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INFLUENCE OF THE REINFORCEMENT VOLUME FRACTION ON IMPACT ENERGY VALUES OF THE CAST Al-SiC_p COMPOSITES

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ABSTRACT
The effect of Mg content in matrix and volume entail of SiC particles in metal matrix composite on impact toughness is analysed. Cast AlMg alloy, with 3%, 5% and 7% Mg content is used as metal matrix. Reinforcement content of 2%, 5% and 10%, with an average particle size of 30 μm, had been applied. Composite is obtained by whirlpool casting method. The impact energy of metal matrix composite with AlMg matrix decreases with increasing SiC content and with decreasing Mg content. The highest total energy is found in MMC AlMg7 with 2% Si C (14,7-17,5 J), and the lowest one in MMC AlMg3 with 10% SiC (3,7-4,1 J). The values obtained for metal matrix composite are significantly less than the values for corresponding alloy, up to 40 to 50%
Keywords: Metal-matrix composite (MMC); MgAl alloy; SiC reinforcement; Impact energy; Charpy V specimen;

1. INTRODUCTION

New structural materials are developed as the response to higher quality requirements regarding service life and properties of structures, including the reduction in weight. For practical application of new materials the analysis of their mechanical properties and serviceability is necessary, in order to achieve prescribed service safety of components and entire structure, e.g. for elevated temperature range application.

The problem in determination of mechanical properties of complex materials, such as metal-matrix composites (MMC) is how to explain test results, such as tensile properties and impact toughness, having in mind the complex structure of MMC. There is also a problem how to apply results, obtained with small size MMC specimens, to the components of real size in a structure. For that, stress field, established in MMC component must be considered, including its effect on reinforcement and matrix behaviour, and also on their contact surfaces [1,2]. In order to understand well MMC composite behaviour in a structure, designer must be supplied by data, necessary to describe material response to acting load [3]. Impact energy as relevant for material behaviour under impact load of notched components is valuable data for designer, but also for in-service behaviour of structure.

2. MATERIALS AND EXPERIMENTS

After preparation of matrix and reinforcement the production of MMC had been performed by whirlpool cast method of melted matrix and reinforcement in order to achieve optimum quality to cost ratio [4]. Matrix was produced using AlMg alloy, obtained from the Institute for nuclear and

other mineral row materials - Belgrade, and SiC, obtained from Nitrogen factory – Ru{e. Three AlMg alloys had been used: AlMg3, AlMg5 and AlMg7. Chemical composition of applied alloys is given in Table 1, and of reinforcement is given in Table 2.

Table 1. Chemical composition, mass. %, of tested alloys for MMC matrix

Alloy	Mg	Mn	Si	Fe	Ti	Zn	Cu	Al
AlMg3	2,90	0,30	0,050	0,18	0,055	0,10	-	balance
AlMg5	4,95	0,35	0,045	0,12	0,035	0,12	-	balance
AlMg7	7,05	0,63	0,081	0,23	0,051	0,030	0,001	balance

Table 2. Chemical composition of SiC reinforcement

C	$Si+SiO_2$	TiO_2	FeO_3	Al_2O_3	CaO	MgO	SiC
0,12	1,88	0,14	0,50	0,14	0,13	0,04	96,65

2.1. Impact testing results and discussion

Combining 3 different matrixes (AlMg3, AlMg5, AlMg7) and 3 different SiC reinforcement contents (2%, 5%, 10%) nine different samples had been produced for experimental investigation. Charpy instrumented impact testing is performed according to ASTM E23 at room temperature on pendulum 150 J with the standard specimen (10x10x55 mm, V notch 2/45°). Typical plots force vs. time, obtained in the tests of matrix alloys AlMg5 and AlMg7 are given in Fig. 1. With increasing Mg content total impact energy increases from 9.1-10.2 J for AlMg3, to 17.5-18.8 J for AlMg5, and to 30.4-32.7 J for AlMg7, and crack propagation energy increases faster than crack initiation energy (Fig. 2). This is in accordance with published results [8] and previous tests [9]. The results are summarized in Table 3, together with impact testing results for tested MMC.

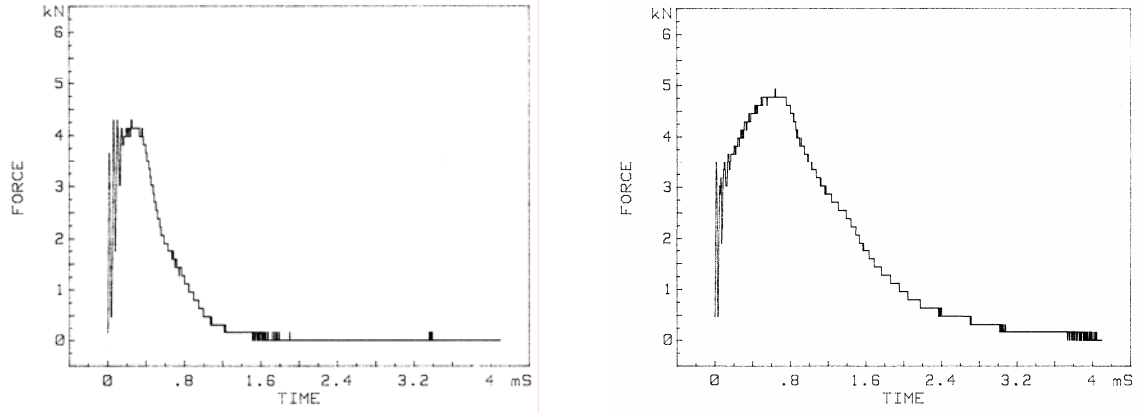

Figure 1. Plots force vs. time for matrix alloys: AlMg5 (up left) and AlMg7 (up right)

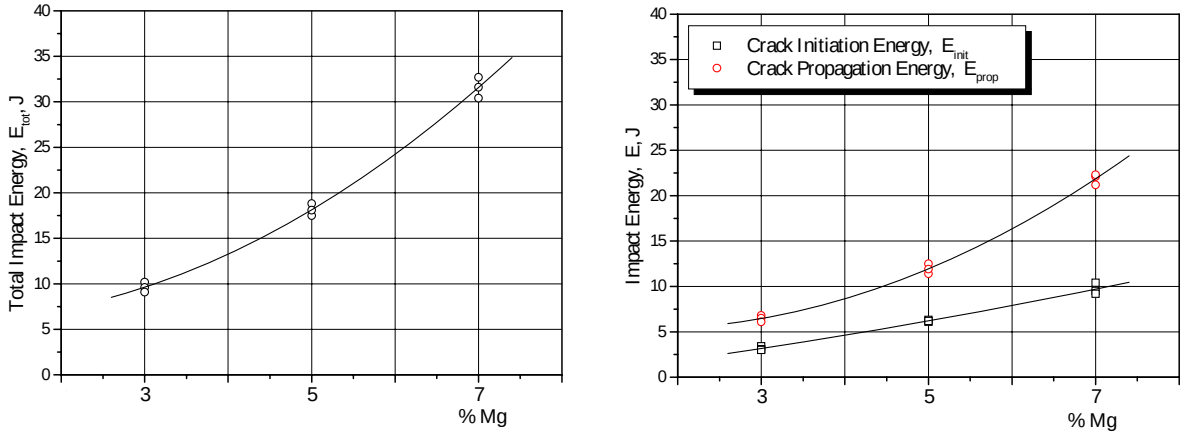

Figure 2. Total energy of matrix alloys (left) and crack initiation and propagation energies (right)

Table 3. Results of instrumented impact testing of metal matrix composites

Alloy	AlMg3			AlMg5			AlMg7		
	Energy, J								
SiC, %	T	C I	C P	T	C I	C P	T	C I	C P
0	10.2	3.4	6.8	18.8	6.3	12.5	31.6	9.5	22.1
	9.6	3.1	6.5	17.5	6.1	11.4	32.7	10.4	22.3
	9.1	3.0	6.1	18.1	6.2	11.9	30.4	9.2	21.2
2	6.1	2.4	3.7	7.8	3.3	4.5	16.0	7.9	8.1
	6.4	2.5	3.9	8.2	3.5	4.7	14.7	7.1	7.6
	5.7	2.1	3.6	7.3	3.0	4.3	17.5	8.5	9.0
5	5.1	1.9	3.2	6.0	2.2	3.8	9.5	4.2	5.3
	5.4	2.0	3.4	6.3	2.2	4.1	10.8	4.4	6.4
	5.7	2.1	3.6	6.7	2.4	4.3	11.5	4.5	7.0
10	3.7	1.5	2.2	5.3	1.9	3.4	7.7	2.8	4.9
	4.1	1.6	2.5	5.1	1.7	3.4	8.2	5.3	2.9
	3.9	1.6	2.3	5.8	2.1	3.7	7.1	2.5	4.6

T - Total energy; CI - crack initiation energy; CP - Crack propagation energy

The effect of SiC reinforcement content and of Mg content in matrix on total impact energy can be followed in Fig. 3 and on its parts (crack propagation energy and crack initiation energy) in Fig. 4. The total energy of MMC with AlMg matrix decreases with increasing SiC content and with decreasing Mg content. The highest total energy is found in MMC AlMg7 with 2% Si C (14,7-17,5 J), and the lowest one in MMC AlMg3 with 10% SiC (3,7-4,1 J). The reduction of total impact energy with increasing SiC content is 40 to 50% compared to corresponding base matrix alloy (without reinforcement). Scatter of results (Fig. 4) can be attributed to irregular distribution of reinforcement particles.

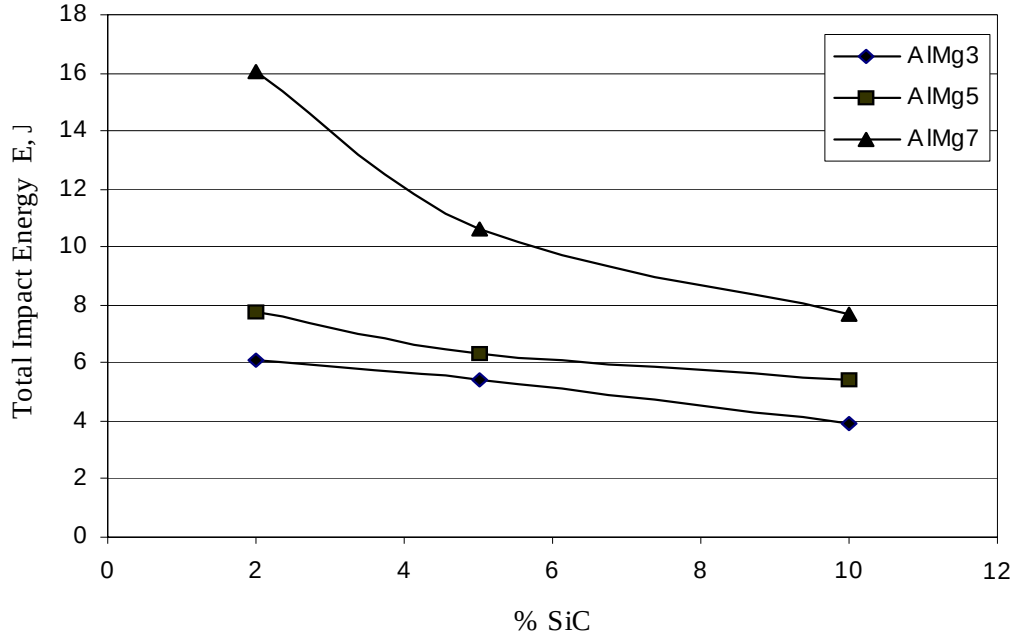

Figure 3. Total energies for different metal matrix composites vs. reinforcement content

Diagrams force vs. time for MMC are characterized by different maximum force levels. In all diagrams fast crack propagation preceded maximum force, at which fast crack growth is arrested and ductile crack growth followed. For that the point of maximum force is selected for separation of crack initiation and crack propagation energies (Fig. 4).Obtained results are in agreement with the data published in references that impact energy of MMC is lower than corresponding value of matrix alloy [8,10,11].

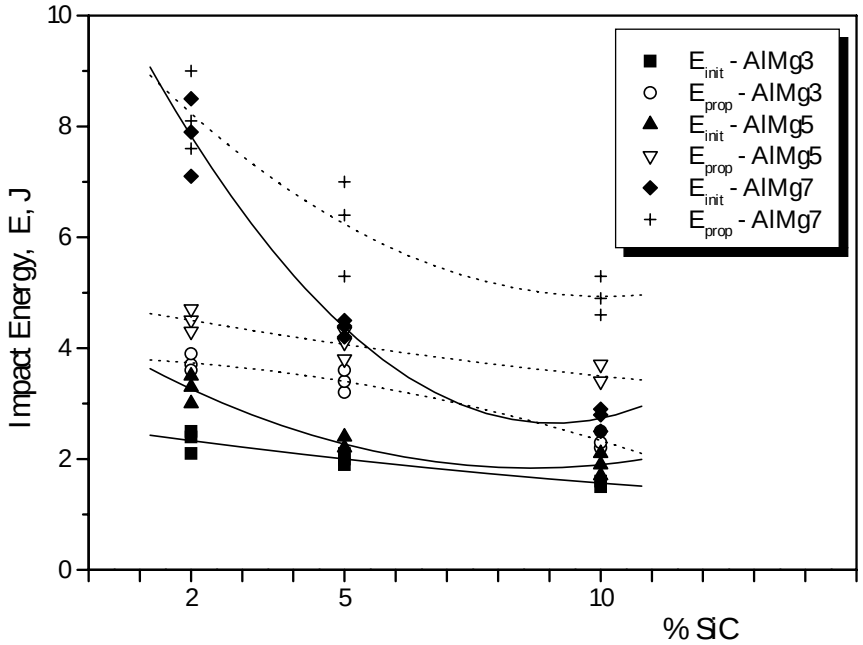

Figure 4. The effect of matrix alloy and SiC content on crack initiation and propagation energies

3. CONCLUSION

Increase of Mg content in MMC matrix alloy is beneficial for total impact energy and its ductile part. Increase of SiC content reduces MMC impact properties for all tested samples, up to 2 to 4 times compared to impact properties of corresponding base alloy. This effect has to be considered when MMC of MgAl alloy matrix and SiC renforcement are designed for specific application, e.g. for elevated application.

4. REFERENCES

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