Dynamic Feed Control for Injection Molding

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An innovative process for manufacturing plastic parts can eliminate the need for retooling and can reduce product development time, while increasing the product quality and process capability.

In many facilities, the current molding process cannot meet these customer requirements, resulting in long product development cycles, excessive tooling costs, low process yields, and inferior product quality.

Concept Description

Dynamic Feed Control is a new method to increase the number of degrees of freedom available in injection molding. Many potential approaches are possible for this concept, but the most generic approach is to provide a way to instantly modify the diameters in each branch of a runner system. As the figure shows, the diameters are modified by positioning a tapered valve stem with a hydraulic actuator. Because the resistance to flow is determined by the gap thickness between the valve stem and the mold wall, the valve stem can be axially displaced to dynamically vary the flow rate and pressure drop through each valve. If used in a closed-loop control system, Dynamic Feed Control directly controls either valve positions or cavity pressures.

Introduction

Injection molding is the most heavily used production process for manufacturing plastic commercial goods because of its ability to quickly form complex shapes that require no finishing operations. However, molders are manufacturing increasingly complex part shapes with thinner wall thicknesses, more precise dimensional tolerances, and more stringent quality control measures.

Dynamic Feed Control introduces three new characteristics that provide extra degrees of freedom to the molding process. First, independent control of each valve allows the process dynamics in each area of the cavity to be isolated. Previously, changes to improve an area of the part being molded often produced other detrimental effects. Second, the valves can be repositioned within the molding cycle. For example, one set of valve positions could profile flow rates in the filling stage and a different set of valve positions could profile pack pressures.
Finally, the valves can be controlled with feedback from process sensors in the mold cavity; this provides closed-loop control of multiple, cavity-state variables that directly determine the product quality. Variation in machines and materials can be compensated for by adjusting the valves to produce consistent parts. Moreover, by controlling the cavity variables, pressure measurements can be used as a process control technique to automatically detect quality problems, eliminating the need to manually inspect the parts.

**Economics and Market Potential**

Conventional injection molding has tool and die costs for technical applications (such as automotive body panels and instrument panels) typically from $100,000 to $500,000, which might include 30% for rework. Between start-up and common defects, process yields are typically between 70% and 90%. For production quantities of 100,000 units, a typical application has $150,000 cost from unacceptable mold and/or part quality. This total does not consider the cost of engineering time, production downtime, or loss in sales from production delays.

Dynamic Feed Control promises to significantly increase process yield, while providing the process flexibility to eliminate some of the required tooling changes. For larger production runs, the concept has potential savings of $100,000 per application. The concept has two implementation costs. First, each application requires an additional tooling cost of $2,000 per gate (list price) for modifying the mold and for inserting the process instrumentation. Second, a control system is needed while the application is in production; multiple applications could use the same control system if they’re not in production simultaneously. The control system consists of capital equipment—hydraulic servos, electronics, and control logic.

Total start-up costs for bringing Dynamic Feed into a molding house would be $60,000. However, once installed, other applications using the technology would impose lesser costs of $10,000 per application for instrumentation and installation on a typical 4-drop mold. Moreover, if the technology becomes pervasive, the control system could easily be imbedded in the molding machine controller, reducing tooling costs. Compared with conventional tooling, the technology could impose only a $50 increase per gate in injection molding equipment costs.

Retrofits offer a large potential market for Dynamic Feed Control, both for molding machines and current tools in production. Many current molding machines do not have feedback control of process variables and provide little feedback on the current production quality. To remain competitive, molders must upgrade their technology and purchase new molding machines ($200,000 to $500,000). This purchase could be eliminated because Dynamic Feed controls the injection molding process and exceeds the capabilities of even new molding machines.

**Future Development Needs**

Concept validation has been completed, and proof of concept and process capability have been established. Now, a system needs to be implemented in production and a prototype developed. This involves a one-year timeframe and a $400,000 investment, originating from several sponsors. After initial validation, a more robust control system will be developed as a production-ready prototype. This effort will involve integrating robust hydraulic and electrical subsystems into a rugged, transportable unit for a variable number of drops. The current control system will need to be expanded to include a simplified, graphical user interface and multi-drop control algorithm. Commercial units could be available in two to three years.

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