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Influence of modification on structure, fluidity and strength of 226D aluminium alloy

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Abstract

In the article the fluidity, solidification conditions, microstructure and tensile properties have been studied for the non-modified and modified 226D aluminium silicon alloy.

Realized investigations concerned modification of alloy 226D for application as the matrix to carbon fibre reinforcement composite (MMC-Cf). One of main factors determining to good connection between metal matrix and fibres reinforcement is good wettability. It is possible to obtain suitable conditions of wettability by modification of chemical composition metal matrix alloy or proper sizing of reinforcement fibres. Into consideration of interaction between liquide aluminium and carbon fibers following modifiers were used for addition to the commercial aluminium alloy (226D). The magnesium (2%Mg), strontium (0,03%Sr) and titanium (0,5%Ti) with boron (0,01%B) modifiers and their combination were used in the presented work.

Keywords: Aluminum alloys, Modification, Microstructure, Castability, Strength

1. Introduction

The aluminium alloys have been the most widely used as structural material in varied industry field for several decades, [1,2]. First of all Al-Si alloys are the most important of the aluminium casting alloys because of high fluidity, low shrinkage in casting, high corrosion resistance, good weldability, easy brazing and low coefficient of thermal expansion. So they find application particularly in the automobile and aircraft industries where it is used for other engine body castings among other things: cylinder blocks and pistons [3-9].

The Al-Si alloys have been used also as the matrix material in composite casts reinforced by ceramic particles and carbon fibres [10-16]. The additions of ceramic reinforcement influence to the change of solidification conditions and lowering alloy fluidity. The formation of the interface between the matrix and the reinforcing phase has a substantial influence on the production and characteristics of the metallic composite materials. The adhesion between both phases is usually determined by the interaction between them. During the production of the molten matrix e.g. by infiltration, wettability becomes significant.

An important aspect in the discussed of components configurations is the wettability of ceramic surface reinforcement by the liquid matrix alloy. Improvement on castability of alloy and obtaining the low possible contact wettability angle has assuring alloy additions adequately selection. The modification have an effect on adequate of the property level especially strength characteristic of alloy on manufactured of composites [3-7].

2. Materials and research methodology

Three kinds of modifiers were used for the modification of the 226D aluminium alloy (Table 1). In researches applied the magnesium (2%Mg), strontium (0,03%Sr) and titanium (0,5%Ti) with boron (0,01%B) modifiers and their combination.

Table 1.
Chemical composition of 226D aluminum alloy

Element	Si	Cu	Mn	Mg	Fe	Ti
Mass %	9,9	2,2	0,21	0,44	0,9	0,03

The aluminium alloys fabricated by the traditional casting method. The processes of preparing of modified alloys were performed with degassing and homogenization under lowered pressure [13, 14].

The course of the solidification process was recorded by means of a system which enabled continuous control and measurement of the metal temperature during solidification of the composite suspension [15]. Also influence of modifiers on casting properties of aluminium alloy was evaluated basted castability test. Test duct was formed as spiral at self hardening phosphate mould.

The microstructure of the aluminium alloys is observed using the optical microscope NICON EPIPHOT 200.

3. Results and discussion

Fluidity of aluminium alloys

The results of spiral test were presented at Figures 1-3. It was fund, that aluminium alloy non modified and modified by 2% magnesium addition filled 11 spiral sections. Otherwise alloy containing 0,5%Ti + 0,1%B + 0,03%Sr modifiers and alloy with 2%Mg + 0,5%Ti + 0,1%B modification filled 12 spiral sections, (Fig. 2a,b). The proper fluidity registered for aluminium alloy modified by 0,5%Ti + 0,1%B and 0,03%Sr (Fig. 3a,b).

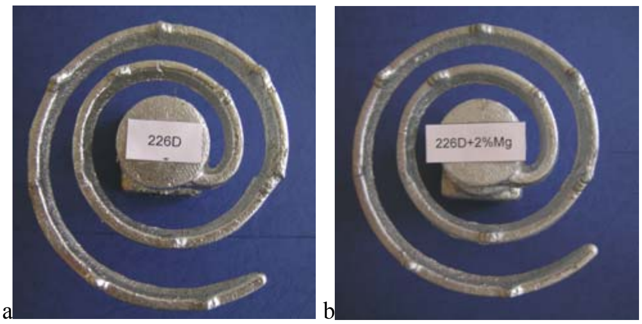

Fig. 1. View of the spiral test of: a) 226D non modified aluminium alloy, b) 226D aluminium alloy modified by 2%Mg

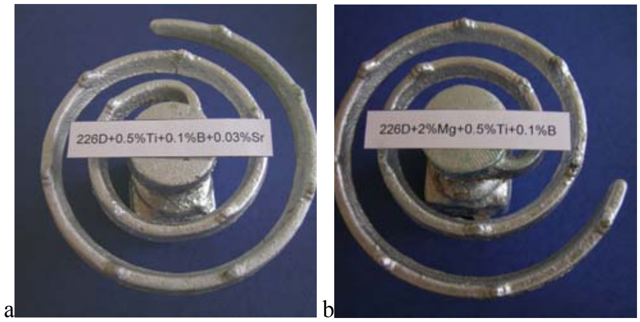

Fig. 2. View of the spiral test of: a) 226D aluminium alloy modified by 0,5%Ti + 0,1%B + 0,03%Sr, b) 226D aluminium alloy modified by 2%Mg + 0,5%Ti + 0,1%B

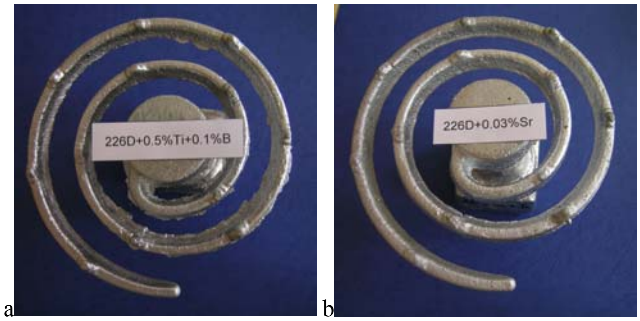

Fig. 3. View of the spiral test of: a) 226D aluminium alloy modified by 0,5%Ti + 0,1%B, b) 226D aluminium alloy modified by 0,03%Sr

Solidification of aluminium alloy and modified alloys

The temperature range and time of 226D aluminium alloy and aluminium alloys modified crystallization described on the basis of solidification curves obtained after numerical analysis (Fig. 4). They affirmed that the non modified alloy solidified during 85s in the temperature range of 568-566^{0}C. The temperature of crystallization beginning of the aluminium alloy containing 2%Mg was 569^{0}C, with the cast solidifying for 201s in the temperature range of 569-542^{0}C. The aluminium alloy containing the titanium and boron modifiers solidified in the temperature range of 588-566^{0}C, in the time of 104s. Long time of solidification (t=258s) was registered for alloy with the magnesium, titanium and boron modifiers in the temperature range of 586-539^{0}C. The time of solidification for the 226D alloy modified with 0,03% strontium average 208,5s. These material solidified in the temperature range of 573-557^{0}C. The highest temperature of crystallization beginning (T=591^{0}C) used for the aluminium alloy containing 0,5%Ti+0,1%B+0,03%Sr modifiers, with the time solidifying for 248,5s in the temperature range of 591-557^{0}C.

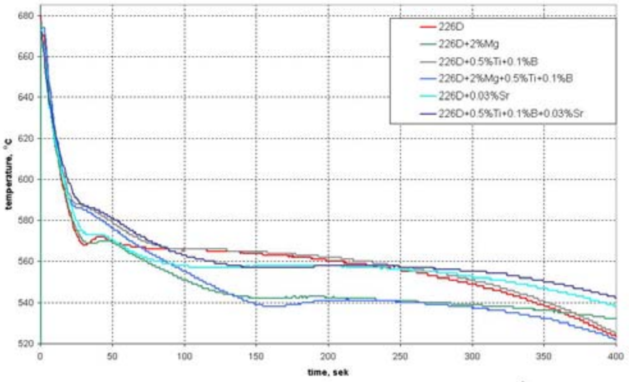

Fig. 4. Cooling curves measured from the non modified aluminium alloy and from alloys with different additions of modifiers

Microstructure of aluminium alloy and modified alloys after solidification process

The eutectic - Si size and morphology observed by the optical microscope of the non-modified aluminium cast alloy and modified cast alloy have been presented on Figures 5 and 6.

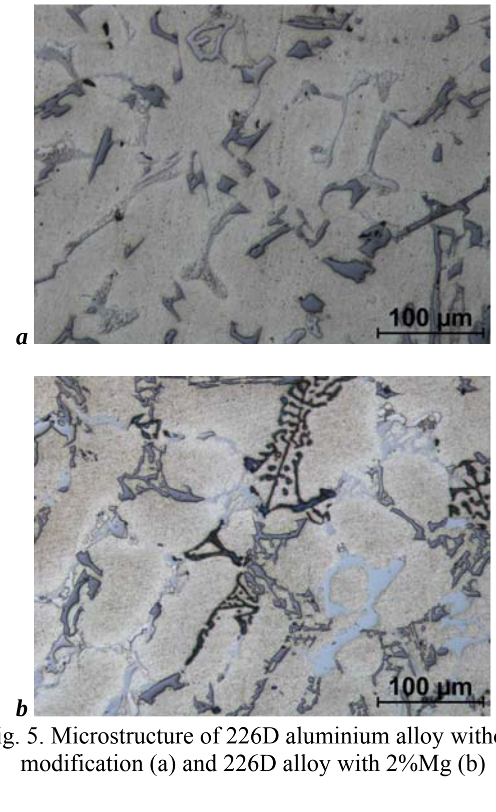

Fig. 5. Microstructure of 226D aluminium alloy without modification (a) and 226D alloy with 2%Mg (b)

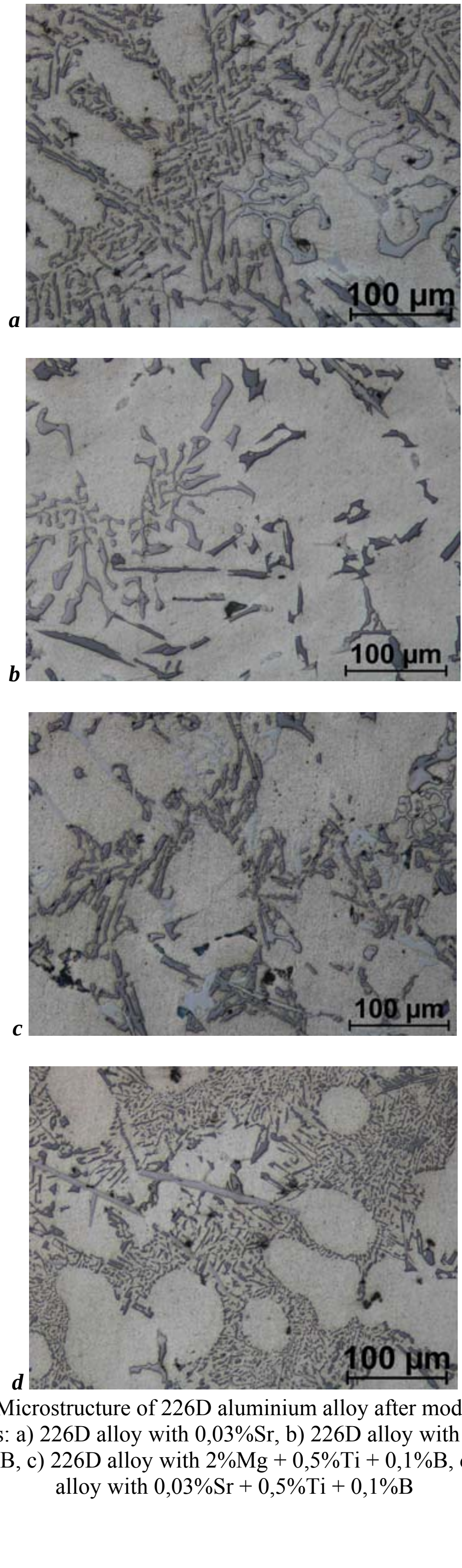

Fig. 6. Microstructure of 226D aluminium alloy after modification process: a) 226D alloy with 0,03%Sr, b) 226D alloy with 0,5%Ti + 0,1%B, c) 226D alloy with 2%Mg + 0,5%Ti + 0,1%B, d) 226D alloy with 0,03%Sr + 0,5%Ti + 0,1%B

Strength test of aluminium alloy and modified alloys

Strength properties were tested at static tensile test on Instron 4469 with 20mm/min speed of load. The comparison among the stress/plastic strain curves of 226D non-modified alloy and modified aluminium alloys shows on Figure 7. Samples were cast to metal mould and there were not put to heat treatment. Addition of Ti, B and Sr enlarge strength of 226D alloy to 200 MPa comparing to non modified 226D strength 140 MPa. It was registered also enlarge of straining to 9%. However addition of Mg even with Ti and B presence gives results near strength of 226D base alloy. Effect of increasing of strength is connected to refinement of structure and it is confirmed also by structure analysis. Obtained better strength, castability and wettability require further researches concerning Mg contents in modification of 226D alloy.

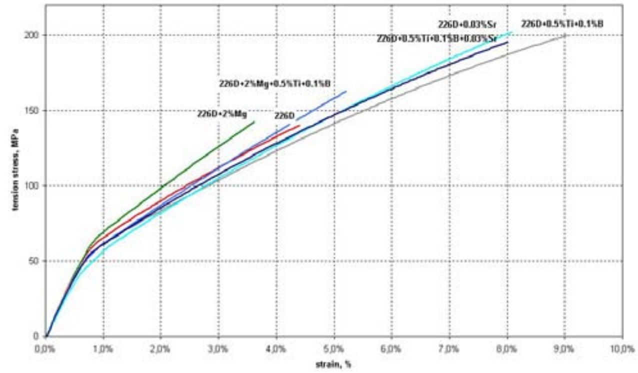

Fig. 7. Comparison among the stress/plastic strain curves of 226D non-modified alloy and modified aluminium alloys

4. Conclusions

Presented researches concerning influence of modification on castability had on aim to establish the Al alloy's composition which would meet the technological, strength and thermodynamic requirements for the Al-C composite's matrix. Based on carry out tests of fluidity, solidification and strength test it was found that the addition of Ti, B and Sr improve properties of 226D alloy. Further investigations attempt to carbon fibre infiltration with Al alloys in vacuums, in order to determine their usefulness as well as the modifying additions' influences.

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References

[1] A. Morita, Aluminium alloys for automobile applications, in:Proc. of ICAA-6, Toyohashi, Japan, 5–10 July 1998, in: Aluminium Alloys, vol. 1, 1998, pp. 25–32.

[2] W.S. Miller, L. Zhuang, J. Bottema, A.J. Wittebrood, P. De Smet, A. Haszler, A. Vieregge: Recent development in aluminium alloys for the automotive industry, Materials Science and Engineering A280 (2000) 37–49.

[3] J. Szajnar, M. Stawarz, T. Wróbel: Influence of impulse magnetic field reaction and inoculation with Ti+B addition on aluminium structure, Archives of Foundry Vol. 6, No 18, 2006, p. 103-108.

[4] W. Orłowicz, M. Mróz, M. Tupaj: Effect of modification with sodium or strontium on microstructure and mechanical properties of AlSi7Mg alloy, Archives of Foundry Vol. 6, No 18, 2006, p. 117-124.

[5] L. Lu, K. Nogita, A.K. Dahle: Combining Sr and Na additions in hypoeutectic Al–Si foundry alloys, Materials Science and Engineering A 399 (2005) 244–253.

[6] Shengjun Zhang, Qingyou Hana, Zi-Kui Liu: Thermodynamic modeling of the Al–Mg–Na system, Journal of Alloys and Compounds 419 (2006) 91–97.

[7] N. Fatahalla, M. Hafiz, M. Abdulkhalek: Effect of microstructure on the mechanical properties and fracture of commercial hypoeutectic Al-Si alloy modified with Na, Sb and Sr, Journal of Materials Science **34** (1999) 3555 – 3564.

[8] S.A. Kori , B.S. Murty 1, M. Chakraborty: Development of an efficient grain refiner for Al–7Si alloy and its, modification with strontium, Materials Science and Engineering A283 (2000) 94–104.

[9] E. Fraś: Particles intereaction with solidification front, Archives of Foundry , Vol. 6, No 18 (1/2), 2006, p. 339-344.

[10] Taha M.A. Practicalization of cast metal matrix composites (MMCCs), Materials and Design 22 (2001) p. 431-441.

[11] A. Dolata-Grosz, M. Dyzia, J. Śleziona, J. Wieczorek: Composites applied for pistons, Archives of Foundry Engineering, Vol. 7/1 (1/2), 2007, p. 37-40.

[12] M. Dyzia, A. Dolata-Grosz, J. Śleziona, J. Wieczorek: Structure of AK12+2%Mg composites reinforced by ceramics particles received in different heat transfer conditions, Archives of Foundry, Vol. 1, No 1 (2/2), 2001.

[13] J. Śleziona, M. Dyzia, J. Wieczorek: Casting properties of AlSi-SiC composite suspensions, Archives of Foundry, Vol. 6, No 22, 2006, p. 540-545.

[14] A. Dolata-Grosz, J. Wieczorek, J. Śleziona, M. Dyzia: Possibilities of the use of vacuous technologies for composite mixture quality rising, Archives of Foundry, Year 2006, Vol. 6, No 18 (1/2), p. 285-290.

[15] A. Dolata-Grosz, M. Dyzia, J. Śleziona, J. Myalski: Analyze of solidification process of heterophase composite, Archives of Foundry, Vol. 6, No 22, 2006, p. 145-151.

[16] A. Dolata-Grosz, M. Dyzia, J. Śleziona: Solidification and structure of heterophase composite, Journal of Achievements in Materials and Manufacturing Engineering, Vol. 20, Issues 1-2, 2007, p.103-106.