

# **Thermomechanical modelling of cold drawing processes of Co-Cr small diameter tubes.**

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Tube cold drawing processes are used to reduce tube diameters and thicknesses, while pulling them through a conical converging die with or without inner plug. An accurate modelling of the material deformation, friction behaviour and thermal effects is required in order to well describe these processes. This study is the follow-up of the work “Tube Drawing Process Modelling By A Finite Element Analysis” presented in the MPMD 2007. It deals with the cold hollow sinking (without inner plug) and the mandrel drawing of Co-Cr alloy tubes of small diameters (typically from 1 to 10 mm). It details the method to obtain all required parameters.

During the forming process, mechanical and thermal measurements are recorded. Load cells are placed between the die and the frame for the drawing force. A thermocouple is placed inside the tube and a pyrometer, fixed on the die exit, records the tube external temperature. When possible, simulation parameters are determined thanks to mechanical or thermal tests. The material properties implied in the process, such as the anisotropy, the rate-dependence or the temperature-dependence are studied. Shear and tensile tests are performed to determine the Co-Cr alloy mechanical behaviour with an isotropic temperature-independent Johnson-Cook law.

The emissivity and the convection of the tube are determined by thermal tests during experimental tests. An infra-red camera is employed to observe the sample temperature rise. As the strain rates are high and the experiments' times are short, heat loss through conduction, convection, or radiation can be neglected in comparison to thermoplastic heating. The plastic work converted into heating is described by the heat equation.

Process parameters such as friction coefficient or contact conductivity are difficult to estimate with mechanical experimental tests. A different approach is therefore proposed here, an inverse analysis is carried out to fit these two last parameters. Indeed they can be fitted through a thermomechanical modelling. The friction coefficient is found with the experimental drawing force and the contact conductance thanks to the external tube temperature. Finally, several drawing tests, with mandrel or not, with different diameters and drawings speeds are modelled with these parameters and compared to experimental data in order to validate the method.