Teeth manufactured in the injection molding process, scarcely distinguishable from "real" teeth. An adjusting pin at the tooth root serves to fix the artificial teeth (figs: Günther)

Injection Molding for False Teeth

Complete Teeth of Plastics can today be economically manufactured in series of up to 20 million pieces each year. A customized hot runner system helps produce these teeth, with their properties quite similar to those of real teeth, at a level of precision constantly high.

JÖRG ESSINGER

When it comes to one's own teeth, only the best is good enough for many people. Forget cheap. Forget amalgam. But no, you want ceramic in your mouth. Plastics? They might be acceptable for plastic fillings – but whole teeth? They'll never stand up to the wear and tear! This is what many people think – but they are wrong! Dens3000 GmbH from Konken, Germany, is proving exactly the opposite by manufacturing artificial third teeth from a high-performance plastic based on PA/PMMA, instead of duroplast or ceramic. The initial results show that the teeth produced in the injection molding procedure are even more durable than conventional extruded teeth, at a fifth to a tenth of the cost. Attractive markets for the artificial teeth include, in particular, Eastern Europe, Africa and China. Because the products are "Made in Germany" and thus of extremely high quality.

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Teeth Must Fit and Look Good

Gaps and whole rows can now be filled simply and safely with the injection molded teeth, because they are completely ready for use once they have come out of the tool, without the need for any subsequent work – except that the dentist has to adapt the chewing surface after fixing the teeth inside the mouth. Günther Heisskanaltechnik GmbH, with its hot-runner system using the nozzle type 5SMT100, played a decisive part in the creation of the newly designed two-component manufacturing tool.

With all visible injection molded parts, it is particularly important that they are absolutely flawless, both in their appearance and in their measurements. Previously, such requirements have tended to be associated more with automotive engineering, but the teeth from Dens3000 are no exception. The instructions that the tool must receive to produce these dental prostheses are extremely complex. Because the highest product quality is required, despite or precisely because of the many free-form surfaces and undercuts. After all, the artificial teeth should feel as much like real teeth as possible when they are in the mouth.

That is why the decision-makers at Dens3000 have from the beginning also →

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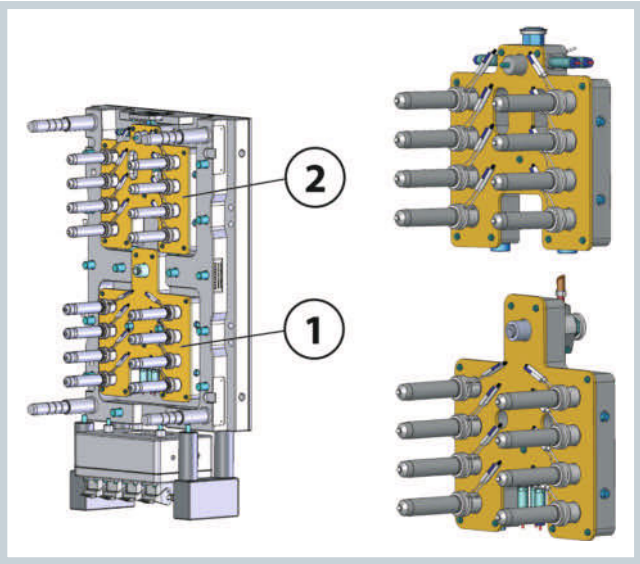

Completely assembled "hot half" of the 2-component mold: Component 1, i.e. PA12, is injected horizontally and processed into a perform (bottom); PMMA serves as component 2 and is inserted vertically to produce the final molding (top)

worked very closely together with a design office as well as with the tool-maker and Arburg – as the manufacturer of the injection molding machines used – in order to be able to solve the special tasks. This includes, for example, manufacturing the plastic teeth without visible mold partings and the gentle preparation of the materials used up to injection.

A Pin Adjusts and Fixes the Teeth to the Denture

Two components are processed in order to provide the teeth with as natural an appearance as possible. The first of these components is a PA12 with advantages of strength and damping behavior and the second is a "dental" PMMA that has been modified for hardness and coloring, which has been adapted to its tasks in the course of extensive testing in dental clinics. This has also allowed the supplier to ensure that the dental prostheses remain largely free of plaque and cracks.

All together, four 8-cavity molds are used to produce 28 teeth, with their component weights between 0.1 and 0.73 g, for a complete set. Progressing from tool development to the acceptance of the mold took about one year. The whole tooth range comprises 144 different prostheses in 16 colors and three sizes. In addition to these, there are various shapes for adapting the incisors individually to the respective physiognomy. The injected part weights of the plastic teeth range from 0.24 and 1.1 g (subject to the respective tooth type, shot weights range from 2.5 to 5.6 g) and the cycle times from 22 to 30 s. The teeth are exact fitted into the mouth by an adjusting pin at their underside, which is molded the same shape on all prostheses. Precise filling of cavities and an additional random-sample test for correct color, hardness and weight ensure consistently high quality production. When production is running at full capacity on three-shift operation, each of the four tools produces approx. 5 million plastic teeth p.a. with a service life of between five and ten years. These can be used to completely renovate some building sites in the mouth.

! Multi-Component Technology

The multi-component technology enables the realization of complex injection molds, which consist of two or more components. During this process, components either connect to form homogeneous, i.e. heat-sealed, (e.g. multi-colored) parts, or to generate heterogeneous (e.g. hard-soft-connected) moldings. In sandwich injection molding, a multilayered construction is generated, consisting of a core component and an outer layer. For the manufacture of multi-component items several methods are suitable:

- Bi-injection – simultaneous or time-delayed injection of two components into the same cavity
- Core-back-technique – injection of two components in one cavity one after the other; the cavity for the second component is made available by drawing a stop valve
- Transfer-technique – the pre-mold will be moved into the second cavity or machine manually or with a robot
- Rotary-method – Moving through axial or vertical rotation in the machine or tool

To users of the multi-component technique, the main benefits are the well-targeted utilization of the property profiles of different materials, process integration to reduce cycles, as well as the low costs and time required for mounting.

Nozzles with Two-Part Shaft in the 8+8 Hot Runner System

On average, the item weight per component is about 0.3 g. Direct injection of the teeth is carried out via injection points, with a diameter of approx. 1.0 mm. An index plate revolves the 2-component molds, with each of them equipped with an 8+8 hot runner system, which allows for sprueless processing without loss of time or materials.

The nozzles (type: 5SMT100) incorporated into the hot runner via H-manifolds are especially well-suited for use in sensitive processing areas such as medical technology and have nozzle lengths of 100 mm in the case of the upper jaw molar mold (item weight: 0.6 g). The teeth are injected vertically, with an injection time of 0.5 s and injection pressure of 900 bar. The holding pressure phase lasts 4 s with a dwell pressure of 450 bar. Finally, the cooling time is 8 s and the entire manufacturing cycle takes 20 s.

The various temperatures in the hot runner and tool might also be of interest. The manifold temperature is 300 °C, the nozzle temperatures measured at the start and in operation and on the machine nozzle remain consistently at 290 °C. The temperatures on the nozzle and ejector side of the tool are each 80 °C.

The special measures that Günther has implemented with the SMT hot runner nozzles as regards thermal separation of the nozzle and cavity and within the nozzle, also have a positive effect in the manufacturing of the tooth implants. The patented two-part shaft, the front section of which consists of a titanium alloy, provides for very good insulation and thus enables minimum heat loss between the hot runner nozzle and cavity. The low heat conductivity of the titanium alloy of the nozzle shaft, with a heat conductivity coefficient of only around 7W/m·K also prevents heat emission in the direction of the mold.

The temperature distribution in the nozzle is in turn very homogeneous. The heat-conductive tip, with its heat conductivity coefficient of approx. 100 W/m·K, provides for very smooth opening of

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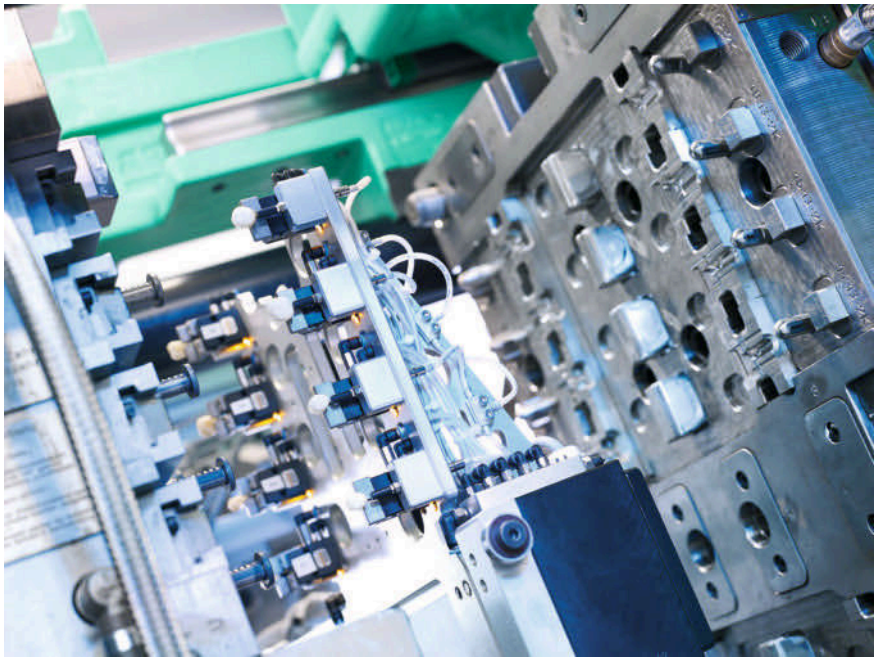
the nozzle and good tear-off behavior. All of this facilitates the trouble-free processing of engineering plastics as well as high-temperature resistant polymers – materials like the ones Dens3000 uses for the series production of its plastic teeth.

The simple geometry of the SMT type hot runner nozzle facilitates mounting to the ante-chamber by a H7 fit, thus saving time in tool-making and design. In injection molding units, good thermal separation minimizes energy consumption. But the production costs can also be reduced because the cycle times are shortened by the lower accumulation of heat in the first-cut area. The hot runner nozzle's homogeneous temperature profile enables gentle processing of the plastic materials, and stabilizes the process.

The two-part shart of the SMT nozzle minimizes heat loss between hot runner nozzle and cavity



On an Arburg-Allrounder 520 A, in each 8+8 tool, eight artificial teeth are produced from two plastic components, in a cycle time of 30 s (Photo: Arburg)

This eventually leads to constantly high qualities of the products in serial manufacturing. Easy insulation between hot runner nozzle and cavity insert reduces the risk of leakage if mounting is frequently required at the cavities. All of these factors lead to higher productivity at a consistently high level of quality. This way they put a brilliant smile on the faces of manufacturers and patients. ■

THE AUTHOR

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