11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Validation of material models for Alloy 718 at elevated temperatures and high strain-rates

T. Sjöberg[1*], K. G. Sundin[1], and M. Oldenburg[1]

[1] Division of Solid Mechanics, Luleå University of Technology, SE-97187 Luleå, Sweden,
*ted.sjoberg@ltu.se

Key Words: *Alloy 718, Validation, Elevated temperature testing, High strain-rate testing.*

The ever growing demand on reduced fuel consumption in modern aircrafts puts high requirements on manufacturers to reduce weight in all parts of the aircraft. With a total weight of up to one fifth of an aircraft's total operating weight, ways to decrease the weight of the engine systems are continuously sought. The containment structure that surrounds the fan and turbine in larger commercial aircrafts is designed to prevent any debris to escape and damage any other systems such as fuel tanks or fuselage in the event that a blade should come off. This structure adds considerable bulk to the engine which means an optimization can save considerable weight. But because of the importance of the containment structure any redesign needs to be rigorously tested. The high costs associated with containment testing means industry is looking into the feasibility of substituting parts of this expensive experimental testing with more economical numerical simulations.

In an effort to find a method to characterize the behaviour of the nickel based superalloy Alloy 718 at the operating conditions of a containment casing surrounding the turbine in a modern civil aircraft engine several experiments have been performed. A high speed VHS machine from Instron was used to perform tensile tests at strain-rates up to 1000 s^{-1}. With the addition of an induction coil the tensile tests were also performed at elevated temperatures up to 650 °C. The data from these tests were then fitted to the widely used Johnson-Cook material model [1]. The resulting parameters obtained were published at COMPLAS XII [2]. In order to verify the accuracy of the parameters obtained for the material model a validation experiment was designed. This validation experiment was based on a reverse impact test, in which thin circular discs were accelerated towards an instrumented long slender rod. The discs were 1.6 mm thick and had a diameter of 46 mm. To accelerate them towards the target an air cannon was used. A carefully designed cylindrical holder guided the specimens towards the target. The cylindrical holder let go upon impact, meaning that it did not interfere with the impact. The target rod had a diameter of 10 mm with a spherical tip. Strain gauges mounted on the target rod captured the force history throughout the impact. A schematic figure of the setup can be seen in Figure 1.

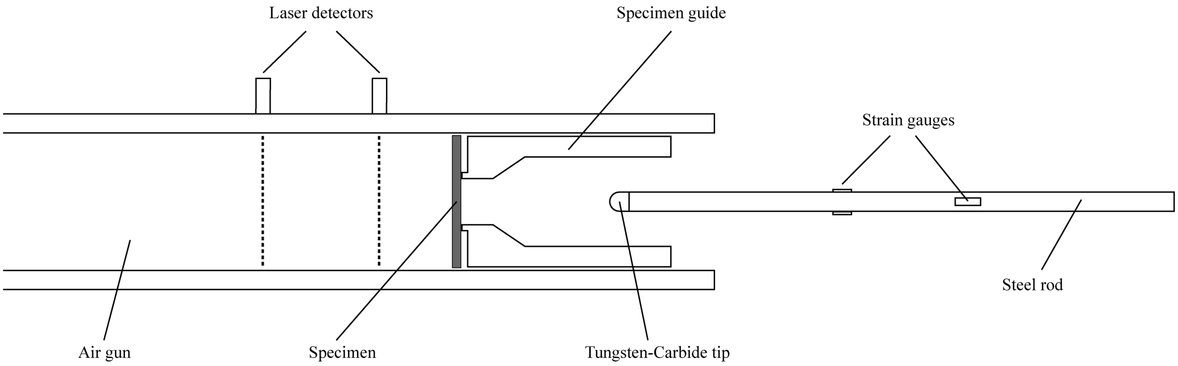

Figure 1. Schematic figure of the experimental setup.

The design of the experiment enabled validation to be performed at high strain-rates. In an effort to expand the validation to elevated temperatures an induction coil was used to heat the projectiles before they were accelerated towards the target. This enabled the validation to be done at conditions closer to an actual blade of scenario within an aircraft turbine. The results from the validation experiments were then compared to simulations performed using FE-analysis in the commercially available code LS-Dyna.

REFERENCES

[1]G. R. Johnson and W. H. Cook, A constitutive model and data for metals subjected to large strains, high strain rates, and high temperatures. *Proc. 7th Int. Symp. on Ballistics*, Hague, Netherlands, 1983.

[2] T. Sjoberg et al, Calibration and validation of plastic high strain rate models for Alloy 718. *COMPLAS XII:* International Conference on Computational Plasticity, 2013.