

## Evaluation of Inconel 718 Creep Behavior

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**Abstract.** Superalloys are used primarily in aerospace applications. These applications require a material with high mechanical strength, good resistance to fatigue and creep, good corrosion resistance and ability to operate continuously at elevated temperatures. These alloys were developed for elevated temperature service, where relatively severe mechanical stressing is encountered, and where high surface stability is frequently required. Inconel 718 has being investigated because it is one of the most widely used superalloys. Constant load creep tests were conducted on a standard creep machine at 600 and 700°C and stress levels of 300 MPa. Sets of curves and experimental parameters for the primary, secondary and tertiary regions, as a function of stress and temperature applied were obtained. The ductility, the creep rate and lifetime was evaluated.

### Introduction

During the gas turbine operation, the material used in the turbine is exposed to different environmental conditions. The structural materials development used in gas turbines are motivated by the challenge of using innovative materials capable of withstand harsh environments without performance degradation. Gas turbines are frequently subject to damage by corrosion, oxidation and erosion conditions and, in some parts, high temperatures too. The choice of material used in the turbine must have, as the first requirement to be complied, a high creep resistance at elevated temperatures. The nickel base superalloys have been developed to withstand high temperatures without losing strength. The study on the behavior of Inconel 718 during the deformation at high temperatures is complex because there are changes of parameters of thermomechanical processing and working conditions.

### Experimental

For this work, it was used the Inconel 718 superalloy in the form of cylindrical bars, acquired from the company Villares Metals SA. The chemical composition characterization of the main elements complies with the requirements of ASTM B265-89. Only major alloying elements have been included in Table 1.

Table 1. Inconel 718 nominal chemical compositions (percent by weight)

Element	(%)
Ni	55.09
Cr	17.86
Fe	16.85
Nb	5.73
Mo	2.98
Al	0.82
Ti	0.67

It was made a Brinell hardness test, with an indenter of 2.5 mm and a load of 62.5 kg during 15 seconds. The test was realized at Vale Soluções em Energia (VSE).

Specimens were prepared through conventional procedures of metallography. To obtain the Inconel surface images, optical microscopy (Leica model DMRXP) was used. Inconel 718 fracture images were obtained from a scanning electron microscope (LEO model 435 VPI).

### Hot tensile test

Hot tensile tests were performed for specimens made of superalloy Inconel 718 at temperatures of 600 and 700°C, with a strain rate 0.5 mm/min ( $2 \times 10^{-4}$  s<sup>-1</sup>) according to ASTM E-8. The specimens were fixed in a static MTS machine with a capacity of 200 kN. After the furnace reached the temperature the specimen was tensioned until the rupture. The specimen used in the hot tensile test is shown in Fig. 1.

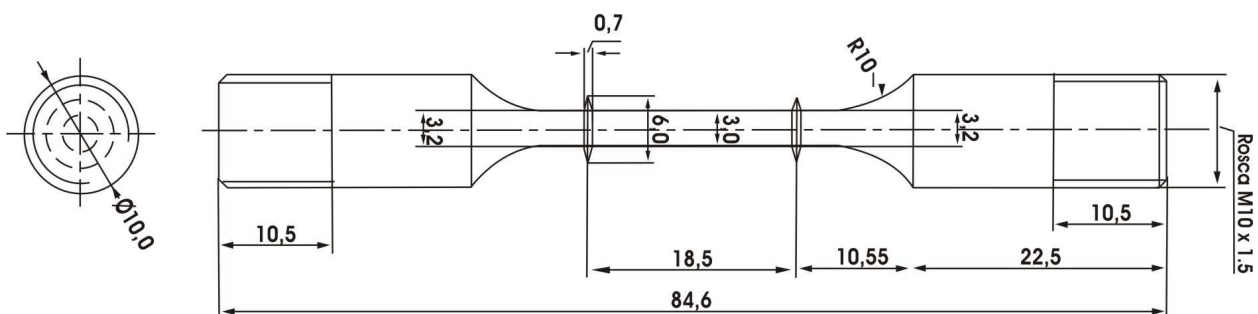


Figure 1. Specimen

### Creep test

The creep tests were made according to ASTM E139/83 (1990). The software Antares was used and the collected data are the specimen stretching, time and temperature. The specimen used in the creep test is the same as used in the hot tensile test. An extensometer was fixed at the specimen and the specimen was put in a furnace. After the furnace reaches the temperature, the specimen was tensioned with 10% of the total load used in the test during one hour. After one hour the total load was placed to reach the test stress.

## Results

The center and edge of the sample was investigated by optical microscopy. To reveal the microstructure, the samples were sprayed with a solution at a ratio of: 3HCl, 2: Glycerol, 1:NHO<sub>3</sub>, with an immersion time around 15 seconds. Figure 2 presents the optical micrograph of Inconel 718 as received center sample. Figure 3 presents the optical micrograph of Inconel 718 as received edge sample.

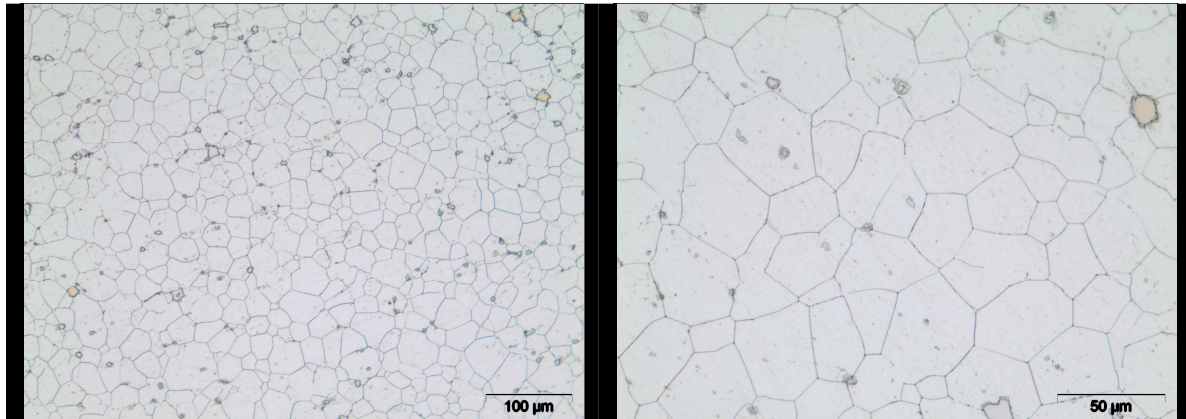


Figure 2. Microstructure of Inconel 718 as received center sample.

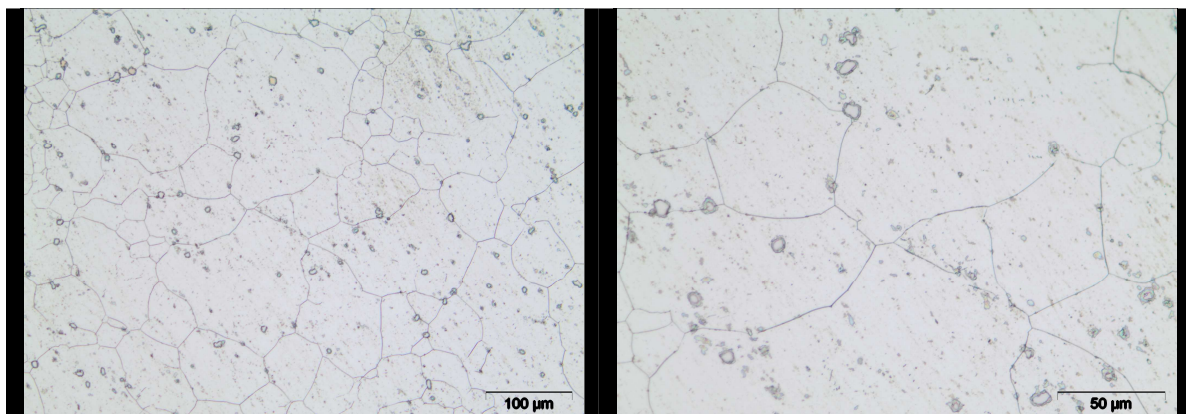


Figure 3. Microstructure of Inconel 718 as received edge sample.

Table 2 presents the hardness test results.

Table 2. Hardness test values of Inconel 718

		Test 1	Test 2	Test 3	Test 4	Test 5
Cross cut	Center	147.38	143.63	146.59	149.77	151.39
	Edge	168.50	169.60	168.47	169.40	170.13
Longitudinal		252.08	256.19	260.43	256.70	253.13

Figure 4 presents stress-strain curves obtained for Inconel 718 at 600 and 700°C.

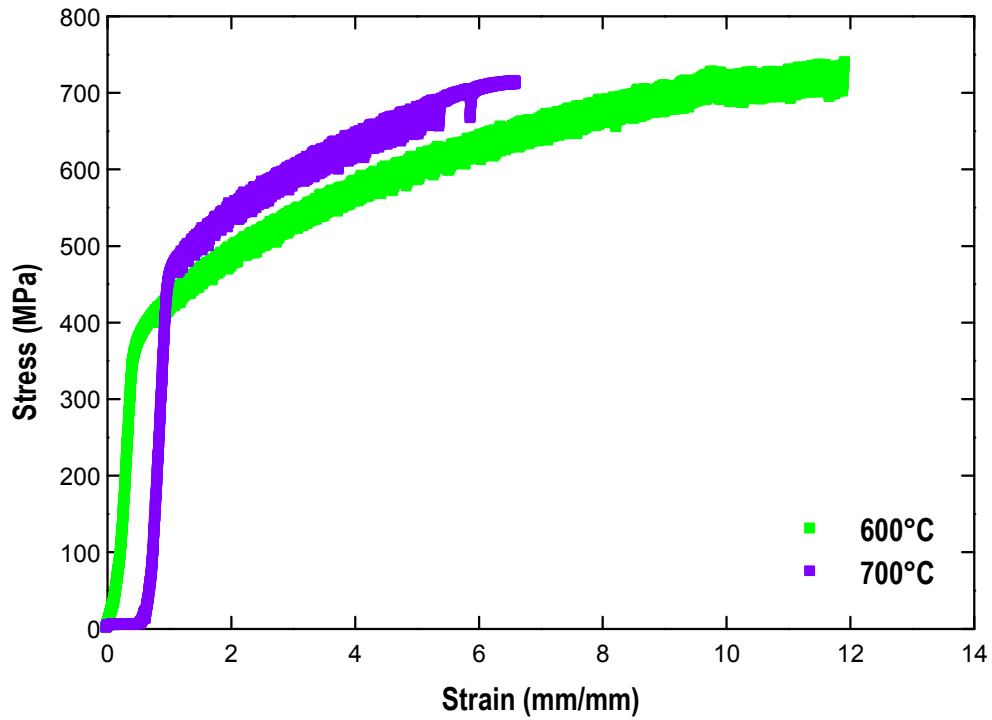


Figure 4. Stress-strain curve of Inconel 718 as received at 600 and 700°C.

Figure 5 presents creep curves obtained for Inconel 718 at 600 and 700°C.

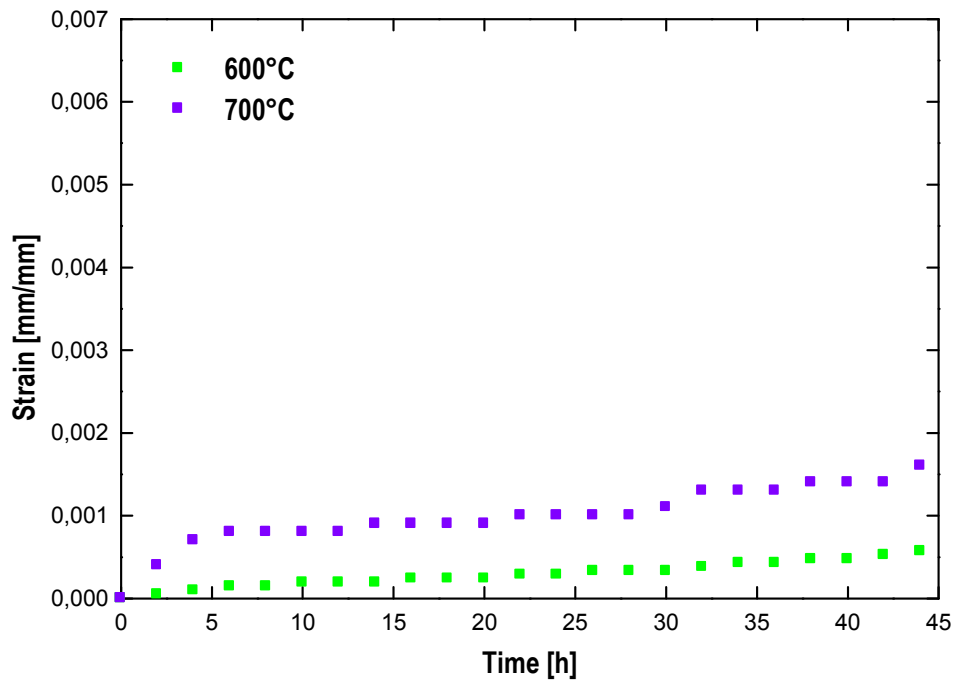


Figure 5. Creep curve of Inconel 718 as received at 600 and 700°C.

In the optical micrographs (Fig. 2 and 3), it was possible observe in the Inconel 718 surface, heterogeneous grains and some precipitates. It was observed a little fraction of carbonates particles distributed irregularly in the matrix. The  $\gamma$  phase appears clearer than  $\gamma'$  due to absence of thermal treatment.

During the hot tensile tests, a typical curve for metals was verified. The low yield point can be explained due the absence of thermal treatment, making the material less resistant to the fracture, as shown in Fig. 4.

The creep behavior presented in the Fig. 5 shows a high resistance of the material due the low stain.

## Conclusion

The superalloy presents a microstructure with heterogeneous grains and some precipitates. The alloy presented a yield point between 450 and 350 MPa at 600 and 700°C, with a typical curve for metals and a high resistance to creep, showing low stain due to recovery of the material.

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