Thermomechanical behavior of C38LTT in the semi-solid state

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Abstract: *Semisolid thixoforming is an intermediate process between casting and forging. This process presents several advantages, such as energy efficiency, production rates, smooth die filling, low shrinkage porosity, which together lead to near net shape capability and thus to fewer manufacturing steps than with classical methods. So far, there are only few applications of semisolid processing of higher melting point alloys. Steel is a particularly challenging material to semi-solid process because of the high temperatures involved (about 1410°C).*

At present, the ability to form steel components in semi-solid state depends on the control of the flow of material during the forming and defects conditions. Semi-solid alloys display thixotropy, which is characterized by time-dependent behavior which drastically changes from a solid like behavior at rest to a liquid like flow when submitted to shear. However, characterizing and modelling such a behaviour for steels is still challenging.

Ascometal has developed the C38LTT (Low Thixoforging Temperature) that is compatible with identified parameters [1] to be suitable for thixoforming: the solidus and liquidus temperatures (TS and TL) have to be as low as possible; the temperature at 50% liquid fraction (T50%) has to be as low as possible; the melting interval (TL-TS) has to be as large as possible; and the slope at 10% and 50% liquid fraction must be as low as possible to ensure a small sensitivity of liquid fraction to temperature.

The aim of the research work was to study the rheological properties of C38LTT. The high temperature range for semi-solid state makes the experiments particularly challenging. An experimental protocol was determined, geometries of specimens, minimize thermal gradients and optical system to improve the precision of measuring temperature (figure1) with a Gleeble simulator to characterize the thermomechanical behaviors.

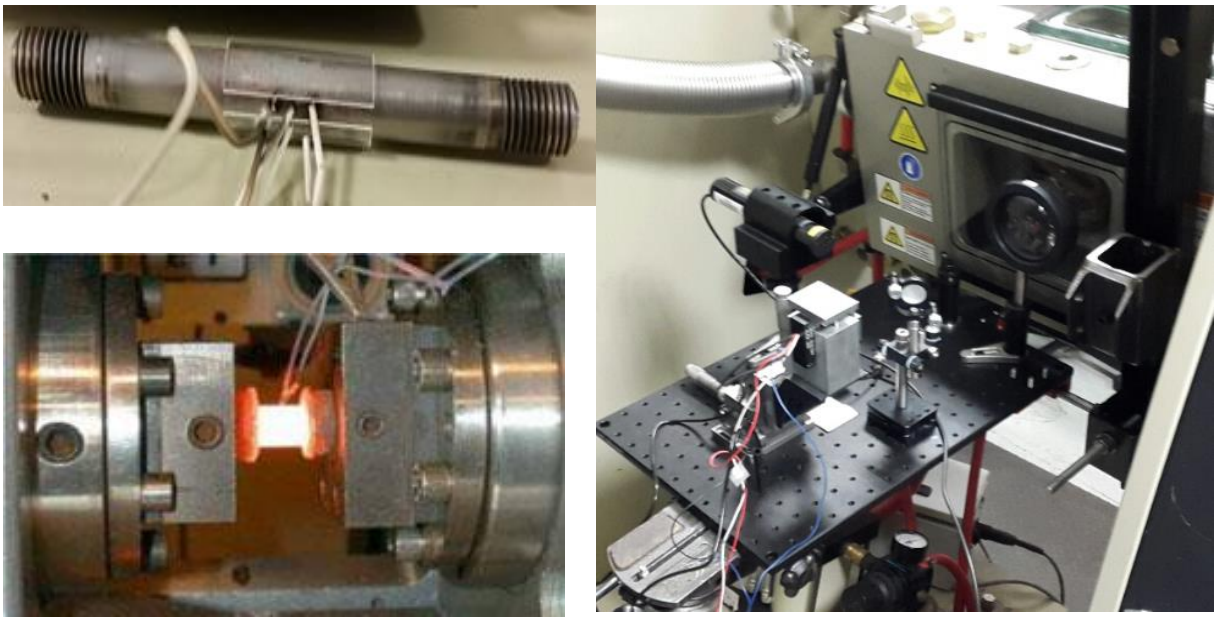

Figure1: Specimens types and Non-Contact Optical System of temperature measure

Uniaxial tensile and compressive tests were carried out on semi-solid specimen having >0.8 solid fraction for different ram speeds and temperatures. The constitutive behavior appears greatly dependent on both fraction solid and strain rate. Furthermore, while the behavior is dominated by the solid phase, the variation in both ductility and stress with temperature has been identified to propose a brittle temperature range and the influence of the temperature on the thermomechanical behavior. Specifically, in tension, a drastic change in ductility with fraction solid/temperature was found in good agreement with some results for aluminum brittle temperature range in literature [2].

Références

[1] FRAIPONT C, LECOMTE-BECKERS J. Alloy characterization to adapt steels to thixoforming: study of a high chromium carbon steel. op. cit.[13] 523-527.

[2] Eliane GIRAUD, Michel Suery 2010, ETUDE EXPERIMENTALE ET MODELISATION DU COMPORTEMENT MECANIQUE D'UN ALLIAGE D'ALUMINIUM 6061 A L'ETAT PATEUX: APPLICATION A LA FISSURATION A CHAUD LORS DU SOUDAGE TIG ET FE, thèse L'Institut polytechnique de Grenoble 2010