Technical Papers

Regional Technical Conference

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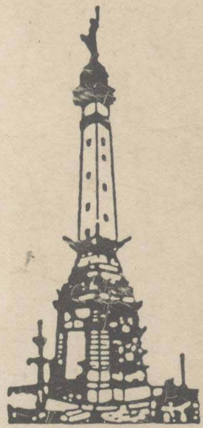

"Modern Techniques for Molding and Mold Making"

November 8-9, 1984

Hyatt Regency Hotel
One South Capitol Avenue
Indianapolis, Indiana

"MODERN TECHNIQUES FOR

MOLDING AND MOLD MAKING"

Regional Technical Conference
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CENTRAL INDIANA SECTION
SOCIETY OF PLASTICS ENGINEERS, INC.

November 8, 9, 1984

"MODERN TECHNIQUES FOR MOLDING AND MOLD MAKING"

Regional Technical Conference

Program

Thursday, November 8, 1984

8:00 a.m. to 9:00 a.m.	- Registration and Coffee
9:00 a.m. to 9:15 a.m.	- Opening Remarks and Introductions, Dr. Leonard Drexler, Chairman; Mr. Lindsey Hahn, Program Chairman and Moderator; Mr. John Kretzschmar, SPE Executive Committee

Morning Session

9:15 a.m. to 10:00 a.m.	- "Design of Hot Runner Systems", Mike Urquhart, Husky
10:00 a.m. to 10:30 a.m.	- "Advances in Vented Barrel Injection Molding of Thermo Plastics", Bill Hammond - Sales Manager, HPM Corp.
10:30 a.m. to 10:45 a.m.	- Coffee Break
10:45 a.m. to 11:15 a.m.	- "Robotics and Automatic Parts Removal for Injection Molding", Russell I. Peterson - Products Manager, Conair, Inc.
11:15 a.m. to 12:00 Noon	- "Increasing Productivity By The Use of Computerized Production Monitoring Systems", Lawrence J. Mercugliano - Vice President Sales, Control Process, Inc.

Afternoon Session

12:00 Noon to 1:30 p.m.	- LUNCHEON How much storage space do you use to store obsolete molds?, State Senator, Richard V. Miller "How State Governments have Responded to This Long Overlooked Problem"
1:30 p.m. to 2:15 p.m.	- "Cartridge Valve Hydraulics For Injection Molding Machines", Michael W. Green - Technical Services, Cincinnati Milacron
2:15 p.m. to 2:45 p.m.	- "Methods for Monitor and Control of Clamp Tonnage on Toggle Machines", Dennis K. Rideout - Senior Process Control Engineer, D.M.E. Company, presented by Micheal Kochajda
2:45 p.m. to 3:00 p.m.	- AFTERNOON BREAK
3:00 p.m. to 4:30 p.m.	- "Mold Design - A Partnership Between Material Supplier, Toolmaker and Molder" - Panel Discussion
4:30 p.m. to 7:00 p.m.	- Vender Displays/Free Hors'doevres in Exhibition Area

Morning Session

Friday, November 9, 1984

8:00 a.m. to 9:00 a.m.	- Registration and Coffee
9:00 a.m. to 9:45 a.m.	- "Justifying A Quick Change Mold System", Bernie O'Donnell Regional Sales Manager - Van Dorn Plastic Machinery Co.
9:45 a.m. to 10:30 a.m.	- "Touch Screen Technology for Plastics Processing", Michael Hamilton - Robinson Equipment and Barber-Colman Company
10:30 a.m. to 10:45 a.m.	- COFFEE BREAK
10:45 a.m. to 11:30 a.m.	- "Computer Numerically Controlled EDM Machines", Clive Greatorex - District Sales Manager - Charmilles Technologies Corp.
11:30 a.m. to 12:00 Noon	- "On Line Quality Control for Injecting Molding", Andrew M. Fricke - Director, North American Sales, Hunkar Laboratories, Inc.

ADJOURNMENT

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TABLE OF CONTENTS

DESIGN OF HOT RUNNER SYSTEMS

BY

MICHAEL URQUHART

HUSKY INJECTION MOLDING SYSTEMS LIMITED

BOLTON, ONTARIO, CANADA

DESIGN OF HOT RUNNER SYSTEMS

In order to ensure efficient molding operation, hot runner systems should be designed to meet the following objectives:

* Equal flow and pressure to each cavity.
* Minimum pressure drop from the sprue to the cavity.
* Uniform heat distribution through the runner.
* Minimum heat loss and allowance for thermal expansion.
* Good cavity support.
* Reduced maintenance requirements.

BALANCED SYSTEM

A balanced hot runner system provides equal flow and pressure so the molten plastic is delivered under identical conditions to each cavity. Non-uniform resin flows that occur when systems are very unbalanced can create part quality problems.

Systems are balanced by having equal flow lengths and the same numbers of bends to each cavity. Systems with any number of cavities can be balanced. In some cases, however, this would require arranging the cavities along the perimeter of a circle, leaving a large area in the middle of the mold which is wasted. This can be avoided by designing systems around numbers of cavities which can be balanced while making efficient use of mold space - for example, 2, 4, 6, 8, 12, 16, 24, 32, 36 and 48.

Hot runner systems with higher numbers of cavities can be balanced by having resin flow to cavities on two levels. In the case of a 16 cavity mold, for example, resin from the machine nozzle can be distributed on one level through four melt channels which in turn each feed one group of four cavities on the second level. In effect, four 4-cavity balanced systems are created.

MINIMIZED PRESSURE DROP

A hot runner system designed to minimize pressure drop will reduce the injection force requirements. In order to minimize friction losses, melt channels should be round and have smooth sides. Sharp corners should be avoided.

The latter can be accomplished by machining a curvature into hot runner plugs. This not only reduces friction losses, but eliminates dead areas where the resin is stagnant and susceptible to degradation.

Systems which have heating elements inside melt channels, creating annular resin flow, have several disadvantages;

* Since the resin flows in an annulus, it is exposed to two friction surfaces - one at the outer wall of the melt channel and the second at the surface of the heating element. Melt channels must intersect at right angles to accomodate cartridge heating elements, creating sharp corners which increase friction losses further and create dead areas. The result is a high pressure drop.

* To reduce the pressure drop, such systems have larger melt channels. The result is a large resin inventory, more resin to decompress and therefore more material losses through drooling at the gate or the sprue bushing, and slower color changes.

UNIFORM HEATING

A well designed heating system which provides uniform heat distribution throughout the hot runner system is important in maintaining a homogeneous melt.

Uniform manifold heating can be achieved by milling grooves into the top and bottom surfaces of the manifold, equidistant from each cavity (see Figure 1). Tubular heating elements, which maintain a uniform temperature along their length, can then be bent to follow this shape, and pressed into the grooves.

The use of band heaters with resistance accuracy to within +/- 1% will provide uniform heating to all nozzles.

This combination of uniform nozzle and manifold heating and the balanced runner system will allow all nozzle heaters to be controlled with a single heat controller. Either a manual percentage time or Variac controller, or an automatic controller with a single thermocouple can be used.

INSULATION AND THERMAL EXPANSION

Hot runner systems should be designed to minimize heat losses - maintaining uniform heat distribution and reducing energy requirements - while allowing for thermal expansion to ensure that no filling problems occur due to misalignment. A manifold completely surrounded by an insulating air gap and supported only on the nozzle housings and insulators will accomplish this (see Figure 2).

The conductive heat losses from such an arrangement will be much greater than convective heat losses. The heat loss from the system can therefore be minimized by keeping the cross sectional area of housings and insulators as thin as possible, and by making these thin sections as long as possible.

Once the system is running, most of the heat needed to maintain the melt temperature through the nozzle housing is supplied by conduction from the manifold and resin.

As a manifold heats up, it undergoes thermal expansion. With the center of the manifold held in the manifold plate by the sprue insulator, the manifold expands equally in all directions. As expansion occurs, the manifold slides across the nozzle housings and insulators, which are held tightly in pockets in the manifold plate and manifold backing plate respectively.

In the cold condition, a clearance should be designed between the housing, manifold and insulator, and the pockets in the manifold plate and manifold backing plate (see Figure 3). Once the system undergoes thermal expansion, the manifold is supported between the insulator and the housing.

Since the manifold is allowed to slide across the nozzle housing, the nozzle tip position relative to the gate does not change as the system heats up, except that the tip expands directly towards the gate. This eliminates the need for the mold designer to calculate thermal expansion in order to ensure accurate alignment of the tip of the nozzle with the gate. The system should be designed so that the melt channels in the manifold and the nozzle are aligned in the hot condition. This requires only a one-time thermal expansion calculation by the manifold manufacturer.

Accurate alignment is less critical at the manifold/housing interface than at the nozzle/gate interface due to the sizes of the channels at the two locations. At the gate, which typically has a diameter in the order of .040" (1.0 mm), a misalignment of only .002" (.05 mm) can cause filling problems. At the manifold/housing interface, such a misalignment will not cause any problems. Therefore, if manifold temperatures must be varied for different grades of material, nozzle misalignment is not a factor.

CAVITY SUPPORT

Good cavity support ensures that the cavity plate will not deflect during clamping and injection. Manifolds should be designed to be as narrow as possible, and placed in machined pockets in the manifold plate which closely follow the outline of the manifold. This maximizes the area in the plate around the manifold available for cavity support (see Figure 4).

With large manifolds, holes can be made in the manifold which support pillars in the manifold plate can pass through. This provides cavity support in the large open area in the middle of the plate.

Some hot runner systems bolt the manifold directly onto the plate. Manifolds must then be wide enough to accomodate the bolts around each cavity, resulting in less manifold plate area available for cavity support, and this also increases the heat loss to the plates.

Still other systems suggest the use of spacer blocks to frame the hot runner manifold, eliminating the manifold plate. The result of this approach is an even larger open rectangular area which provides no cavity support.

MAINTENANCE

Maintenance can be reduced with a well designed hot runner system.

Good cavity support minimizes cavity plate deflection and reduces wear on mold tapers.

A cooling circuit can be built into the manifold plate, separating the hot runner and the cavities. This allows the cavities and the cores to be kept at the same temperature, eliminating different rates of thermal expansion, which can cause wear on the interlocking faces of the mold.

Nozzles should be designed so gates can be cleaned and nozzle tips or heaters changed while the mold is in the machine. Cavities can be individually removed or the cavity plate can be moved forward away from the manifold plate to expose the nozzle tips (see Figure 5).

ADVANTAGES OF A COMPLETE SYSTEM

Hot runner systems which are completely assembled with manifold plates and are fully wired, require no "buyer engineering". They are easily aligned and bolted to the rest of the mold, and can be fully tested before delivery. This simplifies mold start-up.

SUMMARY

Hot runner systems should be designed to ensure part quality, minimize energy requirements, and reduce downtime due to maintenance.

Balanced flow and uniform, accurate heating, both in the manifold and the nozzles, will allow all the nozzle heaters to be run with only one controller. Smooth melt channels and rounded bends will minimize the pressure drop through the system and eliminate dead spots where resin can degrade. A small resin inventory allows fast start-up or color changes, and reduces drool.

Well designed hot runners minimize heat losses and eliminate filling problems due to inaccurate alignment of nozzles and gates.

Downtime can be reduced by reducing mold wear and allowing gates to be cleaned and heaters to be changed while the mold is in the machine.

M. Urquhart/vkh
November 24th, 1983.

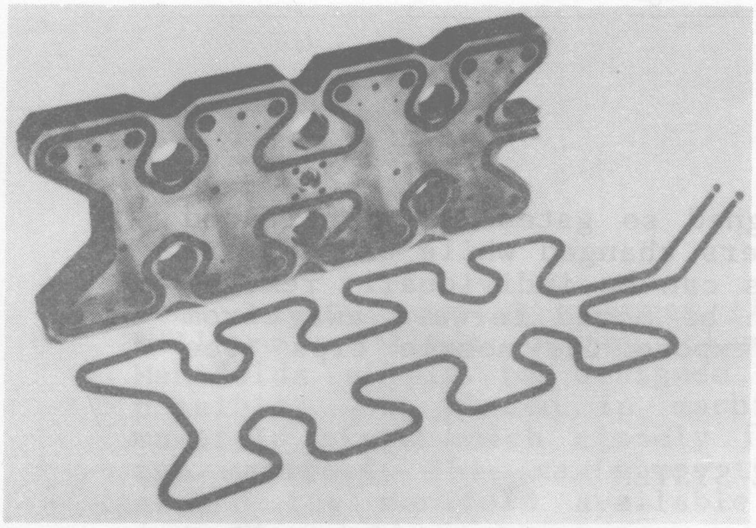

Fig. 1

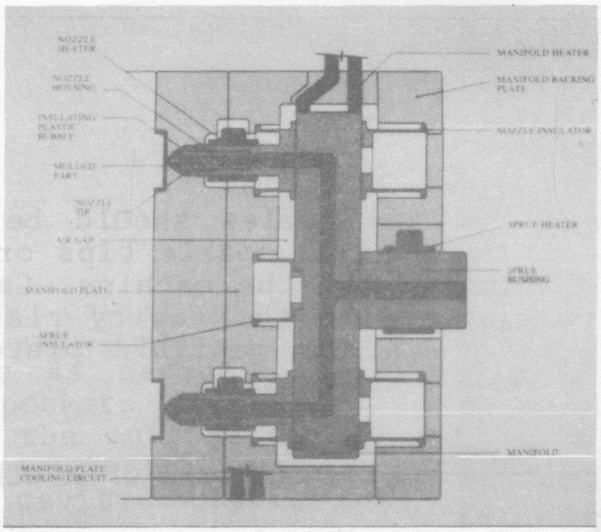

Fig. 2

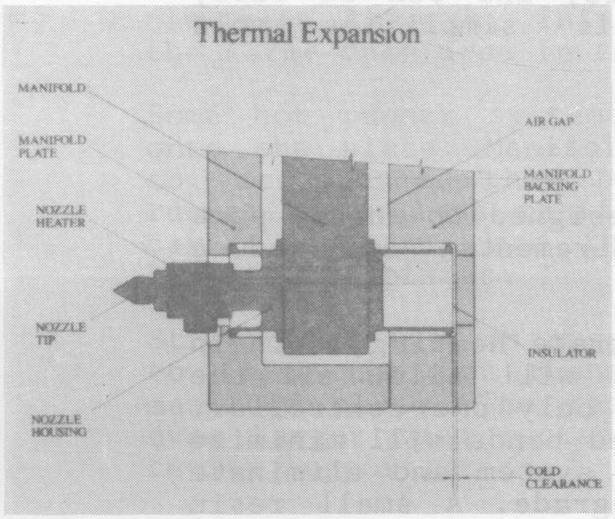

Fig. 3

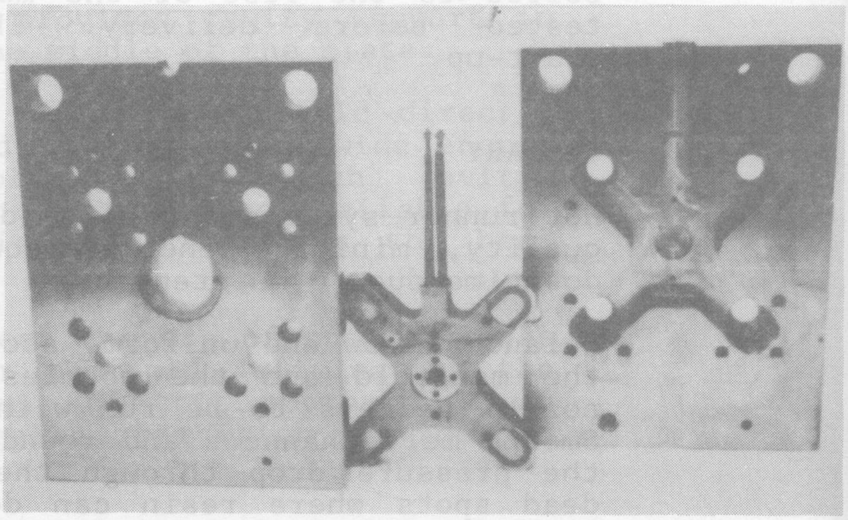

Fig. 4

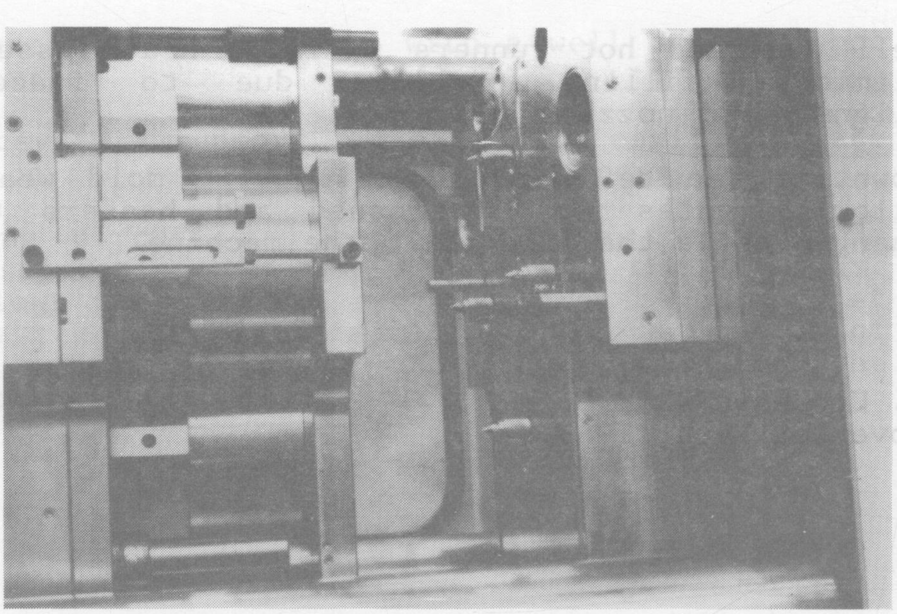

Fig. 5

ADVANCES IN VENTED BARREL INJECTION MOLDING OF THERMOPLASTICS

BY

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Society of Plastics Engineers
Indianapolis, IN
November, 1984

INTRODUCTION

Many engineering thermoplastics are hygroscopic in nature and may produce unacceptable product unless entrained moisture is removed prior to molding a part. In some cases, excessive moisture content may produce appearance defects. In others, losses in physical properties may occur due either to the formation of macroscopic defects or chemical changes in the material composition. One approach to removing entrained moisture is by predrying the material prior to its introduction to the molding machine. However, in most cases, a more viable approach is the use of a vented barrel molding machine without predrying. With this approach, rapid devolatilization of the polymer is achieved directly from the melt. This is accomplished through the use of a specially designed two-stage screw. The first stage of the screw performs the operations of feeding and melting the material; the second stage devolatilizes and delivers the material to the shot reservior downstream of the screw tip.

Vented barrel injection molding has been widely accepted by the industry since its commercial introduction in the U.S.A. a decade ago, and most machinery manufacturers currently offer vented barrel equipment in their product lines. Over the last ten years, continuing development programs have enabled the process to evolve from rather empirical origins to one that is now based upon firmly established scientific principles. In a previous publication (1), the fundamentals of the vented barrel injection molding process were reviewed in some detail. At that time it was evident that some operating limitations were still present in the process, as follows:

Output rates with typical two-stage screws were often much lower than with standard single-stage screws on which machine specifications are usually based. In general, often only 50-65% of standard screw outputs could be achieved, depending upon the material being processed. In most cases, other economic advantages of vented barrel injection molding more than compensated for a marginal increase in cycle time. However, there clearly was an opportunity to further improve productivity by increasing screw output capability by applying new techniques in screw design to the process.

Vent bleed can be a problem, particularly during process setup. Although vent bleed may appear at different points in the molding cycle, its basic cause is overfilling of the devolatilization section of the screw channel due to an imbalance between the conveying capabilities of the first and second stages of the screw. Since second stage metering zones are generally short and since delivery pressure is not insignificant, typically 500-1000 lb./sq. in. melt pressure due to the inertia of the retracting unit plus an increment due to flow through the non-return valve, the pumping capability of the second stage is normally quite low. As a result, the second stage can often be