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Novel Framework for MIMO-Enhanced Robust Selection of Critical Control Factors in Auto Plastic Injection Moulding Quality Optimization

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Abstract : Apparent quality defects such as warpage, shrinkage, weld line, etc. are such an irresistible phenomenon in mass production of auto plastic appearance parts. These frequently occurred manufacturing defects should be satisfied concurrently so as to achieve a final product with acceptable quality standards. Determining the significant control factors that simultaneously affect multiple quality characteristics can significantly improve the optimization results by eliminating the deviating effect of the so-called ineffective outliers. Hence, a robust quantitative approach needs to be developed upon which major control factors and their level can be effectively determined to help improve the reliability of the optimal processing parameter design. Hence, the primary objective of current study was to develop a systematic methodology for selection of significant control factors (SCF) relevant to multiple quality optimization of auto plastic appearance part. Auto bumper was used as a specimen with the most identical quality and production characteristics to APAP group. A preliminary failure modes and effect analysis (FMEA) was conducted to nominate a database of pseudo significant significant control factors prior to the optimization phase. Later, CAE simulation Moldflow analysis was implemented to manipulate four rampant plastic injection quality defects concerned with APAP group including warpage deflection, volumetric shrinkage, sink mark and weld line. Furthermore, a step-backward elimination searching method (SESME) has been developed for systematic pre-optimization selection of SCF based on hierarchical orthogonal array design and priority-based one-way analysis of variance (ANOVA). The development of robust parameter design in the second phase was based on DOE module powered by Minitab v.16 statistical software. Based on the F-test (F 0.05, 2, 14) one-way ANOVA results, it was concluded that for warpage deflection, material mixture percentage was the most significant control factor yielding a 58.34% of contribution while for the other three quality defects, melt temperature was the most significant control factor with a 25.32%, 84.25%, and 34.57% contribution for sin mark, shrinkage and weld line strength control. Also, the results on the he least significant control factors meaningfully revealed injection fill time as the least significant factor for both warpage and sink mark with respective 1.69% and 6.12% contribution. On the other hand, for shrinkage and weld line defects, the least significant control factors were holding pressure and mold temperature with a 0.23% and 4.05% overall contribution accordingly.

Keywords : plastic injection moulding, quality optimization, FMEA, ANOVA, SESME, APAP
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