Spritzgiessautomaten

Fully electric is often not more efficient!

Injection moulding machines are available with different drive concepts. Some of the inexpensive series are still equipped with electro-hydraulic pressure and flow control. However, servo-hydraulic pump drives, fully electric machines or combinations of both, so-called hybrid machines, are significantly more economical.

It is often assumed that fully electric machines are the most efficient of the aforementioned. However, the company BOY cannot confirm this across the board, because servo-hydraulic pump drives offer significant advantages over fully electric machines, including in terms of energy, especially in the lower clamping force range. With this article we want to focus on the energetic differences between servo-hydraulic and electromechanical drive concepts in order to create a differentiated awareness of the respective advantages.

Energy-efficient production has played an important role within the BOY company for a long time. Servo-hydraulic pump drives were introduced at BOY for all E-series machines in 2008, followed by further energy-saving options such as EconPlast® and EconFluid.

In addition, all machines in the E-series are equipped with an energy monitor which, together with the energy analysis tool (Figure 1), supports the user in setting up their machine in the best possible way in terms of energy efficiency. Without knowing what the current consumption is and which process steps have the greatest influence, it is difficult to optimise the process accordingly.

However, before we look at a specific application example, it is first necessary to look at how the total energy consumption of an injection moulding machine is made up for both a servo-hydraulic and a fully electric machine (Table 1).

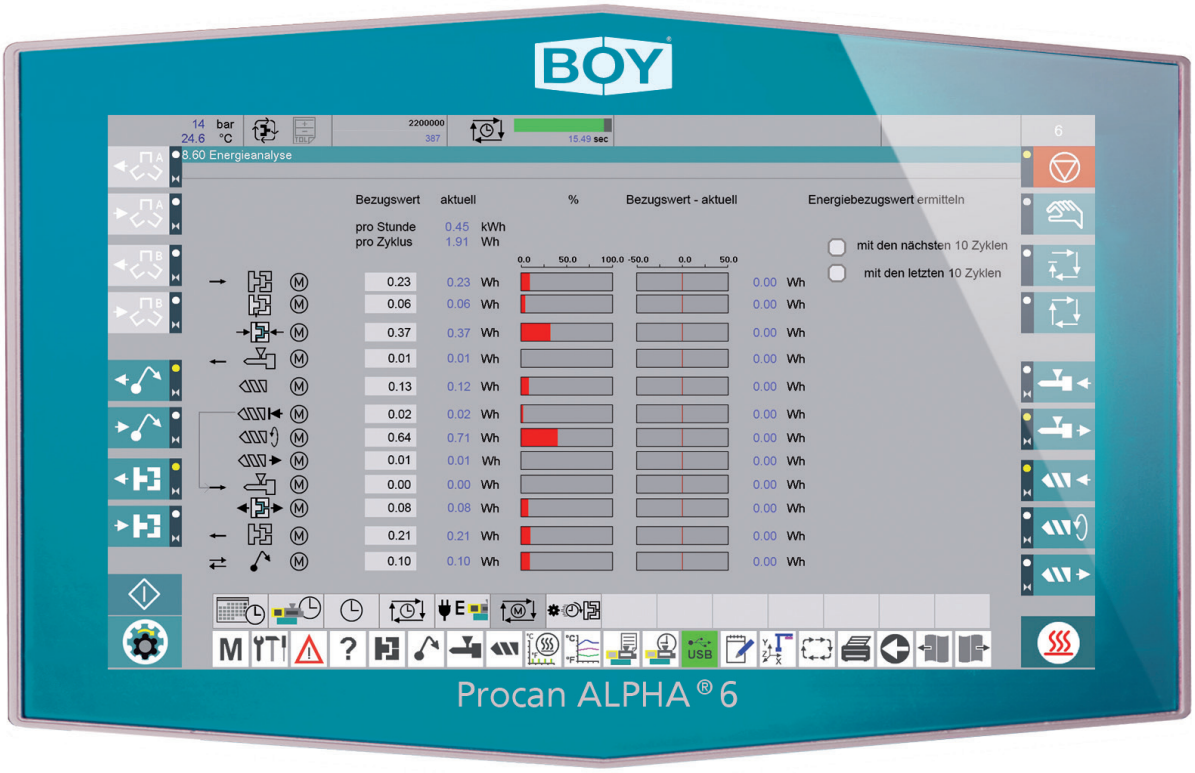

Figure 1: Energy analysis tool on all BOY machines in the E-series.

time-dependent influencing variables:	process-dependent influencing variables:
Standby consumption of the converters	Steering and guiding movements
Machine control	Heating elements
	Dosing process
	Build-up of the closing force
	Injection work
	Holding (residual) pressure

Table 1: Time- and process dependent influencing variables

Time-dependent influencing variables:

Regarding the time-dependent influencing variables, in a 1K-application it can be assumed in both cases (servo-hydraulic or fully electric) that both machine types will function with one control. The first differences become apparent in the number of converters required, because each servo drive requires its own (see Figure 2).

Consequently, in a servo-hydraulic machine with typically one drive, only one converter is required, since all travel movements (axial screw movement, rotary screw movement, movement of the injection unit, movement of the clamping unit, ejector stroke and, if necessary, core pulls) are executed with this.

Measurements have shown that such an converter has a base load of around 100-150 W.

With fully electric machines, each movement axis requires its own drive and therefore its own converter. This means that for a standard machine (without options such as core pulls) five converters are required for the basic functions mentioned above, which are associated with a base load of 500-750 W in total. If the machine is also equipped with core pulls, additional converters need to be added.

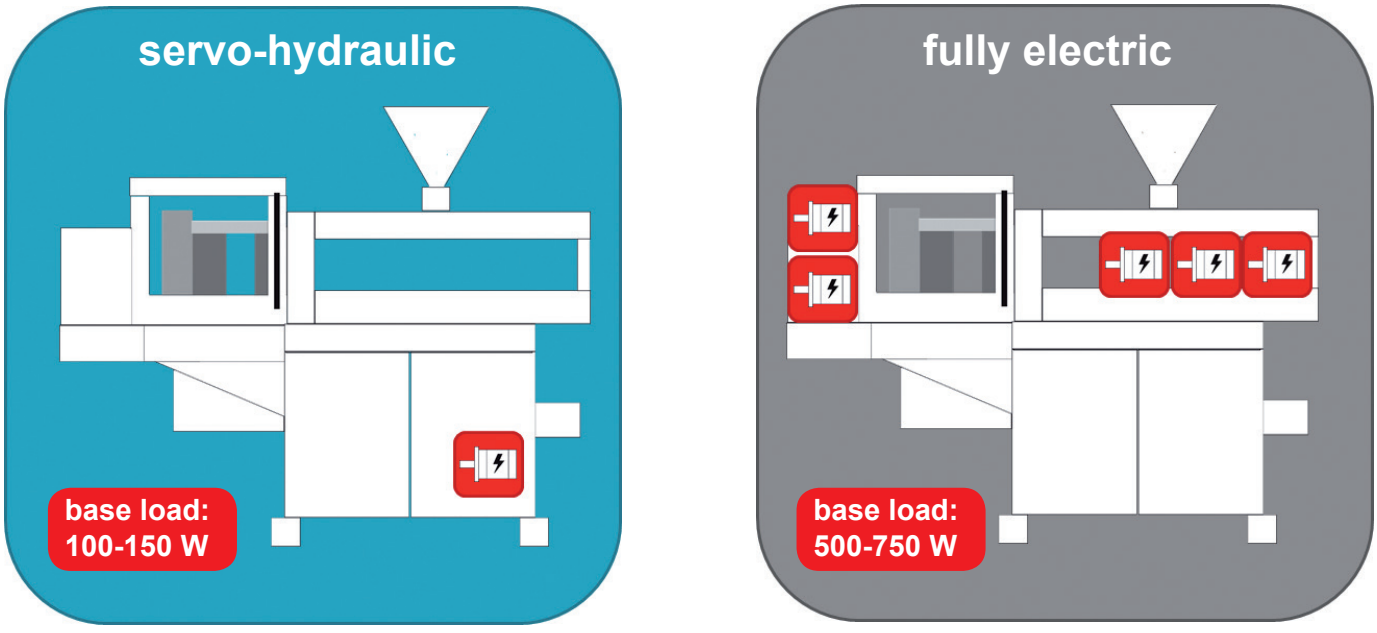

Figure 2: Minimum required number of converters for servo-hydraulic (left) or fully electric (right) injection moulding machines.

Process-dependent influencing variables:

In addition, the process-dependent influencing factors also have a significant influence on the overall consumption. In both cases, energy is put into the plastic by heating elements (heaterbands) and friction. This is basically independent of the drive concept, but by using EconPlast®, BOY offers the possibility of reducing the energy consumption to a minimum compared to conventional barrels.

In both cases, energy is required to build up the clamping force. If a toggle lever system of a fully electric injection moulding machine is compared with the clamping system from BOY, there is no significant difference in terms of energy when it comes to maintaining the clamping force, since both systems hold the clamping force without an active supply of energy and are thus passive.

There are energetic differences between the two drive concepts when it comes to the machine's travel movements (linear and rotational). Figure 3 shows the energy flow from electrical energy to rotational or linear movements for fully electric and servo-hydraulic drive concepts. Due to the higher conversion losses in servo-hydraulic machines, an electromechanical drive has an advantage here.

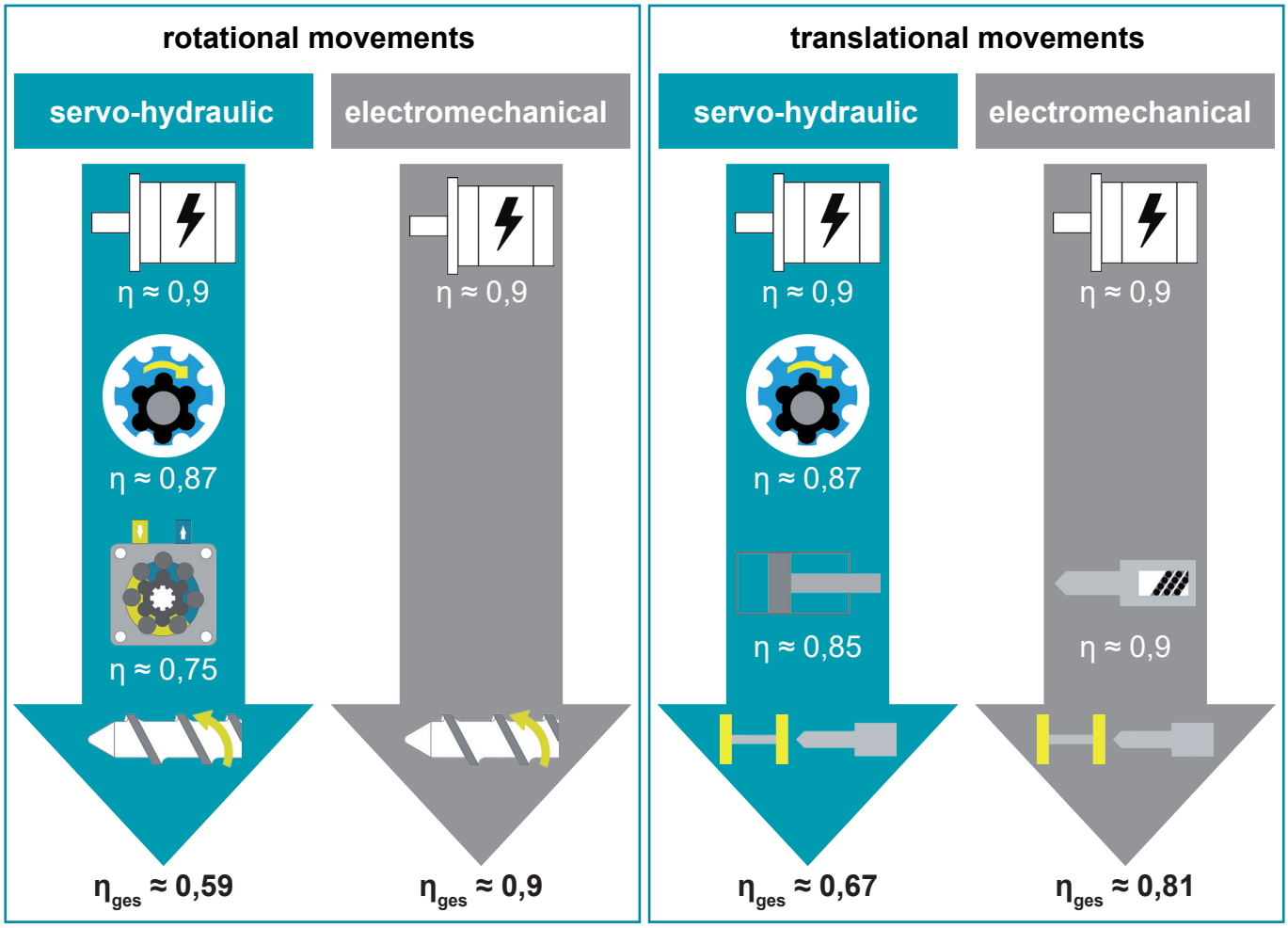

Figure 3: Comparison of the energy flow and the efficiency (η) of servo-hydraulic and fully electric machines.

Preliminary conclusion:

Servo-hydraulic machines cause a lower base load compared to fully electric machines. All-electric machines, on the other hand, have better efficiency (η) when converting electrical to kinetic energy. Which of these two influences predominates depends largely on the process or the item to be manufactured.

Example of application:

In order to transfer this to a concrete example, the energy analysis tool (Figure 1) mentioned at the beginning can be used. With the energy analysis tool, the process-related energy requirement of the servo drive is broken down into the individual process steps of a cycle. The tool offers the possibility of determining a reference in a steady process over ten cycles in order to optimise the process based on this. For example, figure 1 shows that in this application example (shot weight 12.5 g) there is a total energy requirement of 1.91 Wh/cycle. This consists of 0.71 Wh (dosing) and 1.2 Wh (sum of linear movements).

Savings potential through better efficiency:

Dosing:

$$0{,}71\ \text{Wh} \times \left(1 - \frac{0{,}59}{0{,}90}\right) = 0{,}24\ \text{Wh}$$

Linear movements:

$$1{,}2\ \text{Wh} \times \left(1 - \frac{0{,}67}{0{,}81}\right) = 0{,}21\ \text{Wh}$$

According to the efficiencies in Figure 3, a potential saving of 0.45 Wh per cycle (23.6%) would be possible by switching to a fully electric machine. With a power consumption (Figure 1) of 0.45 kW, this corresponds to a possible energy saving of 0.106 kW. If the total energy consumption of the two machine types are now compared, the following table shows the results:

	Servo-hydraulic	Fully electric
Base load (control + converter)	appr. 250 W	appr. 625-875 W
Heating power	appr. 400 W	appr. 400 W
Drive	appr. 450 W	appr. 350 W
Total	**appr. 1100 W**	**appr. 1375-1625 W**

For low to medium material throughputs, servo-hydraulic injection moulding machines are more efficient:

Numerous measurements have shown that total energy consumption of 1000-1200 W is not uncommon for the BOY 25 E/BOY 35 E machine types. The assumptions made can therefore be considered as realistic. In processes with low to medium material throughput, the process-independent base load predominates in fully electric machines. Looking at the overall balance, servo-hydraulic machines have a clear advantage. This can be further improved by using EconFluid hydraulic oil and EconPlast® plasticising cylinders.

Advantage of electric plasticising motors for high material throughputs:

However, if processes with very high material throughputs are considered, the influence of the base load becomes increasingly less important and, in particular, the energy used for the plasticising process increases progressively. Due to their better efficiency, electric plasticising motors have an advantage for this process step.

To remedy this, BOY also offers electric plasticising motors so that the advantages of both drive concepts can be combined in so-called hybrid machines. This is particularly useful if the plasticising process determines the cycle time, since this can then take place in parallel to all other travel movements.

Conclusion:

When which drive concept makes more sense from an energetic point of view always depends on the process. A generalised statement that one of the two drive concepts is fundamentally better can be clearly refuted.

Servo-hydraulic machines therefore offer very clear energy advantages over fully electric machines for low to medium material throughputs. Especially in the clamping force range of up to 1250 kN, this is often the case. However, for high material throughputs, the use of hybrid machines (servo-hydraulic basic machine in combination with an electric plasticising motor) is an extremely cost- and energy-efficient machine configuration.

BOY® Spritzgiessautomaten

Dr. Boy GmbH & Co. KG
Neschener Str. 6
53577 Neustadt-Fernthal
Germany

Tel.: +49 (0)2683 307-0
E-Mail: info@dr-boy.de
Internet: www.dr-boy.de