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COMPARISON BETWEEN THE DENSITY OF ALUMINIUM MATRIX REINFORCED WITH SIC AND GRAPHITE COMPOSITE MATERIAL OBTAINED BY INJECTION TO THE FEEDSTOCK DENSITY

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Abstract: *It was considered composite containing aluminium powder to which was added, 10, 15, and 20 mass % of SiC, respectively, 3.0 and 6.0 mass % graphite. Feedstock contained powder 45 vol %, respectively, binder 55 vol %. Theoretical density increases with increasing SiC content for powder mixes with 3.0 and, respectively, 6.0 % graphite. Experimental feedstock's density is slightly lower compared to the theoretical density. Homogenization temperature of 130 °C is preferred. As the temperature increase the injection density increases for all samples.*

Key words: *density, viscosity, binder, feedstock, injection molding*

1. INTRODUCTION

Mechanical, physical, and technological properties are essential for the process of injection moulding, for setting correct operating parameters of the injection machine.

It is necessary to know the following for injection moulding: the volume and weight of injected material; plasticizing ability depending cylinder dimensions and the amount of determined heat; the injection pressure exerted by the piston; closing force required to maintain the closed mould; the injection cycle is the time required for all necessary operations in obtaining of a injection moulding product [1-3].

The method is applicable to injection moulding composites, for obtaining of a homogeneous distribution of SiC and graphite in the metal matrix.

The purpose of the research was to determine the density of the powder – binder mixture and the composite material obtained by injection and feedstock density, to establish the powder content to obtain an optimum density after injection moulding.

2. EXPERIMENTAL PROCEDURE

Six batches were elaborated with SiC mass % of 10; 15; 20, respectively, graphite 3.0 and 6.0 %, the balance being aluminium powder as matrix.

In order to obtain semi-finished products by injection, the procedure uses a mixture (feedstock) resulted by putting, together and homogenises the main component with a binder. The powders of Al, SiC, and graphite are mixed in a laboratory homogenizer for 60-90 minutes. The binder contain paraffin, stearic acid and polyethylene (LDPE - Low Density Polyethylene). The homogenization is done at a temperature of 130 ºC. The mixture is allowed to cool at room temperature and is crushed into balls [4-6].

Hydrostatic balance method was used to determine the density of the powder and the binder. Obtained mixture (feedstock) was injected using the stand shown in Figure 1. Samples obtained by injection were measured, weighed in air and water to determine their density (hydrostatic balance method).

Fig.1. Experimental stand for injection molding - the injection device [UTCN].

3. EXPERIMENTAL RESULTS

The values of theoretical density for the mixtures of powder and binder are shown in Table 1. All compositions used same binder: 76 mass % wax + 20 % LDPE + 4 % stearic acid, with a calculated density: ρ_{wax} = 0,9105 g/cm^3 [7], ρ_{LDPE} = 0,9250 g/cm^3 [8], $\rho_{stearic\ acid}$ = 0,8470 g/cm^3 [9].

In the feedstock there are 55 vol % Al, SiC, and graphite and 45 vol % binder. The density of the powder - binder mixture was determined experimentally using an analytical balance. This sample was measure in the air (m_u) and water (m_a). Density of water was considered 1 g / cm^3 at 25 ° C (error + 0.3 %).

Density of powder – binder mixture was calculated using: $\rho = m/V = (m_u/(m_u - m_a))\rho_a$, ($m_u$ – air mass, m_a – water mass, ρ_a – density of water).

Table 2 shows the experimental density of the powder – binder mixture.

Formation of voids in the mixture is an unfavourable phenomenon, requiring a certain energy [10,11]. It is avoided by a close packing particle.

In the process of injection moulding the homogenisation temperature is of special importance [12].

Figure 2 illustrates the variation of the feedstock density versus homogenization temperature.

Table 1

The theoretical density of the mixture of powder and binding material (feedstock)

Sample	Powder mixture	Density, g/cm^3
1	87 % Al+10 % SiC+ 3% Graphite+binder	1.9085
2	82 % Al+15 % SiC+3 % Graphite +binder	1.9195
3	77 % Al+20 % SiC+3 % Graphite +binder	1.9307
4	84 % Al+10 % SiC+6 % Graphite +binder	1.8995
5	79 % Al+15 % SiC+6 % Graphite +binder	1.9103
6	74 % Al+20 % SiC+6 % Graphite +binder	1.9214

It is noted that the density decreases with temperature increasing. This is due to an uneven distribution of binder of the powder, so may lead to cracking or blistering in the components [13].

The samples were weighed in water and in the air using electronic balance type 320 x T with measurement accuracy of 0.0001 g. After the material was measured it was subjected to injection moulding, using machine and device from Figure 1.

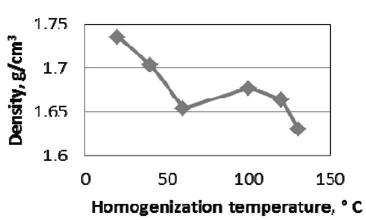

Fig. 2. Feedstock density and homogeneity temperature.

Table 2

Experimental density of the feedstock

Sample	m_u	m_a	M= m_u - m_a	ρ, g/cm^3	ρ_{med}, g/cm^3
1	1.6135	0.6268	0.9867	1.6352	1.7349
	3.3295	1.5407	1.7888	1.8613	
	1.6058	0.6659	0.9399	1.7084	
2	2.4248	0.9804	1.4444	1.6787	1.7035
	1.8795	0.7784	1.1011	1.7069	
	1.3037	0.5480	0.7557	1.7251	
3	2.4585	0.9945	1.4640	1.6793	1.6540
	1.9921	0.7690	1.2231	1.6287	
	1.2648	0.5002	0.7646	1.6541	
4	2.3389	0.9494	1.3895	1.6832	1.6767
	1.2400	0.5187	0.7213	1.7191	
	1.3009	0.5018	0.7991	1.6279	
5	3.1695	1.2713	1.8982	1.6697	1.6640
	1.7934	0.7000	1.0934	1.6302	
	1.9973	0.8100	1.1873	1.6822	
6	4.0582	1.6397	2.4185	1.6779	1.6305
	2.9425	1.1206	1.8219	1.6150	
	1.6578	0.6400	1.0178	1.6258	

Measuring the diameter and height of the samples in the form of pills, by an electronic calliper of 0.01 mm precision, and the obtained average density values are presented in Table 3.

Figure 3 illustrates the variation of injected sample density versus the injection temperature. It is noted as injection temperature increases the pick of density is around 50 °C, then density decreases. This is because the injected samples are more homogeneous than the powder mixture, between the powder particles of injected samples is a point contact, and the structure is void less [12,13].

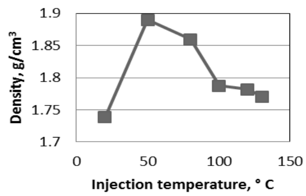

Fig. 3. Density of the samples versus injection temperature.

4. DISCUSSION OF RESULTS AND CONCLUSIONS

Theoretical density for powder with 3 mass % and 6 mass % graphite increases with SiC content. In the samples containing 15 %, 20 % SiC, the theoretical density of the samples have the same value with 10 % SiC, 15 % SiC and 3 % graphite, which has a non-homogeneous microstructure.

The experimental density of the powder and the binder material has a slight decrease to the theoretical density due to voids in the structure. Formation of the voids is an undesirable phenomenon, when can be avoided by providing an optimal mixing temperatures (130 °C) to achieve a point contact between the powder particles in the mixture.

For samples with 3 and 6 mass % graphite, experimental density decreases with increasing homogenization temperature because the binder is not uniformly distributed in the powder mixture, leading to components cracking.

As the injection temperature increase, the density of the sample increases, as compared with the homogenized samples (Figure 3), between the powder particles and the binder is made a point contact and the structure becomes finer, and void free [14, 17].

It is found that the injected obtains samples are more dense than the feedstock, due to the higher injection temperature, and the applied pressure applied during the injection [18, 19].

Table 3

The density of injection molded samples

SAMPLE	Composition	Number of discs	Average density, g/cm³
1	Table 1	7	1.7385
2	Table 1	8	1.8897
3	Table 1	10	1.8593
4	Table 1	13	1.7871
5	Table 1	13	1.7820
6	Table 1	7	1.7703

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Comparație între densitatea matricei din aluminiu întărită cu SiC și materialul compozit din grafit obținut prin injectare la densitatea materiilor prime

Rezumat: Acesta a fost considerat compozit conținând pulbere de aluminiu la care a fost adăugat, 10, 15, și 20 masa% din SiC, respectiv, 3,0 și 6,0 masă% grafit. Materii prime conținute pulbere 45 vol%, respectiv, liant 55 vol%. Densitatea teoretică crește odată cu creșterea conținutului SiC pentru amestecuri de pulbere cu 3,0 și, respectiv, 6,0% grafit. Densitatea materiilor prime experimentale este ușor mai mică în comparație cu densitatea teoretică. Temperatura de omogenizare de 130 ° c este preferată. Pe măsură ce temperatura crește densitatea injecției crește pentru toate probele.

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