**12th International Research/Expert Conference**
**"Trends in the Development of Machinery and Associated Technology"**
**TMT 2008, Istanbul, Turkey, 26-30 August, 2008**

# DESIGN AND MANUFACTURE OF CASTING PATTERN PLATES BY RAPID TOOLING.

**A.Pereira, J.A. Pérez, J.L. Diéguez, G. Peláez, J.E. Ares.**
**ETSII. Universidad de Vigo. Lagoas Marcosende. Vigo**
**Spain**

## ABSTRACT

*The primary target of this project consists of combining the technique of rapid prototyping and casting to produce aluminum parts in a sand mold being made the corresponding models and core boxes by means of the technology of rapid tooling, FDM (fused deposition modeling) of ABS. The followed process to obtain the pieces is casting, that consists of the fused metal spill in a mold pattern previously conformed, followed of a cooling and later rinding of the solidified piece. The models and core box, generally, is made in wood or plaster, but in this case they were made by means of a Rapid prototyping machine of the company 3Ddimension. The phase of design and manufacture of the model and the mold are most expensive and critical of the process. In this work it is tried to study the valuation of the time of manufacture of the models, core box and molds.*

*The application Catia V5 R17 has been used for the geometric definition of the model and care box. This model is exported in stereolithography format (stl) and after this, the file was sent to the printer Dimension BST 768 and begin the construction of the models.*

*The proposal methodology using rapid prototyping to generate the models is a clean and fast solution, and in addition it allows to obtain geometries that are nonviable by another procedure. The surface finish quality of the model is appropriate for the casting process , and reproduces with a high reliability the model CAD.*

**Keywords:** Aluminium casting, Catia V5, RP, FDM

## 1. INTRODUCTION.

In the boxes of moulding, the model is used to create a cavity in the sand, including the tap system, that later will be filled with the fused metal. The phase of design and manufacture of the model and the mold are most expensive and critical of the process *(1)*. The success of the conformed part by casting depends on the good accomplishment and suitable design of the model and the boxes of males *(2)*.

In this aspect, with respect to the elaboration of lost molds for prototypes of pieces to make by casting, there are the document DE 43 41325 mencioned in the European patent ES 2181462 *(3)*, in which it is described as spongy or cellular plastic models make, with the aid of a milling machine CNC. In order to guarantee the fast and exact preparation of the piece, the polystyrene particles that are eliminated of a cellular plastic block during the machining are inhaled immediately in the zone of the milling machine vacuum cleaner. In this mentioned patent it is described, in addition, the process of manufacture of sand molds without mold pattern, forming blocks hardened with gas from casting sand with the aid of a alkaline phenolic resin binder and next mechanized.

Diverse researchers also have developed processes prototype for the machining of molds *(4)*.

First it is necessary to generate a simulation of the mechanining with a program CAM, and later the conversion is made of data CNC to the language of the robot, with an intermediary software, so that

the robot, equipped with an spindle and the corresponding tools, in order to machining the shape in the mold done of compacted sand *(5)*.
On the other hand, the German company ACTech makes works that deal on the accomplishment of molds with mixed technologies like for example, the fast manufacture of molds by means of technology of Rapid Prototyping like sinterized laser (SLS) to manufacture cores and also the molds *(6) (7)*. One of the disadvantages of this technology is the excessive cost of this Rapid Prototyping process.

The principal aim of this project consist in combining rapid prototyping technology and casting process to produce aluminium parts in a sand mold, realizing the respective models and boxes by the rapid prototyping technology FDM (fused deposition modeling) of ABS.
To obtain the parts, we followed the casting process, which it is known, there consists in empty the fused metal in a mold before shaped, continued by a cooling for later obtain the geometry.
Generally the models are made of wood or plaster, but in this project they were realized by a rapid prototyping machine. The printer uses the FDM technologies of ABS, consistent in extrude the fused polymeric material across a nozzle to deposit it layer over layer until complete the model.
The model and mold design and manufacture are the costliest phases of the process. In this project we realize a dimensional study of the parts, measure his superficial roughness and the manufacturing time of the models, males and molds. *(8)*

This work of investigation is included into another project in which the main goal is to study and compare the two methodologies to conform the mold, one by means of model plates by RP and the another way by machining directly the sand compacted with an anthropomorphic robot .
The main target of this work is the elaboration a methodology of valuation the manufacture of sand molds, with models made by Rapid Prototyping, in particular modeled by deposition fused of ABS (FDM) comparing with the traditional manufacture, and studying the dimensional behavior of the elaborated models and the viability of accomplishment of molds.

## 2. METHODOLOGY.

The followed methodology is based on a design of experiments with the goal to select the influencial factors in the process and also to define the variable objective, corresponding to the characteristics of quality selected and economic parameters to measure Also the fixtures and equipment used in the experimentation are designed and manufactured. Basically it had been developed in the following phases:

a. The process to create the product begins with the elaboration of the geometric definition of the piece. That is realized creating a model 3D of the piece, that it reproduces her geometry and dimensions. For the geometrical definition of the model there has been used the application Catia V5 R17.
b. Inicial Study about the parameters that have influence in the process of Rapid Prototyping by FDM and could vary the roughness of the surface and the dimensional tolerances of the model.

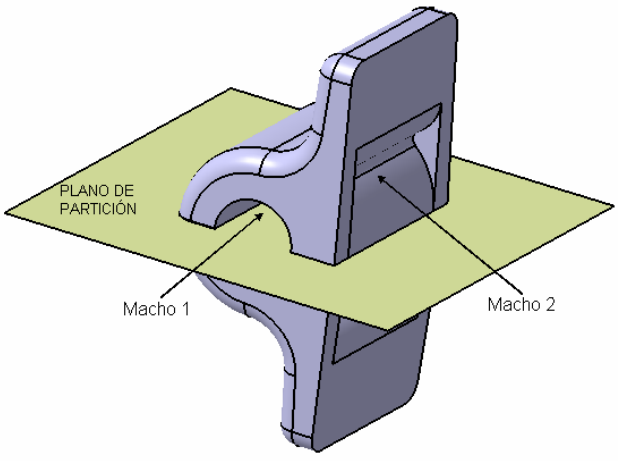



*Figure 1. Model 3D in catia V5*

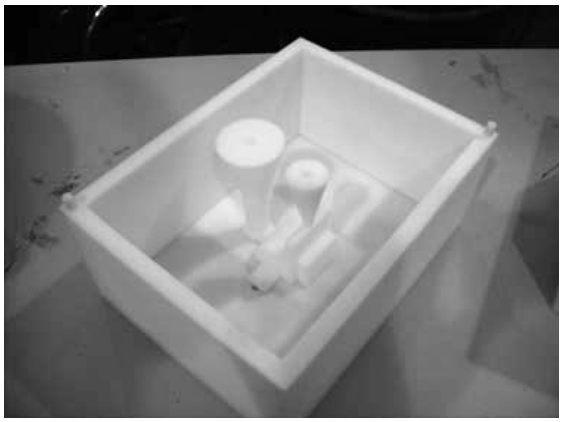


*Figure 2. Superior Model plate*

models.

e. The next step is creating the semimolds. This are realized pressing the sand near to the models that are fixed to the pattern plates.
f. Manufacturer the mold and conformed the piece in Aluminium. Finally they are extracted the models to generate the cavity and proceed to spill the molten metal. Once spent the necessary time for the solidification, the piece is obtained.
g. After we have obtained the part, it had been neccesary to make the dimensional analisys and the measure of the roughness finish.
c. Design of the running, gating and feeding system in the same platform Catia V5. Also is necessary to define the cores and the box cores. In addition the top part of the mold includes the system of nourishment and vents. The location should be chosen so that the minimum free fall of metal after the filter occurs to avoid splashing. *(9)*
d. Manufacturer of the model Plates. The above mentioned model exports him in stereolitographic format (stl) in order that could be interpreted by the printer 3D Dimension BST 768, which it is the machine used in this case to produce the

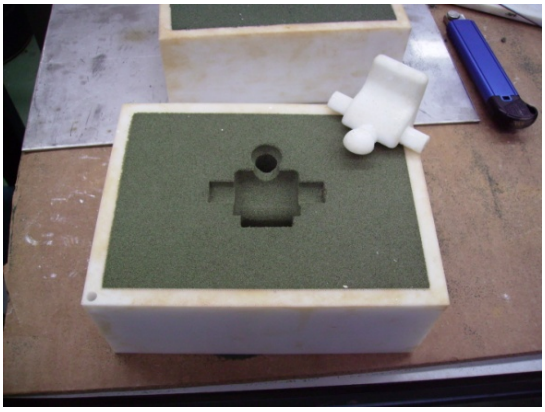
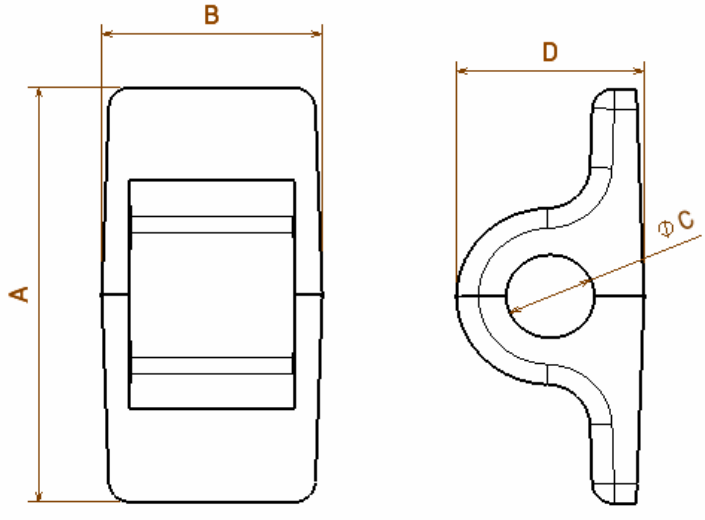


*Figure 3. FDM pattern and sand mold part*

## 3. RESULTS AND DISCUSSION

| | A | B | C | D |
|---|---|---|---|---|
| Medidas nominales (mm) | 80 | 40 | 16 | 34 |
| Medidas reales (mm) | 80,4 | 39,85 | 16,05 | 34,05 |




The application of models made by FDM to the sand casting process generates pieces with good dimensional accuracy.

The first measurements that are made are those of the most important dimensions of the piece, comparing them with the nominal measures of the same one. After make this it is necessary to analyze the dimensional exactitude of the final piece with the model.

On the other hand to make the study of the the surface finish we compare the models created by means of technology FDM and of the pieces obtained by smelting from these models. To make The surfaces measures was used a stylus roughmeter Taylor Hobson.

The value of the casting pieces roughness increases in relation to the model roughness. This may be due that there is an intermediate step between the model and the casting part, which is the sand mold manufacturing. Therefore the piece roughness will be determined by the sand quality.

## 4. CONCLUSIONS

The main advantage gained with the application of FDM patterns in the sand molding is reducing the model development time with respect to the traditional processes and consequent time production for the sand mold. This simple substitution requires no change to a foundry's practices and procedures. Rapid Prototyping techniques allow generating models for geometries that are unworkable by another procedure.

The surface quality of the FDM model is good, which translates into good quality of the casting pieces.

Another conclusion is that industrial waste remainders do not exist in the accomplishment of models, except support materialof RPthat is insignificant.

Finally it is possible to be concluded that with this methodology facilitates the automatization of the process of manufacture the molds increasing the flexibility and efficiency of the process.

The future lines are translated in the accomplishment of the same study considering the elimination of the phase of physical manufacture of the model, by machining directly the sand block mold. (Patternless casting) *(10)*

## 6. REFERENCES


[1] Ammen, C. The complete handbook of sand casting. s.l. : Mc Graw Hill , 1998.

[2] Kalpakjian. Manufacturing Engineering and Technology. 1995.

[3] Hauschild, Rüdiger, Henschel, Bertrand and Wagner, Ralf y Gantner Detlev. 2204656 Alemania, 2004.

[4] Wendt, Florian, Demarcyk, Norbert and Hauschild, Rüdiger (ACTech GmbH Advanced Casting). 2181462 Alemania , 2003.

[5] Pattern-free production of large sand molds using with the help of robots. Degtyarenko, G.I. 2004, Litejnoe Proizvodstvo, , pp. 42-43.

[6] Making a reality out of rapid cast prototypes. ACTech. 2004, Modern Castings, pp. 37-39.

[7] Prototyping process produces sand molds, cores for production castings. Gustafson, Ronald and Spada, Alfred. 2002, Modern Casting, pp. 38-39.

[8] Study of the quality parameters in Fused deposition Modeling of ABS. . Pereira A., Kapinus, V, Diéguez, J.L., Pérez J.A, Ares Gómez J.E. Waterford , Irlanda. : M.G Cotterell., 2007. 24th International Manufacturing Conference.

[9] Foseco, John R. Brown. Foseco Non-Ferrous Foundryman's Handbook. Oxford : Butterworth Heinemann, 1999.

[10] Patternless casting process. Nikko, Sallinen and Sirvio, Matti. 5, 2004, IMS noENewsletter, p. 13.