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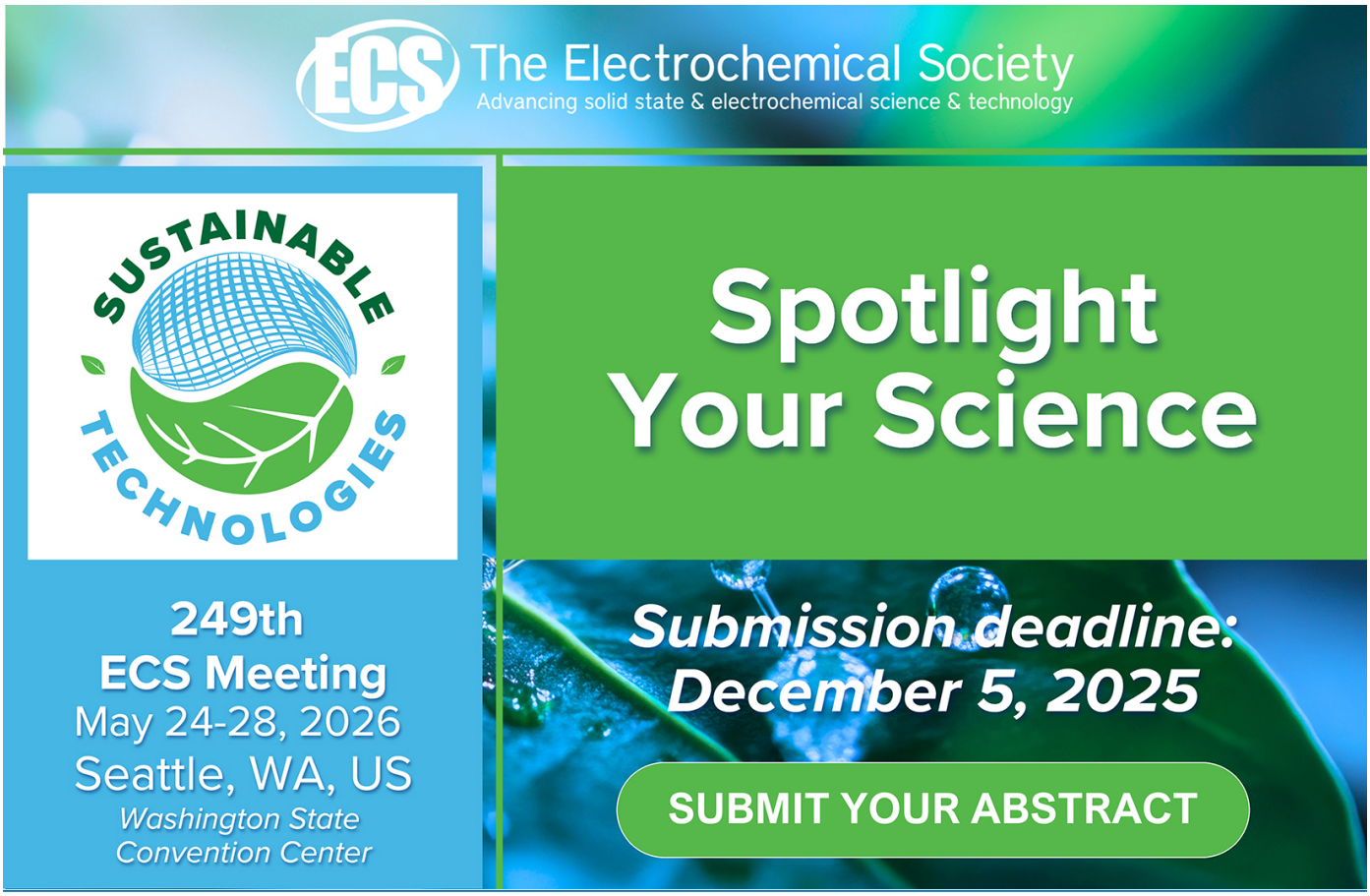
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Development of the manufacturing technique of crucibles to melt aluminum and improve its physical and mechanical properties by microwave oven

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Abstract. There are several techniques that are used to melt metal materials, among which we have conventional casting, by agitation, by compression and by molding. It is currently being studied in a technique based on electromagnetic radiation with the implementation of conventional microwave oven, thus improving the results in terms of time in the casting process; to carry out this electromagnetic casting process, a high-frequency wave-receiving medium is required to reach the melting temperature of the material on which it is being worked. In the case of aluminum, a working temperature of approximately 700 °C is required to achieve phase change of the material. This project produces a fine-grained silicon carbide-based crucible, taking into account that it is a semiconductor and refractory material capable of capturing electromagnetic waves, for the purpose of allowing the use of a microwave oven in the aluminum smelting process; presenting in this way a new casting technique that promises a significant saving in the execution time and saving the implementation process in recycling and reuse of aluminum and improving its physical and mechanical properties by means of irradiation casting electromagnetic.

1. Introduction

There are several techniques that are used to melt metal materials, among which we have conventional foundry that is made in cube furnace or crucible, material is poured until it reaches the liquid state, this is known as casting which is then poured into sand moulds to form specific parts [1]; Stirring smelting which means at the level of a set of processes, which, for a partially solidified alloy, combine the advantages of traditional forging and casting methods [2-4]; compression casting is a process of forming parts in which the material, is introduced into an open mold to which pressure is then applied so that the material adopts the shape of the mold and heat so that the material reticulates and definitively adopts the desired shape [5-7] and Molding It is done by pouring the molten metal onto a mold, so that it moves by its own weight [8]. It is mainly used to manufacture castings of steel, bronze, brass and various aluminum alloys to make it possible there are different techniques: sand, coquille and lost wax.

As you can detail each of the techniques what you are looking for is to give a shape to the material or to be able to manufacture some part, this is achieved by applying heat to the material until it takes it to its melting point or to the point where it is allowed to mold, in this long process of transformation is

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where the different techniques that fit the material and the final use of the part to be manufactured are resulting [9].

Taking into account the environmental impact of the extraction of metallic materials from nature, and in search of a reduction in damage to the environment, the processes of recycling and reuse of these materials arise, mainly aluminum which is widely used in different sectors such as: automotive and food. After the metal packaging is used when the food and drinks are packed in it, they are discarded and in the worst case they end up in garbage dumps without any reuse and causing contamination, what is sought is to give another end to these aluminum packaging, this is achieved by bringing the aluminum to its melting temperature by achieving a phase change from solid to liquid, thus allowing it to be used for a purpose other than that for which it was originally designed [10].

A new, innovative and promising technique that goes hand in hand with a significant saving in processing times of metallic materials is being studied, is talking about the function by electromagnetic irradiation [11], this technique is based on the application of microwaves that allow the generation of high temperatures that allow a material to be brought to its melting point, all this is possible with the use of a magnetron which is a device that transforms electrical energy into electromagnetic energy in the form of microwaves, the generation of electromagnetic waves at the frequency of radiation is approaching 2450 MHz, but for metallic materials to be melted by electromagnetic irradiation there has to be a microwave receiving medium and waterproofness in the process that allows the microwaves to enter and not reflect [12,13]. It is going to treat a point case like aluminum that needs a working temperature of approximately 700 °C to achieve a complete melting of the material. This project produces a functional silicon carbide crucible bonded with bentonite clay; taking into account that silicon carbide [14] is a semiconductor and refractory material with great advantages for working under extreme conditions of temperature, voltage and frequency, capable of capturing electromagnetic waves emitted by the microwave oven and transforming them into high temperatures which reach the melting temperature of aluminum, thus achieving the phase shift of solid state aluminum to liquid state allowing the recycling and reuse of the material through this novel casting technique.

Noting the benefits of this smelting technique, one can see how it contributes to more efficient recycling processes for metal materials, taking into account that silicon carbide being a readily available material makes it possible to carry out this smelting technique, thereby seeking a better use of economic resources and a positive impact on the environment, making the recycling of aluminum take place in less time and with lower production costs, thus achieving a lightening in the process of changing phases in aluminum and with conventional tools. The crucible will be functional and will allow the whole process to be done doing in this way that they propitiate new investigations where other metallic materials are involved and that it is allowed to reduce production costs leading to that many recycling processes can be perform and thus contribute to a low environmental impact that produce metal waste that is not efficiently managed.

2. Materials and methods

The material to be used is silicon carbide and bentonite sand, for the creation of a ceramic crucible, taking into account the characteristics of silicon carbide that makes it possible for us to melt metal materials in conventional microwave, we detail each material and its function in the process.

2.1. Silicon carbide

Silicon carbide (SiC), also called carborundum is a covalent carbide and has a diamond structure, is almost as hard as diamond, achieving hardness on the Mohs scale from 9 to 9.5 [15]. Silicon carbide is a semiconductor and refractory material that has many advantages to be used in devices that involve working in extreme conditions of temperature, voltage and frequency. Silicon carbide can withstand a voltage or electric field gradient up to eight times greater than silicon or gallium arsenide without rupture occurring; This high breaking electric field value makes it useful in the manufacture of components that operate at high voltage and high energy, such as diodes, transistors, suppressors and even high energy microwave devices. Added to this is the advantage of being able to place a high packing density in the

integrated circuits; the high saturation speed of load carriers it is possible to use SiC for devices that work at high frequencies, either radio frequencies or microwaves. Finally, an approximate hardness of 9 on the Mohs scale provides mechanical strength, which together with its electrical properties make SiC-based devices offer numerous benefits over other semiconductors [16,17].

2.2. Bentonite

Bentonite is a very fine-grained (colloidal) clay containing bases and iron. It has applications in ceramics, among other uses. The name derives from a site in Fort Benton, United States of America. The particle size is less than 0.03% of the average grain of kaolinite. The most normal type is calcium. Sodium swells when it comes into contact with water. The iron it contains always gives it color, although there is also a white bentonite. This type will give a better color in reduction than in oxidation when used on porcelain bodies. It also helps the suspension of the varnish. It is a very sticky clay with a high degree of shrinkage (the bonds between the unitary layers allow the entry of a higher amount of water than in the kaolinite) and has a tendency to fracture during cooking and cooling. It is therefore not appropriate to work it alone or as the predominant material of a mass [18].

The crucible manufacturing process is shown below in Figure 1, using fine-grained SiC, 7% by weight of Bentonite clay and water; SiC is uniformly mixed together with Bentonite clay, the water is added and stirred until a mouldable mass is obtained, then placed in the mould and press, then pressed into a muffle oven for approximately 1 hour at a temperature of 1200 °C, is cooled to room temperature and results in a silicon carbide crucible suitable for aluminum smelting in a conventional microwave oven.

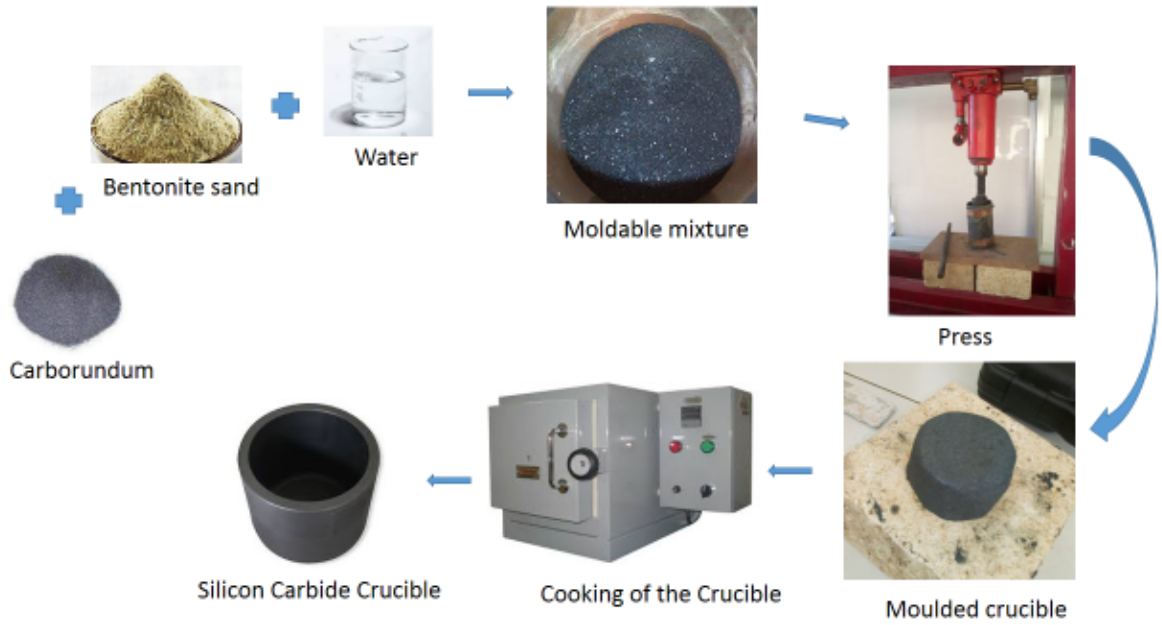


Figure 1. Silicon carbide crucible manufacturing process for electromagnetic irradiation smelting.

3. Results

Figure 2 shows the final result of the manufacturing process of the silicon carbide crucible, it is a crucible that structurally performs the function of capturing the electromagnetic waves emitted by the microwave oven and converting them into heat, thus allowing the realization of the aluminum casting process, a test was subsequently carried out to verify the effectiveness of the crucible which can be seen in Figure 3.

In Figure 3, a silicon carbide crucible tested in a conventional microwave oven is shown, detailing the red color seen in the figure can be said that the Crucible reached a temperature around 800 °C, which makes it suitable for performing aluminum smelting processes which has their melting point around 680 °C - 700 °C, the crucible is tested by doing an aluminum smelting process which is detailed in Figure 4.



Figure 2. Silicon carbide crucible.

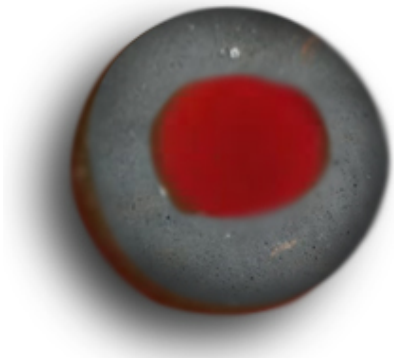


Figure 3. Silicon carbide crucible after leaving the microwave oven.

It can be observed and stated that the manufacture of the silicon carbide crucible was the means that allowed the smelting to be done in the conventional microwave oven, which led to a decrease in casting times by 60% with respect to mufla kiln smelting, making this technique which promises to be more efficient in terms of the casting process implemented in new investigations; which opens up a field for testing with metal materials other than aluminum, in which it is of great benefit and contributes to substantial savings when talking about recycling and reusing different materials that are no longer in use and giving them a useful final arrangement.

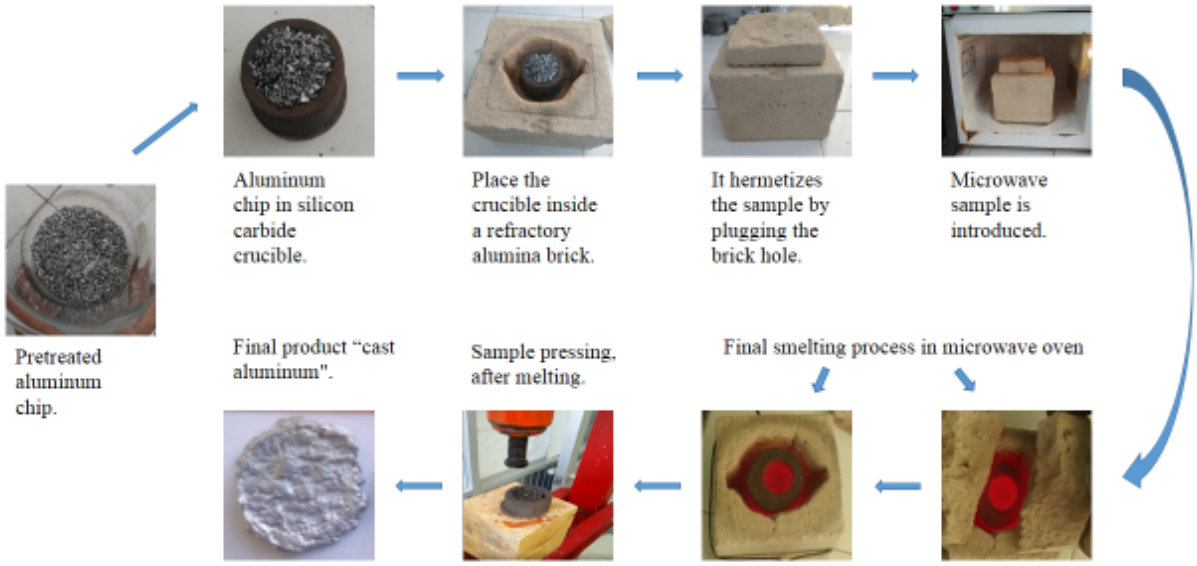


Figure 4. Aluminum casting process in conventional microwave oven with silicon carbide crucible.

4. Conclusions

The silicon carbide crucible is functional and suitable for the realization of aluminum foundries in conventional microwave oven, reaching a working temperature around 800 °C, are slightly above the melting temperature of aluminum which is approximately 680 °C – 700 °C.

A significant saving of 60% was observed in melting times with electromagnetic irradiation compared to the melting process with muffle furnace, thus reducing production costs for melting and recycling aluminum, with easier processes and less time.

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