

## **RP and RT process application for aircraft engine blades cast models manufacturing**

*Abstract: The article presents process application of the rapid prototyping (RP) and rapid tooling (RT) for manufacturing of model blades of aircraft turbine for 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 (SLA) 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 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 to produce the silicone mold under decreasing pressure. Silicone tools allow to create wax casting models as a casting process. Rapid prototyping and rapid tooling technologies allow to create casting wax models of a blade and other parts of casting models. The SLA and RT (VC) allow to accelerate process of manufacturing of blades of aircraft engines.*

Key words: Blade, turbine, Rapid Prototyping, Rapid Tooling

## **Zastosowanie procesów RP i RT do wytwarzania modeli odlewniczych łopatek silników lotniczych**

*Streszczenie: Artykuł przedstawia możliwości wykonania prototypów łopatek silników lotniczych z zastosowaniem szybkiego prototypowania (RP) i szybkiego wytwarzania narzędzi (RT). Opisane zostały metody modelowania wybranych elementów modelowego układu odlewniczego z zastosowaniem systemów RP i RT. Artykuł opisuje analizę przyrostowego procesu szybkiego prototypowania z zastosowaniem metody SLA w aspekcie użycia modeli stereolitograficznych jako modeli odlewniczych do wytwarzania ceramicznych form. Wytwarzanie form ceramicznych jest jednym z etapów procesu produkcyjnego łopatek silników lotniczych. Dlatego w artykule przedstawiono również możliwości wykonania modeli odlewniczych służących do wykonywania tego typu form z zastosowaniem procesu Vacuum Casting (VC). W procesie tym modele woskowe odlewane są w formach silikonowych wytworzonych z zastosowaniem metody Rapid Tooling opartej na technologii Vacuum Casting. Metody RP i RT pozwalają na znaczne przyspieszenie prac nad wytworzeniem modeli odlewniczych łopatek turbin silnika lotniczego oraz innych elementów odlewniczego zestawu modelowego.*

Słowa kluczowe: łopaska, turbina, szybkie prototypowanie, szybkie wytwarzanie narzędzi

### **1. Introduction**

The manufacturing of blades of aircraft engines [10, 11] can be realised with the application methods of RP and RT 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. It is necessary to transform data describing 3D digital object in the program way to possible form for reading by systems of rapid prototyping (e.g. format STL, SLC). 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 RP and RT of elements of model kits were presented to manufacturing of ceramic forms applied

to the production of blades of aircraft engines. In this case process of additive RP 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. 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 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].

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## 2. CAD-3D and 3D-STL models

Modeling of turbine's blades of aircraft engines needs application of 3D-CAD systems having possibilities of surficial and lump modeling (CATIA, NX, MDT, SE, ProE 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]. Figure 1 presents 3D-CAD lump models of initiator and blade of aircraft engines.

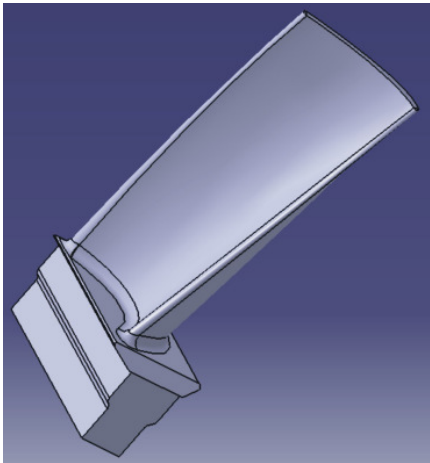


Fig. 1. CAD model of blade

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]. Figure 2 presents 3D-RP models of initiator and blade of aircraft engine written in format STL.

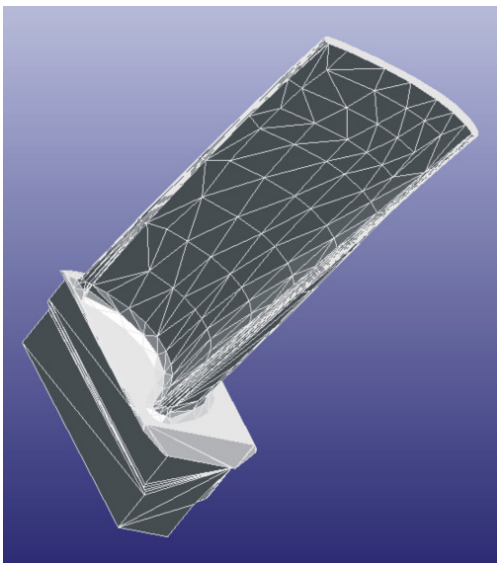


Fig. 2. STL model of blade

## 3. SLA blades model

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 her models is raised above the mirror of liquid resin. Figure 3 presents SLA prototype of blade model.

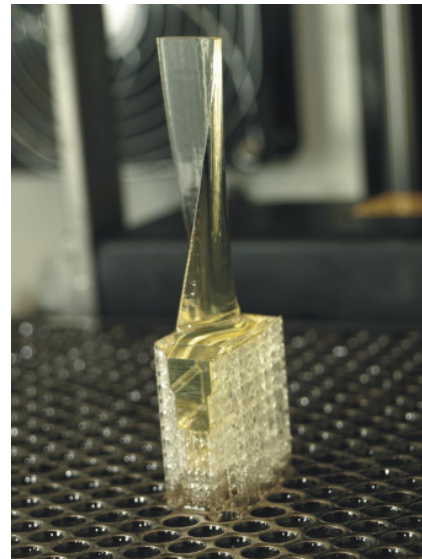


Fig. 3. SLA model of blade

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. RT/VC process for wax models

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

- preparation of the pattern model (e.g. SLA, JS, SLS, FDM, 3DP),

- making of mold's construction and model system,
- preparation of mold's casing and filling of him by means of silicone,
- thermal processing of mold,
- gash of mold and the removal of model system [2].

Silicone matrices enable on manufacturing of casting models from casting waxes. Figure 4 presents silicone mold produced on the basis of model kit. Model kit consists from model of blade manufactured by means of SLA 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 mold.



Fig. 4. Silicone mold and manufactured wax model

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]. Figure 4 presents wax models of blade made in silicone mold from modeling wax B405.

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 were connected in model system.

On this basis ceramic forms were made, put next in casting chamber. After finishing of process of casting forms were broken and blades initially cleaned.

## 5. 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.

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## Nomenclature/Skróty i oznaczenia

CAD Computer Aided Design/*komputerowe wspomaganie projektowania*  
 SLA Stereolithography/*stereolitografia*  
 RP Rapid Prototyping/*szybkie prototypowanie*

RT Rapid Tooling/*szybkie wytwarzanie narzędzi*

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