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MOLD TOOLING VIA RAPID PROTOTYPING

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ABSTRACT

Now, at the beginning of the century and millennium, producers are compelled to launch their products or improved versions of already existing products on the market as soon as possible, nevertheless before the competition. And at the highest quality level but with minimum costs, respectively in accordance with the environment policies, so that eventually the product price is as low as possible.

This makes the producers apply methods that help them reach such results. But such methods should be specified as early as the design stage, more exactly in the conceptual stage, because they generally require some quality conditions that can be reached.

Such a method, that guarantees the presence of the new product as fast as possible on the market, is Rapid Prototyping. It helps create models in a very short time under better and better quality circumstances. Then, these models can be used, directly or indirectly, for the creation of the new product or they can even become the new products themselves.

It is a well known fact that, nowadays, plastics are widely spread because of their excellent features, which in their turn are improved from one day to another (including the recycling/biodegradability). Thus, one should make sure that the conditions for such products to get as fast as possible on the market should be guaranteed. Nevertheless, these products are usually developed with the help of complex tools, called moulds. Creation of these moulds is fast and easy, but the development proper of these tools is difficult, due to their complexity. Here, we have once more Rapid Prototyping, that is through use of RP models for the moulds for plastics which allows for a reduced development time.

Our paper will further discuss, in detail, such applications of RP models.

1. GENERALITIES

It is a well known fact how important the presence of the product or improved variant of an already existing product as fast as possible on the market must be for a producer to survive. This fast launch can not be at the cost of quality or product price because then, this would mean the failure of the product launch on the market.

Under these circumstances, producers want to use fast development and manufacturing methods for their products. One of these methods is Rapid Prototyping. It assures the early visualisation of the product, which makes it possible to remove potential design errors. Then, these RP methods can also be used for the development of tools necessary for the creation of the respective product. Thus, the CAD/CAM integrated product development is guaranteed, as rendered in figure 1.1.

The same happens in the case of plastics. The figure 1.1 entirely applies to this category of products because one must create the moulds in which the products are to be realised. Since these moulds are very complex tools, their creation takes effort, resources, and above all a lot of time. Due to all these factors, the attempt is to create moulds through RP even if not entirely, at least the active part that actually defines the product. And thus, one ends up with the so-called flexible tools, where the active part is fixed in module-like components whose change can be very fast and at rather low costs.

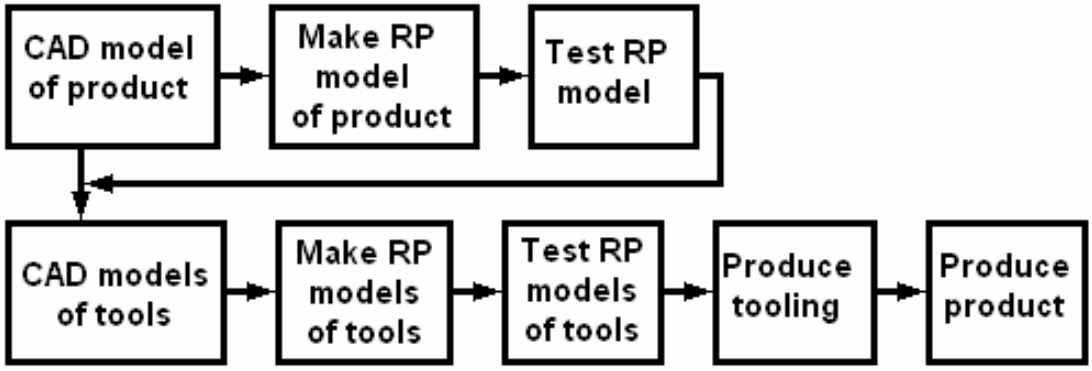


Fig. 1.1.1.

So, in the case of plastic materials, RP is used in most cases for the creation of moulds. Again, in most cases, through the use of RP, nowadays, one can also directly create functional devices. This, because the precision of the obtained results is improved on an on-going basis and one can already apply a wide range of materials, such as plastic or metallic ones. But only for small series. While using the products realised through RP, the classical technology for mass production can be updated.

And the RP models can be, directly or indirectly, be used for the realisation of moulds for plastics. We will further discuss these possibilities.

2. DIRECT USE OF RP MODELS FOR CREATION OF MOULDS

In this case, the RP model is the mould itself that is the mould is realised through RP, or the RP model is used to realise the mould.

2.1. CREATION OF MOULDS DIRECTLY THROUGH RP

Fig. 2.1.1.

This is possible because of the precision one can already get with the help of RP, that is a very wide range of materials used in RP.

Such a technology is D-*M-E MoldFusion™ 3D Metal Printing,* developed by the D-M-E company, a big producer of moulds and injection accessories. The procedure is a development of three-dimensional printing.

Fig. 2.1.2.

The stages for making a mould, as for instance, those rendered in figure 2.1.1., are as follows:

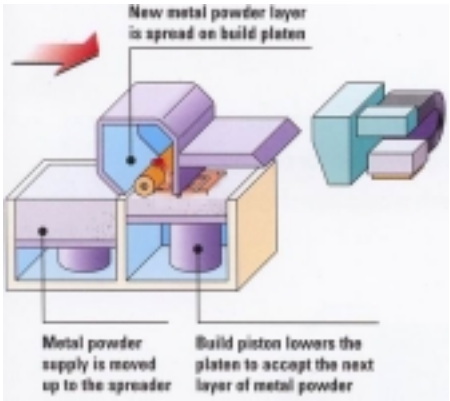


Fig. 2.1.3.

1) reviewing the CAD model and developing the *MoldFusion* machine program, a **.stl* file, Rapid Prototyping standard (see figure 2.1.2);

2) the refined CAD model in the **.stl* file is transferred to the *MoldFusion* machine. A very smooth layer of metal powder is spread onto the part build piston (see figure 2.1.3);

3) the CAD image is printed with an ink jet printhead depositing millions of droplets of binder per second wich quickly dries (see figure 2.1.4);

4) the current layer is dried and the part build piston drops approximately (120÷170) μm (see figure 2.1.5). The

process is repeated until the part is completely printed;

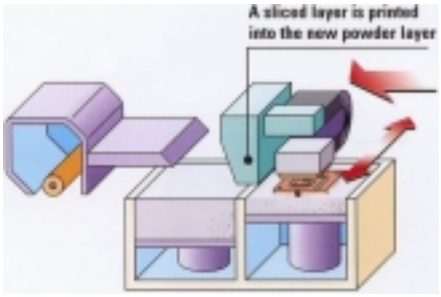


Fig. 2.1.4.

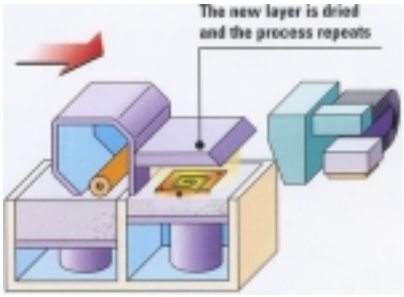


Fig. 2.1.5.

5) the resulting "green part" is removed from the *MoldFusion* machine and excess powder is brushed away;

6) the printed part is loaded into a furnace and sintered to create a structural skeleton of 60% density and eliminate the binder;

7) a second furnace cycle infiltrates the part with molten bronze via cappillary action for full density;

8) the part is machined where is must, if necessary.

Through this procedure, one can make moulds of a very complex geometry. The advantage of this procedure is that one can make the entire mould, not just the active part, together with the cooling network, respectively the ventilation network.

2.2. CREATION OF MOULDS DIRECTLY FROM THE RP MODEL

In this case, the mould is made directly, starting from the RP product model. So, the possibilities for making the mould are: metal coating, the use of the RP model as a master model for the creation of the silicon rubber mould, the use of the RP model as cutting pattern.

2.2.1. Metal coating

The metal coating of the RP model can be done via two methods: „metal spray" and galvanic layer formation.

2.2.1.1. Metal coating through "metal spray"

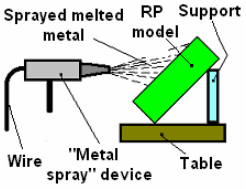


Fig. 2.2.1.

It is one of the most used methods for making flexible tools. The RP model in this case is the positive master model. The method is schematically rendered in figure 2.2.1. As you can see, the „metal spray" device is a spraying gun, similar to the one used for painting. The metal material used has the shape of a wire, fed through the gun, and melted with the help of an electric arch. At the same stage, a gas is introduced under pressure, gas that atomises the melted metal and throws it as spraying waves over the RP model that is tilted on the working table. The thickness of the layer thus formed is about 2 mm.

This method is often used for models of large size, with complex surfaces. But if these have also some narrow channels or small diameter holes, then serious difficulties arise. In such situations, one can make bronze or copper chilled cores or insertions for these special features of the item. These are then fixed on/in the model and are then sprayed on the melted metal all around. After removal of the RP model, these chilled cores/insertions will remain in the metal crust-like layer and will be even harder than the crust itself.

Tools and moulds made with the help of this method are successfully used in various fields, such as plastic cold distortions, injection of plastic mass, moulding under

pressure, moulding with easily fusible models, etc.

Such tools and moulds can be used for making small series products of about 1000÷5000 items, depending on the process, materials used.

2.2.1.2. Metal coating through electroplating

This method is schematically rendered in figure 2.2.2. Before galvanisation, the non-metallic surface of the RP model must electrically be disabled. Several methods can be applied for this, but they are not subject of this paper. This method uses RP models such as positive or negative master models, depending on how the metal would form the layers and how the model must be kept. In both cases, the master model must be removed and the resulting metallic crust must be placed in a melting box so as to mould, around the model, a metallic alloy or an epoxitic resin that would form the body of the mould, as rendered in figure 2.2.3 and thus allow one to assemble it in a module-like tool. If the epoxitic resin is applied, this must contain metallic dust in order to improve the heat conductibility.

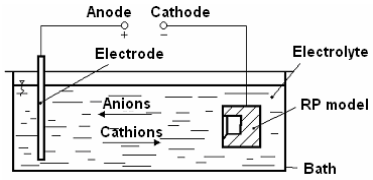


Fig. 2.2.2.

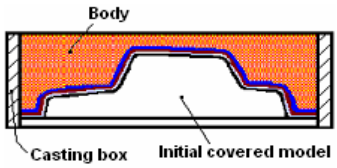


Fig. 2.2.3.

2.2.2. Creation of molds from silicon rubber

Through this method, one can obtain silicon rubber moulds that are used when hollow-moulding plastic materials. We must mention that these moulds are made through hollow-moulding, as rendered below.

Work stages are:

1) examining the master model - to establish the parting line and the arrangement of gates and gas vents (see figure 2.2.4);

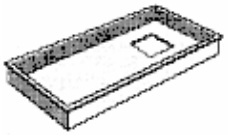


Fig. 2.2.4.

2) achievement of the parting line, gates and gas vents (see figure 2. 2.5);

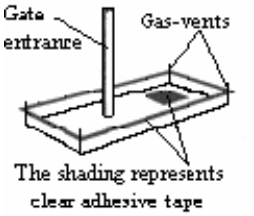


Fig.2.2.5.

3) suspending the master model into the forming box (see figure 2.2.6.);

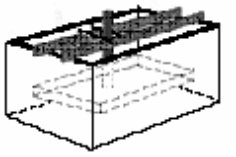


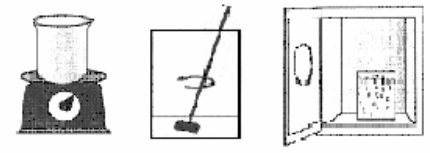
Fig. 2.2.6.

4) preparing the silicone rubber:

a) weighing the components (see figure 2.2.7.a);

b) mixing of the silicone rubber (see figure 2.2.7.b);

c) primary de-gassing (see figure 2.2.7.c);



a) *b)* *c)*

Fig. 2.2.7.

5) casting the silicone rubber (see figure 2.2.8);

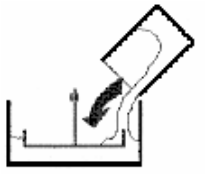


Fig. 2.2.8.

6) secondary de-gassing of the silicone rubber (see figure 2.2.9);

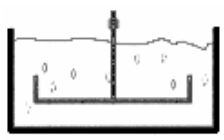


Fig. 2.2.9.

7) curing of the silicone rubber bloc (see figure 2.2.10); separation of the half-moulds and the removal of the master model (see figure 2.2.11).

In such moulds, one can make very small series devices, up to

Fig. 2.2.11.

some tens of pieces. The precision of the resulting devices is directly given by that of the RP model, used as master model. The same applies for the surface quality.

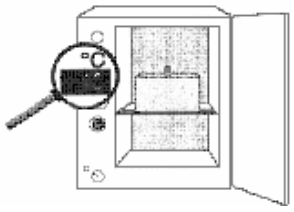
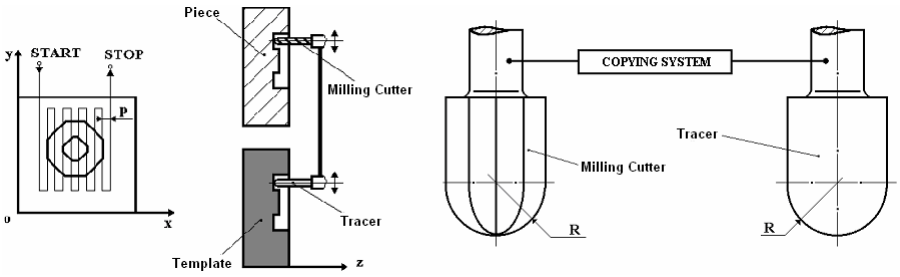


Fig. 2.2.10.

2.2.3. Use as milling templates

RP models used as milling patterns for 3D copy cutting of moulds must have a superficial hardness high enough so as to resist wear. Due to this, the use of RP models as milling patterns is quite restricted.

Mould processing through 3D copy milling is schematically rendered in figure 2.2.12.a. In this case, spatial templates are used. The movements in the *xoy* plan are made through the cinematic of the tool machine, deviation of the template surface and of the processing surface with a given *p* step, that would give the precision and quality of the resulting surface. The movement in the *z* direction is made mandatory by the template through the tracer and the copying system.



a) b)

Fig. 2.2.12.

For this processing, in most cases, one uses spherical milling machines because these allow, under the same circumstance, different adherence points to the surface to be processed. Because, in most cases for these machines, one uses 1:1 copy relations to get the wanted precision, also the tracer must have a spherical head (see figure 2.2.12.b), and the same *R* ray as the milling cutter.

For the processing to be possible, the ray of the milling cutter must be smaller or at most equal to the ray of the surface to be created.

3. INDIRECT USE OF RP MODELS FOR CREATION OF MOULDS

In this case, the moulds are not made starting directly from the RP models. But these models are used for making two degree tools that will be used for making the final moulds.

In this category you have the process of making electrodes for spark erosion, making moulds through casting, respectively some cases of metal coating.

3.1. MAKING ELECTRODES FOR EDM

It is a well known fact that the most spread technology for making active mould surfaces is EDM. But in the case of very complex moulds, the realisation of the electrode is practically impossible or it takes a very long time. In this case, one turns to RP models for the creation of such tools.

Thus, you can create such tools starting directly from the RP models or through metal coating – a case very similar to the case of the metal coating of the RP model for the realisation of the mould, just that the last formed layer (the outer one) must be Cu,

respectively 3D copy milling, using the RP model as template – case similar to the previously described case.

Or you can make them indirectly through casting, case in which the RP model is used as a master model for the realisation of a casting shape, where the electrolytic Cu (copper) will finally be cast.

3.2. CREATION OF MOLDS THROUGH CASTING

In this case, the RP model is used to make a casting shape according to the principle schematically rendered in figure 3.2.1.

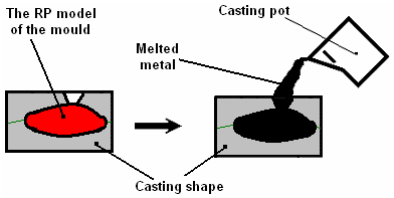


Fig. 3.2.1.

3.3. CREATION THROUGH METAL COATING

In this case, the metal coating is performed exclusively through the „metal spray" method and it refers to the metal coating of a shape made up of silicon rubber cast around an RP model. This solution is chosen so that the removal of the non-metallic material from the metallic crust be easy; in this case as well, around the metallic crust, there is a cast entity, just like in the previously rendered case.

CONCLUSIONS

As you can see from the above mentioned, you can use a wide range of methods to make moulds for plastics, starting from RP models. This range is getting wider and wider considering their combination – some combination examples have already been discussed in this paper – and possibly their combination with other procedures that are not the subject of this paper.

We must nevertheless be very careful when choosing one or another method and even more so when combining them.

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