New methods for producing energy savings when using Hot Runner Systems

Paul Boettger, Technoject Machinery Corp, Bolton ON, Canada

Abstract

The heat produced by heaters in hot runner systems keeps the resin in melt conveying channels of injection molds molten. The molten resin is then injected into the cavity of the injection mold. Some of the heat produced will be lost to the surroundings. This paper will show how new methods and materials can reduce the amount of energy lost from hot runner systems and result in additional cost savings.

Introduction

Hot runner systems are comprised of hot runner nozzles and a manifold. The melt conveying channels inside these components are typically heated with 230V heaters. The energy requirement for these heaters depends on the type of resin, nozzle/manifold mass and other factors.

Through the use of new materials and manufacturing methods the energy consumption of hot runner nozzles and manifolds can be reduced significantly. The energy savings for the nozzles can be significant when higher cavitation molds are produced due to the high number of nozzles installed.

In the past hot runner designers have spent their efforts in designing the heater layouts with the intent of supplying the melt with adequate heat supply as well as achieving a thermal balance. Often times the losses of energy to the surrounding mold plates and components were largely ignored or were not considered a problem. However, this trend is changing as modern production operations are seeking additional cost savings by targeting inefficiencies such as energy waste.

Methods and Materials

The ways heat can transfer from the hot runner components is by radiation, conduction and convection. While there is usually only one manifold in a hot runner system the amount of wattage required to heat the manifold block can be quite high due to the size and mass of the steel block. To minimize the heat radiation from the manifold block the hot runner manifold can be completely encased with insulating material, see Fig. 1. Typical choices of materials include ceramic or fiberglass type materials. The cost of the materials varies and typically the more expensive materials

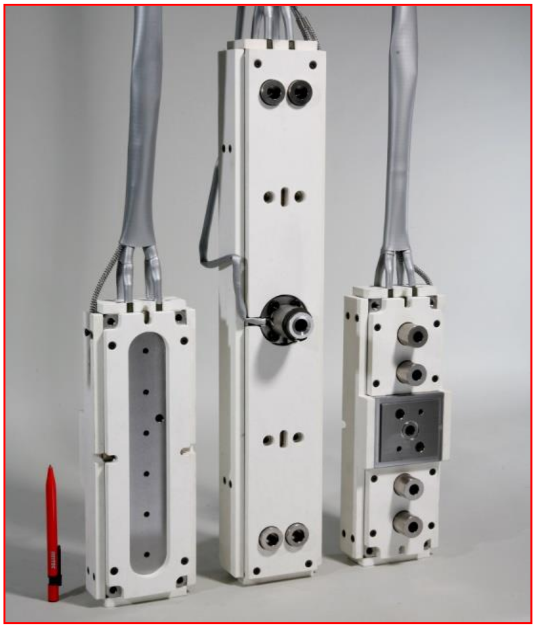


Figure 1 Special enclosures reduce heat losses

tend to have a better insulating value. As an example commercially available fiberboard from mold component suppliers has a thermal conductivity of about 13 W/m°C. This compares to a thermal conductivity of about 1.5 W/m°C for a machineable Glass Ceramic, which carries a higher price tag. The choice of material largely depends on ease of machineabilty as well as cost and length of usage. An injection mold intended to run 10 -15 years may warrant the higher material cost with the better insulating value.

All components of the manifold which are in direct contact with the tool can also be made of special insulating materials resulting in further energy reduction. Such components include Spacer Pads and Centre Supports, see Fig. 2. Typical choices for these types of materials include titanium and ceramic materials. While the ceramic materials clearly have an advantage in providing a better insulating value they do not have the strength that a titanium component would have. However the thermal conductivity of titanium is only about 22 W/m°C.

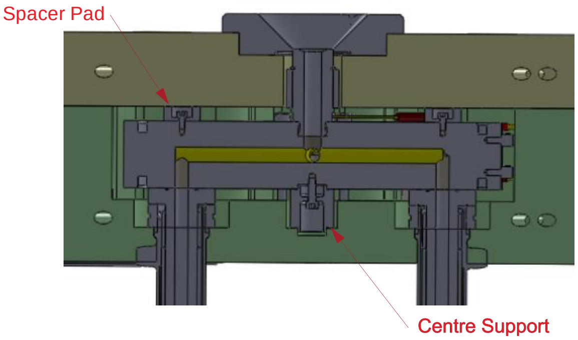


Figure 2 Contact Points Manifold

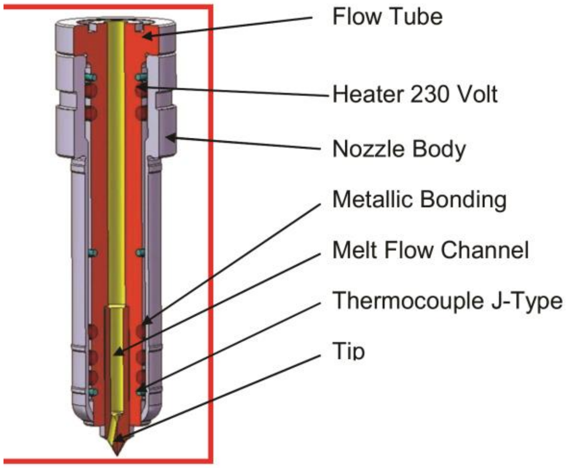


Figure 3 Nozzle Section with Heater Profile

Further energy savings can be realized by concentrating the heat output only in the areas where there is demand for it, such as the tip or gate area of hot runner nozzles. The tip in the gate area often requires more heat to push out the cold slug with the next shot and to counteract the heat losses from the seal contact area, see Fig. 3. However, there is much less heat requirement further back along the nozzle path where there is no mold contact and no cold slug. This difference in heat requirement allows energy savings in the following manner:

- Adding a profile to the coil to minimize heat generation in the middle section of the nozzle, see Fig. 3
- Embedding the heater into a metallic bonding with the flow tube for better transfer efficiency
- Adding layers of thermal separation from the flow tube to the mold

This modified coil profile proves to be much more efficient than a heater coil with no

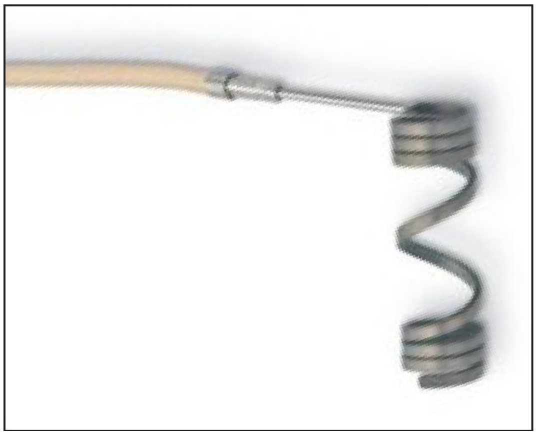


Figure 4 Heater with good profile

profile. A heater with no profile generates a significant amount of excess heat in the centre of the nozzle as there usually is no contact surface to the colder mold. This extra heat radiates to the cavity steel and it also risks damaging the resin with overheating. A good thermal profile is shown on Fig. 4 where the heat concentration is in the tip area. The heater coil in Fig. 5 shows a tightly coiled profile that would result in extra heat, which would go to waste.

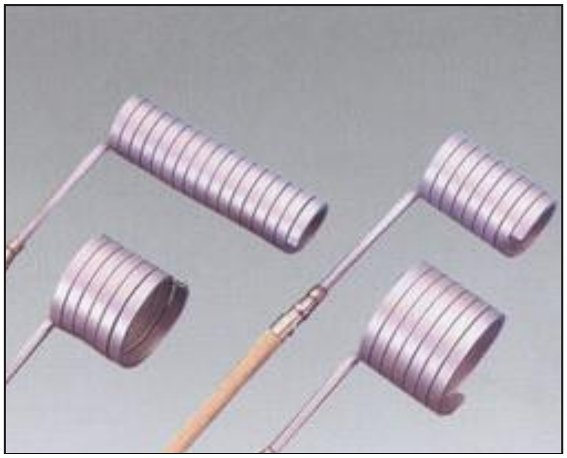


Figure 5 Heater with no profile

The efficiency of the heat transfer from the heater to the flow tube plays another big role in reducing the wattage output required by the system. A heater coil is flexed over the flow tube to provide the heat to the flowing resin inside. It has been observed that the resulting heat expansion of the heater may result in small air gaps between the heater coil surface and the flow tube. Air being a poor conductor reduces the effective transfer of heat to the flow tube. There are several ways to improve the transfer, such as heater clamps, heat paste etc, however, the most effective way to improve heat transfer efficiency is to apply a metallic bonding between the heater and the flow tube, see Fig. 6. The metallic bonding not only provides better transfer it also covers a larger surface area to transfer to. The result of a metallic bond is that lower wattage heaters can be used to satisfy the same heating requirement. For example a nozzle previously requiring 200 Watts could be run with a metallically bonded heater of just 150 Watts. The metallic bond also prolongs the heater life due to less hot spots in the heater coil.

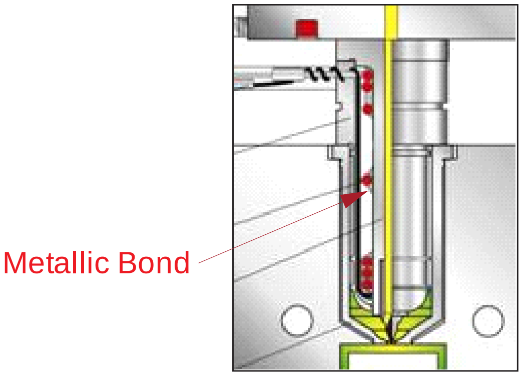


Figure 6 Heater with metallic bond

The manifold heaters are commonly known as round, tubular heaters. These heaters are typically pressed into a groove on the surface of the manifold block. Due to the round shape there is an area of the heater which does not contact the manifold block. This area presents an inefficient way to transfer heat. One way to improve the heat transfer is to use rectangular shaped heaters, see Fig. 7. The contact area of round heaters is approximately 60% whereas the rectangular heaters achieve a 75% contact

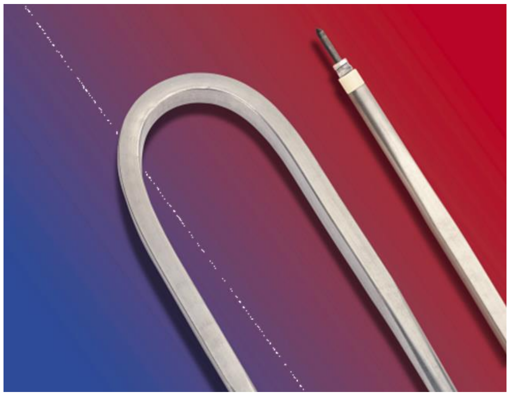


Figure 7 Rectangular shaped heater

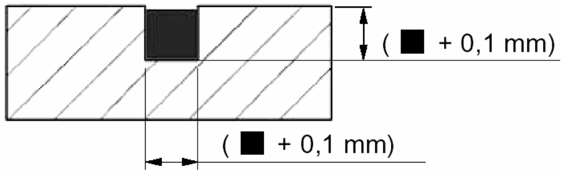


Figure 8 Rectangular groove

surface, see Fig. 8 and Fig. 9. The rectangular heaters not only achieve a better heat transfer, but they also retain a better contact to the manifold block due to the straight sidewalls and the press fit heaters residing in them. The round heaters do not have such a firm contact due to geometry.

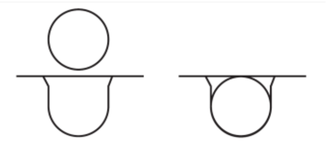


Figure 9 Round groove

The amount of heat required to run a hot runner mold is not only related to the design of the manifold and nozzles, but also to the size of the mold. A large mold brings along

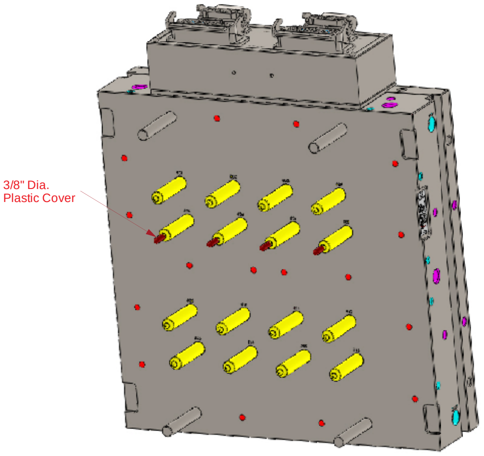


Figure 10 Large Spacing Nozzle Layout

a larger manifold and often bigger nozzles, which in turn require larger heaters. A larger mold is not in itself an inefficiency, but when the mold was made larger due to bigger than necessary hot runner components then it may be possible to reduce the mold size with smaller hot runner components. This is especially relevant when injecting very small articles often found in the medical or electronics industry.

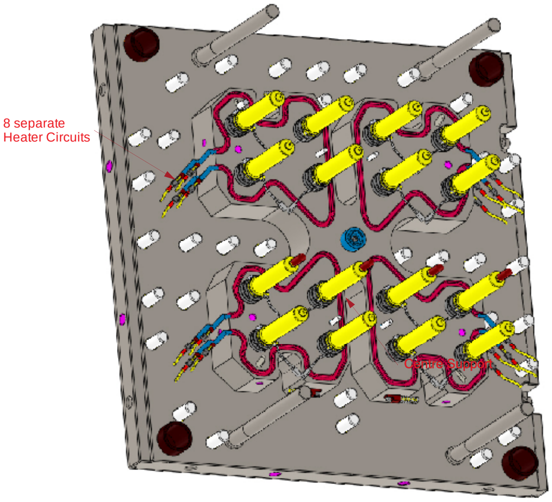


Figure 11 Nozzle Layout with Manifold

As an example a small plastic cover with 3/8" diameter can be made in a 16 cavity mold. The nozzle chosen often drives the required cavity spacing and mold base size in these cases. While the designer may choose to install a more common larger nozzle it will also increase the mold and manifold size, see Fig. 10. The manifold in that case would require 8 heater circuits with 1200 Watts each totaling 9600 Watts for the

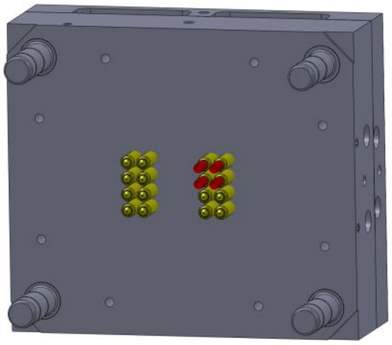


Figure 12 Small Cavity Layout

manifold alone see Fig. 11. Choosing smaller nozzles allows a more compact cavity spacing layout, see Fig. 12.

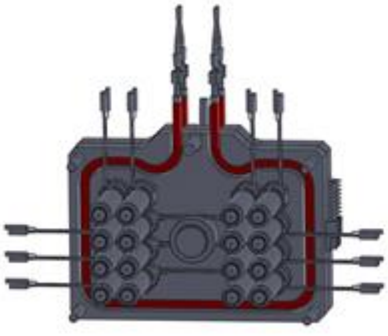


Figure 13 Small Manifold Mass

The efficiencies realized of laying out the cavities with smaller nozzles are significant as the mold becomes smaller, the wattage requirement is much lower and the energy savings are substantial. The smaller manifold results in a wattage requirement of only 2 x 800 Watts for a total of 1600 Watts. The mass of the manifold is much smaller which allows a much lower heater wattage requirement, see Fig. 13.

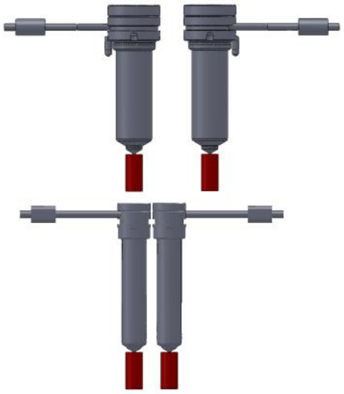


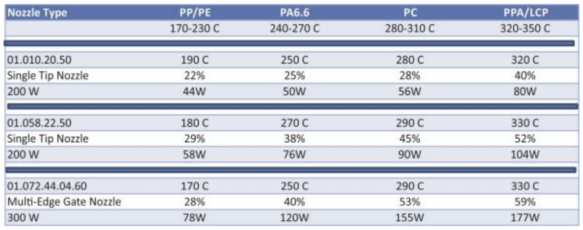
Figure 14 Nozzle Comparison

A further comparison of the nozzles shows that not only can the smaller size lead to smaller spacing, but it can also lead to smaller heaters on the nozzles and therefore a reduced wattage requirement in each case. While the larger nozzle requires a heater with 200 Watts the smaller nozzle can function with a 150 Watt heater, see Fig. 14.

Redesigning nozzle sizes to a smaller mass by keeping the flow channel diameters the same can result in significantly lower heater requirements. One such example is a Multi-Edge Gate Nozzle which was redesigned to reduce the bulky body into a smaller, slimmer version, see Fig. 15. The larger Multi-Tip Nozzle required a 600 Watt heater and the smaller Multi-Tip Nozzle is equipped with only a 300 Watt heater.

Figure 15 Redesigned Edge Gate Nozzle

The heater savings are not only noticeable due to the smaller physical size, but it was also found that a bigger saving was achieved at higher temperatures, see Fig. 16.



Nozzle Type	PP/PE	PA6.6	PC	PPA/LCP
	170-230 C	240-270 C	280-310 C	320-350 C
01.010.20.50	190 C	250 C	280 C	320 C
Single Tip Nozzle	22%	25%	28%	40%
200 W	44W	50W	56W	80W
01.058.22.50	180 C	270 C	290 C	330 C
Single Tip Nozzle	29%	38%	45%	52%
200 W	58W	76W	90W	104W
01.072.44.04.60	170 C	250 C	290 C	330 C
Multi-Edge Gate Nozzle	28%	40%	53%	59%
300 W	78W	120W	155W	177W

Figure 16 Wattage Requirements Smaller Nozzles

Incorporating some or all of the findings into hot runner design and mold design makes it possible to increase the energy savings during a production run. Depending on the number of efficiencies incorporated and mold design optimizations realized the energy savings could be as high as 35% over the lifetime of the molding production.

Conclusion

Various ways to produce energy savings in hot runner molding were investigated. It was found that insulating materials could be used to completely encase hot runner manifold blocks reducing radiation and convection. A closer look was also taken to the way the heaters are contacting the manifold block and nozzle flow tubes. It was found that increased contacting surfaces through metallic bonding and reshaped manifold heaters lead to more efficient heat transfers thus reducing the size of heater wattage. Furthermore, it was noted that profiled coil heaters can supply heat in areas of demand and lower the heat output in other areas of lesser demand translating into further heat reduction requirements. Lastly it was found that choosing a smaller nozzle for small cavities can significantly reduce the wattage requirements due to smaller hot runner components used. Combining the various efficiencies can translate into savings of up to 35%.

References

1. Christopher Schwalm, Heitec Heisskanaltechnik GmbH., R&D Dept.
2. Watlow Heaters, Milled Groove Heaters
3. Corning Inc., Machinable Glass Ceramic for Industrial Applications
4. DME, DME Mold Components - page 250