



Frontal view of an inmx plasticizing unit. Not visible from the outside: the heating elements integrated into the barrel (© inmx)

Energy-Efficient Melting

Retrofittable Plasticizing Units Can Halve Heating Energy Consumption

A new generation of energy-efficient plasticizing units for injection molding machines that can be retrofitted to any make of machine, provides heating-energy savings of up to 55%. This development by start-up inmx enables older machines to be upgraded from an energy viewpoint and electrical machines to be further optimized. The savings stem from an innovative heating system which integrates the heating elements into the barrel.

Energy efficiency is now an important criterion for plastics processors considering buying new injection molding machines – high energy consumption is a heavy financial burden. For example, German industrial electricity prices in 2018 reached a new high of 17.17 cents/kWh on average, equivalent to a price increase of 184% since 2000 [1]. What is more, companies that engage in efficiency-enhancing measures by carrying out energy audits to EN16247 or introducing an energy management system to ISO50001, can look forward to attractive benefits, such as partial exemption from the renewable energy levy. It is therefore perfectly logi-

cal that demand for energy-efficient solutions is on the rise.

Injection molding machine makers have done a lot to meet this demand in recent years. There is hardly a manufacturer that does not trumpet the low energy consumption of its machines and the high efficiency of its drive technology. The fact that most attention has been concentrated on the drive side of the machine and not on barrel heating seems understandable, given that heating energy consumption in the past usually accounted for 25% or less of the overall energy consumption of an injection molding machine. There were therefore clearly

greater potential savings to be made on the drive side.

But times have changed. Where once inflexible hydraulic pumps were driven by power-guzzling, oversized asynchronous motors, there are now energy-saving solutions ranging from servo hydraulics to hybrid machines with electric screw drives through to highly efficient, all-electric machines. So, it is high time to have a look at barrel heating, which has been neglected for far too long and which, thanks to efficient drive technology, now accounts for up to 50% of total energy consumption in modern machines. »

Alarming Waste-Heat Losses

Unlike modern drive technology, barrel heating is not at all efficient. Even with insulated band heaters fitted, some 60% on average of the heating energy input is released into the ambient air at low throughputs (Fig. 1). Without insulation, this figure can be 75% or more, and that does not take into account the energy dissipated via the cooling water of the feed zone cooling system. Even if the waste-heat losses decrease percentage-wise with increase in throughput, these are alarming values that call for action.

inmex GmbH, Sankt Augustin, Germany, meets this problem with a new type of heating system (Fig. 2) that slashes waste heat losses: to a maximum of 20% of the heating energy input (Fig. 1). The trick: instead of conventional band heaters, which enclose the plasticizing barrel from the outside, the heating elements are integrated into the barrel. This substantially boosts heat transfer from the heating element to the barrel and, in conjunction with the use of effective insulation, reduces the heating energy by up to 55%.

In the application under review here, polycarbonate was processed at 280 °C with a material throughput of 2 kg/h on an injection molding machine (type: All-rounder 270 C 500-100; manufacturer: Arburg GmbH + Co KG, Lossburg) with a clamping force of 500 kN and a 25-mm

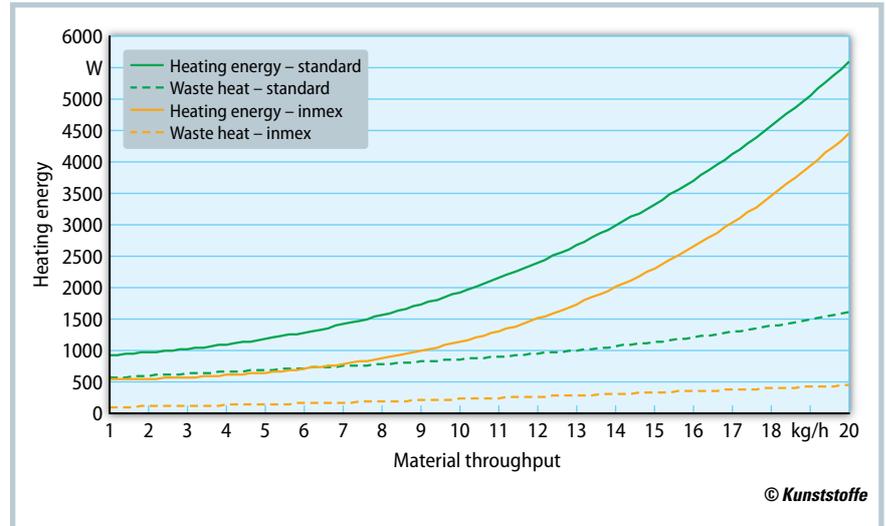


Fig. 1. Heat output with insulation as a function of throughput, based on the measurement results of 30 different applications (source: inmex)

screw. The inmex plasticizing unit lowered the heating energy consumption from 1025 W to 450 W, even though the first (and most energy-intensive) heating zone of the original plasticizing unit was already fitted with insulation.

Fast Heating, Very Good Heat Distribution

The cost of retrofitting an injection molding machine is marginal. inmex GmbH provides the entire plasticizing unit (Fig. 3), no matter what make of machine, while retaining the same number of heating zones and all plugs or connections that

were in the original. Nozzles and screws are also compatible with those of the machine manufacturer, allowing the machine operator to install the plasticizing unit as usual and to operate it with identical settings. Even the heating elements can be changed independently and with reasonable outlay should this prove necessary.

In addition to energy savings, the user benefits from other advantages, some of which even outweigh mere energy saving. For example, the plasticizing unit heats up more than twice as fast and, thanks to a metal housing, offers effective protection against contamination, e.g. in the event of leaks between nozzle and mold. In addition, the inmex barrel has better heat distribution because there are no unheated areas between the heating zones. Andreas Brüggemann, Operations Manager at Heinrich Axmann GmbH & Co. KG in Cologne, Germany, says: "Thanks to this improved homogeneity, we no longer have to compound pre-compounded materials that generate dust clouds, but instead can now color them directly on the machine."

Solution for Rapid Cooling and Energy Efficiency Analysis

The insulation of the plasticizing unit, which makes sense from an energy point of view, however, can also be a focal point for criticism, e.g. where frequent material changes are made. This is because the insulation retains the heat in the barrel for



Fig. 2. Plasticizing unit and plasticizing screw can be retrofitted to any make of machine (© inmex)



Fig. 3. Energy-efficient inmex plasticizing unit for an Arburg injection molding machine (© inmex)

much longer, even if the barrel needs to cool down to allow another material to be processed. But inmex also has a solution to this problem: an optional water-cooling system that can cool the barrel down in record time despite the insulation. Another criticism is the excess temperature that can occur on the compression zone section of fully insulated units at high screw speeds and dynamic pressures. However, this can often be remedied by adjusting the machine settings, e.g. by reducing the screw speed and thus utilizing the entire cooling time for metering. Further possibilities are a reduction in the often unnecessarily high setting for the back pressure and adjustments to the temperature profile.

inmex has been addressing problems of this nature since its foundation. As a spin-off from the Bonn-Rhine-Sieg University of Applied Sciences, the company has a strong scientific ethos, continuously engaging in research and incorporating the results into product development. This has also led to the development of an energy-efficiency analysis service that inmex offers in addition to the plasticizing units. The focus here is on measuring all energy flows related to the plasticizing process which are recorded by external sensors. This reveals where the heating energy input ultimately escapes to:

- The polymer which additionally undergoes dissipative melting by the screw,
- the ambient air, and
- the cooling water of the feed zone cooling system, which can dissipate large quantities of energy.

The decisive factor here is whether the last of these is operated under continuous water flow or is temperature-con-

trolled. Whereas energy losses are close to zero in controlled operation and high feed temperatures, several kilowatts can be wasted in continuous water flow (Fig. 4). The inmex plasticizing units therefore feature simple thermal separation: a recess between the heated area of the barrel and the cooled feed zone. This simple measure can save several hundred watts.

Programs for Promoting Investment

But there are limits to energy savings, because a certain amount of energy is needed to melt the polymer and cannot be further reduced. The minimum energy required to heat a given amount of polymer per unit of time to a specified temperature is called enthalpy [2]. Depending on the temperature, each polymer has a specific enthalpy (kJ/kg) which, when multiplied by the material throughput, gives the enthalpy. The polymer, processing

temperature and throughput determine the proportion of enthalpy in the plasticizing process (Fig. 5).

The ideal situation in which only the actually required amount of energy for the enthalpy has to be supplied to the plasticizing process will probably never be achieved. But through the use of an inmex plasticizing unit and controlled feed zone cooling, the enormous energy losses can be slashed. This is a sensible investment that can even be subsidized, points out Annette Fischer, member of the board of the Federal Association for the Promotion of Energy Efficiency (Bundesverband zur Förderung der Energieeffizienz e.V. or BVFE), in Cologne: "Plastics processing companies in particular have huge savings potential and are often desperately looking for further ways to lower their energy consumption. The inmex technology is an important starting point for this and can be funded under various programs." »

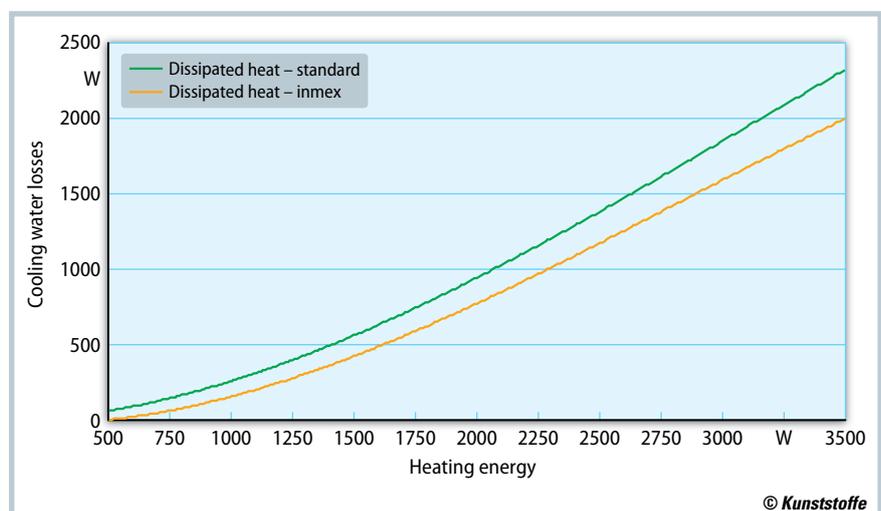


Fig. 4. Energy dissipated via the feed zone cooling system (source: inmex)

The Author

Axel Ifland, M.Eng., studied product development and mechatronics as part of his mechanical engineering degree at the Bonn-Rhein-Sieg University of Applied Sciences. After five years as an engineer with an SME injection molding machine manufacturer, he ventured into self-employment. A scholarship holder, he was supported by the state of NRW under its "Start-Up University Spin-Offs" program and won several awards in start-up competitions. In 2018 he finally founded inmex GmbH, which today employs six people.

Service

References & Digital Version

- You can find the list of references and a PDF file of the article at www.kunststoffe-international.com/7737081

German Version

- Read the German version of the article in our magazine *Kunststoffe* or at www.kunststoffe.de

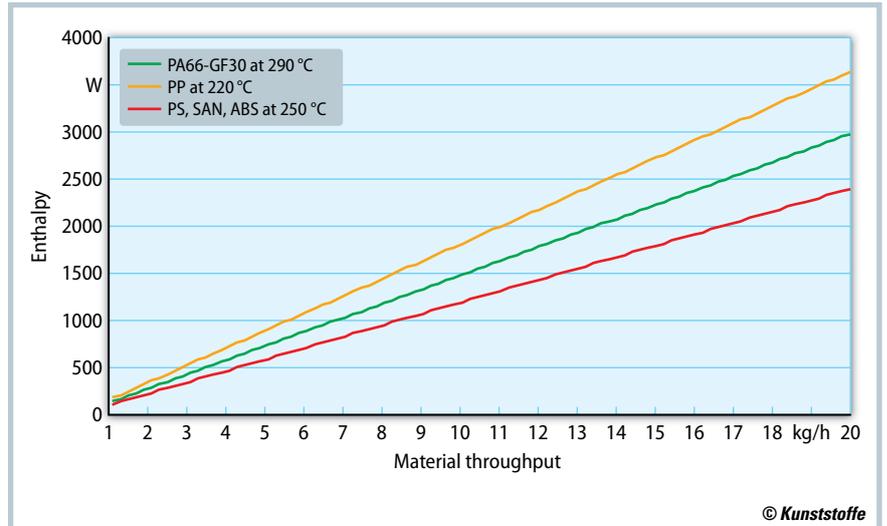


Fig. 5. Enthalpy of different polymers as a function of throughput (source: inmex)

And, indeed, there are several funding programs at federal and state levels that subsidize investment in new energy-efficient plant. Probably the most lucrative program of any Federal German state is the "Green Invest" operated by the Thüringer Aufbaubank, which will subsidize 80% of eligible expenses [3]. But there is also a promising possibility at Federal German level – the "Step up!" program offered by the Federal Ministry of Economics and Energy [4]. There are two competitive tendering rounds per year, with successful candidates having up to 30% of their investment costs reimbursed.

Conclusion

Whether subsidized or not – investing in the energy-efficient technology of inmex is worthwhile, from both energy and technical points of view. The system is additionally attractive because it can be used by all manufacturers and because older machines can also be upgraded to improve their energy efficiency. In its integrated barrel heating, the company offers an uncomplicated alternative to the state of the art and makes an important contribution to more sustainable production – made in Germany. ■



Figure: © private

Five Questions for ...

... **Andreas Brüggemann, Plant Manager at Heinrich Axmann GmbH & Co. KG.**

How long have you been testing the energy-efficient plasticizing unit?

The inmex unit has been on one of our machines for a year now. We specifically chose a machine that runs at full capacity to ensure that this unit is really put through its paces.

Can you tell us about the experience you have gained with it?

At first we were a bit skeptical, but then we quickly realized that this unit did in fact represent a substantial improvement: a completely enclosed system that prevents overmolding, saves energy

and leads to better melt homogeneity due to its very good temperature control on the barrel.

In what way did you benefit?

The improved homogeneity has enabled us to eliminate the need for compounding pre-compounded materials with dust clouds and to color them directly on the machine.

Were there any disadvantages to using this plasticizing unit?

No. We haven't had a single failure yet.

What's the take-away?

We will definitely be fitting out further machines with inmex units in the future.