Variothermal Temperature Control from the Compressed Air Network

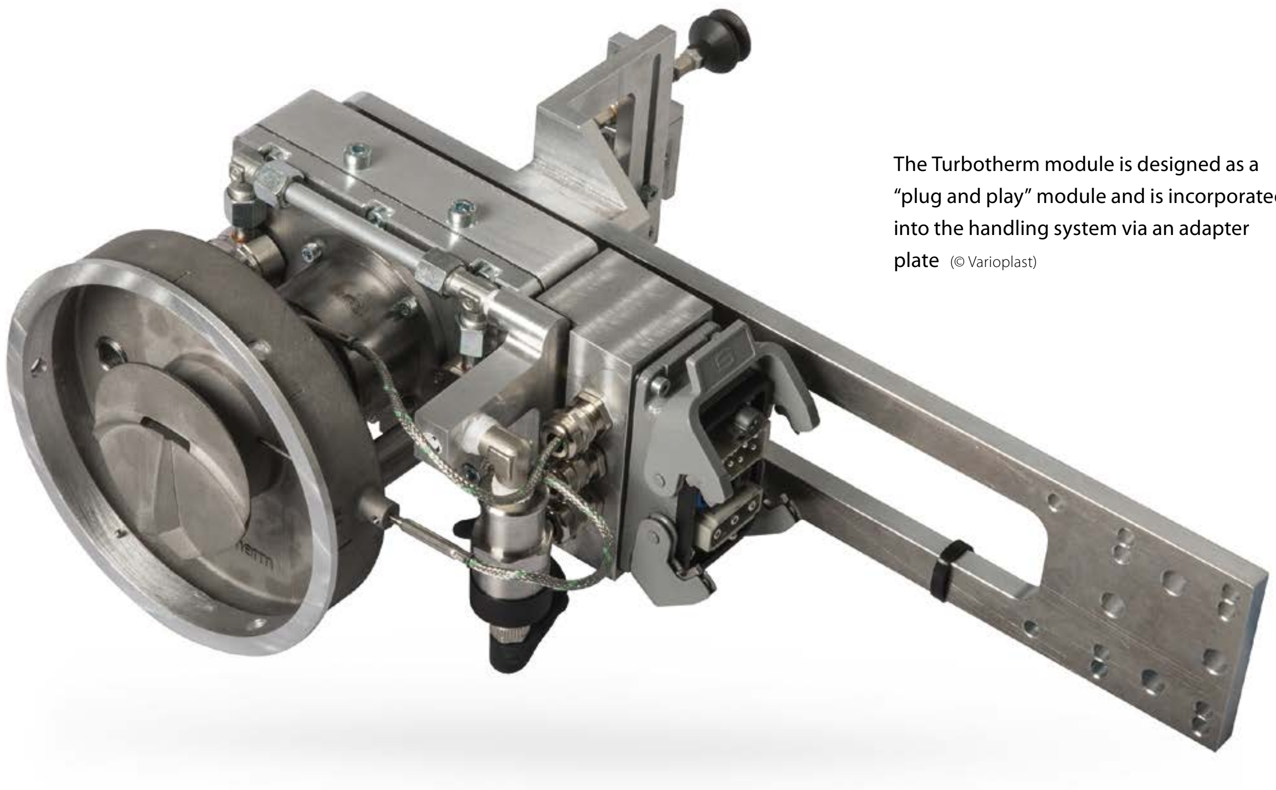
Varioplast Has Developed a Dynamic Temperature Control Process Which Can Be Retrofitted to Injection Molds without the Need for Any Modifications

As a manufacturer of both coated and uncoated high-gloss plastic parts, Varioplast has continually been faced with the problem of visible knit and flow lines on molded parts. Conventional variothermal processes, for reasons of overall economics, are limited in their suitability to offset existing and future cost pressures exerted by customers. Varioplast unveiled a new process at Fakuma 2017.

Only some of the plastic parts made by conventional injection molding are produced as ready-to-use articles. Many of them have to meet such high quality or functionality requirements that it is necessary to either extend simple injection molding with a special technology such as dynamic temperature control or to finish the product downstream, e.g. by coating, printing or joining. This is especially true for decorative parts. Converters seeking to remain competitive must avoid additional working steps wherever possible and incorporate high quality and cost-effectiveness into their overall process design.

The Idea: Hot Air from the Nozzle

The variothermal process in particular offers scope for eliminating downstream operations. Raising the mold wall temperature, for example, makes it possible to optically eradicate knit lines or to reproduce the wall structure more faithfully. This can also benefit the ratio of flow path to wall thickness. Often, the process entails heating the entire mold – but not always. Enter Varioplast Konrad Däbritz GmbH, Ötisheim, Germany, which spent four years cooperating with Pforzheim University of Applied Sciences on developing a process to production readiness which it unveiled at Fakuma 2017. »



The Turbotherm module is designed as a "plug and play" module and is incorporated into the handling system via an adapter plate (© Varioplast)

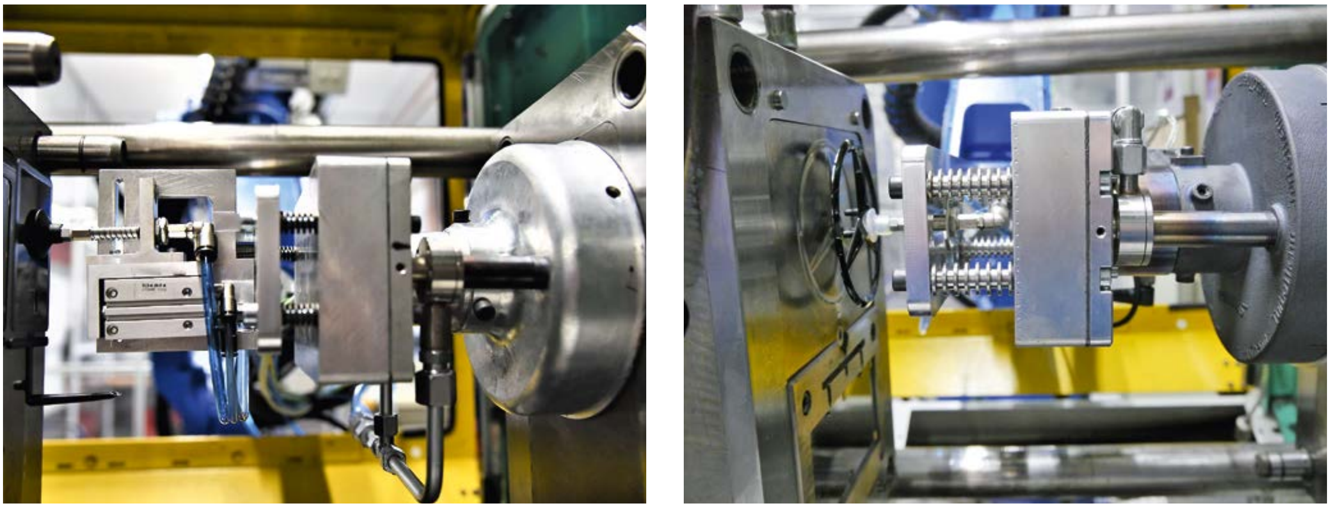


Fig. 1. In series production, the finished part is removed on the ejector side, while the cavity is heated in parallel on the nozzle side (left). The 3D-printed metallic heating head module (right) permits quick adaptation to customer-specific geometries in the mold (© Varioplast)

Marketed under the name "Turbotherm", the process can also be retrofitted to molding tools without the need for any modifications. Its energy and cost efficiency are the result of specifically heating the cavity surface where surface defects occur.

Varioplast commenced its development by conducting a value analysis of the various methods for variothermal process management already available on the market and then came up with ideas for a new type of module. The most important specifications were:

- No modifications to the mold,
- short heating times to ensure economical use,
- use of robotic handling for greater versatility,
- allowance for the mold cavity, and
- strive for energy and cost efficiency.

Analyses showed that there was no process on the market capable of meeting these criteria in full. And so Varioplast set out to develop its own. The idea was to deploy a combination of turbulent flow of hot air, highly effective heating nozzles, venturi-based air acceleration and heat recovery bells with a view to achieving highly efficient variothermal process control during injection molding.

The Heating Module: Designed for Single and Double-Sided Use

The first item on the agenda was extensive fundamental investigations by the Faculty of Technology at Pforzheim University of Applied Sciences: it studied the behavior of turbulent and laminar flow, the influence of different nozzle shapes

Advantages of the Process

According to the manufacturer, Turbotherm stands for efficiency and high product quality because

- no changes to the injection mold are necessary,
- the system can also be retrofitted to multi-cavity molds,
- the process is stable and reproducible,
- visible knit lines are completely eliminated,
- flawless part surfaces for coating processes can be produced,
- faithful reproduction of the cavity surface, even in the case of intricate geometries,
- longer flow paths are possible for thin-walled parts,
- product-specific nozzles and bells can be generated.

Figures, Data, Facts:

- Average power consumption: 1.4 kW
- Average air consumption: 50 l/min
- Power supply: 400 V, 16 A
- Air supply: 0.5 MPa, 120 l/min
- Weight: Approx. 3 kg (varies with the specific geometry)
- Dimensions: Approx. 150 x 150 x 120 mm (L x W x H, varies with the specific geometry)
- Ø of heat-affected zone: Approx. 70 mm
- Heating rate: Up to 10 K/s

The values apply to a 3.6 kW unit; the power output is scalable.

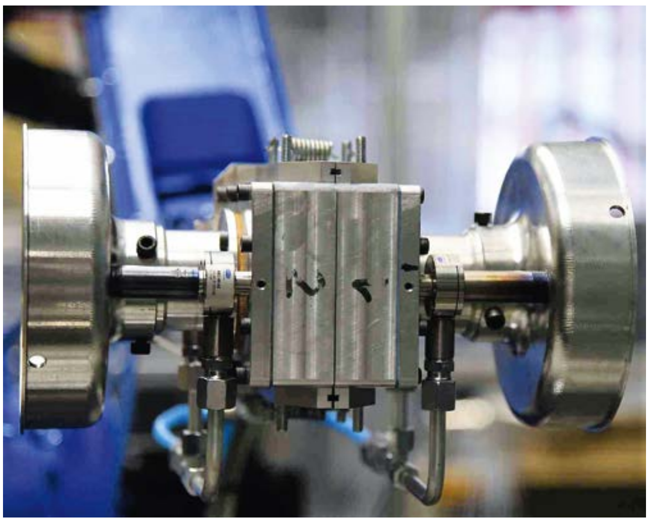


Fig. 2. The Turbotherm modules can be used on the nozzle and ejector side if required (© Varioplast)

on the efficiency of heat transfer to the mold surface, the optimum distance between the nozzle and the mold, and process parameters such as temperature, air pressure and heating times. It arrived at the optimum solution by performing iterative tests on the various embodiments of the heating module on production machines at Varioplast during the various stages of development.

The Turbotherm heating module has the following components:

- A heating head with dedicated nozzle technology and air-supply unit,
- a heat-recovery bell,
- a control box with integrated controller,
- a bypass valve for selective mold cooling in conjunction with the use of the heating module, and
- appropriate connecting cables and mounting plates.

New here is the heat transfer medium: ordinary air from the plant's compressed air network. The system is protected on the controller side against failure of either the compressed air or the power supply. The temperature control unit is compact enough to easily traverse into the open injection mold. However, a handling system is essential here.

In the case of one-sided heating, e.g. on the nozzle side only, the robot arm can remove the part produced in the previous molding cycle while placing an insert (**Fig. 1**). For use on the nozzle and ejector side, a turbothermal unit with two heating heads is available, along with a mechanical delivery unit for docking onto the mold cavities (**Fig. 2**). From a control technology point of view, the heating module is connected to the existing installation via Euromap, thereby ensuring cycle-accurate use.

Process Parameters: A System with Scalable Performance

High heating rates are crucial to the process and are determined by several interdependent factors. Thus, very good results were achieved with hot air at 600 °C and highly turbulent flow in the heat-affected zone (**Fig. 3**). Although the geometrically necessary ratios are a given and offer little scope for change, it is still theoretically possible to further shorten the heating times by raising the air temperature (**Fig. 4**).

Fig. 3. Surface of a molded part with (left) and without (right) Turbotherm. A knit line is invisible in the first case, but visible in the second (© Varioplast)

Like all variothermal systems, Turbotherm is scalable in output, from 120 W to 32 kW. 3.6 kW is standard. This makes it ideal for heating the knit line area. These outputs are to be understood as maximum figures. The average power consumption comes to about 1.4 kW if the air flow is reduced and the electrical output lowered to a fraction of the heating output when the module is used (**Fig. 5**).

This low energy requirement is supported by further measures. For example, some of the hot air consumed is returned to the process, as a result of which the inlet temperature to the heating module can be raised to approx. 150 °C. Consequently, the heating module does not have to heat the process air from room temperature, but merely has to bridge a lower temperature difference. This saves energy. Similarly, this "saved" energy can also be converted directly into a higher volumetric air flow through the heating module, thus further boosting the heating rate. In addition, a special insulation plate in the handling unit's waiting position lowers the average energy consumption even further.

Turbotherm can be used with existing molds without further ado. The heating module is also suitable for new intricate mold designs where sliders, ejectors and the like leave no room for processes integrated into the mold. »

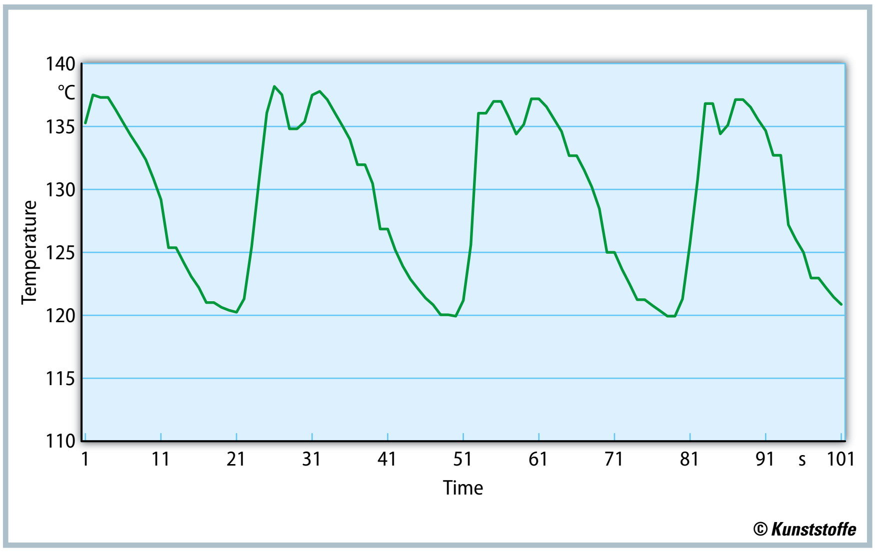


Fig. 4. Representation of the surface temperature of the cavity in the machine cycle. A temperature rise from 5 to 10 °C/s is possible, with the exact rate depending on the surface roughness (source: Varioplast)

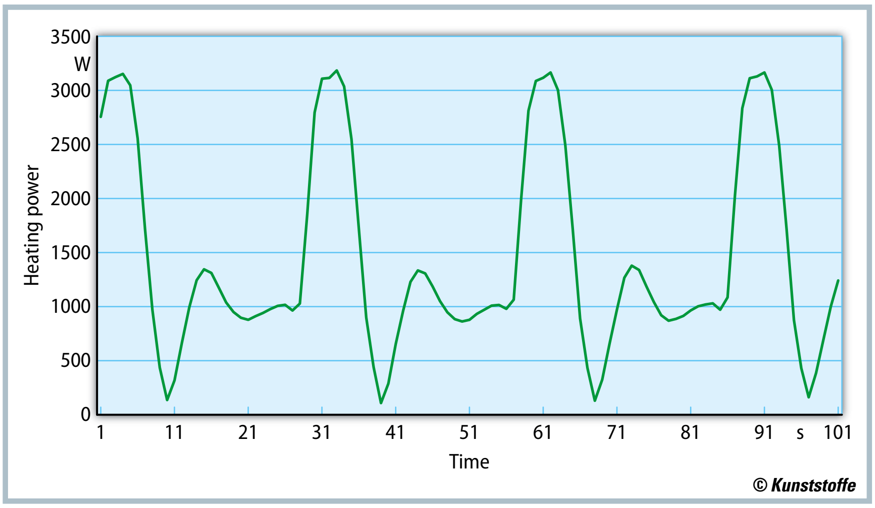


Fig. 5. Representation of the heating power in the machine cycle. The unit requires an average of approx. 1.4 kW power. Variothermal process control via the complete mold plates requires 20 to 30 times as much power (source: Varioplast)

for each part. For example, for series operation, the parameters for the melt injection temperature, the pressure in the injection barrel, the injection times and the holding pressure have to be re-determined.

The module can also be used to heat cavities containing convex or concave shapes. For this purpose, it is necessary to design nozzle shapes and suction bells that match the cavity contours. The free-form surfaces are usually available as a CAD data set, i.e. the CAD data can be used to quickly adapt metal shapes for nozzles and suction bells to the surface contours of the molds by means of additive processes. To this end, a modular system has been generated which covers a multitude of possibilities for shaping nozzles and suction housings.

Test Result: Production Readiness Confirmed

The heating module was tested at Varioplast in the production of exemplary work pieces (including credit cards) and materials. Materials such as PC, PC+ABS, PMMA, PP etc. were used (**Fig. 6**). The modules' suitability for series production as well as the consistency of the manufacturing process were ultimately verified. Over an 8-hour operating period, the unit had a relatively low power consumption of approx. 12 kWh. Variothermal process control via the complete mold plates consumes 20 to 30 times as much power.

An external institute measured the quality of the molded parts on the basis of selected criteria – series of measurements were conducted on the types of material used and as a function of heating times in order to predict long-term part quality. They clearly showed that the knit line depth and width decrease with increase in heating time. The surfaces had a uniform appearance. They did not feature any streaks or other facets.

One of Varioplast's competitive advantages is its in-house inline production technology for painting and PVD coating. In Turbotherm, Varioplast now has an opportunity to further enhance its products, eliminate process steps and ultimately reduce costs.

Experience with the new heating module has shown that the settings for series production must be determined

Conclusion

Due to the positive response at Fakuma, Varioplast intends to now make this resource-conserving technology available to the entire plastics processing industry and to provide it as a commercial product in the form of a heating module with corresponding control technology. To this end, the company is offering parties interested in using the new process for specific parts the opportunity to carry out initial testing at Varioplast – including configuration of suitable nozzles and bell systems, determination of the necessary settings, adaptation to robot handling, and production of sample parts. Turbotherm is currently undergoing qualification for customer processes and adaptation to EU standards and should be available on the market in the spring of 2018. ■

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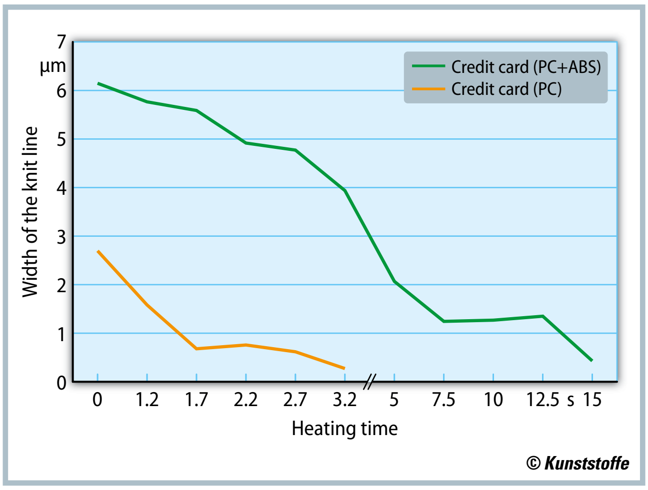

Fig. 6. The width of the knit line decreases strongly with heating time. It can be optically reduced by up to 100 %, i.e. completely eliminated (source: Varioplast)