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Topic of Research: Performance analysis of Injection Moulded materials for automotive Segments

Findings

In order to model and optimize the mechanical properties of plastic products, the tensile specimens (ASTM D638 Type I) made up of isotactic polypropylene (iPP) were moulded on a table top microinjection moulding machine, the moulded specimens were tested on universal testing machine to generate data on various mechanical properties, the results of the experiment-based investigation were summarized under the three heading viz. Screening experimentation, process window development for iPP tensile specimen and RSM-FCCCD based study to optimize the tensile properties of the iPP specimen. The important findings of the three studies are as under,

- The screening result shows that the degree of significance of process parameters is different for each mechanical response. So, for each mechanical response of interest, the process parameters should be considered as per their degree of significance shown in Table 5.6. The result shows that the separate analysis has to be performed for each mechanical response according to their order of significance of the process parameters and for having optimum result for the mechanical properties under discussion. This may be due to the fact that a large number of parameters (more than 100) are involved in transforming the raw material in the form of pellets into the final product (Bryce, 1996). Moreover, it has been observed during the literature survey that the findings of the researchers are not consistent in regard to significant process parameters for an injection moulding process. So, selection of only a few critical process parameters (factors) for further detailed investigation can be made based on the literature or the experience of the moulding personnel.
- Several studies have been conducted to determine the Process window (PW) i.e., feasible processing zone with no short shot and flashes, since the quality of the moulded part is greatly influenced by the specific volume and the condition under which the part has been processed. Researchers have applied various ways with different factors and combinations to know that boundary condition which leads to no short shot (mould underfil) and flashes condition during moulding.

  Table 6.1 provides information regarding feasible processing ranges of the factors for iPP tensile sample developed on micro IM machine (Make- babyPlast, Model- 6/10P), within which the cosmetically acceptable parts are obtained. Table 6.1 have been used to develop three moulding area diagram (MAD) at three distinct mould temperature whereas joining the corresponding corner points of the three MADs have resulted in the development of the 3D envelop called as the moulding volume diagram (MVD) i.e., process window in 3D, using fusion360 software.

  The melt temperature, holding pressure and mould temperature are plotted against x, y and z axis respectively to obtain the moulding volume diagram. The coordinate of the centre of the moulding volume diagram is found to be at: **54.33°C** of mould temperature, **226.50°C** of melt temperature and **90.65 bar** of holding pressure, which has been determined using fusion360 software. Once the centre of the MVD is obtained, one can set the moulding process parameters at the centre of the PW to develop a process which is robust, repeatable and reproducible. Knowledge of MVD for a particular material part and over a specific IM machine will also be helpful in determining the optimized value for each mechanical response under investigation within moulding volume diagram.

- The global maximum for ultimate tensile strength is achieved at 50°C of mould temperature (i.e., Fig. 7.7(ii): a). So it is recommended to use 50°C of mould temperature, ~ 240°C melt temperature and 55bar of holding pressure, to get the optimum ultimate tensile response value (**42.23 MPa**) for isotactic polypropylene (iPP) mouldings.
- The global maximum for stiffness is achieved at 50°C of mould temperature (i.e., Fig. 7.8(ii): a). So it is recommended to use 50°C of mould temperature, ~ 235°C melt temperature and ~55bar of holding pressure, to obtain maximum stiffness of **356813 N/m** for isotactic polypropylene (iPP) mouldings.
- The global maximum for Young's modulus is achieved at 50°C of mould temperature (i.e., Fig. 7.9(ii): a). So it is recommended to use 50°C of mould temperature, ~ 235°C of melt temperature and ~55bar of holding pressure, for optimum Young's modulus (**775.495MPa**) of tensile samples made up of isotactic polypropylene (iPP).
- The global maximum for breaking strength is at 50°C of mould temperature (i.e., Fig. 7.10(ii): a). So it is recommended to use 50°C of mould temperature, ~ 242°C melt temperature and 135bar of holding pressure, to obtain the most optimized value of breaking strength (**4.39696E+07MPa)** for isotactic polypropylene (iPP) tensile specimen.
- The global maximum for strain at break is achieved at 70°C of mould temperature (i.e., Fig. 7.11(ii): c). So it is recommended to use 70°C of mould temperature, 260°C of melt temperature and ~80bar of holding pressure, to obtain the optimum value of strain at break **(0.261466)** for isotactic polypropylene (iPP) moulding.
- The global maximum for toughness is obtained at 70°C of the mould temperature (i.e., Fig. 7.12(ii): c). So it is recommended to use 70°C of mould temperature, 260°C melt temperature and ~85bar of holding pressure, to obtain the optimum value of work to break **(29921.7N-mm)** for iPP mouldings.