

Research on Antiphonic Characteristic of AlMg10-SiC Ultralight Composite Materials

O Rusu¹ and I Rusu¹

¹ Gheorghe Asachi Technical University of Iasi-Romania, Materials Science and Engineering Faculty, Blvd. Mangeron, No. 69, 700050, Iasi, Romania

E-mail: vrusu2003@gmail.com

Abstract. The paper presents the results on the absorption sound testing of an ultralight cellular composite material AlMg10-SiC, obtained by sputtering method. We have chosen this type of material because its microstructure generally comprises open cells (and relatively few semi-open cells), evenly distributed in the material, a structure that, at least theoretically, has a favorable behavior in relation to sound damping. The tests were performed on three types of samples, namely P11 – AlMg10 – 5%SiC, P12 – AlMg10 – 10%SiC și P13 – AlMg10 – 15%SiC. The 15% SiC (P13) cellular material sample has the best sound-absorbing characteristics and the highest practical absorption degree.

1. Introduction

Sound is a form of mechanical energy which traverses the environment from the source of noise in all directions. The noise control process involves blocking its paths and eventually eliminating sound energy wherever possible.

The sum of all absorptions and reflections of sound waves, determined by the interactions with the environment through which the sound propagates creates a "picture", a soundtrack in the human ear. This phenomenon can be estimated by a parameter called NRC (Noise Reduction Coefficient). This is one of the most frequently evaluated and imposed features because it is closely related to the acoustic absorption curve. According to the American Standard ASTM C 423, this parameter is calculated as the average of the absorption values for 250 Hz, 500 Hz, 1000 Hz and 2000 Hz frequencies, with an approximation of 5%. The acoustic absorption degree (α_W) is a parameter determined by a method indicated in EN ISO 11654 [1], the degrees of absorption measured in practice (according to EN ISO 354 [2]) being calculated in practical sound absorption degrees (α_p) for each frequency band that lies on an octave.

According to the standard, the reference curve is plotted over the variation curve of the practical degree of absorption, indicating the existence of deviations zones between the theoretical and experimental values [3]. From graphical representations it can be deduced that if, in the range of the tested frequencies, the trace curve corresponding to the measured values is above the reference curve, then the tested material absorbs obviously more than is estimated by the α_W value.

The fragility of many sound-absorbent materials has led to researches in order to eliminate this unwanted mechanical feature. As there is on the market a new class of sound-absorbent materials based on cellular composites, mainly used in the construction of trucks and heavy machinery, military industry and aeronautics industry [4-7], we chose to test an ultralight composite material type AlMg10-SiC.



2. Experiment

To perform the experiments we took samples (40x40x20 mm, Figure 1) from a AlMg10-SiC ultralight cellular composite material obtained by the bubbling method [8], which were then subjected to the sound absorption tests. We have chosen this type of material because its microstructure generally comprises open cells (and relatively few semi-open cells), evenly distributed in the material, structure that, at least theoretically, has a favorable behavior in relation to the sound damping. The testing of a sound damping element is done on an installation (noise analysis cell), which simplified scheme is shown in Figure 2.

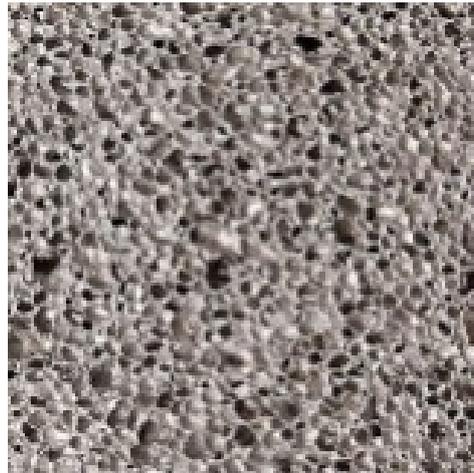


Figure 1. The overall appearance of the AlMg10-SiC composite test plates.

It includes an acoustic source, an enclosure with a window with an antisound element (the anti-noise element or component to be tested), a sound collector placed inside the enclosure and an automatic signal processing system. We used a NORSONIC Nor 850 [9] equipment, with a Klain & Hummel AK120 signal generator and amplifier [10] and a data acquisition system.

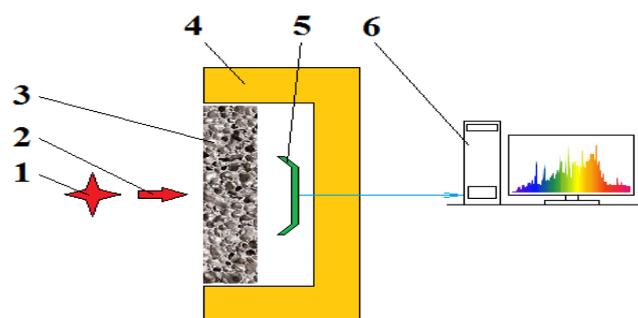


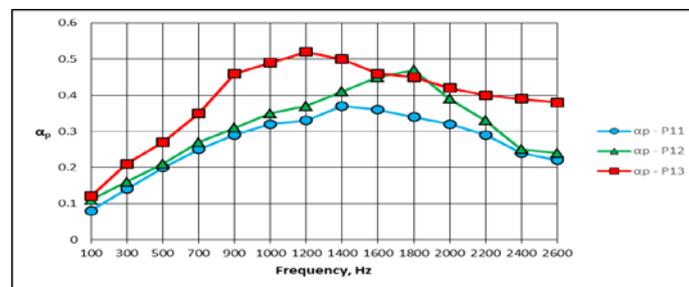
Figure 2. Schematic representation of sound damping measurement cell; 1 - primary sound emission source, 2 - emitted sound, 3 - sound damping element (made of composite material), 4 - test enclosure, 5 - sound receiving device, 6 - computerized recording and processing data system.

Because, in general, the most frequent noise and physical discomfort frequencies, for example, in the field of automotive and railway transport, are between 250 and 2000 Hz [11], we chose to perform the experiments in the frequency range 100 ÷ 2600 Hz.

3. Results analysis

The experimental obtained results regarding the level of sound absorption by AlMg10- SiC ultralight cellular composites are shown in Figure 3.

From the experimentally obtained data it is observed that the cellular materials best absorbs the sound, regardless of the percentage of SiC, in the frequency range of about 900 ÷ 2000 Hz, having, in principle, practical absorption degree values greater than 0.35. It is also clear that these materials are not recommended for damping low-frequency sounds (below 600 ÷ 700 Hz). The cellular material with best sound-absorbent characteristics is that with 15% SiC (P13) – the highest degree of absorption (0.52) at 1200Hz; in terms of this last parameter, the 10% SiC composite is quite close to the first (with a value of 0.47), but at a slightly higher frequency (1800Hz). The most unfavorable from the point of view of sound absorption behavior is the cellular composite with 5% SiC (whose practical degree of absorption does not exceed 0.37%), fact that is explained by its cellular structure more unfavorable to the absorption of sounds (smaller cells, lower relative porosity).



Frequency Hz	α_p - P11	α_p - P12	α_p - P13
100	0,08	0,11	0,12
300	0,14	0,16	0,21
500	0,20	0,21	0,27
700	0,25	0,27	0,35
900	0,29	0,31	0,46
1000	0,32	0,35	0,49
1200	0,33	0,37	0,52
1400	0,37	0,41	0,50
1600	0,36	0,45	0,46
1800	0,34	0,47	0,45
2000	0,32	0,39	0,42
2200	0,29	0,33	0,40
2400	0,24	0,25	0,39
2600	0,22	0,24	0,38

Figure 3. Experimental data concerning the variation of the practical absorption degree depending on frequency; P1i - cellular composite samples, i = 1, 2 or 3 corresponding to the percentage of SiC (5, 10 or 15%).

It is thus clear that, for these types of ultralight cellular composite materials, the technical field of interest in which the sound damping occurs is limited to frequency values in the 800-2200 Hz range (especially for 15% SiC material), the attenuation parameters depending on the degree of resonance damping that occur in the composite, especially for this frequency range [12-14]. In addition to these

favorable sound absorbent characteristics, the experimented cellular composites combine these properties with mechanical strength ones, with a very good resistance to higher temperatures compared to other commonly used sound absorbent materials [15-17]. They are also completely recyclable, the absorption properties remaining constant over time. That is why I consider that these materials can be recommended for the damping of sounds and vibrations in the many fields like auto, railway, etc.

4. Conclusions

AlMg10-SiC ultralight cellular materials best absorb the sound, regardless of the percentage of SiC, in the frequency range of about 900 ÷ 2000 Hz, basically having practical absorbance values greater than 0.35.

Tested materials are not recommended for damping low-frequency sounds (less than 600 ÷ 700 Hz).

The best sound absorbent features were observed for the cellular material with 15% SiC, this one having the highest degree of absorption (0.52) at 1200Hz.

Experimental cellular composites combine sound absorbent properties with mechanical strength, with a high resistance to higher temperatures compared to other commonly used sound absorbent materials.

5. References

- [1] * * *EN ISO 11654:1997 – Acoustics -- Sound absorbers for use in buildings -- Rating of sound absorption
- [2] * * *EN ISO 354:2003 – Acoustics -- Measurement of sound absorption in a reverberation room
- [3] <http://www.scribub.com/biologie/biofizica/Unde-Acustice-I-Unde-Sonore-242182022.php>
- [4] Crocker MJ and Arenas JP 2007 *Use of Sound-Absorbing Materials*, in Handbook of Noise and Vibration Control editor Crocker M.J., John Wiley and Sons, New York
- [5] Nick A, Becker U, Thoma W 2002 *Journal of Polymers and the Environment* **10**(3) 115–118
- [6] Asdrubali F 2006 Survey on the Acoustical Properties of New Sustainable Materials for Noise Control *Proceedings of Euronoise*, Tampere, Finland
- [7] Magrini U and Ricciardi P 2000 Surface Sound Acoustical Absorption and Application of Panels Composed of Granular Porous Materials *Proceedings of Inter-Noise 27–30*, Nice, France
- [8] Bălătescu O, Florea RM, Roman C, Rusu I, Carcea I 2013 *Journal of optoelectronics and advanced materials* **15**(7–8) 823–832
- [9] <http://www.norsonic.com/en/products>
- [10] <https://www.neumann-kh-line.com/klein-hummel/globals.ns/resources>
- [11] Crocker M J, Li Z, Arenas J P 2005 *International Journal of Acoustics and Vibration* **10**(2) 52–60
- [12] Champoux Y and Stinson M R 1992 *Journal of the Acoustical Society of America* **92** (2) 1120–1131
- [13] Kidner M R F and Hansen C H 2008 *International Journal of Acoustics and Vibration* **13** (3) 112–119
- [14] Allard J F 1993 *Propagation of Sound in Porous Media* Elsevier Applied Science, London
- [15] Scheffler M and Colombo P 2005 *Cellular Ceramics: Structure, Manufacturing, Properties and Applications* Wiley-VCH, Weinheim
- [16] * * *2007 *Determination of Weight Elasticity of Fuel Economy for Conventional ICE Vehicles, Hybrid Vehicles and Fuel Cell Vehicles* Report 55510, Forschungsgesellschaft Kraftfahrwesen mbH, Aachen
- [17] Sandberg U and Ejsmont JA 2007 *Tyre/Road Noise – Generation, Measurement, and Abatement* in Handbook of Noise and Vibration Control, editor Crocker M.J., John Wiley and Sons, New York