

Singularities of tensile behavior of advanced austenitic steels obtained by different cold processes

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Work-hardened titanium stabilized austenitic steels have been chosen as cladding material for ASTRID (Advanced Sodium Technological Reactor for Industrial Demonstration). The cold-worked level and the stabilization by titanium allow delaying the beginning of the swelling under irradiation and make 15Cr-15Ni steel suitable for use up to 110 dpa at least which is the required target for ASTRID first core.

Several fabrication routes involving three cold processes (i.e. drawing, pilgering or swaging) are conducted to produce 15Cr-15Ni cladding tubes. This study investigates the effects of processing paths using various heat treatments and amount of cold work (from 17% to 37%) on the final microstructure and the tensile properties. The microstructure is characterized by examinations in the optical and electron microscopes. Tensile tests are carried out on both longitudinal and circumferential directions by means of respectively tile and ring tensile specimens for temperatures between 20°C and 700°C.

The stress-strain curves show strong temperature dependencies of strength and ductility. Both yield strength and ultimate tensile strength decrease linearly from 600-800 MPa below to 450-550 MPa as test temperature increases from 20°C to 700°C. But, on contrary to most metals, the effect of temperature on ductility is not monotonous, with uniform elongation decreasing between 20°C and 200°C, increasing up to 500-600°C and finally decreasing above 600°C (see Figure 1). Very low uniform elongation is thus measured in both directions at 200°C.

For the same cold worked state, no effect of the different processes could be highlighted. However, the higher the amount of cold work ($\varepsilon \sim 37\%$), the higher the yield strength and the ultimate strength and the lower the uniform elongation.

In the circumferential direction, the levels of strength are slightly higher and the uniform elongations are weaker than those measured in the longitudinal direction, suggesting a low degree of anisotropy.

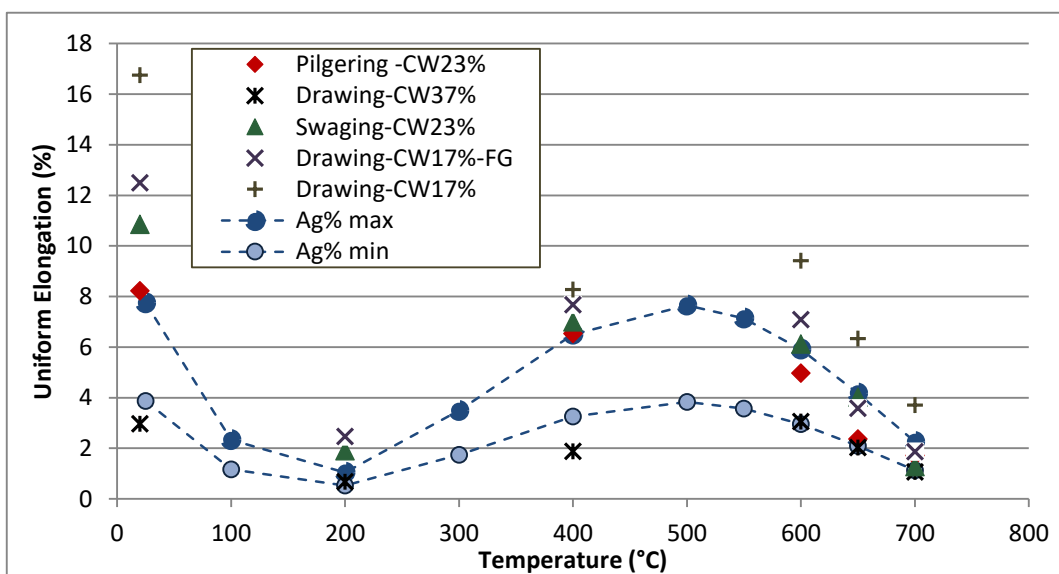


Figure 1: Uniform elongations measured as a function of the temperature and comparison with an interpolated law proposed for 20-25% cold worked 15Cr-15Ni titanium stabilized steel