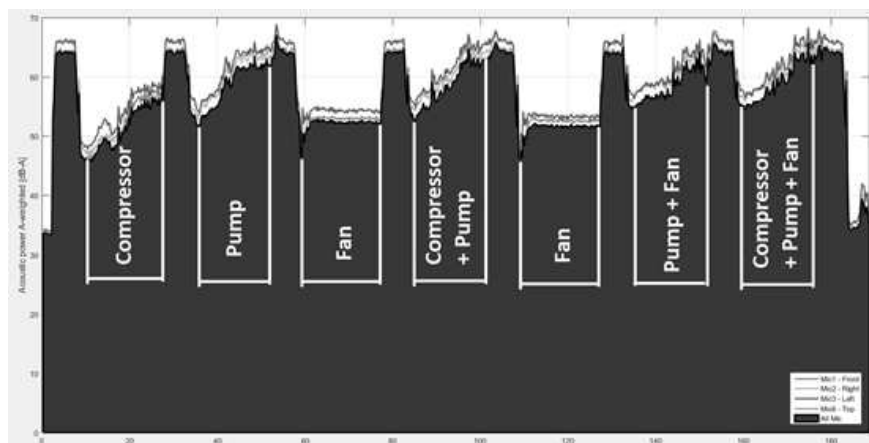


Figure 3. Acoustic performance levels of secondary noise sources.

3. Measurement of partial sources of noise

For the primary sources, interventions in the appliance assembly were necessary in addition to external control, including disconnection of the dryer drum belt and of the radial drying fan. The measured values were statistically processed in order to obtain values for the accessory sources of noise components, such as the motor noise component of the noise from the spinning drum.

The comparison of secondary noise sources was easy since the external control allowed measurement of both individual partial sources and their combinations. [8]

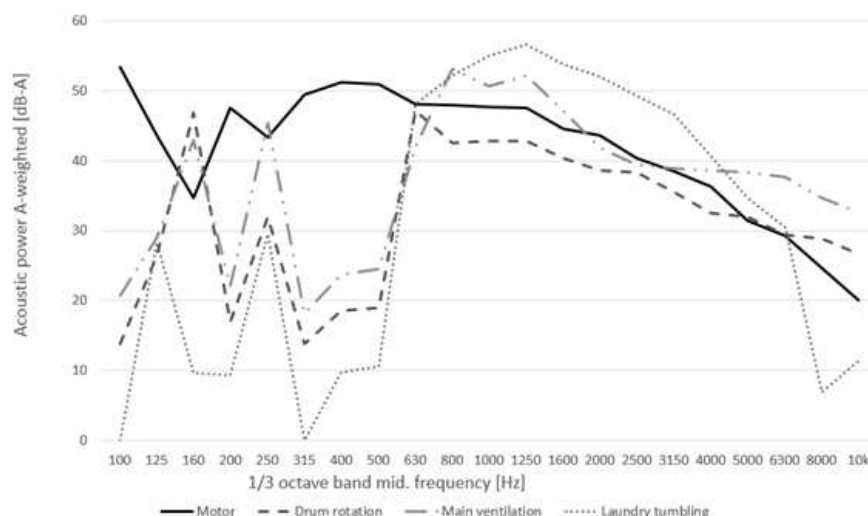


Figure 4. Specific one-third octave FA of primary noise sources dB(A).

The measurement demonstrated that the primary sources of noise were making the highest contribution to the overall noise level of the dryer. During a drying cycle, the secondary sources increased the overall noise level by 0.2 to 0.5 dB(A). Therefore, any efforts to reduce noisiness should be focused on the primary noise sources. [5]

Table 2. Specific acoustic performance levels of primary noise sources.

Primary source of noise	dB(A)
Motor	59.9
Drum rotation	52.9
Main fan	58.2
Laundry tumbling in the drum	61.9

The values measured for the partial sources will provide useful inputs for the designing of noise control enclosures and insulations. Their appropriate placement will be determined with the help of measurement by an acoustic camera.

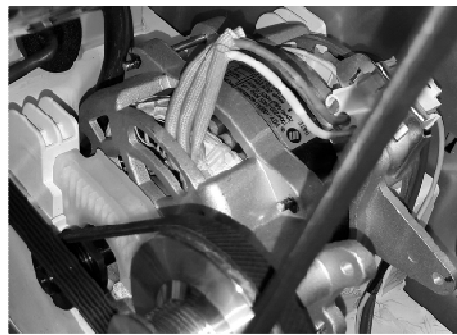


Figure 5. Engine mounting in the clothes dryer housing.

3.1. Design of noise control measures

Besides the frequency spectrum which clearly determines the noise damping material to be used, another important input for the design of noise control measures is the transmission paths of sound from the appliance. The best way to identify them is by using an acoustic camera. The employment of such device will prevent loss of materials for the manufacturer, in addition to allowing many effective configurations, for example, for the placement of soundproofing insulation on the panel of the product.

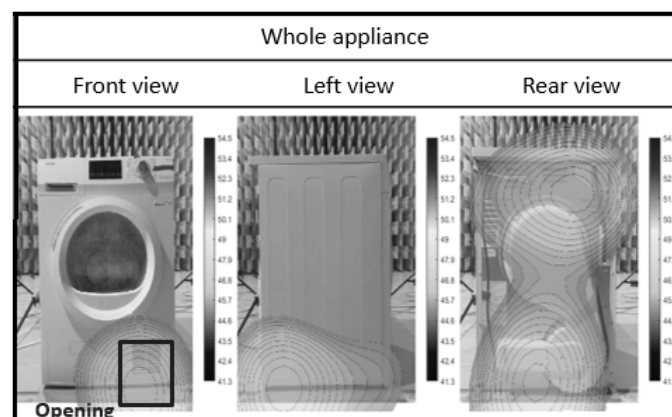


Figure 6. Record from an acoustic camera at 630 Hz of the appliance with covers.

In order to directly suppress sound transmission from the different partial sources of noise, it is necessary to perform acoustic holography of the appliance without covers so that the different noise sources are easier to identify [2, 3].

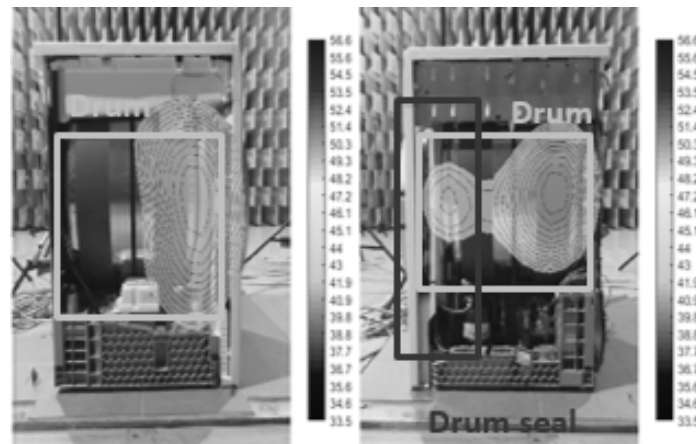


Figure 7. Record from an acoustic camera at 1600 Hz of the appliance without covers.

When all sources of noise and their sound transmission paths have been identified, noise reduction theories should be defined and modifications recommended to the manufacturer. A detailed analysis of primary sources revealed that:

The tumbling of laundry has a knocking effect on the drum surface, which generates vibrations of the drum. The sound passes through the housing panels and openings and propagates to the surroundings.

Electromagnetic forces inside the motor produce 100 Hz and 200 Hz frequencies within the frequency spectra of motor vibrations. Vibrations pass through the motor mounting to the housing. The motor fan also generates a broadband noise. Further, it was found out that vibrations are transmitted from the motor to its belt and then to the drum.

The noise from the secondary sources (compressor, front fan) generates vibrations with lower frequencies which are transmitted through the housing to the environment. The partial sources are also relevant to overall noise reduction. [9, 10]

4. Conclusion

An analysis of individual, partial sources of noise in domestic appliances is highly important for the finding of overall noise reduction options. Once identified, the noise reduction efforts in production may then be focused on the major noise sources that have the highest bearing on the overall noise level. This will help to minimise costs of the sound dumping modifications of an appliance. Customers may significantly influence the manufacturers' efforts to reduce noisiness of their appliances: noise levels are shown in rating plates of appliances and thus comparable across competing products. Manufacturing companies that invest substantial amounts in noise reduction measures in appliances will, naturally, reflect those costs in prices. This implies that buyers have a marked influence on the noise reduction trends and approaches.

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