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Using of CelluBOR on Noise Enclosures

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***Abstract*—An investigation was conducted into the reduction of the noise caused by machines used in the manufacturing industry. Four noise cabin models, outfitted with two types of insulation-materials for the cabin walls – Styrofoam (Expander Polystyrene - EPS) and CelluBOR – were constructed. For each cabin model, a high-level noise source was employed, in accordance with operation conditions, to perform noise measurement and frequency analysis. The results indicated that CelluBOR was an effective material for ensuring noise insulation**

***Keywords*— CelluBOR, Noise enclosure, Noise Isolation**

I. Introduction

Many countries apply various measures for protecting their workers from high-level noise [1, 2]. Numerous studies on this issue have been conducted, including the hearing health problems involving children born from pregnant women subject to occupational noise [3], the effect of noise in cement plants on human health [4], the noise that workers in civil aircraft maintenance are subjected to [5], the noise-induced hearing loss in steel industry workers and the relationship between hearing loss and lead level in the blood [6], and the impact noise has on the cardiovascular system [7].

Covering the noise source is one of the methods used for noise control. Research focusing on different methods of concealing the noise source includes studies by Pääkkönen and Tikkanen [8], who constructed a low-frequency noise cabin with a sound frequency of 0.2—320 Hz; Locati et al. [9], who designed a special noise cabin; Dupont and Galland [10], who designed an active absorber for a noise cabin; Li [11], who used a two-walled acoustic cabin, where voids served as resonators in the walls; Tarabini and Roure [12], who modelled the parameters affecting the active noise control on a cabin wall; and finally, Yu and Cheng [13], who investigated the optimization of the location of T-shaped acoustic resonators.

In this study, the effects of CelluBOR use on the noise reduction in designed noise cabins were investigated by measuring and analysing noise levels. Another sound insulation material—Styrofoam—which has the same density as CelluBOR, was used for comparison. Results indicated that CelluBOR could be used effectively as a sound insulation material.

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II. Cabin Models and Noise Measurements

CelluBOR is composed of boric acid, borax penta hydrate, cellulose, waste paper and sodium silicate neutral Fig. 1.

Figure 1. CelluBOR material in a sack

It is a mineral fibre based environmentally and friendly materials. Actually CelluBOR is an ecological and economical thermal insulation material to be used on ceilings, attics, floors and wall structures. Run through a blowing machine, loose fill can be installed in a wall or on a surface through access holes after the interior finish has gone up, or installed into a netting system or reinforced poly-barrier retaining membrane Fig. 2. Its density ranges between 15 and 150 kg/m^3 [14].

Figure 2. CelluBOR material in a sack

Two 120x120x120 cm CelluBOR and Styrofoam cabins, each of whose wall thicknesses were 5 and 10 cm, were constructed, as shown in Fig. 3, Fig. 4.

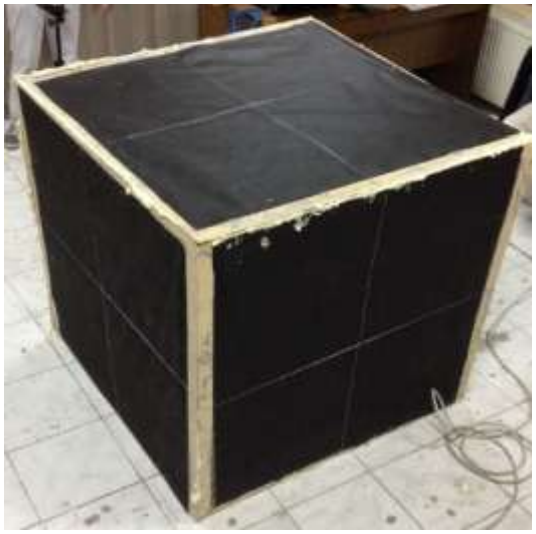

Figure 3. CelluBOR cabin

Figure 4. Styrofoam cabin

Five models were constructed for measurements and analyses, as seen in Table 1.

The noise source, which was constituted of white noise, was placed in the middle of the cabins Fig. 5. The sound level meter used was the Bruel&Kjaer 2250 hand-held analyser. The sound level meter was calibrated before and after all measurements.

Table 1. Cabin model parameters

Cabin Model	Wall Material	Thickness (cm)	Designation
0	No cabin	-	-
1	CelluBOR	5	B5
2	Styrofoam	5	S5
3	CelluBOR	10	B10
4	Styrofoam	10	S10

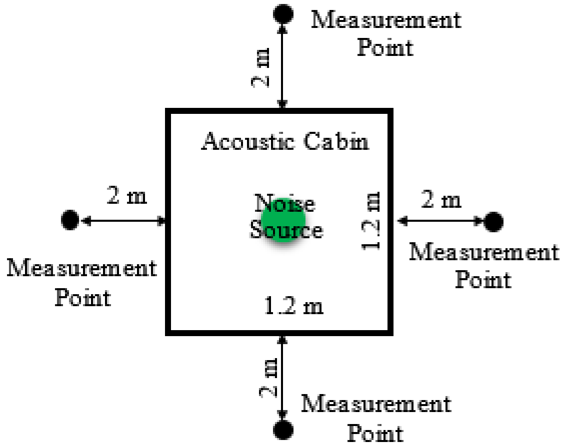

Figure 5. Measurement diagram

All measurements for the five models were conducted under the same conditions. The average values of A-weighted equivalent noise levels (*LAeq)*, taken from four different directions, were calculated using (1).

$$LAeq = 10\log\left(\frac{1}{n}\sum_{i}^{n} 10^{LAeq_i/10}\right) \quad (1)$$

Insertion loss (IL) — the most suitable parameter for demonstrating cabin performance capability - was defined by (2). *LAeq0* and *LAeq1* indicate A-weighted equivalent noise levels at the same point before and after cabin capability performance test, respectively.

$$IL = LAeq_0 - LAeq_1 \quad (2)$$

III. Evaluation of Measurement Results

It was observed that the equivalent noise level of the B5 model was lower than that of S5, and similarly, that the equivalent noise level of the B10 model was lower than that of S10, as shown in Fig. 6. Since the model numbered 0 was an open model, without any cabin, it had a higher noise level. Based on Eq. 2, Fig. 7 shows that the B5 model resulted in more 9 dBA noise reductions than the S5 model and that the B10 model resulted in more 13 dBA noise reductions than the S10 model.

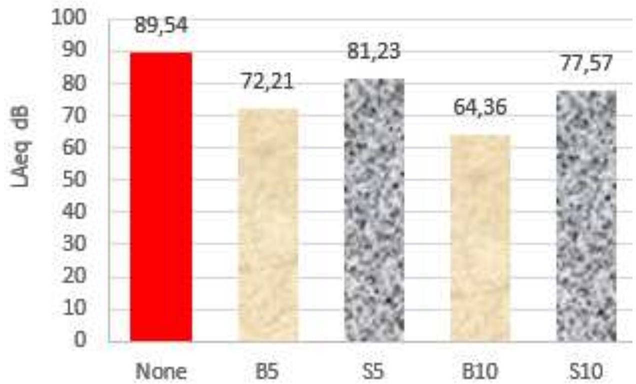

Figure 6. Equivalent noise levels

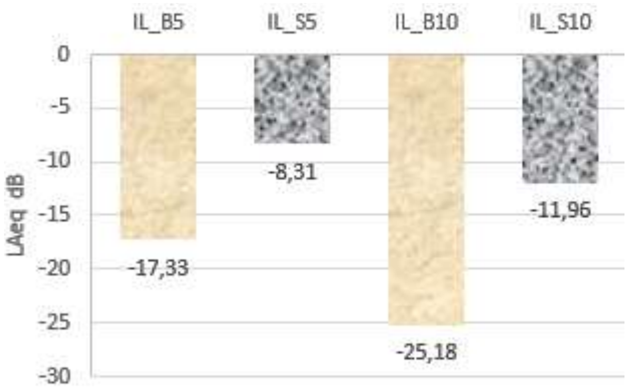

Figure 7. Insertion loss

1/1 Octave band frequency analyses of cabin models were performed. Equivalent noise levels of the B5 model at 31.5, 63 and 125 Hz central frequency bands were slightly higher than those of the S5 model. However, equivalent noise levels of the B5 model at 250, 500, 1000, 2000, 4000 and 8000 Hz central frequency bands were lower than those of the S5 model, as shown in Fig. 8. Similarly, equivalent noise levels of the B10 model at 31.5, 63 and 125 Hz central frequency bands were slightly higher than those of the S10 model, but lower at other frequency bands, as seen in Fig. 9.

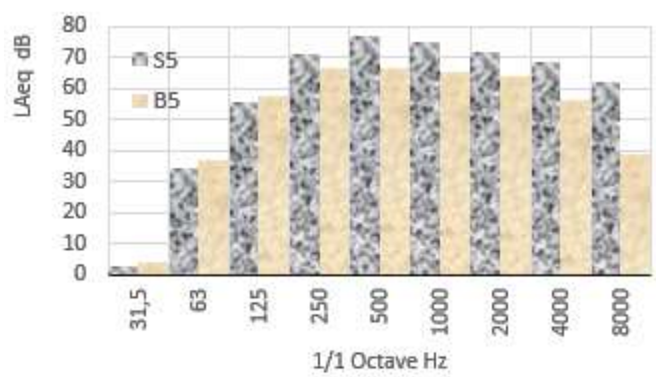

Figure 8. 1/1 Octave band analyses of S5 and B5

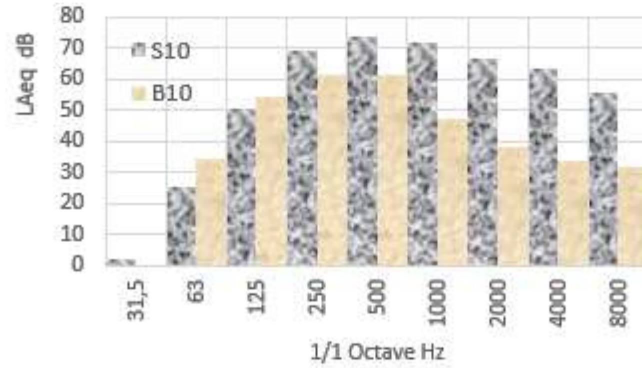

Figure 9. 1/1 Octave band analyses of S10 and B10

1/1 Octave band analyses of all models were also performed according to their wall thicknesses. The S10 model at 63 and 125 Hz frequency bands resulted in effective noise reduction. At frequencies above 250 Hz, where human ears are so sensitive, no significant change was observed for equivalent noise levels of S5 and S10 models, as shown in Fig. 10. Fig. 11 indicates that the B10 model resulted in more effective noise reduction than the B5 model at all frequency bands.

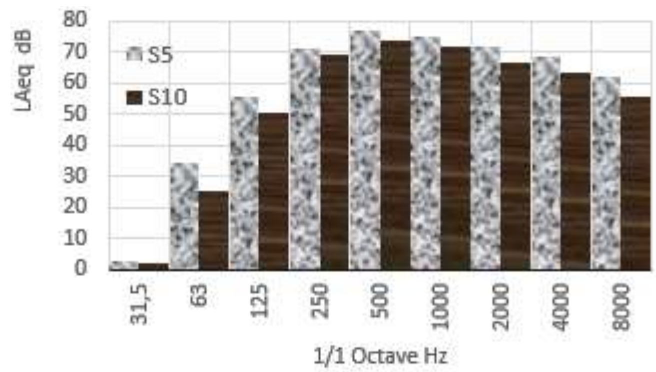

Figure 10. 1/1 Octave band analyses of S5 and S10

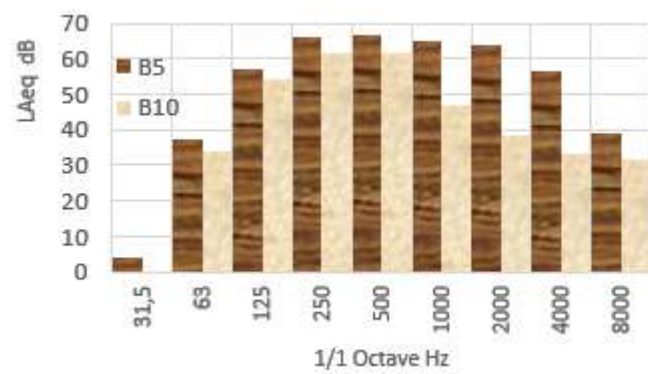

Figure 11. 1/1 Octave band analyses of B5 and B10

IV. Conclusions

It was observed that CelluBOR resulted in stronger and more efficient noise reduction than Styrofoam; in other words, it provided better noise insulation. Based on octave band analysis results, the noise insulation of CelluBOR was less effective at lower frequency bands, but at higher frequency bands, where human ears are so sensitive, it was considerably more efficient than Styrofoam. The effect of Styrofoam's thickness on noise insulation was slightly low, while the thickness of CelluBOR had a significant effect on the noise reduction.

Acknowledgment

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