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TITLE

RAPID PROTOTYPING TECHNOLOGY FOR MANUFACTURING TURBINE BLADES

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Abstract

The purpose of this paper is to present the conventional approach to manufacturing turbine blades by investment casting is expensive and time-consuming, as it takes a lot of time to make geometrically precise and complex wax pattern. In this paper compaires the rapid prototyping method to the conventional technology. The conventional process is very time consuming and expensive process. The rapid prototyping process needs to be able to compete with conventional investment casting from a dimensional accuracy view of point. The purpose of this paper is to investigate the manufacture of gas turbine blades to indirect rapid tooling technologies. This paper is to shows the advantage of computer-aided and single solidification of aircraft engine turbine blades. The process of modelling three-dimensional CAD geometry of research blade in relation to the model.

Key Words: *Turbine blades, Rapid Prototyping/Rapid Manufacturing, Production.*

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1. INTRODUCTION

Rapid Prototyping Technology is a group of manufacturing processes that enable the direct physical realization of 3D computer models This technology convert the 3D computer data provided by a dedicated file format directly to a physical, layer by layer with a high degree of accuracy. The rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is used usually done using 3D printing or "additive layer manufacturing" technology. The first method for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today they are used for a wide range of application and are used to manufacture production-quality parts in relatively small numbers if desired without a typical unfavourable short from-run economics. It is the most developing methods for part forming and manufacturing the product by using CAD system. The application of Rapid Prototyping technology in the manufacturing of turbine blade. The RP of blades casting model is based on three dimensional(3D). Blades are one of the most heavy loaded parts of gas turbine unit (GTU) and gas turbine engine (GTE). Blades require perfect surface quality and geometric precision. The only possible way to make such a blades is the casting of heat-resistant nickel alloy ceramic model. Silicon models are mold are usually made by using a 3-D printed master pattern. One of the biggest disadvantages of investment casting is its high general cost. The paper describes the development and improvement the used of this technology for making complex and highly precise products for aerospace industry. The computer aided analysis was used to check any deviations encountered in cast blades compared to the model design dimension.

The prototype gives the user a fair idea about the final look of the product. The main objective of the paper is to improve the manufacturing technology to make geometrically complex casting of required precision and surface quality by using RP method.

2. RAPID PROTOTYPING MANUFACTURING PROCESSES

All RP techniques employ the basic five-process:

- Create a CAD model of the design
- Convert the CAD model to STL format (stereolithography)
- Slice the STL file into thin cross-sectional layers
- Construct the model one layer atop another
- Clin and finish the model

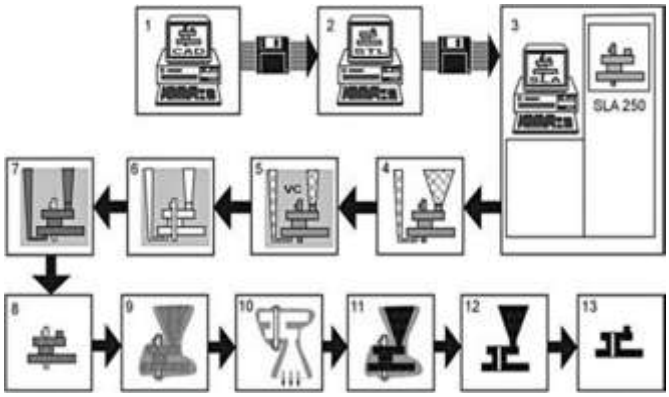

Figure 1: The application of RP techniques for precision casting core models using an RP process

First, the object to be built is modeled using a Computer-Aided Design (CAD) software package. Solid modelers, tend to represent 3-D objects more accurately than wire-frame modelers such as AutoCAD, and will therefore yield better result. The most important advantages of the method are: precision in model creation, possibility of complex internal and external structure production and large reproducibility. The manufacturing of precise element like blades of aircraft engines is possible using Object Eden 260 machine by Polyjet. Manufacturing of polyjet model is based on the liquid polymerization of resin with use of ultraviolet lamp in layered process. The figure 2 represent the 3D printing Polyjet process (Figure 3a) and prototypes of blade model (Figure 3b).

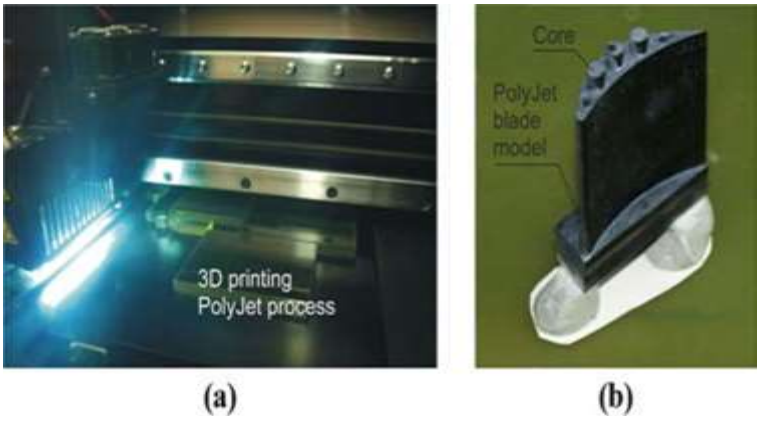

Figure 2(a): 3D printing Polyjet process, **(b)** prototype of blade model

The RP of blades casting models in silicon moulds related to indirect RP methods relying on application of RT technique, i.e. silicon mould in VC technology. Manufacturing of silicon mould contains the following stages:

- The first stage is to prepare a model pattern;
- Then the manufacturing of moulds construction and model system;
- Pouring the silicon and prepare the mould;
- Thermal processing;
- Scrape the mould and removal of model system [4];

Figure 3: Silicon mould annealing (a) and pouring with the modelling wax (b)

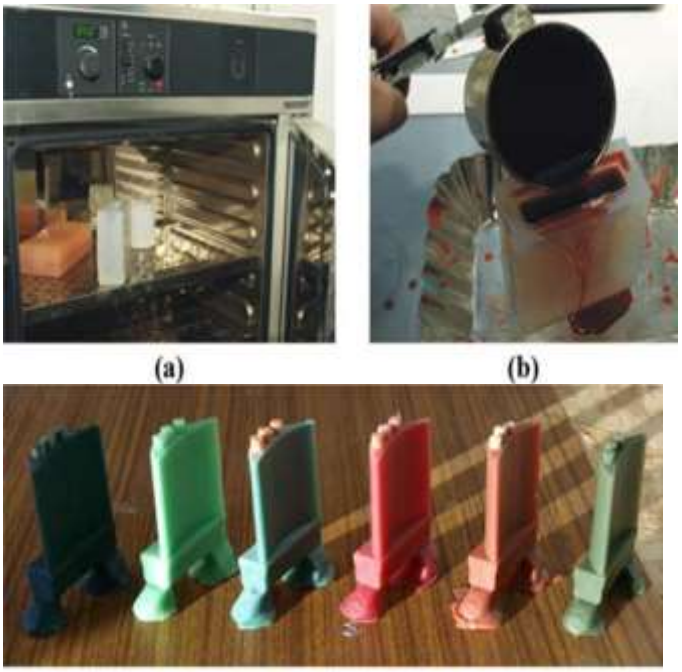

Figure 4: Cored blades wax models made of different waxes [2]

MATERIAL AND METHODS

A blade of an auxiliary GTE power unit turbine was selected as the object of study. The blades are made of Nickel-based heat-resistant alloy. The table shows the chemical composition alloy.

Table 1. Chemical composition of the heat-resistant alloy

Elements	%content	Elements	%content
Ni	Base	C	0.13÷0.20
Cr	9.5÷12.0	Si	≤0.4
Al	5.0÷6.0	Mn	≤0.4
W	4.5÷5.5	B	≤0.02
Co	4.0÷5.5	Ce	≤0.015
Mo	3.5÷4.8	S	≤0.015
Ti	2.5÷ 3.2	P	≤0.015

The manufacturing process are as follows [3,4]: -

1. At the time of polishing the inner surfaces of the blades are removed the shrinkage and stock;
2. Growing the master pattern;
3. Making a silicon mold;
4. In the silicon mold making the wax pattern;
5. Assembling the wax patterns by using sprue system;
6. By applying refractory ceramics and removing the wax;
7. Casting metal into the ceramic type of shell;
8. Removing the sprue system.

3. MAKING THE MASTER PATTERN

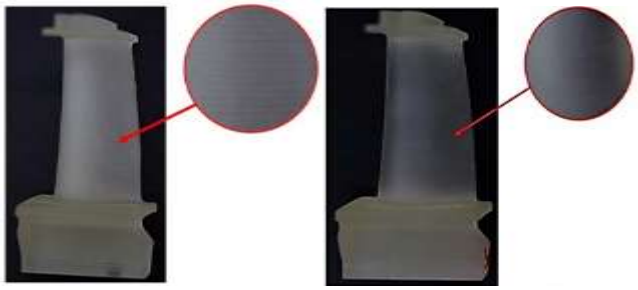

Figure 5: Master pattern, a- before polishing, b-After polishing

The master pattern was built in Siemens NX a CAD/CAM/CAE package. The first formed the 2D section profiles. The advantages of the design process is that one can take into all the stock are removed in machining and the shrinkage of all the components. The fast prototyping process produces quickly and easily a 3-D physical object on the basis of 3-D CAD model. By using 3D-model the production of parts is fast and quickly. Air foil and inner surface polishing s done manually in multiple steps. In the first step remove the first layer by using a P1200 sandpaper; For every step, the finer sandpaper; for every step the finer sandpaper was used until they reached a fines of P2500. After the inner surface polished, then check the surface roughness by using CMM machine.[1]

4. CONCLUSION

From this paper we conclude that the fast prototyping is a very low-cost solution for small batch manufacturing of GTE blade. Rapid prototyping/Rapid manufacturing technologies constitute, in view of their dynamic development, a very important area of today used method for products forming and manufacturing. These methods important element in product development cycle. It is very reliable assessment in every stage of its development. Silicon mold have a number of advantages over conventional technology, mainly faster production rate and minimum cost. In the paper shows the silicon molds can be used to make blades as they provide necessary accuracy. Silicon molds can be used to make geometrically complex wax pattern for multiple-item small-batch or pilot manufacturing. Hence eliminating the needs for CNC production of metal molds.

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