THREE-DIMENSIONAL ASTROID WITH VARIABLE ROUGHNESS

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Summary: This paper discusses the technological process of casting molten metal, in this case an alloy of tin and lead commercialized under the name of "fludor", in temporary forms. An analysis of the differences in the processes for the two created pieces will also be presented, based on the roughness obtained and the casting defects observed. This text follows details such as the composition of the materials, up to the different paths taken in creating the parts and what were the final consequences of said paths. The conclusion states which process suits rough parts better, and which process suits the casting of finer parts, based on the observations.

KEYWORDS: casting, tin alloy, roughness

1. Introduction

The paper talks about the casting of two parts of tin and lead alloy in temporary forms and goes into detail: both about the technological process in general and about the particularities discovered during the experiment. Afterwards, a discussion is started on the defects of the parts, which evolves towards a comparison between their different roughness.

2. Current research

At the moment, the two pieces are cast. The first piece was cleaned of the casting material, but could not be sanded to a much lower roughness, and the second piece was sanded until it was smooth enough, so that its finer defects could be observed.

Henceforth, we will talk about the technological process that took place when casting these pieces, as well as their defects and roughness.

Fig. 1. First part

Fig. 2 . Second part

3. The first casting and its roughness

This paper will discuss briefly beforehand the technological process of casting in temporary or non-reusable forms. This particular experiment overlooked sand casting. In sand casting, molten metal is poured into a sand cavity, which will later on be destroyed in the process of taking out the said metal, after it has solidified. It is one of the most used processes under the wide array of metal castings, accounting for a relatively high amount of the total cast in weight. During this process, the metal is heated to a previously known temperature, which can also be treated chemically in order to assure a certain outcome. Since it allows the user to create a great range of parts, both economically and geometrically, it accounts for just over 70% of the total metal castings. As we will see in this chapter, it unfortunately has low dimensional accuracy and poor surface finish, but if used correctly, it can be very efficient for mass production of rougher parts. Going forth, we will discuss the experiment.

In advance, we purchased a quantity of 1kg of alloy of 40% tin and 60% lead for casting the first part.

The process consisted of 6 main steps: creating the wooden frame for the semi-temporary casting form, preparing the casting mixture and placing it in the previously created form, carving the casting cavity and preparing it, melting the metal and casting it, and finally, removing it from shape and allowing it to cool and solidify.

Fig. 3. The cavity for the first part

Firstly, we took 4 wooden planks that we cut in order to build a frame of 0.8m by 0.8m, which we later joined to create the initial shape. In the next step, we prepared the mixture for the casting cavity. We combined construction sand with water to give it a certain solidity and to be able to sculpt it in the shape of the desired model. We poured the respective mixture into the form of wood and smoothed it by successive additions of mixture and pressing it with another wooden plank.

After we made sure that the sand was solid enough, we started to sculpt the desired shape of the astroid with the help of some measuring tools and a modeling knife. For the preparation of the mold, we also sprinkled a small amount of calcium carbonate in the form of powder, so that the molten metal would not have other defects and would come out easily from within the mold.

Next, we moved on to the steps regarding the melting of the metal. We untied the alloy wires and placed them in a thermally resistant metal container. To make sure that the molten metal would not stick to the container, we put an unguent paste on the walls of the vessel. We kept the heat source at a temperature of 200 degrees Celsius, above the melting point of the alloy of 183 degrees Celsius, to ensure a slow melting and a homogeneous mixture at the end. After several checks, we reached a point where the metal was fluid and had enough liquid flow and could be cast without problems.

We took the container from the heat source and took it to the temporary mold. We poured the molten metal to below the upper edge of the cavity. We let it cool down for a short period of time, so that no cooling defects would appear, after which we removed the piece from the sand with the help of thermally resistant tools. After it cooled down, we removed the grains of sand embedded in certain points, after which we sanded the piece for the final look.

We came to the conclusion that due to the using of the construction sand that had a significant grain, we obtained a piece with such a high roughness, unlike the second piece that will be presented in the next chapter, where the technological process had some differences, hence the fineness, respectively the accuracy, of the piece. That is why this process could be used for rough parts. Nevertheless, these final product differences were the most important parts of the work, being the ones that led us to the scientific conclusions regarding the casting process.

Also, the casting mold was destroyed at the end of the process, as we needed to remove the piece from the sand, hence the name temporary casting mold.

4. The second casting and its defects

In this part of the article, we will discuss the process of paper casting, how it differs from the first process and in the final we will discuss about the advantages and disadvantages and point out some possible applications in industry. Paper casting is used on a smaller scale than sand casting, and at the present moment it is used for manufacturing small pieces of civil equipment like fishing tools or even spare parts for the furniture. It can easily be used by most of the people for obtaining simple parts used in the daily life, respecting some elementary protection measures. It is not a dangerous or complicated process, and it doesn't require special facilitates. We chose this method of casting to highlight its simplicity and efficiency in obtaining small pieces of tools.

Firstly, we chose for the form an origami model that we learned about during the research time period. The choice of the origami model as a casting mold was justified by the possibility of creating complex shapes out of simple pieces of paper, which made the process cheaper and less time consuming than any other choice. A small disadvantage of the paper as material is represented by its bending property, which makes it difficult to resist during the action of pressure forces. To mitigate the risk of paper bending during the metal casting, we stabilized the paper mold inside a box filled with sand.

For the choice of the material that was used to create the piece, we considered solder to be the best option, because of its properties. Solder is an alloy mainly composed of lead and tin. The presence of lead into the alloy is raising the melting point of the alloy just enough to be melt with a simple gas cooker, but also maintaining a resistant structure. After putting 350 grams of solder inside a pot on the gas cooker, we waited for approximately ten minutes for it to melt.

Once the metal was completely melt, we poured it into the mold, and then we waited for it to cool. After the metal was completely hardened, we opened the mold, and we extracted the piece. The extraction was an easy process, as the paper is a soft material and it was easily ripped away. The finishing process was needed because, the piece was covered with burnt material, that made the observation of the details and imperfections difficult. For this process we used a simple file.

After the finishing was complete, imperfections could easily be observed. The imperfections we identified are cracks on the surface of the piece, voids and incomplete filling of the part.

The cracks on the surface are usually caused by the high pouring speed, the lack of flexibility of the mold and big thermic or contraction tensions. The voids are represented by empty holes at the surface or inside of the body. They look like a dent on the surface of the body and they form under the influence of the contraction during the solidification process. The main cause of this defect is represented by the high contraction of the material during the solidification process or by the high temperature of the liquid metal. The main causes of the voids are the low fluidity of the liquid metal, the insufficient quantity of material inside the melting pot.

5. Conclusions

With this article we are aiming to detail and compare two different processes of casting: sand casting and paper casting. As we have seen in the previous part, both have undeniable advantages, but they also have some decisive disadvantages making them suitable for specific purposes. The pieces obtained with sand casting are heavier and they present a high degree of roughness with less dimensional precession. Due to its roughness, imperfections are more difficult to track. The sand casting is widely used in industry and offers the possibility to make a large number of pieces.

On the other hand, the paper casting creates parts with a smaller degree of roughness and a better dimensional precision. It can be used to make tools useful in the daily life, being a cheap and easy process. One big advantage of the process is the possibility of recycling paper by using it as a mold.

All of these characteristics are to be found in the attached Table 5.1

Table 5.1.Advantages and Disadvantages of the parts

First part	Second part
Harder	Finer
Higher roughness	Lower roughness
Hardly noticeable defects due to high roughness	Defects easy to follow: patches, cracks, incomplete filling
Average shape accuracy due to the process	High accuracy
Process suitable for mass-produced parts	Process suitable for finer parts

6. References

[1] Ştefănescu,D.M.(2007) – *Ştiinţa şi ingineria solidificării pieselor turnate*, Editura AGIR, Bucureşti

[2] Gheorghe Simionescu, Constantin Cernat, Elena Ţigănilă.(2007)- *materiale tehnologice pentru turnătorii.* Editura BREN, Bucureşti.

[3] Petrescu, Maria, ş.a.(2006) - *Tratat de ştiinţa şi ingineria materialelor metalice*, vol.1, Editura AGIR, Bucureşti.

[4] Marinescu, M., s.a. (2016)– *Tehnologia materialelor. Lucrări de laborator*: Editura PRINTECH, Bucuresti.

[5] https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/rugosity

[6] https://www.scrigroup.com/tehnologie/tehnica-mecanica/OBTINEREA-SEMIFABRICATELOR-MET74975.php

[7] https://sim.tuiasi.ro/wp-content/uploads/G.Barbu-Tehnologia-turn%C4%83rii-indrumar-proiectare.pdf

[8] https://www.scritub.com/tehnica-mecanica/PRELUCRAREA-PRIN-TURNARE62258.php

[9]https://scanare3d.com/industria-auto/identificarea-defectelor-in-procesele-de-turnare-utilizand-tehnologia-ct/