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Research of processes at heating FeSiMg7 alloying composition

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Using the method of the synchronous thermal analysis of the processes that occur in Fe – Si – Mg alloying composition at heating to 900 °C was studied. The changes of the phase composition of the alloy in the temperature range was established, that allowed to explain the mechanism of dissolution in the liquid iron.

Performance and stability of alloying is largely defined by the mechanism of dissolution of solid alloying composition (AC) in liquid iron. Phase composition of AC is one of the most important factors that affect the process of its dissolution. It defines the transition kinetics of alloying elements in iron, which determines the effectiveness of alloying on the crystallization and structure formation of castings.

Introduction of AC into liquid iron takes place with heat absorption. To reduce overheating of cast iron, which is partly spent for overheating and melting AC, the main phases of its composition should have a relatively low melting point. For magnesium AC it is necessary to decrease the initial temperature of iron to reduce magnesium loss and improve its assimilation by iron.

Magnesium based alloy with iron and silicon FeSiMg is often used. The easiest method to obtain FeSiMg alloy is dissolving magnesium in a liquid ferrosilicium. Silicon forms a strong compounds with alloying metals, which reduces the intensity of its reaction with molten cast iron, improves assimilation of magnesium. Due to the complexity of working with alloys that contain magnesium, triple phase diagram FeSiMg for system is absent so the phase composition of Fe – Si – Mg AC is experimentally determined. It is believed that the interaction with liquid cast iron magnesium from AC starts to evaporate that intensifies of mixing process. However, the explosive behavior of magnesium at heating is not investigated due to complexity of the experiments. In addition, at the actual conditions AC dissolution in iron is affected not only by the temperature, but also by chemically active environment of liquid iron. In this context, purpose is to study processes occurring in Fe – Si – Mg AC when heated at temperatures ranging from 20 to 820 °C.

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The study was performed using FeSiMg7 AC (% by weight): 7.1 Mg, 0.7 Ca, 50.2 Si, Fe – the rest. According to the phase diagram Mg – Si [1], magnesium is in the form of magnesium silicide Mg_2Si and MgSi. Silicide Mg_2Si melts congruently at 1078 °C. According to reaction at 805 °C, the formation of MgSi compounds takes place. Modern literature [2] deny the occurrence of reaction with a MgSi compound.

Taking into account the explosive behavior of magnesium when heated in the air in this work mode was selected following heat treatment FeSiMg7 alloy: heating to 500 °C, holding 1 hour and cooling the furnace to room temperature.

Research on phase change of alloy composition of the sample was performed by microanalyzer REMMA-102. Using thermal analysis [3] the processes that occur during heating FeSiMg7 AC is studied. The study was performed by the instrument STA 449F1A-0026M NETZSCH (Germany). The sample was heated in argon at 20 °C/min. The device allows one sample to simultaneously conduct thermogravimetry (TG) and Differential Scanning Calorimetry (DSC).

Microstructure of sample before and after heat treatment is shown in Fig. 1 and 2, respectively. Original sample has a microstructure with large crystals of $FeSi_2$ and silicon in a ratio of 1:1 (Fig. 1). Silicon contains based phase a small amount of magnesium (about 1 %). The basic amount of magnesium is presented in Mg_2Si AC in a small black inclusions that are relatively evenly spaced. There is also a small amount of iron silicide FeSi.

During heating to 500 °C followed by 1 hour holding high temperature diffusion of alloying components takes place, leading to the change of the microstructure (Fig. 2). Thus, in the diffusion the large crystals break down and lose their contours. Original dark refractory silicon crystals with small

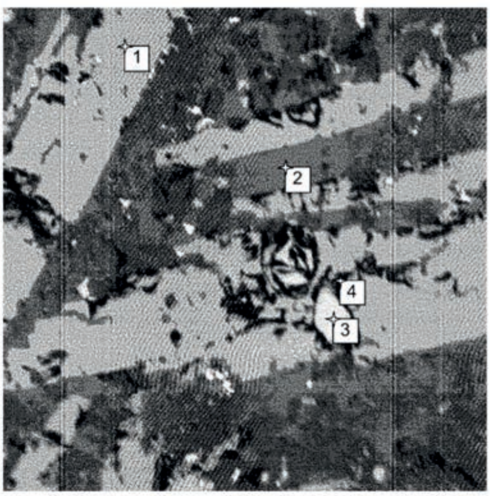

Fig. 1.Microstructure of original alloying composition FeSiMg7. 1 – $FeSi_2$, 2 – Si, 3 – FeSi, 4 – Mg_2Si.

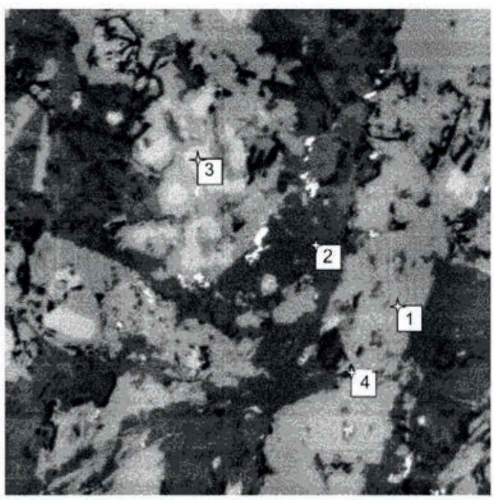

Fig. 2. FeSiMg7 AC microstructure after heat treatment (holding for 1 hour at 500 °C) with phase composition: 1 – $FeSi_2$, 2 – MgSi, 3 – FeSi, 4 – Mg_2Si.

magnesium content is partially converted into silicide with variable magnesium content. Quantity of Mg_2Si phase is not changed.

The phases containing iron, are transformed, i.e. the number of FeSi phases and original gray crystals $FeSi_2$ are converted to areas of mixed $FeSi_2$ and FeSi phases.

The results of the study of phase transitions (by DSC) and weight loss of the alloy sample (by TG), depending on heating time are shown in Fig. 3.

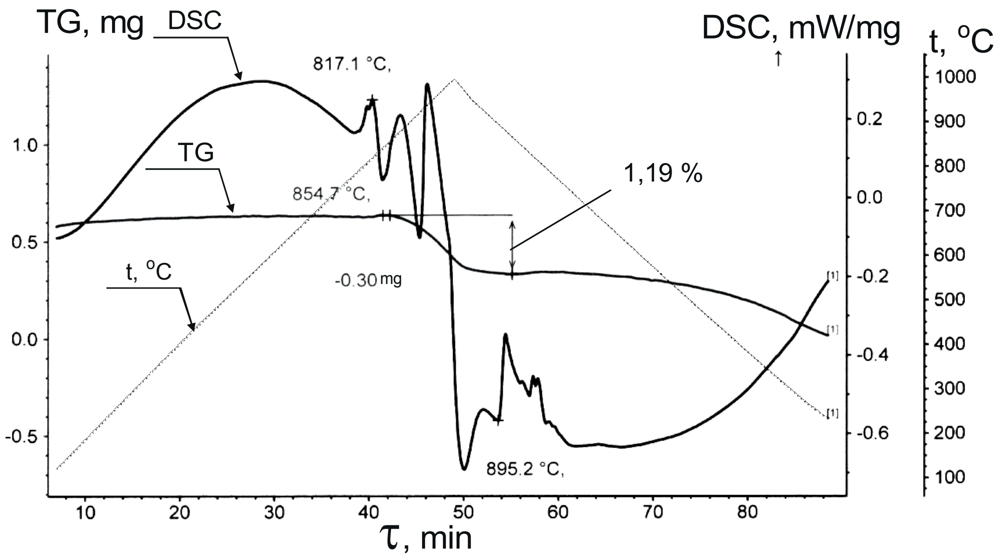

Fig. 3. Phase transformations (by DSC) and mass change (by TG) of the AC sample of FeSiMg7 when heated to 900 °C under an argon atmosphere.

An AC sample weighing of 25.4 g was heated in argon to a temperature of 817.1°. Above this temperature it starts to be partialy melted,which occurred with the absorption of heat observed on the curve as a DSC endothermic peak. Low melted MgSi phase when heated to 854.7 °C is melted, after that it begins to evaporate magnesium. Quantity of magnesium, which evaporates, according to TG analysis is of 1.19 %. The sample was heated to 895 °C, after which it was cooled, followed by crystallization, which is accompanied by heat in an amount of 40.2 J/g (Fig. 3).

Fe – Si – Mg AC interacts with active high-temperature environment of molten iron, resulting in both high speed and undergoing complex physical, chemical and heat and mass transfer processes. Superposition of these processes complicates the study of AC behavior. Using simultaneous thermal analysis allows to investigate the processes occurring in AC before and during the achieve its melting point.

As a result of this work the processes occurring in AC are investigated. It is shown that the MgSi is the first phase that starts melting, resulting in the formation of pores in the sample, which accelerate melting FeSiMg7.

Observation of microstructure of FeSiMg7 AC shows unstable MgSi phase.

It is shown that pre-heating the AC to 500 – 600 °C can increase the number of low melting phases and also offers the possibilities of reducing the overheating temperature of liquid iron and increase the degree of magnesium assimilation.

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Дослідження процесів, що відбуваються при нагріванні феросилікомагнієвої лігатури ФСМг7

Резюме

З використанням методу синхронного термічного аналізу досліджено процеси, які відбуваються в феросилікомагнієвій лігатурі при нагріванні до 900 °С. Встановлено зміну фазового складу лігатури в досліджуваному інтервалі температур, що дозволило пояснити механізм розчинення лігатури в рідкому чавуні.

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Исследование процессов, протекающих при нагреве железокремниймагниевой лигатуры ФСМг7

Резюме

С использованием метода синхронного термического анализа исследованы процессы, происходящие в железокремниймагниевой лигатуре при нагреве до 900 °С. Установлено изменение фазового состава лигатуры в исследуемом интервале температур, что объяснило механизм растворения лигатуры в жидком чугуне.