Economical Solution for the Production of Thermoplastic Large-Structure Components

Flexible Injection Solutions with Adapter Plates

For the transformation of industrial production into an economic system with waste-free, low-CO_2 manufacturing processes, injection-molded, highly stressable thermoplastic large components are also required. Production systems for these molded parts can be flexibly and economically reconfigured or expanded using hot runner adapter plates.

Melt transfer from two on the side injection units of an Engel v-duo 2300 RTM into the middle of the hot runner intermediate plate mounted on the sliding table. © A&E Produktionstechnik

In order to meet demands for a reduction in the carbon footprint of vehicles and aerospace, there is no way around thermoplastics. Injection molding has proven to be an effective and economical process for the production of heavy-duty lightweight components for these product groups. This process is depending on high quantities as well as high machine- and/or plant costs. The requirements and functions of a molded part determine its geometry, which in turn determines the size and design of the tool, machine- and installation engineering. If special requirements are placed on the thermal, mechanical or other properties of the molded parts, combinations of different thermoplastics, the incorporation of glass or carbon fibers and/or the overmolding or injection of organic sheets as well as LFT tapes (long fiber-reinforced thermoplastics) are state of the art.

In order to meet today's market requirements for productivity, production plants must be adapted quickly and flexibly to newly manufactured molded parts. Hot runner adapter plates increase flexibility and productivity in the injection molding production of large

thermoplastic lightweight molded parts. In contrast to definitions of the size of general industrial products according to Behrens [1], injection-molded parts can already be described as "large" from dimensions over 1000 mm.

The Area of Conflict between Productivity and Flexibility

The sizing (configuration) of an injection molding machine is always under pressure between productivity and flexibility. More generally, high productivity can only be achieved with less flexibility, which is colloquially referred to as the "contradiction of manufacturing technology" [2, 3]. Highly productive injection molding machines with low flexibility are or have been machines for the production of CD blanks with extremely short cycle times. The drives of the individual machine axes are designed for this specific product and then have the lowest energy consumption at this operating point. Multipurpose machines, on the other hand, have an operating range – their drives operate predominantly in the partial load range with lower efficiency.

Since operating times of between 20 and 30 years are expected, especially for large injection molding machines, the equipment features once taken during the design/condition are difficult to change again and at great cost. On the other hand, it is difficult to produce "reconfigurable" injection molding machines, as described for machine molds [2, 4]. A flexible adaptation and expansion of the technical possibilities to new production tasks is possible by additional assemblies on the individual machine or plant components if the configuration of the fixed and moving plate is retained and the tool is changed. The control of the individual plant components for the combination of different production technologies is a complex matter [5]. For such complex production lines hot runner intermediate plates can be a cost-effective alternative compare to new machines or to machine and molds.

The main criteria for the design of the injection molding machines in relation to the geometry of the molded part to be manufactured are shot volume, injection pressure and closing or locking forces. Large-volume molded parts require high injection volumes at relatively low injection pressures and have long cooling times. Large-area molded parts have long flow paths with thin wall thicknesses and thus require high injection pressures. Thus, the flow properties of the polymer melts and the geometric dimensions become the limiting criterion for the molded part size. This geometric-rheological boundary can be partially circumvented with cascade injection molding.

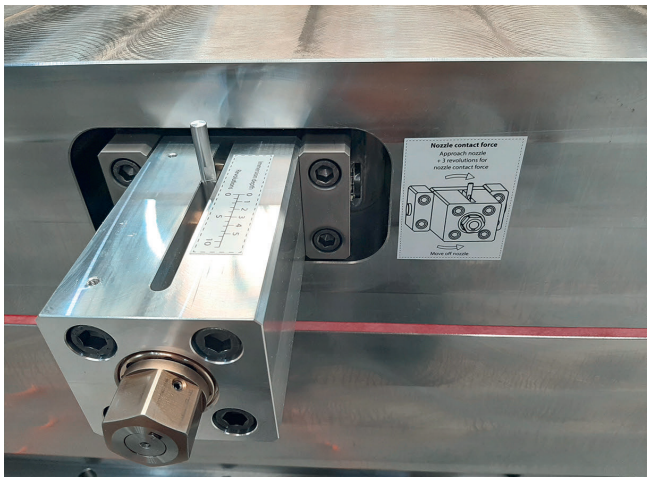

Fig. 1. Adjustment device for nozzle stroke and nozzle system force with nozzle position indicator.
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Hot Runners Are Installed Movably

Hot runners in injection molds are state of the art and well described in their functions [6, 7]. The hot runners for the adapter plates, as offered by A&E Produktionstechnik GmbH, are rheologically designed and dimensioned. They are installed movably in the adapter plates. Reasons for this are:

- The clamping of different molds, each with different layers of the sprue bushes, is easier than with a fixed installation, because a time-consuming dimensional coordination between the layers of the hot runner nozzle and the mold sprue bush is no longer necessary.
- The connection of the hot runner nozzle to the mold sprue bush is not visible to the machine operator. This masked connection is reliably designed to be leak-free.

The hot runner is pivoted in a manually adjustable frame in the steel plate. By adjusting the frame, a nozzle stroke is possible – depending on the size of the adapter plate and customer requirements between 5 and 30 mm.

Monitored Connection Point

Sprue bushes and nozzles are designed with radii. Compared to other designs, such as flat surfaces or immersion nozzles, the radius design allows a greater tolerance for a possible offset of the melt channel of the mold to the hot runner. Since no melt may escape at the connection point between the hot runner nozzle and the mold sprue bushing even under the effect of 2000 bar injection pressure, the hot runner adapter plates have integrated assemblies for applying the nozzle contact force. This force thus acts independently of the nozzle contact force of the injection unit of the machine. Depending on customer requirements and the available installation space, the nozzle system force can be built up in the steel plate via spring packages or by hy- »

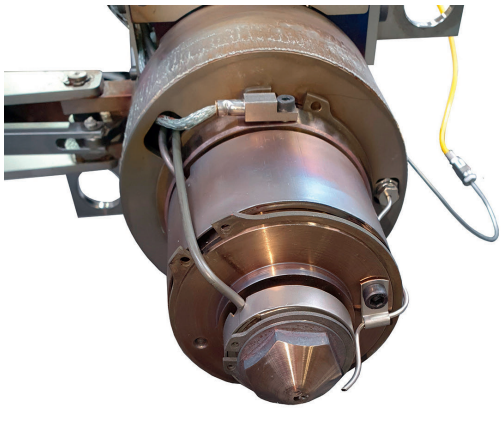

Fig. 2. Compressed air flow capillary on a hot runner nozzle for detecting melt leakage.
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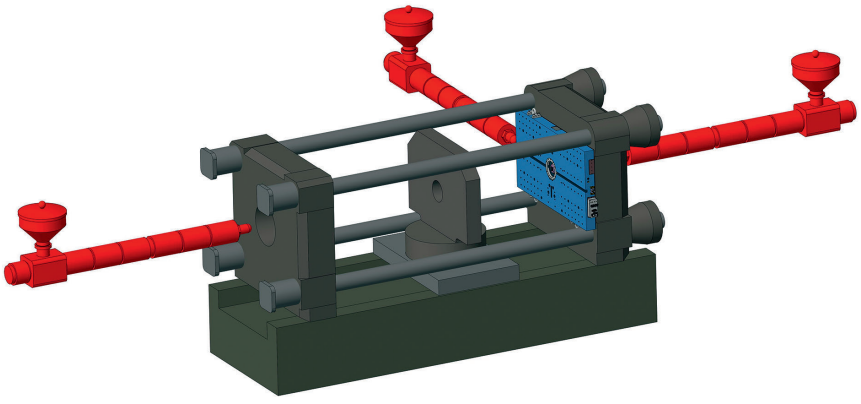

Fig. 3. Installation version of the hot runner intermediate plate on the fixed plate of the KM 2300 MXW Twin SP24500/810 injection molding machine with bolt-on unit SP3000. © A&E Produktionstechnik

draulic or pneumatic cylinders. The nozzle stroke and contact force of the hot runner nozzle are manually adjusted via an adjustment device on one side of the hot runner adapter plate (**Fig. 1**).

In order to reliably prevent melt leaks at the non-visible connection between the hot runner nozzle and the mold sprue bushing, this point is monitored by a capillary with a small stream of compressed air. Escaping melt leads to an increase in pressure of the compressed air flow (**Fig. 2**). A sensor converts this pressure increase into a signal for the machine control. Experience in the field has shown that the masked connection without this monitoring is a source for overmolding for some hot runners.

Reduced Carbon Footprint by Using Recyclate

If the installation space in the steel plate allows it and customers required it necessary, sensors can be installed in the hot runner adapter plates that record the melt parameters: temperature, pressure, pressure difference and, if necessary, other process variables. In addition, the hot runner adapter plates can be offered with shut-off nozzle as well as shot-off sprue bushings. Optimized melt-flow channels are just commonly.

Current demands to reduce the CO_2-footprint for plastic molded parts are already leading to an increased use of recyclate (regrind, granulate). In order to continue to meet this requirement, the sandwich process (co-injection) is ideal for using the recycled material as a core material. This process can be carried out easily and cost-effectively with hot runner adapter plates on commercially available 2-component injection molding machines (due to the function-related shut-off of the nozzle when "filling"/dosing the injection cylinder).

Various types of "sandwich nozzles" are offered on the market in different process variants. These variants are all based on the technical implementation of the source flow effect and laminar flow. They are characterized in everyday production by more or less large advantages and disadvantages, for example by a simpler machine design but also by a less flexible process sequence (no sealing or rinsing phase) and partial occurrence of melt leaks in the nozzle chamber (due to the function-related shut-off of the nozzle when "filling"/dosing the injection cylinder) [8, 9].

Shut-off nozzle and shut-off sprue bush which are installed in the hot runner enable high process stability – comparable to well-known machine

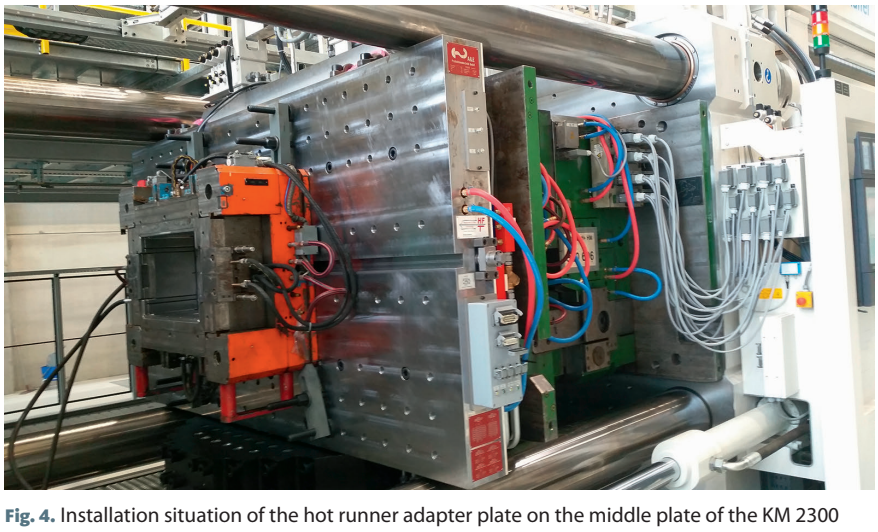

Fig. 4. Installation situation of the hot runner adapter plate on the middle plate of the KM 2300 MXW Twin SP24500/810 machine with bolt-on unit SP3000. © A&E Produktionstechnik

Info

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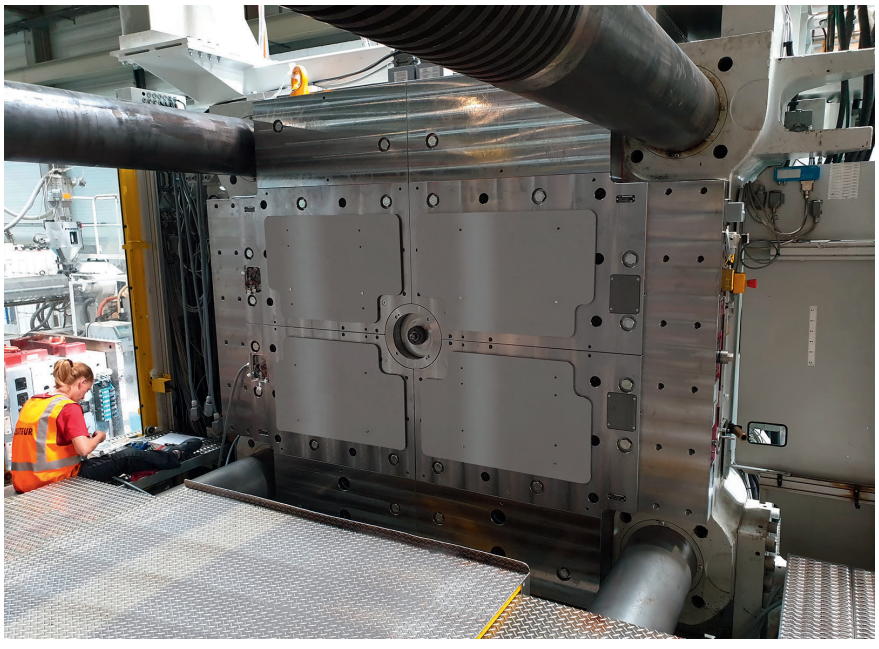

Fig. 5. Installation situation in the mold room of the Engel duo 2700: magnetic mold clamping plate in front of hot runner adapter plate. © A&E Produktionstechnik

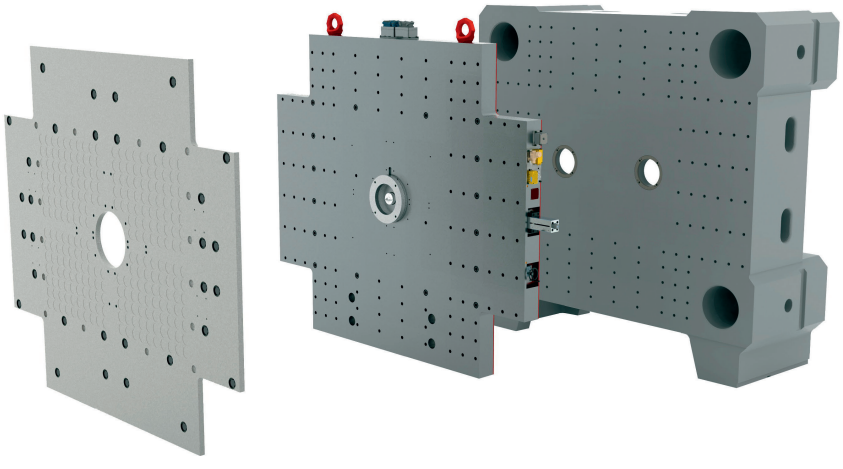

Fig. 6. Graphical representation of the arrangement of (from left to right) magnetic clamping plate, hot runner adapter plate and fixed mold mounting plate in the Engel duo 2700. © A&E Produktionstechnik

shut-off nozzles that are mounted directly on the plasticizing and injection units. In processes with the machine nozzle moving away, for example in injection molding systems with sliding table, the sprue bush shut-off prevents the melt from leaking out of the hot runner. For other special injection molding processes, such as foaming or processing of long-fiber material, the hot runners can be modified accordingly.

"Ambitious" Cases

At Chemnitz University of Technology, Germany, an injection molding machine of the type KM 2300 MXW Twin SP24500/810 with bolt-on unit SP3000 (manufacturer: Krauss Maffei Technologies GmbH, Munich, Germany) is used as part of the Federal Excellence Cluster Merge. For them, a hot runner adapter plate measuring 2850 x 1580 x 196 mm was built with two exchangeable hot runners, each with shut-off nozzle and sprue bush shut-off. A hot runner directs the melt from the bolt-on unit to the center of the plate. A second hot runner leads the melts from the bolt-on unit and from one of the two centrally arranged injection units simultaneously and/or sequentially to the nozzle in the center of the plate. The hot runner adapter plate can be attached to all four mold mounting platens of the machine (**Figs. 3 and 4**).

For an injection molding machine of the type Engel duo 2700 (manufacturer: Engel Austria GmbH, Schwertberg, Austria) with two parallel horizontally arranged injection units, a hot runner adapter plate of size 2180 x 1750 x 120 mm was built, which combines the melt flows of both injection units on a centrally arranged nozzle. This made it possible to increase the injection volume. The tool is fastened with an electromagnetic quick-release plate (**Figs. 5 and 6**). This configuration shows production of interior parts for the automotive industry.

Further examples of the use of hot runner adapter plates are described in literature [9–11] and on the authors' websites.

Outlook

Hot runner adapter plates are supplementary assemblies to increase the flexibility and productivity of injection molding machines. Experience gained so far from many years of production of these plates confirms the described advantages of this technology. We are continuously working on the further development and development of new areas of application. In the technical center of Chemnitz University of Technology, there are opportunities for interested parties to test these intermediate plates in combination with the company's own molds. ■