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Experimental and Numerical Analysis of Butt Welding of Polyethylene Tubes

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Butt welding of polyethylene tubes is widely used for gas or water distribution networks, especially for large tube diameters, for which the competing electrofusion technique becomes expensive. The objective of the work is to combine experimental and numerical thermo-mechanical analyses in order to have a better knowledge of the process.

In a first step, the tips of each tube are heated by contact with a metallic plaque (the mirror). Then the mirror is removed, and the tips are maintained in contact. Welding takes place, and the polymer cools down in ambient air. Different level of forces are imposed on the tubes during the process.

The deformation of the molten polymer due to the applied pressure has been monitored with a video camera. The relative displacement of the two tubes has been measured. Curiously, during the heating phase under pressure against the mirror, the pipes are moving back. This has been attributed to the thermal expansion. Several thermocouples have been inserted at different positions, and allow monitoring the evolution of the temperature.

For the numerical simulation, we used the finite element software package Forge 2. The material is assumed to be a viscous compressible fluid above the melting temperature. The thermal equation is coupled to the mechanical problem, with appropriate boundary conditions (conduction against the mirror, convection and radiation in contact with air), and the enthalpy of fusion or crystallization is taken into account. The resolution of the kinetics equations of fusion or crystallization is coupled to the two first set of equations. The following data have been measured: evolution of the density with temperature, kinetics of fusion and crystallization, rheological data in the solid and liquid domains. Models for the evolution of the data in the transition between solid and liquid have been established.

The results of the computation are compared to the observations and measurements.