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Morphological and mechanical analysis of polypropylene (PP) injected in moulds with different thermal characteristics

Due to intensive demands for polymeric prototype testing and the growing popularity of personalized products a higher interest is noted for the production of smaller batches in the polymer processing industry. This small quantity production of polymeric parts can be at first side economically realized within a short time span by many rapid prototyping techniques. However, in case a sufficient number of parts are required, these production methods are time-consuming and expensive. Shifting the rapid prototyping technique from manufacturing the parts to manufacturing the production tools such as hybrid mould inserts would pose the ideal solution. In this research, the use of additive manufacturing techniques to produce inserts for hybrid injection moulds is therefore investigated and compared with non-convention steel mould materials, with a focus on the effect of their different thermal behaviour on the final injected part properties.

The alternative mould inserts explored in this research are based on multi-jet fusion (MJF) polyamide eleven (PA11). This material has a much lower thermal conductivity than the conventional mould steel which is used for comparison. The focus of the study relies on the effect of the mould material and its thermal behaviour on the properties of polypropylene (PP) injected parts. PP is a semi crystalline material frequently used in the polymer industry, being its structure affected by the processing conditions applied. Two PP types were chosen for comparison, namely PP ho-mopolymer and PP with a nucleating agent. ISO 527 1BA tensile bars and ISO 179 impact bars have been produced via injection moulding considering both mould materials. The mechanical properties were determined by executing a tensile and impact test in a conditioned room, possessing a temperature of 23 °C and humidity of 50%, and the has been morphology accessed by optical microscopy techniques.

The results show a great influence of the mould material on the final PP homopolymer morphology. Slower cooling given by PA11 moulds causes a homogenous morphology. This results in a lower Young's modulus and tensile stress at 0.2% yield for the homopolymer. Also, the strain at break is much smaller since the rough surface structure of the PA11 mould initiates regions of high localized stress. The PP with the nucleating agent has a very similar morphology if produced in the steel or PA11 mould. This results in an equal Young's modulus comparing both parts. The stress at yield is however be 16% lower compared to parts made in a steel mould. Furthermore, voids are observed inside the part due to the cooling gradients in large thickness parts such as those of 10 mm x 4 mm thick impact bars. For tensile

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