Operando X-ray scattering Measurements during the Injection Moulding of Plastics

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Injection moulding is the most common technology employed for shaping polymers. Despite its long history dating back to the 19th century, it remains a remarkably under instrumented technology. The vast majority of quality control and scientific study takes place on products post production. There is a substantial body of studies using simulation, but again there is little data to validate the predicts of simulations. In this work, recent work performed at CDRSP in partnership with the ALBA Synchrotron Light Source in Barcelona focused on developing an industrially relevant operando X-ray scattering during injection moulding capability. The challenges in such a project are identified and the design of the equipment to meet those challenges are described. The capabilities of this equipment when mounted on the NCD_SWEET beamline at ALBA The advantages of operando measurements are identified, in which the different processes are separated in time, rather than consolidated into a single average data set available from post-product analysis. The operando system is equipped with pressure and temperature sensors and we correlate these measurements with the data available from X-ray scattering, which also includes a transmission monitor which enables the thickness of material in the mould cavity to be evaluates as a function of time. We contrast the transformation from the melt state to the solid state for a number of materials including both synthetic and biobased polymers. The scope for dynamic measurements during the moulding cycle is explored and future planned work for detecting moulding defects such as weld lines will be critically discussed. The role of this equipment in enhancing sustainability will be underlined.