

RAPID PROTOTYPING PROCESS OF MONOCRYSTAL AIRCRAFT ENGINE BLADES

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Abstract

The article presents process application of the rapid prototyping (RP) for manufacturing of blades of aircraft turbine in mono- crystallization and also directional crystallization of casting process. It is describing the method of modeling of the chosen elements of casting model kit with the usage of RP and RT systems. The article presents the analysis of a additive rapid prototyping methods (stereolithography) in an aspect of manufacturing of casting models. The possibilities of RP system usage to the ceramic form were the main criteria of the analysis. The ceramic form is a one of the parts of process casting of monocrystal blade of aircraft engine. In the article the possibilities making of models by means of rapid tooling system based on the Vacuum Casting (VC) technology were also analysed. The Vacuum Casting technology allows producing the silicone mould under decreasing pressure. Silicone tools allow creating wax casting models as a vacuum casting process, casting process and low pressure of injection. Rapid prototyping and rapid tooling technologies allow creating casting wax models of a blade and other parts of casting models. RP and RT methods allow creating connectors of the parts. These connectors allow connecting the parts of model kit in a fast and simple method. The stereolithography and Vacuum Casting allow accelerating process of manufacturing of monocrystal blades of aircraft engines.

Keywords: *Rapid Prototyping, monocrystal, aircraft engine, blades*

1. Introduction

The manufacturing of blades of aircraft engines [10-11] can be realised with the application methods of rapid prototyping methods on chosen stages of technological process [1, 9].

The rapid prototyping of casting models of blades is based on three-dimensional models manufactured in 3D-CAD systems having options of surficial and lump modelling. It is necessary to transform data describing three-dimensional digital model in the program way to possible form for reading by systems of rapid prototyping (e.g. format STL). Software of devices RP transforms three-dimensional model 3D-RP on set of layers from which the physical prototype is produced [2, 4-5].

In this article the main stages of process of the rapid prototyping of elements of model kits were presented to manufacturing of ceramic forms applied to the production of monocrystal blades of aircraft engines. In this case process of rapid prototyping consists with the following stages: manufacturing of 3D-CAD model, program processing and preparation of data to process of manufacturing 3D-RP, manufacturing of the physical models. The additive method RP - stereolithography was applied to the production of base prototypes (so-called masters) . The opinion of possibilities manufacturing of casting models was carried out by means of one of methods Rapid Tooling based on technology Vacuum Casting (VC). This technology concerns manufacturing of tools (matrices or silicone forms) and also prototypes under lowered pressure in the vacuum chamber. Tools of this type enable on production of the wax casting models [1, 5].

2. Manufacturing of 3D-CAD and 3D-STL models

Modeling of turbine's blades of aircraft engines needs application of 3D-CAD systems having possibilities of surficial and lump modelling (CATIA, UGS-NX, Mechanical Desktop, SolidEdge, ProEngineer etc.). The complex shape of blade's plume can be exactly made with application of option of surficial modeling. The production of the physical prototype and the export of data to format of devices RP needs transformation of surficial model in lump model [8]. Fig. 1 presents 3D-CAD lump models of initiator and blade of aircraft engines.

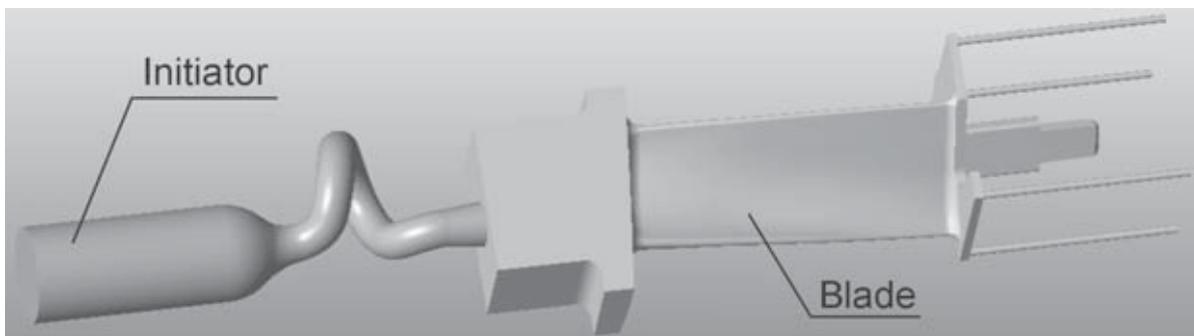


Fig. 1. Model CAD of blade and also initiator

The 3D-CAD lump model is necessary to write in form of data read by means of software of devices of rapid prototyping. Format STL is the widest applied format of writing and reading of data in RP systems [7]. Fig. 2 presents 3D-RP models of initiator and blade of aircraft engine written in format STL.

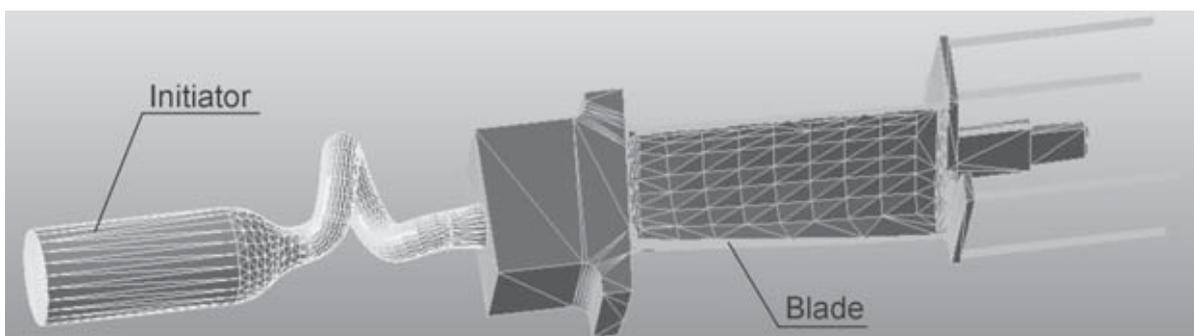


Fig. 2. Model STL of blade and also initiator

Format STL describes surface of 3D-CAD model by means of triangles's grid. Format STL enables in simple way to transform 3D-CAD model, and next to submit him successive processing and the final distribution on layers. The presented format became standard in almost all RP/RT techniques as a result of increasing application of him and also is used in systems of reverse engineering as well as methods of finite elements (MES) [7, 9].

3. Manufacturing of blades's prototypes by means of method stereolithography

Stereolithography (SLA) is one with the methods of rapid prototyping. Above all the most important advantages methods are: large repeatability, the precision of creation model and also possibility of the creation of complex internal and external structure. From this reason if is necessary manufacturing of elements about large degree of precision – blades of aircraft engines stereolithography will be particularly useful [2].

The creation of stereolithographic model is based on the liquid polymerization of (photo-hardenable) resin by means of laser's bundle. During of process produced model is put on working platform in the container with the liquid resin. After finishing platform together with put on it models, is raised above the mirror of liquid resin. Fig. 3 presents stereolithographic prototypes of model system.

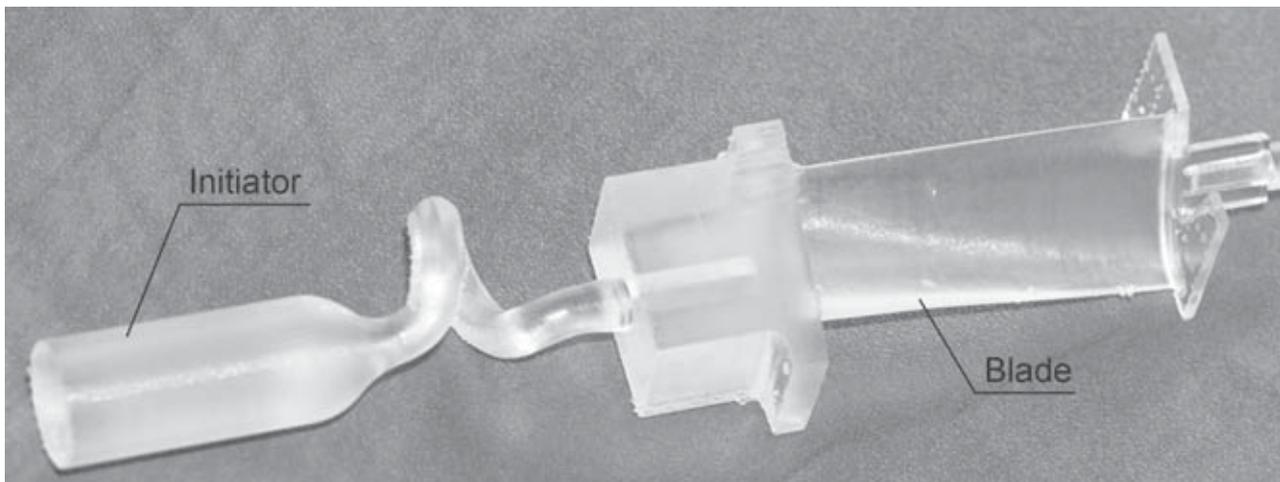


Fig. 3. Model SLA of blade and also initiator

Next finishing processing – so-called Post Processing – contains removal of supports, washing of model in the acetone or izopropanol and also additional irradiation light UV in purpose of completion of polymerization in whole model's capacity [6].

4. Manufacturing of the wax models of blades's models in silicone matrices

The Rapid prototyping of casting models of blade in silicone matrices belong to indirect methods RP relying on application of technique Rapid Tooling (RT) i.e. silicone matrices in technology Vacuum Casting (VC). Manufacturing of silicone mould contains the next stages:

- preparation of the pattern model (e.g. JS, SLS, SLA, FDM, 3DP),
- making of mould's construction and model system,
- preparation of mould's casing and filling of him by means of silicone,
- thermal processing of mould,
- gash of mould and the removal of model system [2].

Silicone matrices enable on manufacturing of casting models from polymer resins and also casting waxes. Fig. 4 presents silicone mould (Fig. 4a) produced on the basis of model kit

(Fig. 4b). Model kit consists from model of blade manufactured by means of stereolithography method and also the channel leading liquid wax to form. The leading channel is connected in the bottom part to model of blade what enable correct course of process of filling of mould.

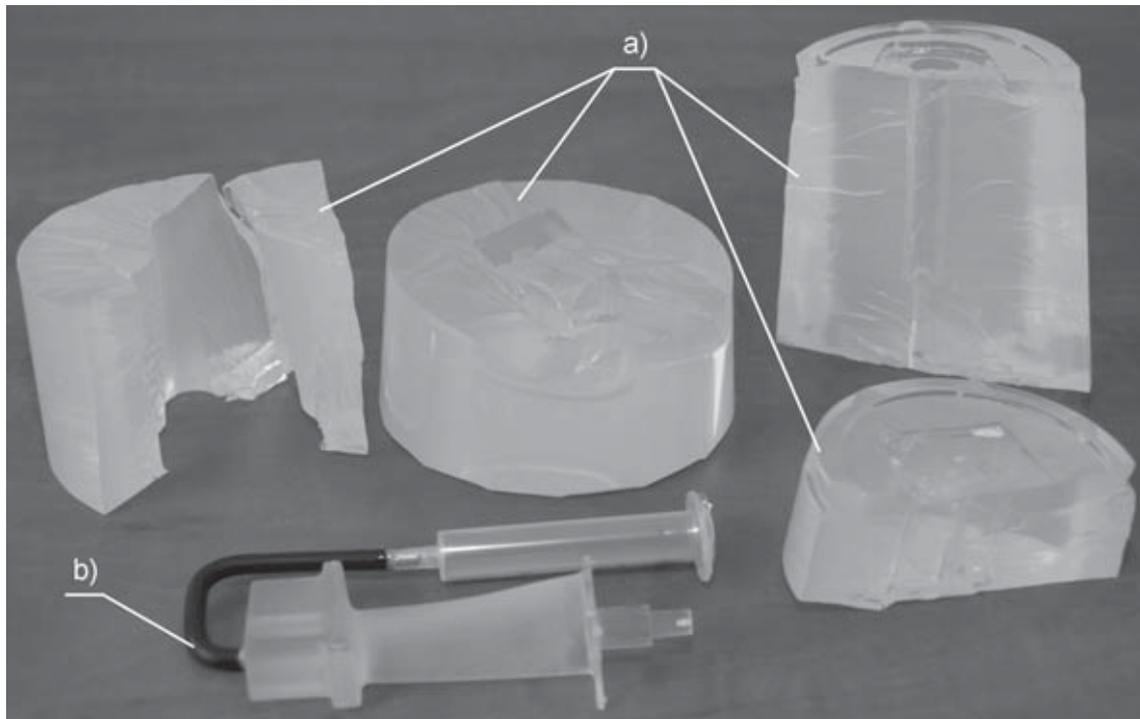


Fig. 4. Silicone mould (a) manufactured on the basis model kit (b)

To manufacturing of models of blades were applied different kinds of waxes used in serial production to production of elements of model system in process of the n injection to metal matrices. Application of this type waxes needed determining of parameters of technological process of manufacturing wax models in silicone tools. These parameters were determined on research way [3]. Fig. 5 presents wax models of blade and initiator made in silicone mould from modeling wax A7FR/60 of the firm BLAYSON.

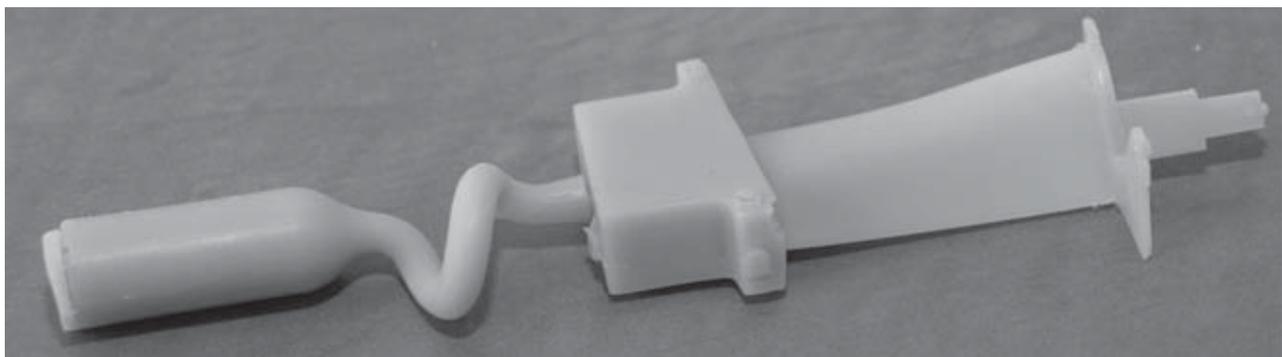


Fig. 5. Model kit from casting wax

Wax models of blades as well as remaining elements of model system were made with application of technique RP and also traditional technology of injection was connected in model system (Fig. 6a). On this basis ceramic forms were made, put next in casting chamber (Fig. 6b). After finishing of process of casting and mono-crystallization (Fig. 6c), forms was broken and blades initially cleaned (Fig. 6d).

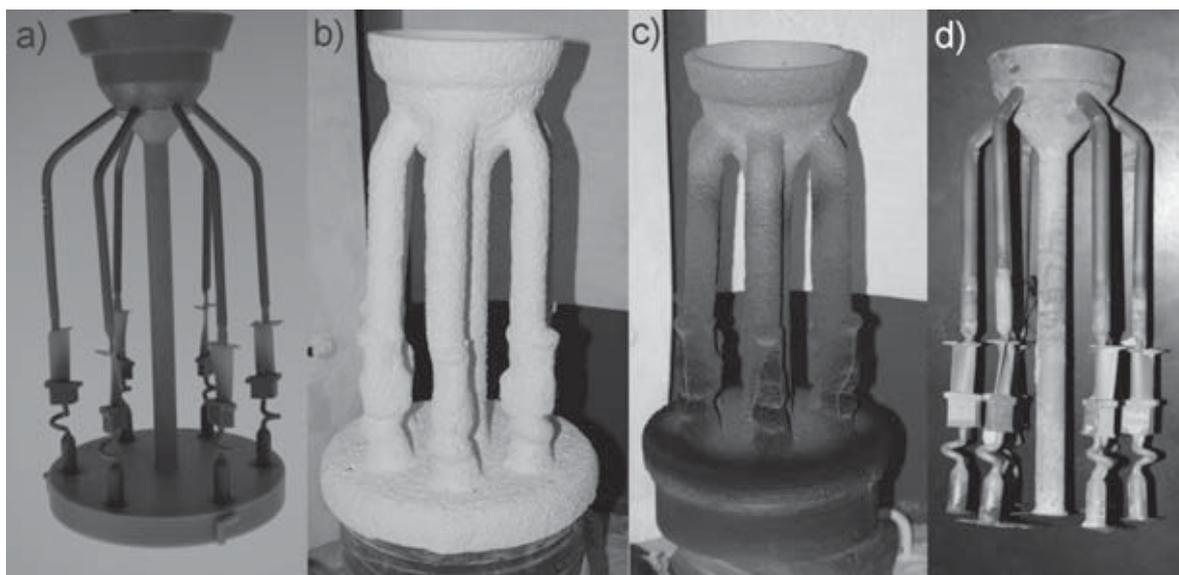


Fig. 6. Application of wax models to manufacturing of monocrystal blades: a) wax model kit, b) ceramic form before casting, c) form in the stove after casting, d) monocrystal blades

4. Conclusions

Technologies of rapid prototyping enable on manufacturing of elements of model kits for ceramic casting forms. Prototypes of elements of model system were produced by means of stereolithography's method need application of special ceramic construction of casting form as well as special process of removal of models. It is caused as a result of course of removal's process of model produced from epoxy and polyester resins from ceramic form. During of such process large of gasses is created, and which pressure often causes damage of forms. It is possible to prevent this as a result of application of indirect method of rapid prototyping based on rapid manufacturing of tools (silicone matrices), in which next wax casting models are manufactured.

Application of combination of methods Rapid Prototyping and Rapid Tooling enable on achievement of casting models of blades of aircraft engines and also remaining elements of model system. These methods enable also on suitable form of connections of respective of elements of model kit, what enables acceleration of process of preparation of casting forms and in this way made monocrystal casts of blades of aircraft engines.

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