INCAS QUICK THERMAL TEST SHOCK INSTALLATION - QTS1

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DOI: 10.13111/2066-8201.2009.1.2.16

Abstract

From the assembly of the wear factors which act on the "hot parts" of the turbo engines, respectively on the protective coatings, the thermal shock acts the most perturbing.
The behavior of the materials at thermal shock is evaluated at present on unique installations, constructive and methodical different, in the specialized laboratories of the materials manufacturer, protective coatings included as well as of those specialized in testing.
The thermal test shock installation conceived by INCAS and achieved in collaboration with INCDT COMOTI for testing of the materials at thermal shock, especially those from the aerospatial domain, represents a versatile construction, in progress in comparison with those known.
The QTS1 - quick thermal test shock installation assures with reproducible results the material evaluation in the heating and cooling speed conditions up to 100°C/s at heating and 60ºC/s at cooling, situations which correspond to the extreme functional conditions of the turbo engines, space shuttle, cogenerative systems, etc.

Introduction

The aim of thermal test shock is the obtaining of the necessary data in order to evaluate preliminary the coatings materials properties taking into account the extreme functional conditions of turbo engines or other important parts in the aimed domains.
The similarity between the test and the exploitation of the achieved coatings became an essential condition to evaluate as exact as possible.
The test of the specimens coated with different material are more complexes than the classical ones because are implied not only the combined properties of the coating, of the substrate but also the bonding between them as well as the internal tensions resulting from the differences between the physics properties of the materials involved.
The thermal test shock consists in the heating of the specimens from temperatures of tens degrees to hundreds degrees in a very short time and vice versa the cooling of them from high temperatures to low temperatures.
The thermal test shock proposes to relieve the microstructural modifications of the shocked specimens, the decreasing of the mechanical strength of the coating as well as the number of the shocks without damages, respectively cracks or exfoliations.
We mention the fact that there is not a standard method and an installation for thermal test shock for coatings materials.

Generally the companies interested achieved their own installations.
These installations cannot give results in the case of the parts form aero space industry, space shuttles, “hot parts” of turbo engines, etc. stressed at quick thermal shock.
There are some quick thermal test installations where the heating is achieved by laser or induction.
The major disadvantage of these is the fact that is not possible to test coated materials with non metallic powders. In the case of laser heating, the test zone is a small one, few microns and in the respective area the material is damaged.
Taking into account the above mentioned resulted the necessity to conceive and achieve a new installation, with high heating/cooling speed closed to those from the extreme conditions of the parts form aerospace, power, cogenerative systems, metallurgical domain, etc.

1. QTS1-quick thermal test shock installation presentation

The QTS1 is a quick thermal test shock installation, a facility of Materials and Tribology Department of INCAS. (Fig. 1)

Fig.1 Thermal test shock installation QTS1

The main characteristics of the QTS1 installation are:

- Oven temperature: max. 1300ºC
- Specimen temperature: max.1200°C
- Heating speed: max. 100°C/s
- Cooling speed: max 60ºC/s

- Specimen size: 2,6 mm x 30mm x 50 mm
- Cooling agent: compressed air at max.9 bar
- Pneumatic movements
- Vertical oven

The installations permit the test of materials at high heating and cooling speed utilizing specimens of parallelepiped or cylinder shape according to the holder.
In order to be tested the specimen mounted in a holder is moved from the environment temperature inside o f a vertical oven, maintained the time required, than is taking off and cooled at high speed with compressed air.
The specimen temperatures in the oven and in the cooling area are measured with two Raytek pyrometers. The data acquisition is performed with the appropriate Raytek soft.
The specimen outside the oven can be visualized also by a thermovision camera. (Fig. 2)

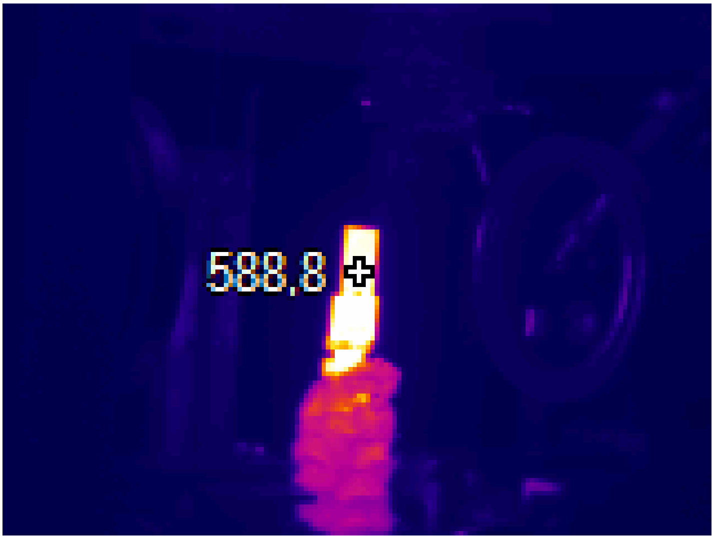

Fig. 2 Specimen during the cooling soon after oven extraction

The experimental activity is carried out according to the „Testing Manual QTS1".

2. Description of the installation

The QTS1 installation is formed from a vertical oven heated with 8 Kanthal Global SD elements disposed circularly. The oven is powered by a 7 kW stage transformer.
The movement of the specimen from the environment temperature inside of the oven and then out in the cooling zone is obtained with a pneumatic system, with FESTO components, working up to 10 bars.
The heating of the oven and the specimen movements are controlled form a control panel. (Fig. 3)

Fig.3. Control panel

The measured parameters are: environment temperature, oven temperature, surface specimen temperature at heating and cooling, pressure of pneumatic moving system, pressure and temperature of cooling air.

3. Instrumentation, measurements

Environment and cooling air temperatures are measured by TURK transducers.
Oven temperature is measured with a thermocouple PtRh13% (max.1500ºC), CAOM type mounted vertically in the upper zone close to the specimen.
There is another thermocouple same type mounted perpendicularly to the specimen surface in the lateral part of the oven. Oven heating is controlled by a SCHIMADEN controller.
Specimen temperature inside and outside of the oven is measured with Raytek pyrometer D5JTXLTSF (0÷800ºC) and RAYTXSHTSF (500°C÷2000°C) types.
Pneumatic pressure system is measured with FESTO manometer and a pressure transducer.
Cooling air pressure is measured with a manometer and a TURK transducer. The cooling air is provided by a single stage piston compressor, with a 100 liters tank.

4. Data acquisition system

The installation is equipped with data acquisition system provided by Raytek together with the pyrometers, system controlled by a PC computer.

5. Performances

The number of tests per day depends on the temperature test. The period between tests is about 10 minutes the tank never being fully exhausted. In a working day is possible to perform 25 cycles of test, the run test being about 7 minutes.
Quick test shock diagrams are presented in the fig.4 for cooper alloy specimen and in fig.5.for Nimonic alloy specimen.

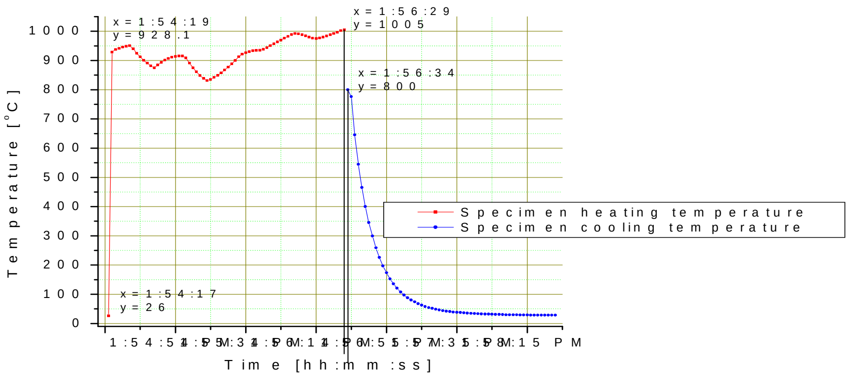

Fig.4. Quick thermal test shock diagram for cooper alloy

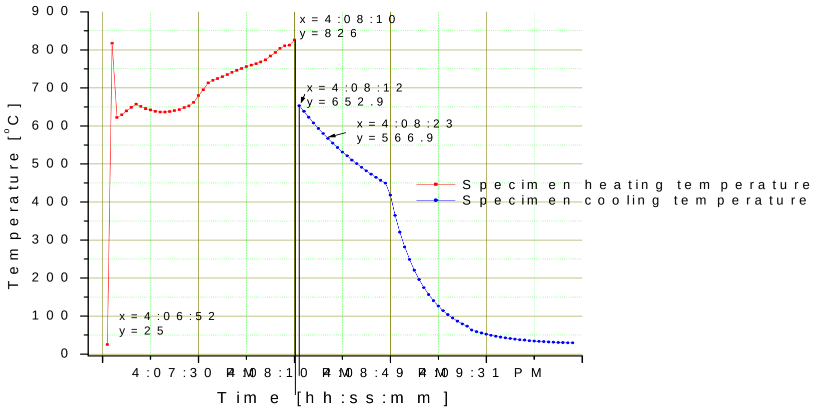

Fig.5. Quick thermal test shock diagram for nickel-chromium-cobalt alloy

Conclusions

- The thermal shock represents in comparison with the wear factors associated to the turbo engines- erosion at 2÷3 Mach speed, working temperature over 1000°C, corrosion, slide friction wear-the most perturbing parameter on the turbo engine "hot parts" materials life time.

- The quick thermal shock is associated to the turbo engine working in extreme conditions for short period of time (take off, emergency landing, start-stop engine, etc.) and corresponds to some high heating-cooling till 100°C/s.
- The QTS1 installation, conceived by INCAS, presents as against the known installations, the possibility to test thermally of the materials in a large domains of experimental parameters which corresponds to the functioning in the same time in current working conditions and extreme of the "hot parts" of turbo engines.
- The testing installation and the associated testing method provide technical-scientific data, necessary to the hierarchy and selection of the materials solutions, potential utilizable at the turbo engines, space shuttle, co generative systems, etc.
- The testing installation, versatile, functioning in semiautomatic and manual mode assures reproducible results for testing temperatures till 1300°C and heating speed (100°C/s)/cooling speed (60°C/s).
- The test results crates the possibility to the study of the protective coatings delaminating mechanism as well as the relation between the dynamic of the microstructure modifications induced by thermal shock in the coatings.

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