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Experimental and Numerical Simulation of Melting and Sintering of a Polymer Powder Bed on a Heated Plate: Application to the Rotational Moulding Process

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The process of rotational moulding consists in manufacturing plastic parts by heating a powder polymer in a mold with biaxial rotation. To decrease the energetic consumption and cycle duration, and to improve the product quality (mechanical properties, surface aspect) , it is necessary to understand complex heat and mass transfer phenomena during the heating and cooling phases. Including the description of such phenomena in models will allow to optimise rotational moulding processes.

In this study, an experimental device has been built. It consists of an open plane static mold on which an initial thickness, e, of a polymer powder is deposited. This powder is then heated until it melts. The geometry of the system has been designed so that heat transfer is 1D in the mold and in the powder which are instrumented with thermocouples in order to measure the temperature variations during the experiment. An inverse heat conduction method is used to determine the heat flux and temperature at the interface between the mold and the powder.

This interfacial heat flux (or temperature) is taken as boundary conditions in a numerical heat transfer model witch takes into account such as heat transfer in granular media with phase change, coalescence, sintering, air bubbles evacuation and crystallization. This fine modelling, close to the real physical phenomena makes it possible to estimate the temperature profile and the evolution of the polymer powder characteristics (phase change, air diffusion, viscosity, evolution of the thermophysical properties of the equivalent homogeneous medium, thickness reduction, air volume fraction...).

Indeed, the predictions of the temperature rise as well as the evolution of the material composition agree well with the experimental data which were obtained. Thanks to this experimental comparison, the numerical model could be validated and some unknown parameters could be identified, like the contact thermal resistance.