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Revert Alloy Impact on Mechanical Properties of Nickel Based Superalloys Used in Production of Aircraft Engine Critical Components

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The requirements of jet engine critical components investment casting process determine the operational strength of cast components and are strictly enforced by the engine final manufacturers. One of the main factors affecting technological process of casting is the charge alloy, provided by so-called approved source of supply. The quality of supplied charge material is of fundamental importance for quality of castings as all bad characteristics of the alloy transfer naturally into castings. Charge melts are ordered in form of rolls having a diameter of 60 to 90 mm in batches having a mass of 3 to 5 tons. In further steps they are cut into batch portions of 5 to 15 kg weights suitable for casting furnaces capacity. Supplier produces alloys in so-called "Virgin" state - without revert alloy, or with revert alloy of the same type, which is recovered in a form of gating systems and defective components that have been rejected in the quality control process. The weight percentage of revert alloy that is added to the production process can affect the quality and properties of resulting material. In the article compares the effect of the amount of revert material on the properties casting parts.

Keywords: *investment casting, virgin and revert superalloys, tensile and creep strength*

1. Introduction

Elements of aircraft engines, including high and low pressure turbine blades and vane clusters, made of nickel and cobalt based superalloys, during long-term operation at elevated temperatures, are exposed to mass forces as well as corrosive agents (Ref 1). These facts force very high quality requirements for castings, both in terms of dimensional requirements, surface condition, as well as requirements for micro- and macrostructure. Castings quality is dependent on a complex, multi-step production process (Ref 2). One of the main factors affecting technological process of casting is the charge alloy, provided by so-called approved source of supply. The quality of supplied charge material is of fundamental importance for quality of castings as all bad characteristics of the alloy transfer naturally into castings. Charge melts are ordered in form of rolls having a diameter of 60 to 90 mm in batches having a mass of 3 to 5 tons. In further steps they are cut into batch portions of 5 to 15 kg weights suitable for casting furnaces capacity. Along with charge material obtained from the manufacturer, a certificate of chemical composition analysis is provided, which corresponds to the material standard for a given alloy type and, as was proven by previous experience, certificate coincides with analysis results carried out in the quality control laboratory.

Supplier produces alloys in so-called "Virgin" state - without revert alloy, or with revert alloy of the same type, which is recovered in a form of gating systems and defective components that have been rejected in the quality control process. The weight percentage of revert alloy that is added to the production process can affect the quality and properties of resulting material. Therefore, the maximum number of elements in the revert alloy has to be approved by preparing and examining test series of the castings.

2. Material and experimental procedure

2.1 Scope of the research

Since it was found that content of revert alloy affects the quality of resulting material, in the present study an analysis of the test alloys with various contents of the revert alloy is presented. The analysis was performed for IN713C alloy, four different masterheats were analysed, that were delivered at different times and manufactured in different melting processes. Among tested alloys there were ones in "Virgin" state and ones produced using revert alloy.

For the purposes of this study, the following designations of the amount of revert alloy was adopted. INC713C was subjected to strength tests according to the materials standards.

Table 1 List of investigated alloys.

Alloy	Virgin	Revert	Designation
IN713C	100	0	A
IN713C	60	40	B
IN713C	50	50	C

2.2 Preparation of specimens for strength tests

Before any taken action on the alloy, supplier sends a portion of the material in order to conduct study and to qualify the material for production. For each batch of a material received from the supplier, a separate sample is prepared. Test samples are casted to a ceramic mould according to standardized, repeatable procedure.

Fig. 1 Ceramic mould

The casting of the sample - the so-called. "Carrot" - has shape of a truncated cone, which is machined to obtain a rod of a diameter required by standards. The ends of the sample are machined to appropriate diameter and threaded to allow assembly in the testing machine.

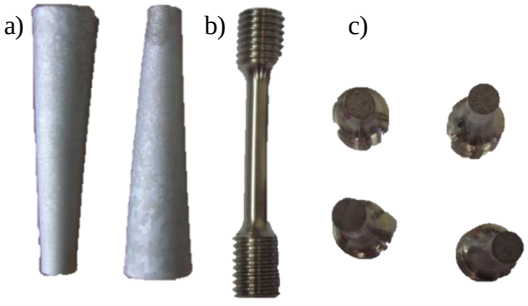

Fig. 2 (a) Casting samples prior to machining. (b)) sample after machining (c) sample after the strength test

Materials standard specify parameters: creep strength, time to sample rupture subjected to 152 MPa (22 kpsi) load at a temperature of 982°C (1800 F) and hardness.

3. Results and discussion

The following fig. presents the example results for INC713.

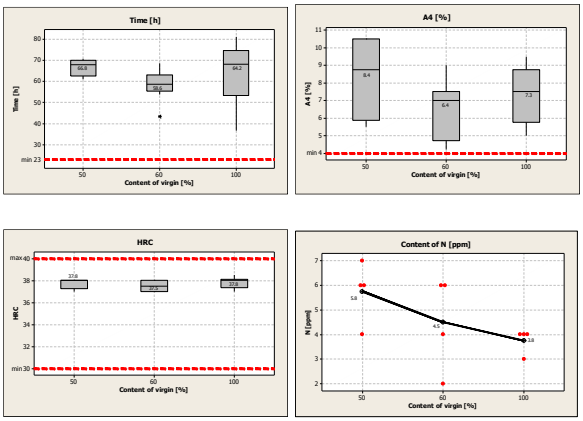

Fig. 3 Impact of pure elements in the IN 713C alloy on: (a) creep strength (b) elongation (c) hardness (d) nitrogen content

4. Conclusions

IN713C - tested materials show no dependence of revert alloy content on mechanical properties at elevated temperature. 100V alloy is characterized by low nitrogen content. Conducted study confirms that the procedure applied by the manufacturer for cleaning, preparation of revert alloy for remelting and casting allow the use of remelted material in the investment casting process. All parameters of tested INC713 superalloy are within the limits of the standards. In most cases, it is difficult to determine the dependence of the contents of the revert alloy on parameters of final material. Revert alloy does not affect the properties of the resulting alloy in studied range.

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