APPLICATIONS OF RAPID TOOLING TECHNIQUES FOR INJECTION MOULDING

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1. Introduction

Rapid tooling techniques have an important role in many industrial branches.Rapid prototyping (RP) has become more mature through the materials, accuracy parts, reduce costs and replaced techniques for producing different parts. Indirect tooling methods used RP inserts to produce moulds. But direct RT methods allow injection moulding and die-casting inserts to built directly from 3D CAD models. In this paper classification of direct RT methods are used for producing tools for making plastic parts.

All RT methods can be subdevided into two main groups:

- indirect methods and
- direct methods

Indirect tooling methods are intended as prototyping or pre-production tooling processes and not production methods. Tools produced by these methods are exibited differences compared to production tools.Differences are evident in larger draft angels, simpler part shapes and lower mechanical and thermal specifications. The differences affect the production cycle time, the part mechanical properties and the tool life. However, the aim of indirect tooling methods is not replace production tooling but to make only up to a few hundred parts and therefore these tools do not require the strength for a long life. For the same reason they do not need to be as efficient as production tools and it is justifiable to adopt a longer cycle time per part to compensate for poor thermal conductivity.

To overcome disadventages of indirect methods some RP apparatus manufacturers have proposed new rapid tooling methods and allow injection moulding and die casting inserts to be built directly from 3D CAD models.

2. Classification of Direct RT Methods

Direct RT enable very flexible production from a few dozen to tens of thousands of cyclesand this is good alternativecompared to traditional mould making techniques.The quality of the inserts produced by direct methods varies depending on the material and RT method employed.This makes the application area of RT processes very wide,covering prototype, pre-production and production tooling.Direct RT processes can be devided into two main groups.

The first group includes less expensive methods with shorter lead times that are appropriate for tool validation before changes become costly.These methods are called "firm tooling" (bridge tooling). Firm tooling is not soft nor hard tooling.It produces tools capable of short prototype runs using the same material and manufacturing process as for final production parts.

The second group includes RT methods that allow inserts for pre production and production tools to be built.RP apparatus manufacturers market these methods as "hard tooling" solutions .Hard toolingprocesses are based on the fabrication of sintered metal (steel, iron and cooper) powder inserts infiltrated with cooper or bronze.Methods developed on this manner are:

- Direct ACES™ Injection Moulds (AIM™),
- Direct RapidTool™ Process (Raspid Steel)
- Laminated Object manufactured (LOM) Tools,
- Cooper Polyamide (PA),
- SandForm™,
- EOS Direct Tool™Process,
- Direct Metal Tooling Using 3DP™,
- Topographic Shape Formation (TSF).

2.1. Direct ACES Injection Moulds

First steps in the moulds production concerns 3D model of the injection mould. It can be drawn and then built using stereolitography process. The mould is built using the Accurate Clear Epoxy Solid (ACES) style. After finishing the model of the mould the rest of the material removed.The thermal conductivity of the stereolitogrraphy resins is about 300 times lower than that of conventional tool steels.To reduce the amount of heat from the tool and reduce the injection moulding cycle time, copper water cooling lines are added and back of the mould is filled with the mixture made of 30% of aluminium granulate and 70% of epoxy resin.

The quality of the process depend of the shapes of the parts which is intended to be produced in the moulds. The second problem is a cooling of the moulds. But at the same time Direct AIM mould is as durable as an aluminium filled epoxy mould.The moulds are filled with the plastic.Injection cycle time is longer (3to 5 min.) in comparison (5 to 15 s) to clasical injection moulding.This process is sutable for moulding up to 100 parts. All activities (design, mould and part production) can be finished within one week.

2.2. Laminated Object Manufacturing

LOM process is used to produce laminated moulds made of sheets of paper.Recent moulds are coated by the layers of metal.Inspite of that, LOM moulds are used only for low melting thermoplastics and is not appropriate for injection moulding.

2.3. DTM Rapid Tool

This process developed two processes:

- Rapid Steel 1
- Rapid Steel 2.

The first method is caracterised by the used low carbon steel powder.This process has three steps.First step is a green part which is obtained by SLS process. At the same time in the powder low melting material is mixed as a binder.The green part is not durable and in the second step the part is heating at a low temperature and bind the particles of the material.This step includes long drying time which depend of the part size.The last step is a finishing the part. In this stage part is covered into fully dense matal part by infiltration with a molten cooper.At the 1000°C sintering of the steel powder is happened and at the 1120°C cooper infiltration occurs.The finished surfaces have a good roughness and moulds can be developed by machining to the quality IT16.

The second mentioned process of mould producing has several changes in comparison with firs one.The material is changed to the stainless steel.Bronza has replaced copper as an infiltrant.Binder is changed too.Technology parameters are changed and finished parts are less sensitive to the geometry of producing parts.Quality of the parts is increased and injection moulds can produce ±0.1 mm accurate product.

2.4. Copper Polyamide (PA)

This process is suitable for production of the 100 to 400 parts from common plastics.Tooling inserts are producing by SLS process.After the CAD stage inserts are produced by the copper PA .They are very convenient for machining and finishing.Inserts have a better conductivity than the most palstic tooling materials.

2.5. EOS Direct Tool Process

This process uses specially developed machines, powders abd binders.SLS process is used for sintering and strenghtening tool.After finishinfg the process polishing can be done to increase the quality of the part.This process is comercialy oriented .Thousand products can be made for ordinary necesities from the engineering plastics.

2.6. Direct Metal Tooling

This proces enables a production of the moulds using printing process to build mould. Ptinting materials in these cases are stainless steel, tungsten,and carbide. Process is continuoing after printing powder and binder.The next step is a sinteringin a furnace to increase the strength.At the end the melting material infiltrate into the sintered part.Variation of this process can be applied at the ceramic materials and build the moulds of ceramics.

3. Conclusions

After rewiev of almost all methods for injection mould producing one thing have to be mentioned.No one process is definitely mature. All of them can be developed and improved.The main things in the new processes which are dealing with the metal and ceramic moulds producing are materials, specially powders. Relationship between design of the product and tool have to be improved additionaly improving the surface quality.The powerfull processes can save a time and a money and ask for development in the future.

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