Carbon Busters, Part 2: Jointly Identifying, Classifying and Reducing Energy Consumptions

Transparency as a Basis for Energy Efficiency

The Product Carbon Footprint is increasingly being calculated for the assessment of injection molding products. The PCF indicates what amounts of harmful substances – converted into carbon dioxide equivalents – are emitted during both the production and use phases of the product. Besides raw materials, the energy required for production makes up a considerable share of this value. This makes the issue of energy saving a must, even in times of stable energy prices.

The most varied measures help to save energy, but not all of them are equally profitable for every company. © iStock

Energy efficiency means saving more than money. But the road to the energy-optimized injection molding cell is often stony and confusing. The first thing is to create transparency and build up a profound understanding of the individual energy consumptions. Only then will the next steps follow: the identification of potentials, definition of goals, at which points how much energy is to be saved, and the drawing up of a plan to achieve the set goals (**Fig. 1**).

Digitalization is an important tool for creating the necessary transparency, recording and monitoring individual energy consumptions, and supporting processors in achieving savings targets.

For the injection molding machine manufacturer Engel, based in Schwertberg, Austria, energy optimization products have always been anchored in the corporate strategy, and an important part of the "inject 4.0" product family.

Towards the Consumption-Optimized Machine

There are two key indicators for the energy consumption of an injection molding cell:

- the mean electrical power consumption (kWh/h) and
- the specific energy consumption (kWh/kg), which indicates the energy input per kilogram of processed raw material.

Only the specific energy consumption describes how energy-efficiently and with what carbon footprint a part is produced on a machine.

The specific energy consumption depends on the machine and also on the particular operating point, which takes into account the cycle time and individual process parameters (**Fig. 2**). An energy-efficient injection molding machine with short dry-running times and a robot with rapid, path-optimized removal paths generally offer advantages. They ensure a low basic level of energy consumption. The basic prerequisite for energy-efficient and sustainable production is to use an injection molding machine that is precisely suited to the process.

What does this machine look like for the production of a specific part? At Engel, transparency begins before an injection molding machine is purchased. For all modern, as well as many older, machines, the machine manufacturer issues a certificate for the machine efficiency class according to Euromap 60.1. Euromap 60.1 describes how the machine-related energy efficiency class is determined – in a similar way to standard consumption. However, the product-based energy consumption depends on the part and process parameters, such as injection pressure, clamping force and cycle time. This is where Euromap 60.2 comes into play, which deals with determining the energy consumption for a specific product on a defined machine based on process parameters. Sound test reports are used to identify

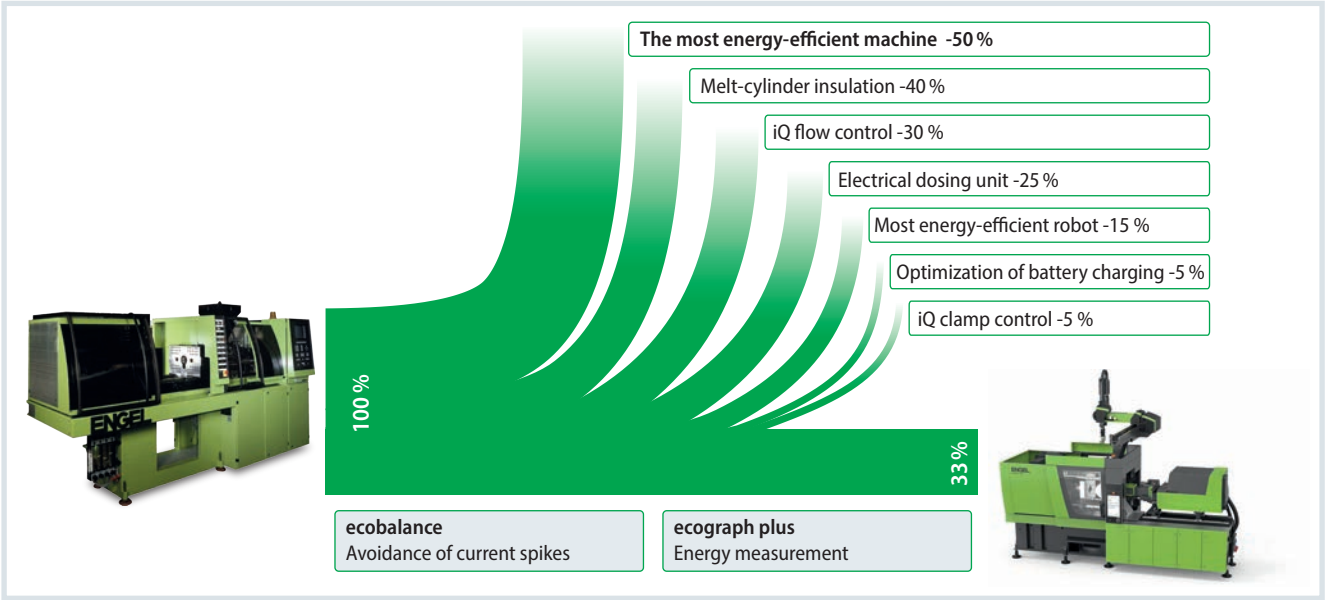

Fig. 1. The most diverse measures help with energy saving. The extent of the potential in detail depends on the starting point and the particular application. © Engel

the significant consumers and energy saving potentials.

In addition to making energy consumption measurements according to Euromap 60.2, Engel also offers to calculate the process-specific energy consumption for a planned injection molding process already in the offer phase. This makes it possible to choose the energy-optimized machine for the particular application. The data also help with reliable calculation of the return on investment when purchasing a new injection-molding machine.

Certificates not only support the future machine operators in applying for grants to increase energy efficiency, they also generally verify the estimation of product-specific energy consumption based on Euromap 60.2. This guideline contains the specific energy demand for the production of a part and makes clear the increase in energy efficiency with a new machine.

Seeing the Energy Consumption Overall and Individually

These figures are reliable because they also take into account the overall efficiency. Although electrical machines enjoy the reputation of being front-runners in terms of energy efficiency, they are not necessarily the best solution for every application. The energy efficiency of hydraulic and hybrid injection molding machines has been continually improved. For example, a hydraulic tie-barless injection molding machine can perform better in the overall efficiency than an all-electric machine if production of the specific product requires a long holding time or the advantages of the tie-barless clamping unit are exploited in favor of a smaller machine size. Over and above the different drive technologies, innovations in the last two decades have more than halved the energy consumption of injection molding machines. This development can be readily illustrated with the example of manufacturing a plate-shaped part of ABS recyclate with a shot weight of 51,545 g and a cycle time of 15,84 s (**Fig. 3**).

If we consider the entire production cell, it depends on the efficiency of each individual component. In the production of the plate-shaped part, the biggest energy consumer in the injection molding cell is temperature control (**Fig. 4**). In other applications, temperature control can even make up over 50 % of total energy consumption. This shows that special attention should be paid to mold temperature control for optimizing the energy consumption. »

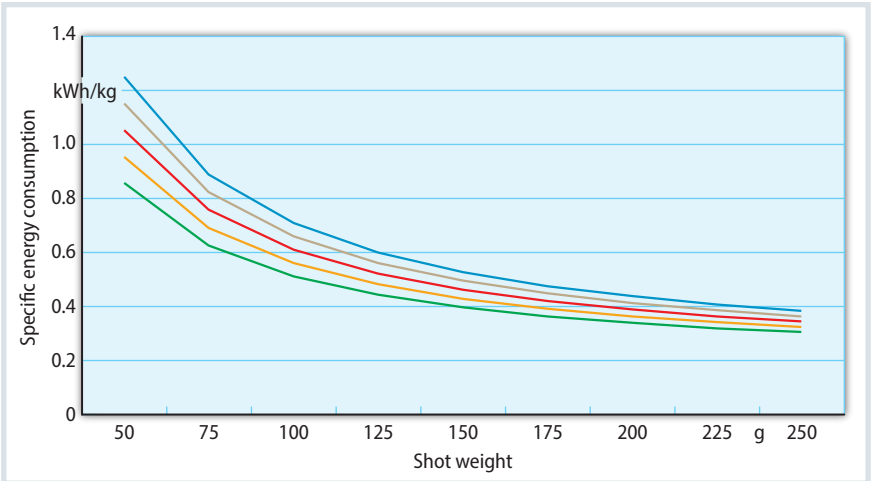

Fig. 2. The specific energy consumption makes clear how energy-efficiently a part is produced. It depends, among other things, on the shot weight and the cycle time. The individual curves show increasing cycle times (from bottom to top). Source: Engel; graphic: © Hanser

In injection molding production, Engel, with the "ecograph" product family, ensures transparency of energy consumption. In the machine control, the ecograph shows the total energy consumption of the injection molding cell and the individual consumptions, for example of the machine drives, melt cylinder heater, mold heater, external hot-runner control units, temperature control units and, if necessary, other ancillary equipment. For this, external systems are integrated via OPC UA.

Transfer of the Consumption Values to Higher-Level Systems

For even more accurate measurement of the energy demand, *ecograph plus* allows the power consumption to be measured directly in the switch cabinet by means of an energy measurement terminal. With both variants, the energy consumption can be monitored and actively limited.

And the transparency of the energy consumption here is not limited to individual injection molding cells. The standardized interface (Euromap 77) allows the energy consumption values to be transferred to higher-level systems, such as the Engel *e-connect* customer portal or the *TIG authentig* MES. This allows energy-guzzlers to be easily identified.

The *iQ process observer* smart assistance system also displays changes in the total and partial energy consumptions in the machine control cycle by cycle. The automated processing of the process data gives the process engineer the necessary context and supports the continuous energetic optimization of the injection molding process.

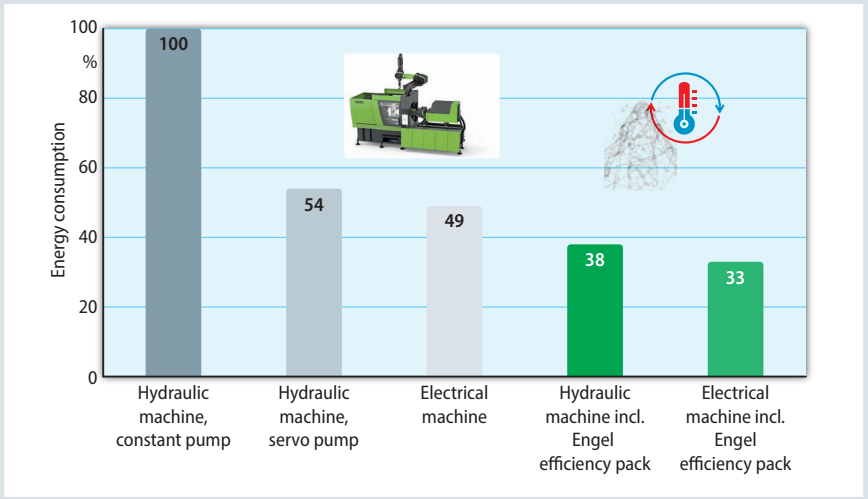

Fig. 3. Innovations in drive technology and integrated systems have greatly reduced the energy demand for injection molding production. Source: Engel; graphic: © Hanser

Optimizing Consumption Step by Step

Once the energy saving potentials have been identified, the question arises of how they can be leveraged. Overall, there are many different aspects that, if optimized, will increase the overall efficiency and are considered in greater detail below. If all the optimization potentials are exploited, the energy consumption of a production cell can be reduced by up to 67% (**Fig. 1**).

A range of optimization possibilities can often already be discovered by checking the machine equipment. A particularly high energy saving potential lies, for example, in the melt-cylinder insulation. This allows savings of up to 40% of the heating energy, and therefore about 10 % of the total energy. Avoiding heat losses on the melt cylinder reduces the basic consumption of the injection molding machine. Another way of saving energy for hydraulic machines is to upgrade to an electrical dosing unit. This allows up to 25 % energy saving during dosing. It is also worthwhile calculating the retrofitting of energy-saving drives. For example, *ecodrive R* in Engel-duo machines saves up to 50 % of the drive energy.

Reliable Capping of Power Spikes

Energy-efficient production planning means avoiding spikes in electrical power throughout the production hall. For the energy spikes of more than 15 minutes that can occur at the start of production, when several machines are heated simultaneously, the energy suppliers demand a high price.

To avoid this, Engel's weekly time is used to stagger the heating of the injection molding machines. In addition, the ecobalance function in the CC300 control system of Engel injection molding machines helps to avoid power spikes. For this purpose, the ecograph or ecograph plus is used to limit the maximum total power consumption of the injection molding machine. The power consumption of drives and heaters is controlled so precisely that the product quality is not affected.

Another simple but effective way of saving energy is the "Engel Activity Check". This control feature permits controlled shut-off of the injection molding machine. Here, movement monitoring and adjustable time frames prevent an injection molding cell from being still available for production after production has ended, and thus consuming energy unnecessarily.

Stable Temperature Control, Low Energy Consumption

Mold temperature control accounts for up to 50 % of the energy consumption of

Info

Text

Dipl.-Ing. Dr. techn. Ruth Markut-Kohl is Team Leader for Digital Injection Molding at Engel Austria GmbH in Schwertberg, Austria; ruth.markut-kohl@engel.at
Dipl. Ing. Andreas Neuhold is Team Leader for Measuring Technology at Engel; andreas.neuhold@engel.at
Dipl-Ing. (BA) Hannes Fritz is Head of Product Management for Control Systems at Engel; hannes.fritz@engel.at
Martin Holzer is Product Manager for Smart Machines at Engel; martin.holzer@engel.at

Continuation Follows

Part 1 of the series (Technologies for Widespread Use of Recyclate) was published in Kunststoffe international 5/2023. The theme of the series is "**Carbon Busters**" and describes the industry's commitment to reducing its carbon footprint. One of the next issues will discuss the topics of direct recycling and the material rPET, among other subjects.

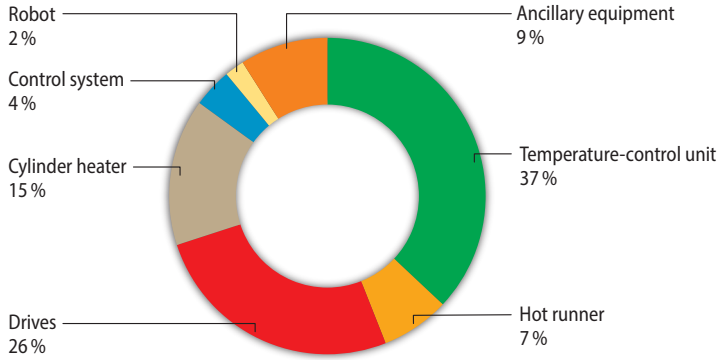

Fig. 4. Temperature control can make up the lion's share of the total energy demand of an injection molding cell. Special attention is therefore paid to the cooling processes.

Source: Engel; graphic: © Hanser

an injection molding cell, but, in many applications, this saving potential is not yet exhausted. With the *e-flomo* electronic temperature-control water manifold and the *iQ flow control* assistance system, Engel offers a solution for minimizing the energy consumption required for temperature control. For this purpose, the flow rate, pressure, temperature and temperature difference are monitored and automatically regulated to keep the temperature control process constant and produce consistently high part quality.

When integrated temperature control units of the Engel e-temp series are used, the iQ flow control software can also continually adapt the speed of the pumps to demand. This reliably avoids energy loss.

Optimizing Process Parameters with Smart Assistance Systems

Some process parameters have a significant influence on the required energy of the injection molding cell and offer great potential for efficiency optimization. Assistance systems help to find the optimum settings and keep them constant throughout the entire process.

For example, the clamping force is often set higher than necessary, which unnecessarily consumes energy. This is where Engel applies *iQ clamp control*. The assistance system calculates the optimum clamping force for continuous production and automatically adjusts it. With hydraulic clamping units, up to 5 % energy can be saved, not to mention the higher reproducibility and better mold protection.

Another example is the holding time, which has a significant influence on the cycle time and therefore also on the specific energy consumption. To determine the minimum holding pressure time, iQ hold control analyzes the mold breathing and the position of the plasticizing screw, and determines the sealing point fully automatically. In many applications, the holding time can be reduced, which shortens the cycle time and reduces the specific energy consumption.

Not least, rejects are a frequent cause of unnecessary resource consumption, and, here, too, digitalization offers a solution. The *iQ weight control* assistance system detects deviations in the raw material and ambient conditions during injection, and regulates the process parameters before even a single reject part is produced. On start-up, acceptable parts are produced after only four to five cycles.

Efficiency Analysis as a Service

Many different assistance systems are now available for improving the injection molding process. For many users, it is not easy to answer what influence they have in detail on the energy efficiency of the application. With the performance.boost service, Engel supports its customers in optimizing the injection molding process and advises on the use of digitalization solutions to increase energy efficiency. Various packages are available, which start with a thorough analysis of the running processes and include, for example, in-house training and technical support. ■