FLOW RESISTANCE AND SOUND ABSORPTION OF POLYESTER FIBRE MATERIAL WITH DIFFERENT COATINGS

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Aim of the work

Coatings are extensively used in several applications to protect absorptive linings from dust or grazing effect. The effect of this thin protective layer is generally thought to be insignificant. To validate this frequent assumption an experimental study has been developed: the effect of different coatings on acoustical properties of samples made by polyester fibre has been investigated in the frequency range 160 – 1250 Hz. The tested polyester fibre material had bulk density of 30 kg/m³ and melting point at 260°C; the samples' thickness was equal to 100 mm.
Three different surface conditions have been tested: sample A represents the reference condition, with no coating on surface; both samples B and C were coated by a commercial kind of polyester nonwoven fabric (named TNT) and varnished by means of an industrial process. B sample was varnished by acrylic paint, whereas C sample was varnished by acrylic enamel.

Table 1: Description of the samples.

Sample	Coating	Varnishing	Specific Flow Resistance (Pa·s/m)
A	-	-	428
B	TNT	Acrylic paint	1213
C	TNT	Acrylic enamel	1257

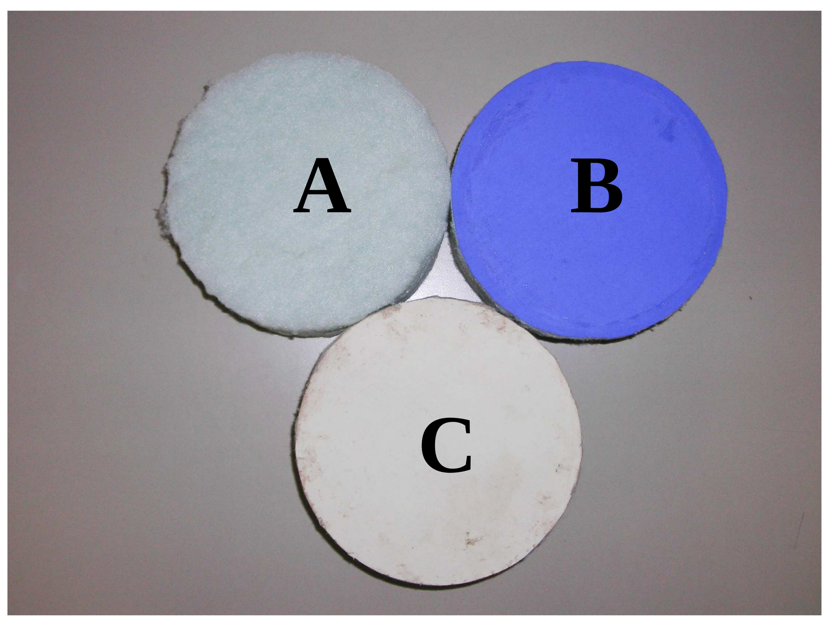

Fig. 1. Polyester fibre samples used in the experiments.

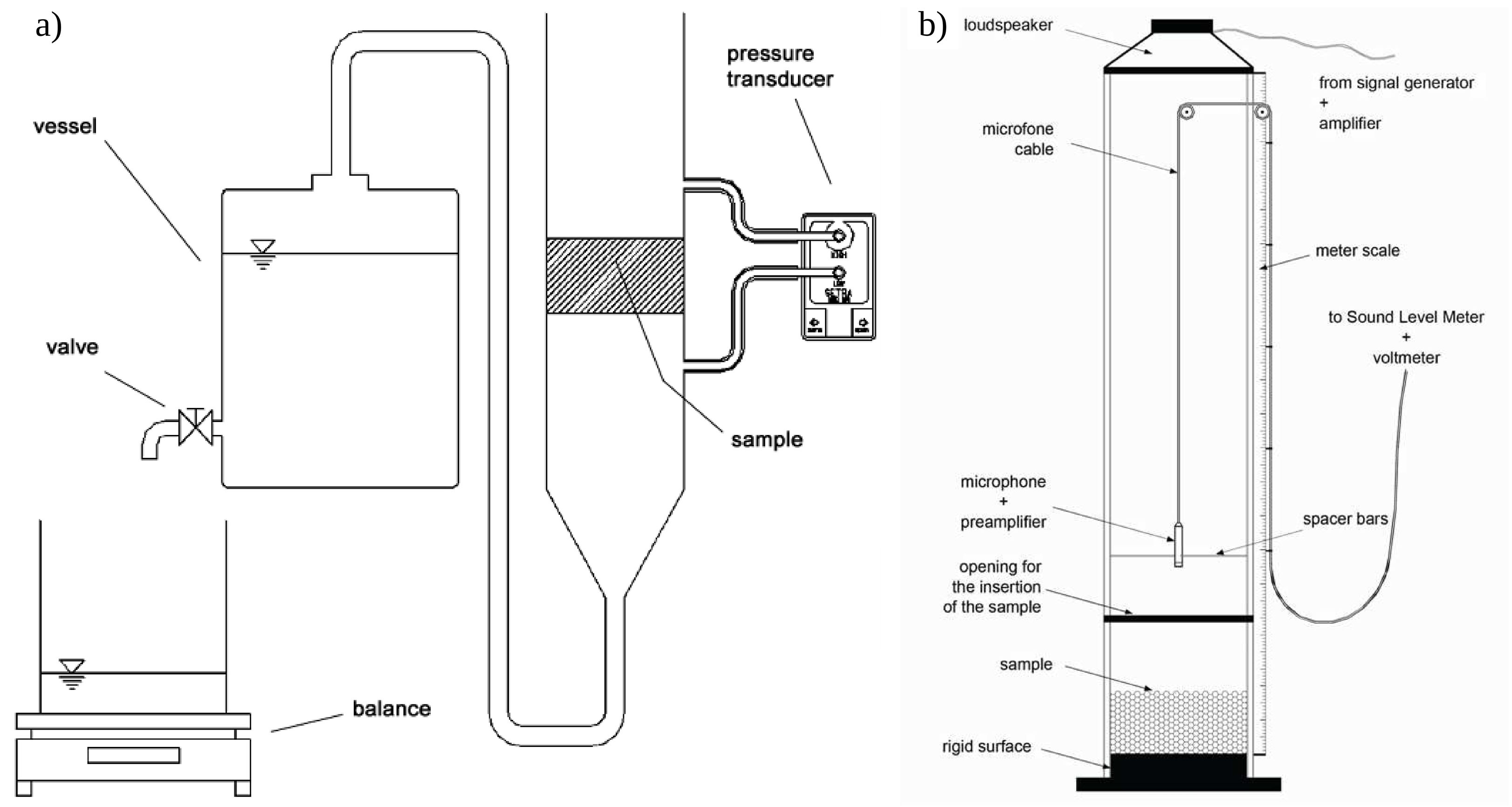

Fig. 2. Experimental setup: a) Flow resistance measurement equipment; b) standing wave tube.

Flow resistance

The acoustical behaviour of the samples has been firstly characterized by measuring their specific flow resistance, R_f, in accordance with the ISO 9053:1991 standard; direct airflow method (method A) was used.
The specific flow resistance R_f is given by:

$$R_f = \frac{\Delta p}{q_v} A \qquad \text{(Pa·s/m)}$$

where Δp is the pressure drop (Pa), A the cross section area of the sample (m²) and qv is the volumetric flow rate which passes through the sample (m³/s).
The flow resistance measurement equipment was validated by the comparison with the results of a previous inter-laboratory round robin test. Present setup gave a percentage difference of +12.5% compared to the average value of the round robin test, within the range between the extremes of -17.8% and +18.2%.
In Table 1 flow resistance values have been reported. A considerable effect of coating on R_f values can be noted: flow resistance is about three times greater than for uncoated sample. While flow resistivity value for A sample is typical of polyester fibre material, B and C flow resistances show the effect of protective coating on physical properties of absorbing layer, thus suggesting a non negligible influence on its acoustical performance.

Sound absorption

Then sound absorption coefficients at normal incidence and superficial acoustical impedances were measured in accordance with ASTM C384-04 standard by means of the standing wave ratio (SWR) method; the experimental set-up consisted in a vertical cylindrical Kundt's tube made of PMMA (Fig. 2), with an inner diameter of 0.19 m and an effective length of 2.00 m.
Normal incidence sound absorbing coefficients are reported in Fig. 3. The comparison shows that protective coatings deeply influence the acoustical properties of the samples: B and C curves clearly differ from A curve, and the assumption that protective layers do not modify the acoustical behaviour of the lining appears not to be correct. The effect of varnishing on the contrary seems to be not much relevant: R_f values are almost the same for both coated samples and α curves little vary on the whole measurement range.
Even if the coated samples are made by a non homogenous material, an attempt was made to compare experimental data with literature correlations proposed by different Authors for porous homogeneous materials in order to calculate absorption coefficients at normal incidence. The apparent flow resistivity R'_1, that is the ratio between the specific flow resistance and the thickness of the samples was introduced into the correlations. The comparison is shown in Figure 4. Of course this approach does not respect the actual physical behaviour of sound absorbing material; nevertheless, a certain ability to describe experimental performance of coated samples has been however observed. In Figure 5 curves for modulus and phase of the normal-incidence superficial acoustical impedance of the tested samples are shown.

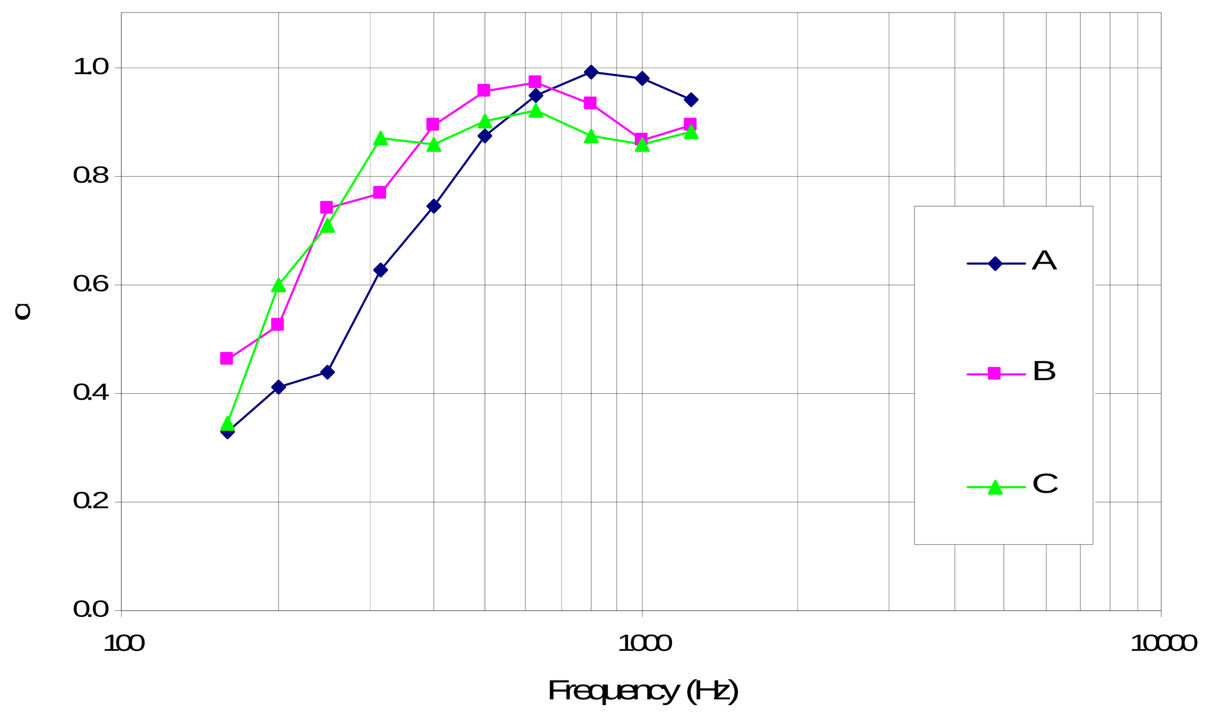

Fig. 3. Sound absorption coefficient curves for all the samples.

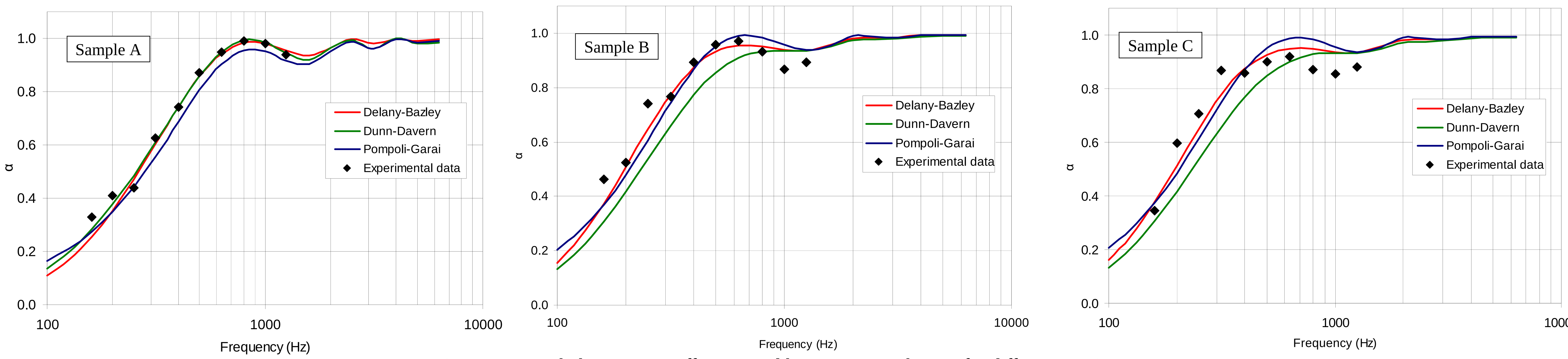

Fig. 4. Experimental absorption coefficients and literature correlations for different coatings.

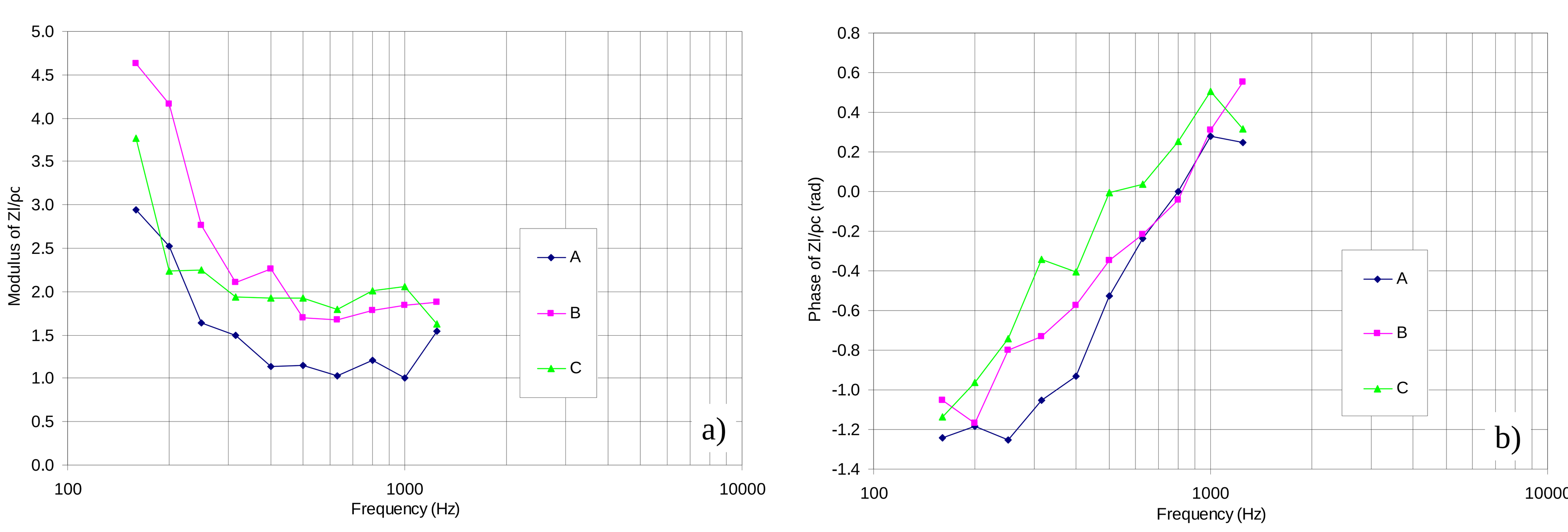

Fig. 5. Normal-incidence superficial acoustical impedance of the samples: a) modulus; b) phase

Conclusions

Analytical and numerical models have been proposed in literature to predict coating effect, but a certain weakness persists in its effective valuation because of the poor definition of actual coatings properties. Few specific experimental results have been found in literature about the effect of thin protective layers on acoustical absorption of "backing" material. It probably depends on the huge variety of technical solutions that can be adopted in protecting porous material, like clothes, non woven fabric, plastic films and synthetic materials. Sometimes the protective layer is impermeable and its flow resistance assumes such high values that standard procedures and equipments cannot be used to measure flow resistance. Briefly, the real possibilities are so various and so difficult to be contained in a specific study, that any experimental contribution risks to seem poor and low significant.
Nevertheless, this study wants to be a step in the direction to begin a essential investigation. Three preliminary results have been obtained: coating can deeply affects the acoustical behaviour of the porous lining; when lining is not impermeable traditional experimental techniques for porous material can be however used to characterize the coated material properties; correlations for porous material can constitute a useful starting point to predict the effect of coating on acoustical properties of porous materials.