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MOULD MANUFACTURING BY RAPID TOOLING TECHNIQUES

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Keywords: Rapid Tooling, rapid techniques, rapid models, master model, soft tooling, Metal Spraying, electric arc, metal deposition, metallic coating.

Abstract: The metal spraying techniques is one of the most common procedures used in flexible tools manufacturing. The metal layer should have 2 mm. The back side of the created metallic coating is filed with epoxidic resins and other elements in various proportions (hardener, metal powder and Al ball).

1. INTRODUCTION

Rapid Tooling (RT) is general terminology for using a technological process to rapidly produce mold inserts for injection molding of plastics and casting of metals.

Rapid Tooling is a means of transferring non-functional models constructed from the range of Rapid Prototyping techniques into a functional prototype part. This is normally carried out using a casting process, such as investment casting. It would typically use expendable rapid prototype models, particularly those made by the Selectiv Laser Sintering (SLS), Laminated Object Manufacturing (LOM) or Stereolithography (SLA) QuickCast processes **[3], [4], [6]**. Development and manufacture of products using the rapid prototyping route can be achieved effectively, saving time and eliminating costs associated with traditional manufacturing methods. Rapid Tooling can utilise rapid models in two ways, as a master for the production of casting moulds or as a sacrificial pattern for one casting. At this stage of the manufacturing process the rapid model becomes less significant than the next step, the development of tooling. Tools need to be manufactured to specification and must be durable enough to last a certain time period. Metal Spray tooling can be used for parts that are to be constructed using plastic production processes. Most rapid tooling is created in two until four weeks rather than four or more weeks, and is best-suited to limited run quantities of 1 to 100 000.

2. METAL SPRAY TECHNIQUES

In essence, Metal Spraying involves the melting of a raw material in wire or powder form, before propelling the atomised material towards the workpiece at high velocity to create a metal coating.

The Rapid Prototype model is an ideal starting point to produce spray metal tooling. Metal spraying is used for the production of soft tooling, especially flexible moulds **[4], [9]**. It involves spraying a thin shell of about 2 mm in thickness over a pattern and backing this with epoxy resin to give it rigidity.

The longevity of the tool is process dependent. Low pressure operations such as casting, blow molding or rim will yield more parts than the higher pressure.

The process for application of Spray Metal is relatively simple and consists of the following stages **[7], [9]**:

1. Melting the metal at the gun;
2. Spraying the liquid metal onto the prepared substrate by means of compressed air;

3. Molten particles are projected onto the cleaned substrate.

Alternative application methods.

There are two main types of wire application available today namely Arc Spray and Gas Spray.

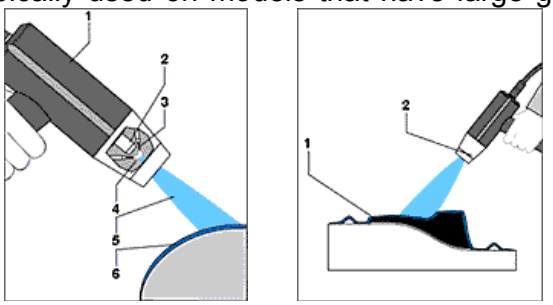
Arc – a pair of wires are electricaly energised so than an arc is struck across the tips when briught together through a pistol. Compressed air is blown across the arc to atomise and propel the autofed metal wire particles onto the prepared work piece.

Gas – In combustuion flame spraying the contonously moving wire is passed through a pistol, melted by a conical jet of burning gas. The molten wire tip enters the cone, atomises and is propelled onto the susbstrate.

The most popular techniques for use with RP models are spraying low melting point alloys with a gun (figure 1 **[8]**), similar to a paint sprayer and metal deposition with an arc system. The arc system feeds two wires into a gun and an electric arc is struck between them. This causes the wire material to melt and then a compressed gas atomizes and sprays it onto the pattern. The higher the melting point of the wire material, the more difficult it is to keep the pattern cool. Therefore, it is common to spray zinc or aluminum based alloys directly onto RP models. It also is possible to spray higher melting point materials onto RP models, but it is necessary to be a little devious. One technique is to apply a metallic coating by using electroless plating or physical vapor deposition. Once there is a metallic coating on the model, heat will be transmitted more readily across its surface.

One problem associated with metal spraying is that it produces shells with high internal stresses. It is possible to counteract these by simultaneously shot-peening the sprayed shell. Steel shot fired at the shell during spraying induces compressive stresses that counteract the tensile stresses.

Metal spraying is typically used on models that have large gently curved surfaces



1. Metal Spray gun
2. Air nozzle
3. Feed wires
4. Electic arc
5. Molten metal spray
6. Metal coating

Figure 1 [8]

and is indeed most suited to this type of geometry. It is very difficult to spray into narrow slots or small diameter holes. When these types of features are included on the model, it is common to make brass inserts, locate them in the model and spray around them. When the model is removed from the shell, the inserts are permanently fixed into the shell. These inserts also are stronger than the shell material, which is weak and breaks easily if formed as a tall, thin feature.

Spray metal tools can produce more than 1000 parts depending on the process, material being formed and the amount of tender loving care given to the tool. Clamping and injection pressures for metal-sprayed injection tools are usually less than those for steel or aluminum tools and may affect the mechanical properties of the injection-molded part. And because the shell is very thin and generally backed up with an epoxy-based resin, the thermal conductivity of a metal-sprayed tool is less than that of an aluminum or steel tool. This also will affect the mechanical properties of the injection-molded components and will increase cycle time. Some plastics are much more corrosive and abrasive on tool faces. This can be partially overcome by a variety of techniques, such as plating the tool surface with nickel or chrome, or using aluminum or steel inserts.

Spray metal tools have been used in many applications including sheet metal forming, injection molding, compression molding, blow molding and pre-preg sheet lay up. Various plastics have been molded including polypropylene, ABS, polystyrene and difficult process materials such as reinforced nylon and polycarbonate.

3. CASE STUDY FOR MOULD MANUFACTURING BY METAL SPRAYING TECHNIQUES

The mould manufacturing by metal spraying was made in the laboratory Inovative Technologies, at the University of Cluj-Napoca and its stages are the following:

1. An SLS model (figure 2 **[4]**) surfaces of the master model were finished;

Figure 2. The prototype part model made by SLS process was used as master model for the manufacturing of the Metal Spraying mould [4]

2. The model was located in a division (parting) plane so thet metal could be sprayed on the first half of the mould;
3. The model and the separeting plane were covered by a thin polyvinyl alcohol layer (PVA) to facilitate further RP model removal;
4. A 2 mm metal material was sprayed then;
5. In order to ensure the hardness of this thin metal crust, a support material was added on its back side (Al ball, epoxidic resins);
6. After casting the back side of the mould, it was then processed by milling in order to provide its smoothness.

Following the 1-6 above mentioned steps we only obtained a semi mould. The same manufacturing technique and stages were used to create the second semi-mould. The model was turned by 180° and was then set on the previously milled smooth surface, removing the board limiting te separating plane of the create the second mould.

7. The 4-6 stages were repeated to create the second mould.

After having removed the master model, two semi-moulds (figure 3 **[4]**) were obtained, which were then assembeld for the polypropylene part manufacturing by injection (figure 4.a **[4]**) using the MCP 100 KSA machine (figure 4.b **[4]**)) owned by C.N.F.R.P Cluj-Napoca.

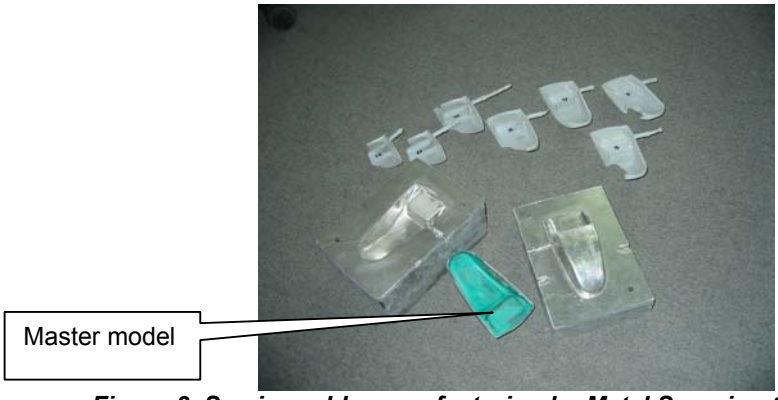


Figure 3. Semi-moulds manufacturing by Metal Spraying techniques [4]

a) ***b)***

Figure 4
a) Polypropylene part manufacturing by injection [4]; b) MCP 100 KSA machine [4]

4. CONCLUSIONS:

Comparatively with traditional technology by using Rapid Tooling technique for mold manufacturing by Metal Spraying method, the main advantage are:

- low development cost;
- short time of development;
- can produce large tools quickly;
- short time to market;
- bring products to market faster;
- by using rapid tooling methods, products may be brought to the marketplace faster then through conventional tooling methods;
- low manufacturing cost, comparatively with traditional technology;
- possibility to materialize the less radius than by milling**;**
- by using Metal Spraying method the shape of the master model to be used, there is copy with accuracy.

Rapid Tooling offers the potential to develop better quality products and to slash product development times from months to weeks or days. It also provides real opportunities to cut the overall costs of a product launch and considerably increase the chances of its commercial success.

The main disadvantage is that it may be difficult or impossible to spray into narrow slots or deep holds - meaning that the part geometry must be relatively simple. Molds are not particularly strong and the process requires special equipment and special operating environment.

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