Application of Electronic Waste Cable Sheathing as Secondary Use Sound Insulation

Student: Kamilė Ryliškytė

Environmental Protection Engineering, Bachelor level, Faculty of Environmental Engineering, Vilnius Gediminas Technical University, Saulėtekio al. 11, 10223 Vilnius, Lithuania
kamile.ryliskyte@stud.vilniustech.lt

Mentor: Raimondas Grubliauskas

Environmental Protection Institute, Vilnius Gediminas Technical University, Saulėtekio al. 11, 10223 Vilnius, Lithuania
raimondas.grubliauskas@vilniustech.lt

Abstract. *Cable is the main component of electronic equipment which leads to increasing amounts of hollow sheaths after the removal of cores: metals with insulation layers. The continuously growing dependence on technology makes it more important than ever to reuse electronic waste that outlived its primary function, conserving the non-renewable resources and promoting secondary use. Tests done on different heights of 5 cm, 7 cm, 10 cm round structures (d = 30 mm) filled with different homogenous sheathings. The sound absorption coefficient measurements done with Kundt Tube were analysed according to length, hardness and number of strands: samples included single-stranded (soft (0.8 mm)); single-stranded (hard (0.6 mm)), double-stranded (hard (0.6 mm)); triple-stranded (soft (0.9 x 0.4 mm) sheaths. The results showed that the single stranded hard sheathing (0.6 mm) from 1600 Hz to 5000 Hz had the highest absorption values (αs = 0.31 - 0.69), corresponding to sound absorption class C/D.*

Keywords. Cable sheathing, sound absorption coefficient, Kundt Tube, hollow covers

University of Maribor Press

DOI https://doi.org/10.18690/um.4.2023.12
ISBN 978-961-286-783-6

1 Background and Motivation

Currently, technology is changing and improving drastically to adapt to the constant shift in the public and industry needs, but most do not know - what happens and what is done when electronic appliances, equipment go obsolete or in the end simply break down. Usually they become growing waste piles in dumps that are difficult to recycle or in worst case scenario hard to get rid of without doing detrimental damage to the environment/ human health. And since most e-waste components are made from non-renewable natural resources including the main focus of this contribution (plastic cable sheaths), it makes it more important than ever to promote secondary use of electronic equipment that has outlived their primary function, conserving valuable resources and taking care of the electronic waste pollution. This two-year project funded by ATHENA could be a first step in spreading green ideas on how to work with the complicated e-waste leftover parts problem.

2 Introduction

The continuously growing dependence on digital, electronic technology who's rapid expansion comes with not only incredible innovations but also exponentially growing piles of already useless electronic equipment/components that couldn't compete anymore with the yearly big news. This constant cycle of growth leaves humanity with uncontrollable e-waste streams that never stop growing as the usage of electronics keeps spreading into new frontiers. And with that comes many unique waste types that make up the wide array of electronic devices: from cables to microchips. At this case, cable sheathing, the main connecting part of electronic equipment, was chosen since there are increasing amounts of hollow sheaths after the removal of cores in recycling waste centres: metals with insulation layers. These sheaths are tested to check whether it is possible to reuse them to deal with noise pollution.

2.1 The Work Process

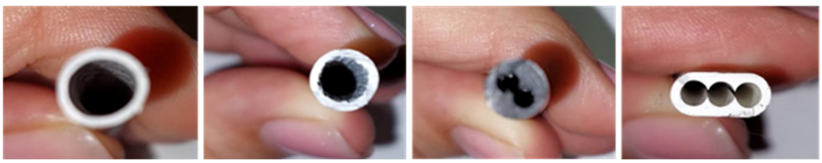
At the beginning of the research, the main tasks and requirements to fulfil the objective were discussed with mentor. Then samples were taken from Vilnius "EMP Recycling" facility where an educational tour around the different e-waste management and sorting facilities in the company was done before collection. Then preparations were made for the prototype structures: separation of metal and insulating layers from cable sheathing and creation of 3D printed round tubes for insertion into the Kundt Tube. With the use of the "Acousti studio" software, sound absorption measurements were carried out on three different heights (5 cm, 7 cm, 10 cm) with 4 different homogenous sheathing combinations. The end results were displayed graphically in EXCEL after measurements have been examined with MATLAB sound absorption coefficient code.

3 Methodology

The objects of research are round structures made using e-waste hollow sheathing. As the cables were only tested for their ability to provide sound insulation by observing their length and hardness and the number of cores, the samples selected were single-stranded (soft sheath (0.8 mm); hard sheath (0.6 mm)), double-stranded (0.6 mm) and triple-stranded (0.9 x 0.4 mm) cables (Fig. 1).

Figure 1. Samples selected for analysis

The waste cables shown in Figure 1 have their cores - the metals (copper) with the insulating sheaths - removed by cutting across them. The prepared hollow cable coating is then used in the test (Fig. 2).



a b c d

Figure 2. The cross-cut hollow cables used in the study: a) single-stranded (hard (0.6 mm)); b) single-stranded (soft (0.8 mm)); c) double-stranded (hard (0.6 mm)); d) triple-stranded (soft (0.9 x 0.4 mm)

The test is carried out with a Kundt tube in which we insert 3D printed tubes (d = 30 mm) of different heights: 3 cm, 7 cm, 10 cm (Fig. 3).

Figure 3. 3D printed tubes in heights of 3 cm, 7 cm, 10 cm

The test measures the sound absorption coefficient of four sample combinations at three heights from 160 Hz to 5000 Hz range using the “Acousti studio” software (Fig. 4).

Figure 4. Round structures with cable sheathing filling

The measurements are examined with the help of "MATLAB" code and in the end represented in line graphs by height cm.

4 Measurements

The tests are repeated 3 times to measure the sound absorption coefficient at different heights using only one type of cable sheathing. The average of the values of the 4 samples is then calculated and plotted on a dot plot (Fig. 5, 6, 7).

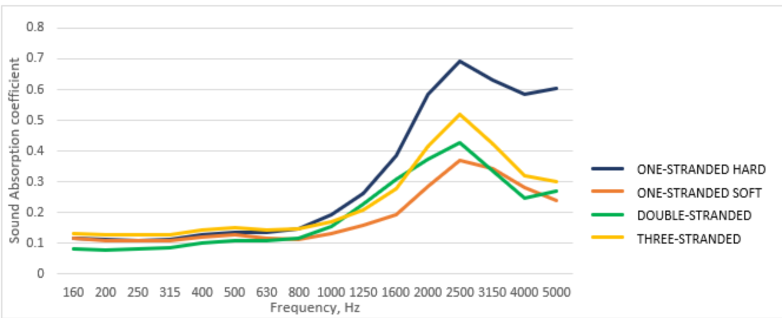


Figure 5. Sound absorption coefficient values of 3 cm height round structures

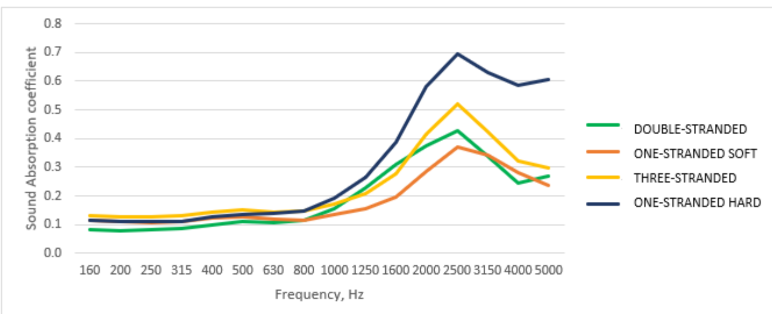


Figure 6. Sound absorption coefficient values of 7 cm height round structures

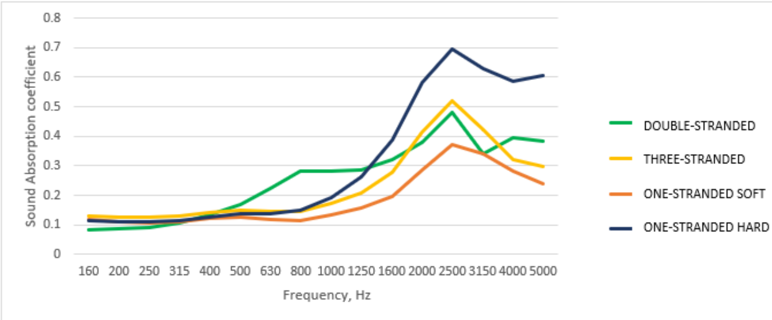


Figure 7. Sound absorption coefficient values of 10 cm height round structures

4.1 Results

The graphs show that the plastic cable sheathing does not have good absorption at lower frequencies (only from 1600 Hz do most structures reach a value of αs = 0.3), but there was an exception to this – double-stranded in a 10 cm structure had αs = 0.29 at 800 - 1250 Hz, which proves that, with the appropriate cable material, it is possible for the cable coating to be utilized at even lower frequencies.

It was also found that the hardness/stiffness of the sheathing had a significant effect on sound absorption capabilities - the harder/stiffer the coating, the better the sound absorption: **one-stranded hard > three-stranded semi hard > double-stranded flexible > one-stranded very soft**. There was also not a huge difference between the values based on the length of the structure, there were only small deviations (around 0.02 to 0.04) between the measurements of the different heights, but it cannot yet be fully established that length does not affect the sound absorption capacity of the structure (exception: double-stranded in a 10 cm structure). And the main advantage of the cable coatings was their ability to absorb higher frequency levels, as the strongest sound absorption in all cables was recorded on average between 2000 and 5000 Hz.

However, in order to assess the sound insulation performance of the constructed structures, it is important to refer to performance standard ISO 11654:1997 [1] for all sound-absorbing materials, which classifies such materials into classes A to E according to their ability to absorb sound (Table 1).

Table 1. Sound absorption class of the material according to ISO 11654:1997

A	B	C	D	E	NOT CLASSIFIED
SOUND ABSORPTION COEFICIENT VALUE (αs)					
1.00 – 0.90	0.85 – 0.80	0.75 – 0.60	0.55 – 0.30	0.25 – 0.15	0.10 - 0

Based on the classification given in the standard, it can be stated that at high frequencies from 2 kHz, all types of coating structures (3 cm, 7 cm, 10 cm) are classified as:

- One-stranded hard αs = 0.38 – 0.69 (absorption class C/D)
- Three-stranded αs = 0.30 – 0.52 (absorption class D)
- Two-stranded αs = 0.31 – 0.43 (absorption class D)
- One-stranded soft αs = 0.28 – 0.37 (absorption class D)

The results showed that for all designs, the one-stranded hard web cable sheathing from 1600 Hz to 5000 Hz had the highest absorption values ($\alpha s = 0.31 - 0.69$), which corresponds to sound absorption class C/D.

5 Future Plans

Finally, once the metals and insulating layers have been removed, the cable covering has the potential to provide effective sound insulation at higher frequency levels. And by selecting appropriate lengths and hardness's, it is possible to create a cheap and effective noise reduction that will reuse unwanted cable coatings and lessening its streams. While seeing good results related to the cables, a question has been raised: Can there be a possibility to better the absorption mechanism by mixing different cable sheathing materials creating a bigger obstacle for the sound waves/vibrations to go through? With this question in mind first result analysis has been done to start the development of new structures with heterogenous fillings for future testing.

Acknowledgements

This research received partial funding from the VILNIUS TECH initiative aimed at promoting student involvement in scientific activities, in collaboration with the ATHENA – Advanced Technology Higher Education Network Alliance.

References

[1] *ISO 11654:1997- Acoustics — Sound absorbers for use in buildings — Rating of sound absorption* 1st ed. Geneva: International Organization for Standardization, 1997-04.