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Rapid Prototyping of wax foundry models in an incremental process

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Abstract

The paper presents an analysis incremental methods of creating wax founding models. There are two methods of Rapid Prototyping of wax models in an incremental process which are more and more often used in industrial practice and in scientific research.
Applying Rapid Prototyping methods in the process of making casts allows for acceleration of work on preparing prototypes. It is especially important in case of element having complicated shapes. The time of making a wax model depending on the size and the applied RP method may vary from several to a few dozen hours.

Key words: Rapid Prototyping, wax models, 3D-CAD

1. Introduction

Rapid Prototyping incremental methods are used more and more often in manufacturing cast prototypes made of metal alloys both on aeronautic industry and for fabricating artistic elements including jewellery [1-8].

One of the first incremental RP methods applied for making models used in lost object method was LOM method. It consists in making a founding model of paper layers. Nowadays this method is rarely used. It is ousted by methods where models are made of acrylic and epoxide resins – SL, JS. The next group are methods based on stratified construction of models made of thermoplastic materials (ABS, wax).

At present a technology of stratified spraying of liquid wax is applied in fabrication of wax founding models in an incremental process. There are two basic production engineering methods to be distinguished here: DODJET [18] developed by Solidscape firm and ProJet developed wax by 3DSystems firm [19]. A choice of incremental RP method for creating models requires cognition of technological parameters.

2. DODJET production engineering

DODJET production engineering is applied in devices by Solidscape firm (fig.1). It consists in joining together two methods: an additive one and a subtractive one during making a wax model. The prototype in its geometrical basis is made of modelling wax applied layer by layer while the auxiliary material, which does not get into the proper model texture, is disposed in hollows and supports ledges. Minimal size of a created model falls to a cube with a side of 254 micrometers. Minimal thickness of the spread layer amounts to 12,7 micrometers. Maximal size of object for T612BT printer has an outline of 304,8x152,4 x 152,4 mm.

The proper layer thickness and its smoothness is retained by cutting the excessive material by means of a rotating planer. The planer passes along the horizontal surface each time after applying a subsequent layer. A diagram of the model's structure is shown in figure 2. Thickness of the applied layers is monitored and depending on the set parameters it is kept at a range of 12,7 to 76,2 micrometers. It allows for minimization of arising of disparities (steps) on the surface of a model.

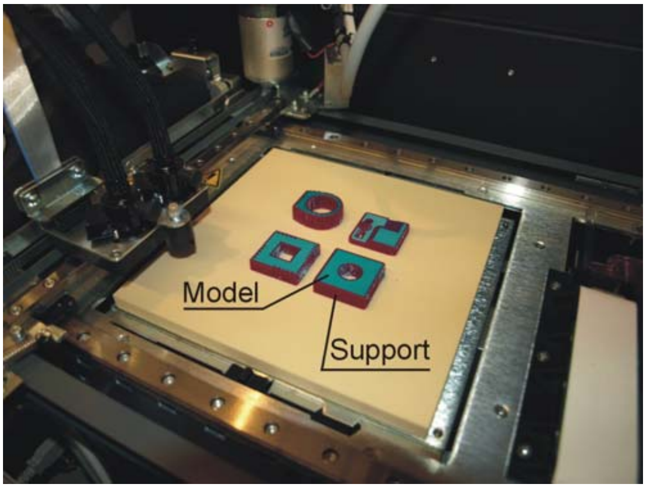

Fig.1. A working chamber of the Solidscape device during printing

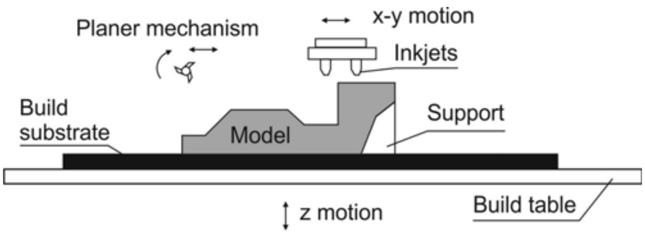

Fig.2. A diagram of the model's structure made by DodJet

After finishing the printing process and detaching models from the working platform, the supporting material is removed by dissolving. Thanks to that it is not necessary to apply additional procedures like polishing or shape correction.

Wax models with high surface accuracy can be used to make founding moulds. Their high quality is achieved thanks to the DODJET production engineering of applying layers. The method allows for creating objects with complicated geometry and surface roughness not exceeding 0,8 micrometer. The dimentional accuracy assumed by the manufacturer amounts to 24,5 micrometers. The process of constructing the model by means of Solidscape and DODJET production engineering is characterised by the following features:

- the possibility of setting the parameters of the process for the created object and of optimization of the device's efficiency,
- the possibility of continuous work of the device for 72 hours,
- resupplying of the modeling material (wax) while creating a model,
- automatic monitoring of the device condition and diagnosing faults (on the spot or remotely),
- easy dissolving of the supporting material i.e. the auxiliary wax,
- final processing of the model's surface is not necessary.

The view of exemplary wax models made by means of DODJET – Solidscape production engineering is presented in figure 3.

Fig. 3. Wax models made by means of Solidscape device

In Solidscape system BlueCast™ material is used for making models. This material is odourless, safe and environmentally friendly. It has got thermoplastic qualities. BlueCast™ has also got very low value of linear thermal expansion ratio which is vital because of the danger of damaging the founding mould while melting out models. After melting out and burning out it is removed completely from the inside of founding mould and does not leave any ashes.

BlueCast™ has the following qualities:

- similar to thermoplastic polymers. Structural features place it between wax and ABS resins,
- melting temperature ranges from 94 - 106°C,
- resistance to warping, twisting,
- it has unlimited storage time without losing operational properties,
- the surface of the model can be sandblasted, painted, coated,
- wax burns out and does not leave any contamination or ashes.

For supporting models an auxiliary wax ProtoSupport™ Material is used. It is made with fat ester base. It is easily removed by an appropriate solvent. The supporting material is red. It is applied to fill hollows in models. It makes a support and stiffness of models which causes that edges of the model are not exposed to cutting or crushed while planning a layer.

ProtoSupport™ material is made of a mixture of natural and artificial waxes and of fat esters. It is dissolvable in BIOACT® VSO liquid in a temperature of 45 - 55°C.

Applying the system it is possible to make founding models of aero-engine elements, car parts, small jewellery and toys.

3. PROJET production engineering

PROJET production engineering drives from a system using MJM (Multi Jet Modeling) production engineering applied in stratified prototyping of models made of chemo- and opto-hardenable plastics. In PROJET production engineering a thermoplastic material-modelling wax is used for making a model. Creating the model consists in applying subsequent layers of modelling wax and supporting wax on one another by means of a printing head (fig. 4).

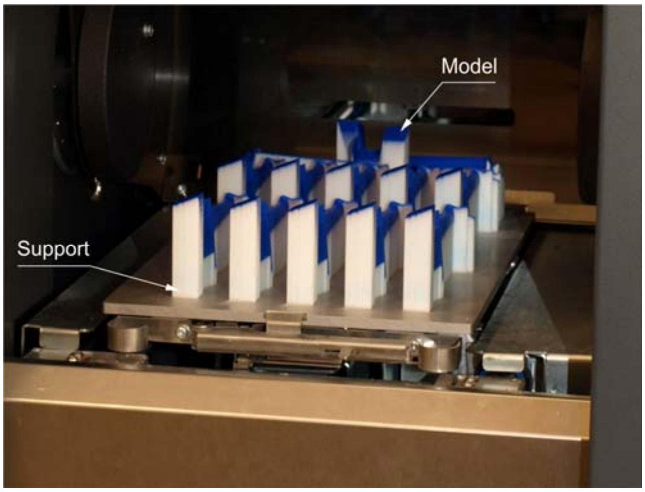

Fig. 4. A set of blades of aero-engine made on CPX 3000 device

The head consists of a set of nozzles arranged in parallel with one another. The flow of the drifted material is adjusted separately for each nozzle. The process of applying layers is controlled by means of special systems. The data determining a layer's shape is sent to the printer by the device software. The model is created on the working platform fixed to the device's table. The printing heads move along X and Y axis. If the created element is narrower than the head's width, the head moves only along X axis so that the whole element could come into being. A big number of nozzles assures quick and even drifting of material.

The wax prototype, like in other incremental methods of RP, is created layer by layer on the basis of prepared earlier 3D-CAD model. While building the model, it is secured by a supporting construction. Planning the surfaces of individual layers does not appear during the building process (like in DODJET production engineering).

The CPX3000 printer makes it possible to print models of two kinds of definition HD and XHD. In case of HD printout the working space has the following dimensions; 298x185x203mm and in case of XHD printout the space diminishes to dimensions of 127x178x152mm. Additionally for high definition, a barrier defining borders of HDX area appears together with the model. It causes additional use of material. The printing time of a single model in XHD can be even twice as long as printing it in HD. The use of modelling and supporting material also increases while XHD printing. The software does not make it possible to visualise the supporting constructions or to interfere in their structures. The supports are generated automatically for the model entered into programming space.

RealWax VisiJet CPX200 modelling wax is used for making models (fig. 5) and VisiJet S200 Wax Support Material is used to make the supports.

After finishing the printing process it is necessary to pull a working platform out of the printer and then detach models from the platform. It can be done by cooling the platform together with models and breaking them out of the platform or by heating the platform which causes melting the supporting construction and makes it easy to detach the models.

Fig. 5. Wax models made by means of CPX 3000 device

The melting temperature of the modelling material (RealWax VisiJet CPX200) equals about 62°C and the supporting material (VisiJet S200 Wax Support Material) is 42°C.

4. Conclusion

Incremental production engineering allows for precise making wax founding models which significantly accelerates the process of making a prototype founding mould and a cast itself.

The presented techniques make it possible to build models in a layered manner. In DODJET production engineering beside layered application of modelling material, a process of planning layer surface is also required. It causes improving repeatability of layer thickness but extends the time of building a model.

In DODJET production engineering the material has higher melting temperature than the wax used in PROJET production engineering. Thanks to that DODJET models are less exposed to thermal deformation which can appear while removing supporting material than PROJET models.

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Szybkie prototypowanie woskowych modeli odlewniczych w procesie przyrostowym

Streszczenie

Artykuł przedstawia analizę przyrostowych metod wytwarzania woskowych modeli odlewniczych. W praktyce przemysłowej i badaniach naukowych stosuje się coraz częściej metody szybkiego prototypowania modeli woskowych w procesie przyrostowym.

Zastosowanie metod RP w procesie wytwarzania odlewów pozwala na przyspieszenie prac nad przygotowaniem prototypów. Jest to szczególnie ważne w przypadku elementów o skomplikowanych kształtach. Czas wykonania modelu woskowego w zależności od gabarytów i zastosowanej metody Rapid Prototyping może wynieść od kilku do kilkudziesięciu godzin.