

# DESIGN OF SPECIFIC EXPERIMENTAL TESTS TO EVALUATE FORMABILITY PREDICTION OF COLD DRAWN CoCr TUBES

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High precision small metallic tubes are widely used in medical applications. Tubes for such applications are made by means of a cold drawing process. It consists in progressively reducing the inner and outer diameters of tubes. Small tubes processing requires a specific control of all the forming parameters in order to reach the highest dimensional precision and quality. In the industrial context of continuously improving tube quality and reducing production costs, there is a strong need to deeper understand the mechanisms of cold tube drawing and to determine the limits of the process.

The process understanding gives rise to three main problematics which are strongly linked. The first issue is the material mechanical behavior and more precisely the plastic response that must be known and modeled with a very good accuracy. The second one is the friction between the tube and the drawing tools. Friction is influenced by the nature of the contacting materials, the surface aspect, the drawing speed, and the used lubricant, thus its determination is rather complex. Finally, the last issue is the prediction of the onset of ductile fracture.

In this study, both experimental and finite elements simulations were used for process optimization. Concerning experimental analysis both laboratory and industrial experimental tools were developed.

The material of study was a CoCr alloy namely L605. First the material visco-plastic constitutive equation was characterized by means of pure tensile test at high strain rates close to strain rates reached during drawing process. Second a high pressure tube bulge test was developed in order to reach more complex stress states. Strain, displacement and curvature fields were measured using a stereo-correlation system coupled to tube bulge test. Next stress state fields were evaluated from curvature fields and pressure measurement under membrane hypothesis. The two previous tests were used to calibrate phenomenological failure criteria aiming to predict formability limit. Third, an industrial drawing experiment was specifically developed to study friction between the tubes and the drawing tools and to find formability limit. It consists in a mandrel drawing test in which the mandrel geometry was modified. The newly developed conical mandrel enabled to draw tubes from zero section reduction up to a section reduction leading to fracture.

Parallel to the experimental analysis, finite element modeling of tube drawing was performed. It enabled to determine the friction coefficients through an inverse analysis. Phenomenological failure criteria were computed on the conical mandrel drawing simulations. The fracture loci predicted by the phenomenological ductile failure criteria and the experimentally observed ones were compared quantitatively. A further study was performed in order to evaluate the influence of some forming parameters on tube formability.