Modelling and monitoring in injection molding

This thesis is concerned with the application of statistical methods in quality improvement of injection molded parts. The methods described are illustrated with data from the manufacturing of parts for a medical device. The emphasis has been on the variation between cavities in multi-cavity molds. From analysis of quality measurements from a longer period of manufacturing, it was found that differences in cavities was that source of variation with greatest influence on the length of the molded parts. The other large contribution to the length variation was the different machine settings. Samples taken within the same machine set-point did not cause great variation compared to the two preceding sources of variation. A simple graphical approach is suggested for finding patterns in the cavity differences. Applying this method to data from a 16 cavity mold, a clear connection was found between a part's length and the producing cavity's position in the mold. In a designed experiment it was possible to isolate the machine parameters contributing to the variation between cavities. Thus, with a proper choice of levels for the machine variables, it was possible to reduce the variation between cavities substantially. Also an alternative model for the shrinkage of parts from a multi-cavity mold is suggested. From applying the model to data from a shrinkage study, it seemed that the observed part differences were not only due to differences in cavity dimensions. A model for the in-control variation for a multi-cavity molding process was suggested. Based on this model, control charting procedures have been suggested for monitoring the quality of the molded parts. Moreover, a capability index for multi-cavity molds has been suggested. Furthermore an alternative method for in-line quality charting is suggested. The method is for continuous control by attributes, and it is an alternative to the batch oriented approach mostly used. The procedure is especially efficient for quality requirements of very low proportion non-conformities. For the proposed charts the ARL function is derived. It is shown that in the case where a non-conforming unit is only expected very rarely during sampling, a moving sum chart and a CUSUM chart are equivalent. Finally, the correlation structure of 21 process variables has been studied prior to monitoring the process. It is illustrated how the process can be analysed with multivariate techniques. It was found that two principal components reflected changes in machine set-points. Thus, there seems to be great potential in monitoring the process variables using a multivariate approach.

General information
State: Published
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Publication date: Apr 2001

Publication information
Original language: English
Electronic versions:
imm788.pdf
URLs:
Source: orbit
Source-ID: 58005
Research output: Research › Ph.D. thesis – Annual report year: 2001