

# **Abstract- Ph.D Thesis Umberto Vietri**

## **IX° Ciclo Doctorate Chemical Engineering**

English Version

*The quality requirements of injection-moulded components have become more stringent because of the growing applications of plastics and increasing customer demands. The quality of the moulded parts depend on the processing conditions and this creates a continuous demand for developing advanced techniques for monitoring and controlling the process. The current practice in industry is to adjust the parameters based on the product defects through trial and error, starting from information from the material supplier, mould designer, and, largely, on the basis of the moulding engineer's (or setup person's) own experience. Nevertheless, defects can occur in moulded parts due to, for instance, the variation in material properties (particularly when reground or biodegradable resins are used), the change in environmental conditions (e.g., humidity or temperature in the surroundings), and the machine characteristics (particularly those using hydraulic power). In this case, the process conditions have to be readjusted in order to re-establish the part quality targets. To overcome these difficulties, injection moulding quality control has been the subject of many off-line and on-line quality control studies. The purpose is to achieve automatic and adaptive quality control able to guarantee a stable and repeatable process, from the part quality point of view.*

*Temperature and pressure transducers are increasingly employed in the industry; therefore the use of their measurements to obtain indications concerning the product quality could overcome the traditional resistance of industry to introduce new sensors in their production. Cavity pressure is often considered the dominant factor determining the quality of the final product in injection moulding. A great deal of software for the control of quality and of cycle reproducibility is based on the comparison of the cavity pressure profile with a reference: when the profile substantially diverges from the one chosen as a reference, the cycle is considered not consistent with the specification and the part is often rejected.*

*In this work, an attempt is made to identify a single parameter (using the cavity pressure and temperature signals) satisfactorily correlated with chosen quality parameters (i.e. in-plane shrinkage), in order to give a useful approach regarding on-line quality control in the injection moulding process. To reach this goal, a series of injection moulding tests have been conducted on several polymers, changing holding pressure and time, injection time, mould and injection temperature, nozzle length, gate and cavity thickness. The pressure histories and the temperature evolution at the interface with the mould at several positions along the flow-path were measured by means of pressure-temperature transducers. The samples were measured after moulding, in correspondence to the transducer positions and width shrinkage was assumed to be the target quality parameter. It was demonstrated that even the complete pressure curve cannot be adopted as a suitable parameter correlated with these quality features, and a criterion based on the reproducibility of the*

*pressure profiles can cause the rejection of parts which are consistent with quality parameters. A different approach was thus considered, which basically consists in the determination of a single parameter, namely the local average solidification pressure  $P_{s\_av}$  (the average over the thickness of the pressures at which each layer solidifies locally) which requires knowledge of both the local pressure history and the local solidification history. By plotting width shrinkage data versus the average solidification pressure values,  $P_{s\_av}$ , it was demonstrated that this parameter is adequate for describing the quality of moulded parts.*

*Since the solidification history is not experimentally obtainable, a procedure was developed to obtain it directly with the local experimental pressure profile. The analysis was carried out using different materials: a Polystyrene, a Polycarbonate and Polypropylene.*

*A different parameter was detected for correlating with the part weight data. In fact it was observed that for samples having a positive average width shrinkage, weight is directly related to width shrinkage, and thus to  $P_{sav}$ . However, for samples showing an expansion, the correlation was poor and a further analysis was needed. With regard to this, as suggested in the literature, it was shown that cavity deformation plays a pivotal role, so the normalized part weight can be directly correlated with the average pressure inside the cavity at the instant when the gate solidifies, namely,  $P_{gf}$ . This approach used for analyzing sample weight data was adopted for all polymeric materials considered and led to a satisfactory result for our purpose.*