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Manufacture of reinforced nano metal melt aluminum sponges for oil collection in spill from water sources

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Abstract. At present, it is necessary to use various materials to manufacture parts used in different fields such as industry, food, automotive, aviation, etc. Depending on the purpose of the part is the manufacturing process and the materials used, the most widely used material is aluminum, for its mechanical properties and low strength/weight ratio, aluminum is one of the most demanded materials, you can find various manufacturing processes, by casting, molding, injection and machining, This last process is developed by separating materials in the form of fragments, so that the required parts can be created, the chips are completely discarded, causing environmental contamination. This research aims to recover aluminum chips produced in the metal processing workshop and machine tool laboratory of the Universidad Francisco de Paula Santander, Seccional Ocaña, Colombia, to create a metal sponge of aluminum that will also allow nano-reinforcement with carbon nanotubes under special conditions for the collection of petroleum or petroleum derivatives when environmental impacts occur on water sources, in this way, the use of aluminum chip will help protect the environment and the metal sponge will reduce the risk that oil and its derivatives will generate environmental impact reflected by the spill in water sources.

1. Introduction

Primary aluminum is a metallic material that is extracted from nature, its process begins with the extraction of bauxite, material from which the aluminum comes, which means that in order to obtain 1 ton of primary aluminum, it is necessary to extract 4 tons of bauxite from the wild, not counting the large energy costs to complete the process [1-3]. Secondary aluminum is that which is obtained in recycling processes to give it a final disposition that allows the use of the same, among the products that are recycled are the packaging of food products, worn parts of automotive, motorcycle, etc. And chip product of processes carried out in metalworking workshops; the latter is not considered to give it an adequate final disposition, and in the worst case ends up polluting in sanitary landfills [4,5].

According to the information found in the literature reviews on the different techniques for melting aluminum chip, an exact procedure for melting aluminum chip is not shown [6]. Various techniques such as powder metallurgy, hot extrusion, smelting and agglomeration by electromagnetic induction furnace are generally analyzed. Therefore, the decision is taken to develop techniques in an experimental way that guide us towards the development of these techniques [7-9]. Using the study of physical processes that allow the development of techniques to carry out a good process of recycling and use of metal materials that have not been reused so far [10,11].

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We cannot ignore the environmental problems that occur when oil spills from water sources, the result of different factors, among which there are attacks on the pipes that transport this product extracted from nature, which incurs in great pollution and affectations to the populations that in many of the times are supplied with this vital liquid that is obtained from these water sources that are affected [12,13].

With the proposal to improve a suitable technique for melting aluminum chip, different experiments were carried out, changing, and controlling parameters that would show the way to the right technique [14]. Among the parameters we have the temperature, chip type, chip compression before and/or after melting, furnace type, raw material decontamination and mold type to use [15,16].

The next step is to nano-reinforce metal sponges with the use of decorated and functionalized carbon nanotubes, which have magnetic properties that can attract hydrocarbon particles present in petroleum, in this way it is achieved that the sponges fulfill the initial function posed, as it is, metal sponges with the ability to collect oil and its derivatives in spills in water sources.

2. Methodology and materials

The material used is recycled aluminum chips, which are transformed into metal sponges with the addition of heat, without neglecting the main purpose which is to recycle, reuse and contribute to the preservation of the environment; the transformation of the chip requires a process of physical phase change of the aluminum, including the heating of the material up to its melting temperature, allowing the union of the small particles and thus obtaining metal sponges of aluminum. The next step leads to the realization of alloys of the chip with a material that allows the metal sponges the collection of petroleum and its derivatives in spills in water sources.

According to small-scale laboratory tests, the conditions for melting aluminum shavings in a muffle furnace were determined by pre-treating aluminum shavings with an aqueous solution of caustic soda, to achieve the removal of alumina forming on the outside of each small particle resulting from oxidation with the environment, the next step is the removal of the air bubbles that form between particle and particle with the use of a hydraulic press of 16 tons of pressure, is carried to the baking muffle on a ramp temperature of 10 °C per minute up to 750 °C; this temperature is maintained for a period of at least 3 hours and then the sample is removed from the furnace and re-pressed to obtain the metal sponges from the melting of the aluminum chip; finally, the sample is cooled to room temperature and the cast aluminum part is removed.

The entire process complies with the sequence described as shown in Figure 1. Physical phase change processes and nano boosters will make it possible to obtain metal sponges for the collection of oil and its derivatives in water sources.



Figure 1. Manufacturing process of metal sponges from recycled aluminum chip.

3. Results

Figure 2 shows the product obtained by melting the aluminum chip in the laboratory using the muffle furnace, just as aluminum chip foundries have been formed which can be seen in Figure 3 [17], where it is evidenced in previous investigations the fusion of the small particles to obtain a final product, following the scheme of the Figure 1 mentioned above. The process is carried out by changes in the physical state of the aluminum, which consists of bringing its liquid state to about 700 °C for the union of the chip, and by cooling to room temperature makes the material solidify and generate a part with defined pores, allowing the creation of a piece in the form of a sponge with favorable physical and mechanical properties to carry out the filtering of liquids as in this case of study that are water sources.

The next step is to be able to make aluminum chip alloys with materials that can absorb components such as petroleum and its derivatives, bearing in mind that the use of nanomaterials can help achieve this purpose, which is achieved with the functionalization and decoration of carbon nanotubes for the final development of metal sponges capable of collecting oil and its derivatives in spills in water sources. The nanotubes in their initial state are magnetic, after performing the functionalization and decoration nanotubes that attract hydrocarbons can be made and by magnetic attraction after making part of the metal sponge the captured hydrocarbon can be collected and the sponges cleaned; in this way they allow the sponge to be used again and mitigate the environmental impacts that have been caused on water sources.

During this investigation, metal sponges of aluminum shavings capable of absorbing and performing the established function were produced, in the same way, progress is made in the deepening that gives rise to close investigations where implementation on a real scale in water sources is reflected. Sponges are ideal because they allow water to flow through their interior and the nanotubes that are allotted to the base material can trap the hydrocarbon particles that are the main polluting agent in this case.

The metal sponges were manufactured following a cooking curve, which consisted of raising the temperature to the material 10 °C per minute, until achieving a final temperature of 700 °C, this temperature is the melting temperature of aluminum that allows the aluminum particles to bond together and form the metal sponge, this physical phenomenon experienced by the solid to liquid phase change material also depends on a permanence at that melting temperature for a range of 1 hour, allowing all particles to have the same temperature and the conformation of the metal sponge to be carried out efficiently, the final step is the application of a pressure with a hydraulic press of 16 tons, to obtain the metal sponge of recycled aluminum chip.



Figure 2. Aluminum sponge with recycled chip.



Figure 3. Aluminum sponges AA6061 with aluminum chip. Adapted from [17].

4. Conclusions

The metal sponge was manufactured from recycled aluminum chip, complying with environmental conservation requirements, and applying physical processes of state changes in the matter, allowing the material to melt and the recycled aluminum metal sponge to consolidate. The project is in a 70% development in which the manufacture of the metal sponge is evidenced; nano-material alloying is under investigation to enable sponges to collect oil and its derivatives in environmental spills from water sources, this gives way to the realization of a megaproject on a larger scale that allows to contribute when these environmental accidents occur.

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