Proceedings of the 16th International Conference on Manufacturing Systems – ICMaS
ISSN 1842-3183
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THE RAPID TOOLING IN THE PRODUCT DEVELOPMENT

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Abstract: *It is well known that nowadays, due to the diversification of human needs, the life-cycle of the products presents a diminishing tendency. Thus, the producers are compelled to launch new products on the market more and more often. And this means that the time of developing and making of the new products must be reduced, even drastically, in order to ensure the launching on the market before the competitors. However, the quality level has to be kept and framed in the ecological conditions. And all these at a minimum cost, in order to provide a maximum competitivity for the new product. This fact obliges the producers to make use of modern developing and making methods, which will allow the framing in these conditions.*
From the category of the methods that correspond to the above mentioned requests, we also mention the ones based on the Rapid X methods, such as the ***R****apid* ***P****rototyping (RP), the* ***R****apid* ***T****ooling (RT), and the* ***R****apid* ***M****anufacturing (RM).*
The Rapid Tooling is part of this category because it reduces the making time, especially by diminishing the time of the making tools necessary for the product realization. It also provides a checking of the product technological aspects and it permits the re-projection of the product from this point of view, allowing he rapid making of the possibly new necessary tools.
Usually, through Rapid Tooling there can be obtained tools called "soft" – of modern conception – which resist only at small or middle batch series. While these tools are made, the "hard" tools can also be finished – the classical ones – which already allow big batch series.

Key words: *Rapid Manufacturing, Rapid Prototyping, Rapid Tooling, Rapid Molding, Product Development, CAD-CAM-CAE.*

1. INTRODUCTION

In these the begin days of the new millennium, when even the human needs have changed radically, we witness a very intensive development of science and technology. Due to this development, there appear new principles, methods and technologies of manufacturing and new materials compatible with the new technologies.

Thus, there appeared new conditions on the market, the demand being limited in time due to the fierce competition. So, in order to survive, a producer must appear with a new product or the improved alternative of the existent one, in a very reduced time - anyway before the competition - but with a high quality and costs as low as possible. The series demanded of a product are small, possibly middle, due to the market competition. These demands can be fulfilled by making use of new products development methods, which allow these accomplishments.

From the category of these methods are, for example, those based on the so called *Rapid X* procedures, such as the **R**apid **P**rototyping (RP), the **R**apid **T**ooling (RT), and the **R**apid **M**anufacturing (RM). This happens due to the fact that they provide a high CAD-CAM-CAE integration, schematically presented in Fig. 1, and by this providing an overlapping between the finishing of the product, as well as the study and making of the necessary tools, thus reducing considerably the time of manufacturing preparation, which makes possible the early appearance on the market with the new product. This process is very much helped by the Rapid Tooling, which is the theme of this paperwork.

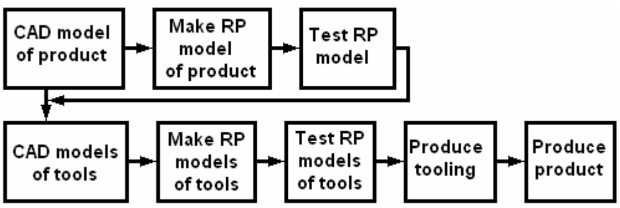


Fig. 1. The CAD-CAM-CAE integration [10].

2. RAPID TOOLING TECHNOLOGIES

The RT technologies are actually applications of RP technologies. They can be also considered as specific developments of RP. This fact has to be taken into consideration when we talk about these technologies.

Having in view the above presented facts, we must mention that these technologies are also relatively new ones, which still have to develop a lot. They also present many unknown facts, which may turn into surprise elements, both positive and negative.

2.1. The classification of RT technologies

Up to the present any unanimously adopted classification of the RT technologies hasn't been made. This is also due to the fact that the making of a precise classification is extremely difficult, because many interferences between the different elements which stay at the base of the classifications appear, and also due to the fact that they are relatively new, in a continuous perfection.

The classification of these technologies can be made according to many criteria, such as the working method, the used materials, the application field and the production type at which the made tool will be made.

According to the working method, we can talk about direct or indirect accomplishment, which is direct-tooling, when the tools are made directly through an RP application, and indirect-tooling respectively, when the tools are made starting from an RP pattern through different classical or new procedures.

Having in view the used materials, we can talk about soft-tooling - when new materials are used from the point of view of tools making, meaning soft materials, such as different resins, silicone rubber or alloys with low melting point, respectively hard-tooling - when classical materials are used for tools, meaning hard materials, such as the alloyed steels.

According to the type of the tool, we can talk about the making of different moulds, both for plastics and metals, respectively shapes and cores for casting, or templates, or complex electrodes for EDM.

According to the production type for which the made tool will be used, we can talk about tools for unique products, for small and middle series and more rarely for big series, respectively in an exceptional way for mass series.

Having in view the facts presented previously, in Table 1 a combined alternative of the classification of RT technologies is presented.

2.3. The RT technologies and the strategies of products development

As it was shown at the beginning of the paperwork, there is a tight connection between the using of RT technologies and products development, in the sense that using such technologies, the time of a product development can be reduced significantly. This is manifested in the last part of a product development, meaning the stage of checking from different points of view (among which the technological point of view). Using these technologies, the technological deficiencies of the tool can be

Table 1

Classification of the Rapid Tooling

<table>
<tr><th>RT</th><th colspan="2">DIRECT TOOLING</th><th colspan="2">INDIRECT TOOLING</th></tr>
<tr><td rowspan="6">SOFT-TOOLING</td><td colspan="2">metal casting shapes</td><td colspan="2" rowspan="3">silicon rubber mould</td></tr>
<tr><td>sand shape</td><td>chill-mould</td></tr>
<tr><td colspan="2">DSCP</td></tr>
<tr><td colspan="2">resin mould</td><td colspan="2" rowspan="3">epoxidic resin mould</td></tr>
<tr><td colspan="2">ceramic powder mould</td></tr>
<tr><td colspan="2">metallic powder mould</td></tr>
<tr><td rowspan="4">HARD-TOOLING</td><td colspan="2" rowspan="2">laminated mould</td><td colspan="2">metal coating</td></tr>
<tr><td>metal spray</td><td>galvanization</td></tr>
<tr><td colspan="2" rowspan="2">rapid milling</td><td colspan="2">metal casting</td></tr>
<tr><td colspan="2">Keltool procedure</td></tr>
</table>

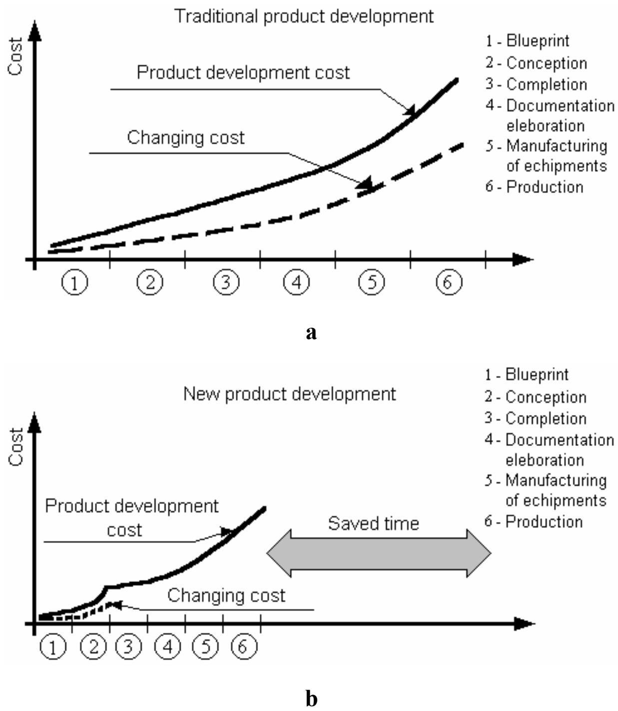


Fig. 2. The advantages of using the new strategies of product development [2, 6]: *a* –traditional product development; *b* – new product development.

early detected and there can be made the necessary changes with still relatively low costs (see Fig. 2). Also the design and making errors of the tool can be early detected, errors that can be corrected in acceptable technologic and economic conditions.

Considering a product and the making tool, according to the Fig. 2, we can notice how its making time can be reduced by using new methods and technologies, such as RT. Going further, we can realize how the product developing and making time can be reduced by using RT, because in this case there appears a reduction of multiplied time.

As we can notice from Fig. 2, the costs connected with changes regarding the product, or regarding necessary tools, are lower, a fact that that is also in favor of adopting these new strategies of products development.

2.4. Applications of the Rapid Tooling

Due to the outstanding results obtained through the adopting of RT in the development process of the products, the applications of these technologies also had a very accentuated development, respectively a very wide use, from the ordinary ones to some that are even strange. This utilizations range is also in a continuous expansion. This is also due to the fact that it allows the making of different tools in a short time.

As mentioned in this paperwork, tools for different technological process can be made. We have to mention that through these technologies of tools making, flexible tools are usually made, both in the specific meaning of the word and the technical one. For example, by using the moulds made of silicone rubber, it is possible to make tools in a short time, which allows their rapid changing at relatively low costs, which is actually a definition of the flexible tools.

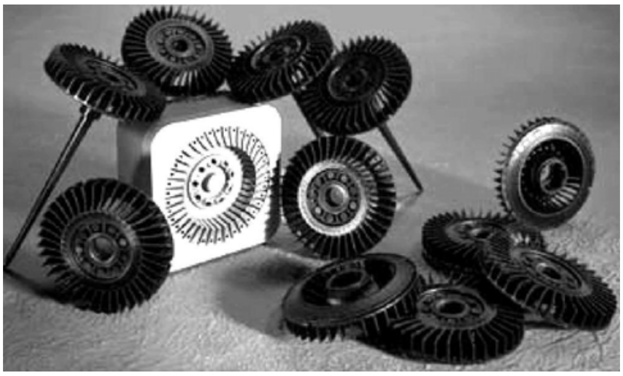


Fig. 3. Mould made through SLS with pieces obtained in it [13].

Many times only the active part of the tools, the one presenting a higher complexity degree, is made through RT technologies.

Next we will present a few specific applications of the RT technologies.

The making of the moulds

It may be the most used application of the RT.

As it results from the classification presented in Table 1, the moulds can be obtained through direct-tooling or indirect-tooling. At the same time they can be metallic or non-metallic. The metallic ones are usually made of alloys with low melting temperature - which limits the applicability. They can be entirely metallic, or metallic only on the active side.

The metallic moulds can be made from metallic powders, through RP procedures or developments of these procedures. Through SLS, moulds with fine details (see Fig. 3), or moulds with good mechanical properties through *MoldFusion^{TM} 3D Metal Printing* [7] (a development of the 3D Printing made by the D-M-E company [14]) can be obtained. They can also be made in layered alternative, as an STRATO-CONCEPTION application procedure. The making principle in this case is presented in Fig. 4, where we can notice that through the changing of different component parts, different configurations for the mould can be obtained, thus increasing the flexibility. We must not forget the possibility of the making from massive block through rapid milling. Metallic moulds can also be obtained through metal casting. In this case, the pouring is made in shapes made in their turn through *rapid procedures*, such as RP.

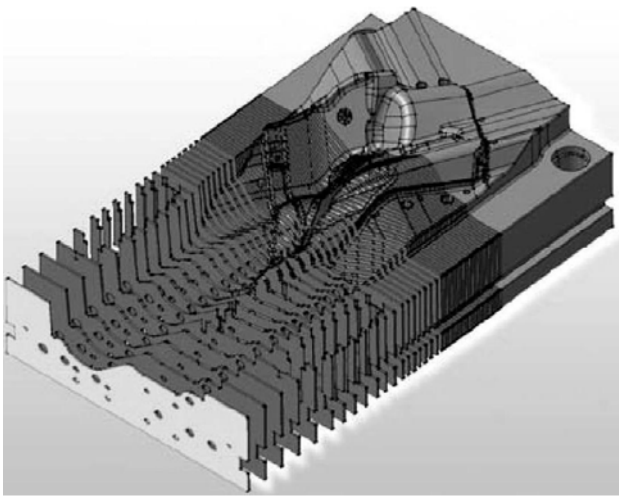


Fig. 4. Layered metallic mould [19].

A special case is the making of metallic moulds through Keltool procedure, developed by 3D SYSTEMS Company is a combination of the classical sintering technologies with the new RT technologies. Thus, a powder metal is sintered around a pattern obtained through rapid procedures, and post-processed in order to obtain the necessary properties. The advantage of the injection moulds obtained through this procedure is that they resist up to 1 million cycles.

The partially metallic moulds have only the active part in the shape of metallic layer, layer that can be obtained through metallization [4], as galvanization or as metal spray [8, 9]. The metallic layer can be directly deposited on the body of the mould, or on a negative that will be removed afterwards, and the body of the mould is made by pouring around the active part of a resin, or of a ceramic material – more rarely.

The non-metallic moulds are usually made of different resins and silicone rubber. The making of the resin moulds is a specific application of the Stereo-litography (SLA) [11]. Having in view that the silicone rubber moulds are more and more used lately, their making is an RT procedure very widely used. This is also due to the fact that flexible moulds can be obtained in this way, from all points of view. Usually, two types of silicone rubber are used, a transparent one and an opaque one, a fact that differentiates the making method of the mould [1, 2, 3, 16].

A special category of non-metallic moulds is the one of the ceramic powders. Their making is an application of 3D Printing, meaning the one for which a ceramic powder is used as basic material.

The making of the casting shapes

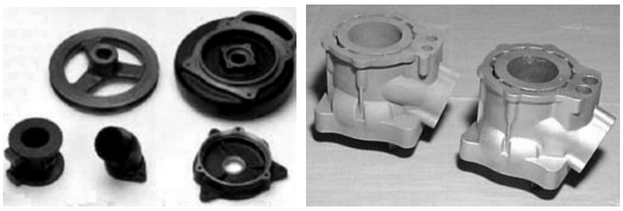
Given the importance of the cast products we can state that the making of the casting shapes and cores is an important RT application. The most known procedure for the making of mould shapes and cores is the one patented by the German company EOS-GmbH. This is based on SLS procedure and it is made on machines especially developed by EOS-GmbH. The advantage of this procedure is that, in very short time, shapes and cores of great geometric complexity can be obtained, but also with minimum contractions. At the same time, it provides the cast parts a surface quality identical with the classic processes, and can be used for the casting of very different types of alloys.

Through RT, shell shapes can also be obtained, through the procedure called ***D****irect* ***S****hell* ***P****roduction* ***C****asting* (DSPC), developed from 3D Printing by SOLIGEN Company. This procedure combines the advantages of the metallic tools obtaining through moulding with those of obtaining the tools through mechanic processing [2].

In order to prove the facts shown previously, a few tools obtained in shapes made through *rapid procedures* (Fig. 5,*a*) and *DSPC* respectively (Fig. 5,*b*) are presented.

Other RT applications

Besides the applications presented up to now, the RT technologies have many other applications, some of them even strange, such as the making of marking stamps through metallization.



a b

Fig. 5. Pieces obtained: *a* - in shapes made trough *rapid procedures* [15]; *b* - through *DSPC* procedure [18].

Another important application is the making of the electrodes for EDM. This can be made either through rapid milling or through other RT successive processes, such as the casting of the copper in shapes made through RT [12].

An interesting application is the making of the hybrid patterns for casting, where some parts of the pattern are made in the classic way, and others, which are usually fine details or elements that change regularly, are made through RT technologies and in the end they are assembled [5].

10. CONCLUSIONS

According to this paperwork we can conclude that there are many RT technologies with very many applications. At the same time, we can notice and state that their number can increase may be, but must to declare. Thus, the possibilities of applications of the new development strategies of the products based on *Rapid X* procedures are becoming wider and wider.

Having also in view the development tendencies, we can predict a better development of RT technologies, which certainly will lead to a greater widening of the applicability range, thus contributing to the appearance of new products development methods.

At the same time we have to mention the fact that, besides the presented advantages, these technologies also have disadvantages, which may not be known or well known, due to the fact that they are new technologies. Therefore they can offer negative surprises, as it has been already mentioned in this paperwork. In conclusion, these technologies must be used carefully, especially the amount of use, because the excessive use can be seriously damaging, especially in the economic field.

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