The First Additively Manufactured One-Part Hot Runner Nozzle

Algorithmically Modified Inner Workings

It is a hot runner nozzle such as had never been seen before Fakuma 2021: with a honeycomb structure on the outside and, in the nozzle interior, integrated insulation gaps manufactured in one part by the additive SLM process, in which even the fastening nut is captively printed on the nozzle body. The pride of the concept is the special algorithmic modification of the nozzles for any application case.

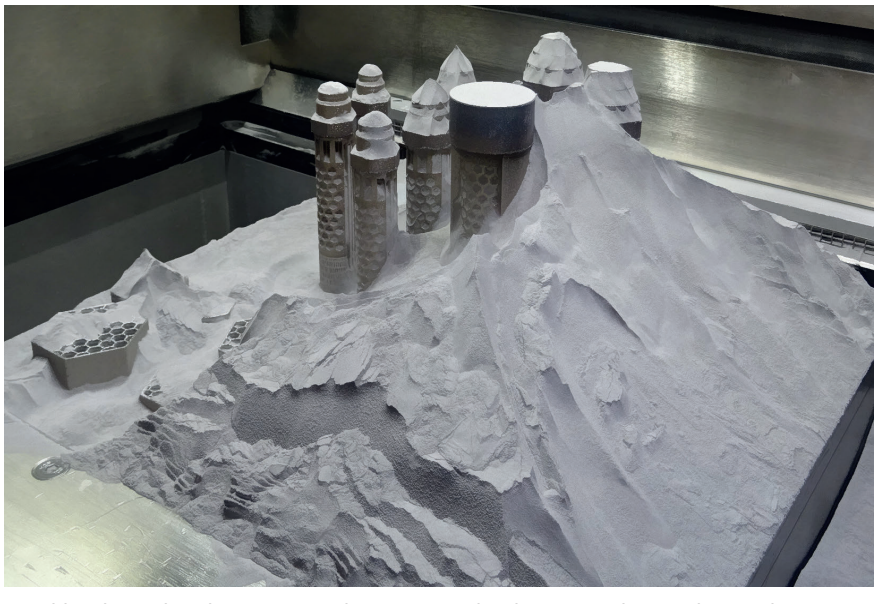
Multipart hot runner nozzles often reach their technical limits, which impacts the homogeneity of the temperature management, the energy demand, the high-quality gate and the maintenance outlay. At least that is how it is seen by Torsten Glittenberg, CEO of the hot runner manufacturer Witosa. So, with a closely-knit team, he began some five years ago to decide whether the 40,000 articles in the company's own catalog program alone could not be countered with a single solution that would make such a proliferating portfolio superfluous in the long term, while still being able to cover as many differentiated customer requirements as possible. At least since the portfolio is continually being refined with further options and configuration possibilities. Witosa presented the result a few months ago at Fakuma under the trade name Monolith.

It is the first additively manufactured one-part hot runner nozzle. Through selective laser melting (SLM), Witosa applies metal powder layer by layer to produce nozzle blanks, which consist essentially of a pressure tube in the core and an outer honeycomb structure. And between them? "In principle, we also print an insulation gap in the interior, so that the multi-shell structure acts as an insulation and heat-conducting system. In this way, we regulate where we direct the heating energy or where heat energy is to be dissipated," explains Glittenberg in a discussion with ***Kunststoffe***.

After the roughness in the melt-carrying part has been smoothed by secondary machining, the 3D-printed blanks are enhanced by installation of the heater and the electrical connections to produce the final hot runner nozzle. The heater is only mounted with a meandering path in the upper region, and otherwise runs linearly down the tube; it is thus not a conventional spiral heater; according to Glittenberg: "Due to the onion-principle behind the construction, we obtain a very homogeneous temperature in the interior, compared with commercial multi-part nozzles. That means we utilize the design possibilities of 3D printing in order to adapt the Monolith nozzles precisely to the customers' specifications and processes." This is particularly advantageous for plastics that are technically challenging to process.

The Point Cloud Is Becoming Denser

This is where we come to the crucial question of how this modification works in an individual case. "The customer must give us a little more information than in the past. To ideally modify a nozzle, you have to know something about the process, so we need an injection molding simulation," says Glittenberg. In addition, every hot runner system is thermally simulated with Ansys, so that the result is a fully parameterized CAD model. Glittenberg continues: "The nozzle interior is built up from »



A mold-making job with up to 30 nozzles is processed in the SLM machine in about 24 hours.

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Witosa CEO Torsten Glittenberg: "We still have a lot of plans this year." © Witosa

algorithms that we have developed ourselves, by entering, e.g., parameters such as injection velocity and time, shot weight, shear velocities and crystallization points. If users do not have the necessary data for this, we suggest process parameters for configuring the nozzle, of course."

Each nozzle comes onto the test rig after 3D printing, where the simulated temperatures are measured in reality in multiple heating cycles. The innovation is that "With every system, we record data points – the larger the point cloud, the more accurately we can design new nozzles," explains Glittenberg. The mesh thus becomes ever finer with each empirical value.

Up to 35 Percent Lower Energy Consumption

The hexagonal design allows the nozzles to have a lower weight together with high stiffness. In combination with the integrated insulation and heat conducting system, this not only ensures very rapid control response (more about that below), but also a huge reduction in the energy consumption. For the installed electrical power depending on the application and field of use, Glittenberg speaks of savings up to 35 % in the manufacturing environment compared with conventional hot runner nozzles.

Another advantage for the user is the movable fastening nut printed on the shaft. Monolith nozzles can be dismounted without removing cables and rotated to any orientation. The melt emergence can thus be freely positioned. Orienting the 3D printing nozzles can thus achieve even more homogeneous filling in multicavity hot runner systems, or an orientation appropriate to a sub-manifold.

Pocket-Sized Lateral Gating

And development work is not standing still. Only a few months after the Monolith premiere, Witosa expanded its portfolio with 3D-printed nozzles also for side-gated hot runner systems. As multipart conventional nozzles, Witosa has already had this type in its portfolio for a long time. The advantage is that "For parts that otherwise would have to be gated to small sub-manifolds with tunnel gates, the sub-manifolds can now be eliminated. In view of the current high raw materials and energy costs, this pays off particularly in systems with large numbers of cavities with high production volumes," says Glittenberg. With immediate effect, the company is offering two variants of this: first, the "linear system" for small to medium shot weights of 10 to 80 g per nozzle and, second, the XS system for very small weights from 0.1 to 10 g. Both have already been tested in pilot applications with customers.

In contrast to some competitor products with passively heated tips – which draw their heat from the manifold – the Monolith nozzles are fully fledged nozzles with heating and a sensor, and are screwed sideways into the manifold. As a result, each gating point is also controllable in a defined way. But the implementation was not trivial: "The XS system caused us quite a few headaches. The nozzle must be a certain length in ratio to the clearance from the center of the manifold to compensate for the expansion of the manifold bar during heating, and so as not to deform the nozzle too much. Otherwise the thread would snap off," is how Glittenberg sums up the difficulties. The solution was to place an injection-tight length compensation element in the interior of the small manifold.

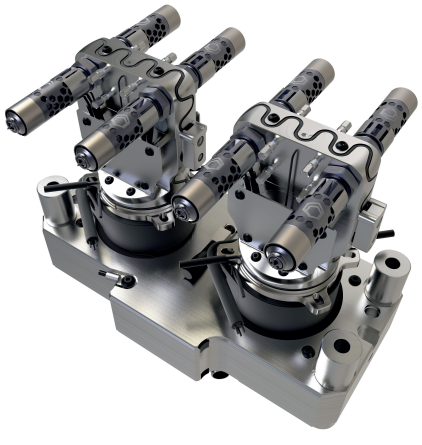
The system is claimed to be predestined for manufacturing extremely small electric plugs in large volumes. What is meant my "small" is shown by this figure: "If we use our shortest nozzles, the tip-to-tip distance on opposite sides is only 62 mm. In principle, the XS system fits in your pocket. Though it would tear the lining," smiles Glittenberg.

For all Monolith systems, as well as for lateral gating, Witosa provides a warranty against wear of a million shots, provided that the glass fiber content of the processed plastics does not exceed 30 %. In the event of wear, a nozzle tip can be easily reprinted and in this way the system operates reliably at low cost over a long lifetime.

Big Plans

While he is in a generous mood, so to speak, Glittenberg announces yet another innovation: from the end of February, Witosa will already be offering three hot runner control units:

- the R6 film controller for up to twelve zones (operation with film keyboard),
- the R7 touchscreen controller for up to 36 zones (tabletop unit with fold-out display) and
- the R8 tower controller for 42 to 120 zones.



8-cavity model of the XS system for lateral gating with very small shot weights. © Witosa

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The underlying idea was that "We have studied the topic of energy saving intensively. The Monolith nozzles are very lightweight due to their design and the integrated hollow spaces. In addition, the heater and thermocouple are very close together in the tip. This means the nozzles respond very rapidly to a heating pulse. For this, corresponding control algorithms are required, namely a good PID controller, and we have therefore developed this series of devices together with Feller Engineering," explains Glittenberg. The nozzles can generally be operated with commercially available control units, though if you want to achieve an optimum it is advisable to use a velocity adapted control technology.

And what are the next steps on the way to the K 2022 show in October? "We have all kinds of plans this year. In the development of the Monolith nozzle, we had other ideas about what can be done with 3D printing," says Glittenberg. "We are sure that is the future: there will be fewer off-the-peg products and far more individual solutions. 3D printing is ideal for this because of the huge freedom it allows." ■

The new hot runner controllers are each available in various stages of development. © Witosa

Dr. Clemens Doriat, editor

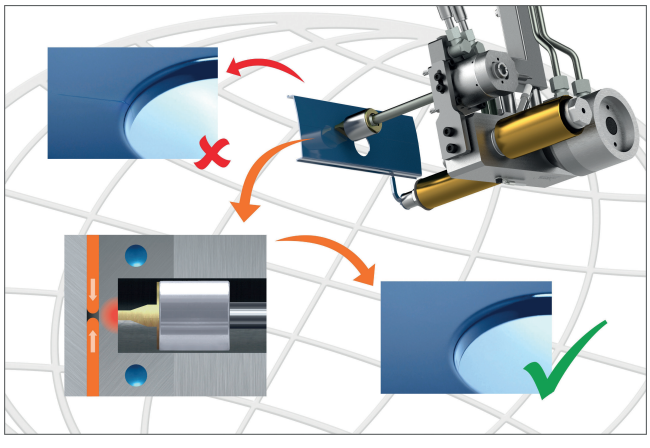
Part and Process Optimization

Targeted Heat Pulses in the Cavity

The new "Heat-Inject" product from Incoe International Europe stands out in that it uses the hot runner system as a carrier platform, but instead of melt, it brings heat into the cavity. The question following this concept "But why additional heat directly into the cavity?" is answered by Christian Striegel, Head of Development and Technical General Manager at Incoe: "This is not an additional heater, but a movable tempering stamp, whose heated tip introduces a heat pulse there by briefly pressing against the rear wall of the cavity."

According to Striegel, this short local impulse can contribute in many ways to optimizing the quality of the molded part and the process: weld lines and flow lines are still there, but no longer visibly appear on the surface, matt points no longer appear in the area of the gate, areas with low wall thickness the cavity, such as in film hinges or thin-wall injection molding, can be flowed through more easily, and delicate geometries and microstructures are easier to manufacture. "This innovative temperature control technology, based on the patent-pending Z-system from our partner Hotset, works extremely quickly with very low energy consumption. In doing so, it offers a technically relatively simple and robust solution for molded parts with visually demanding surfaces, such as panels for household appliances, consumer electronics, or instrument panels in vehicles," adds Frank Daniel, Commercial General Manager at Incoe.

The idea of assembling "Heat-Inject" on hot runner systems has its origins in the concept of pre-assembled modules. The idea here is to offer customers components for their injection molds that are already assembled into ready-to-use and ready-to-plug-in modules, thus saving effort and time during tuning and installation. "Of course, the tempering stamp needs to be spotted in order to create a suitable contact surface for optimum heat transfer," explains rank Daniel. "But the fact that all Heat-Inject connections are combined on the central connection plate of the hot runner system, for example, eliminates the need for time-consuming installing and connecting of individual cables or hoses in the mold – everything is already mounted in a module and can be inserted in the sense of "plug and produce" after all adjustment actions have taken place."



The heat pulse from heat-inject ensures good surface quality where a weld line may otherwise be visible due to the part geometry and gating. © Incoe

An essential part of using Heat-Inject, continues Frank Daniel, is clarifying in advance whether and how Heat-Inject can be used. Incoe offers a multi-stage process for this, consisting of a feasibility study, a quotation, and support with coordination, installation and sampling. "A big advantage for us with this new product is that we can build on Hotset's many years of experience and thus offer our customers additional benefits that have already proven themselves in practice." Christian Striegel adds.

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