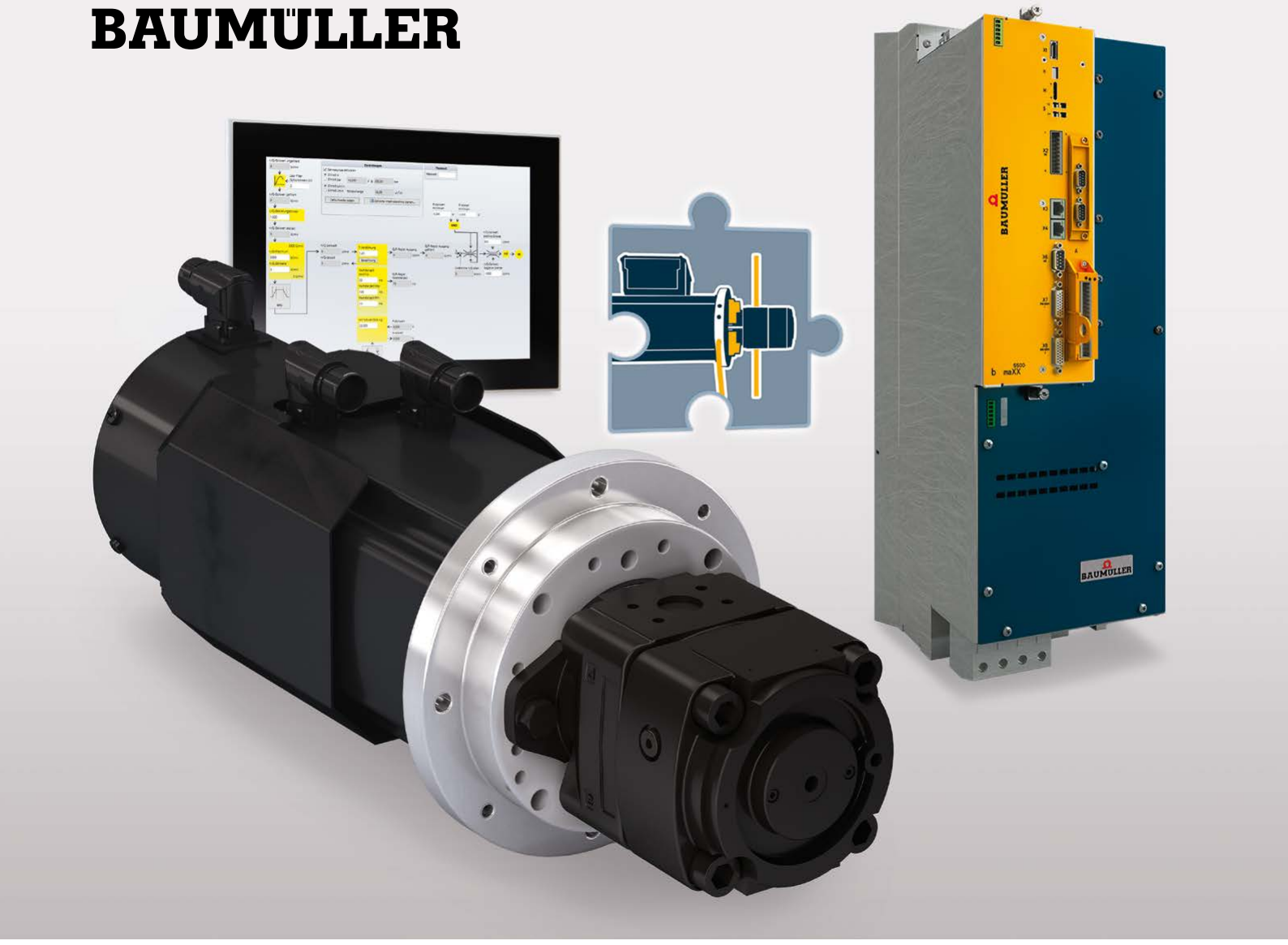
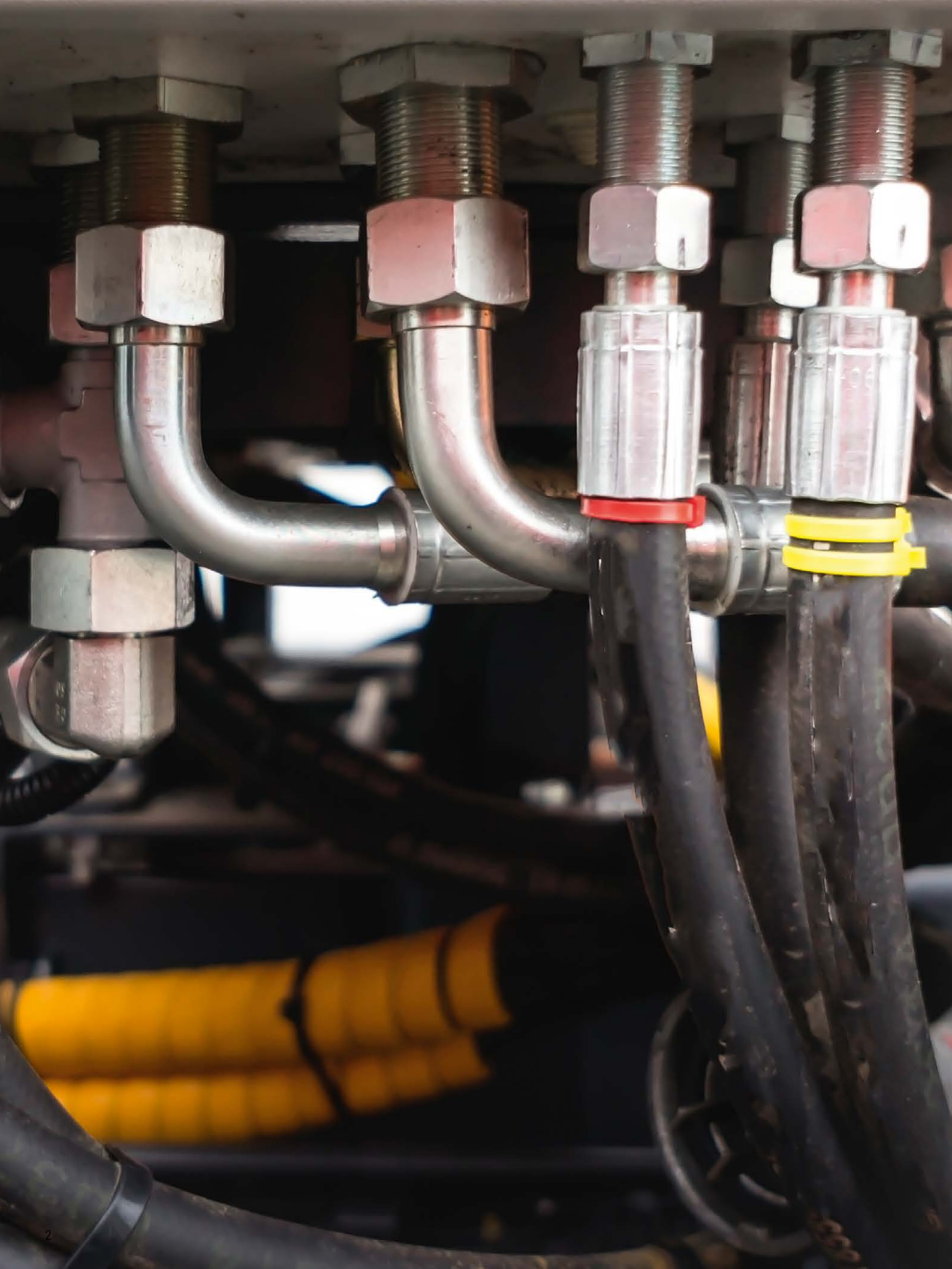
BAUMÜLLER



SERVO HYDRAULICS

Expertise for your machine with hydraulic drive
Energy efficiency and dynamics

Our servo hydraulic system combines the advantages of hydraulic power transmission with those of electric servo drive technology. Save up to 50% on energy costs.



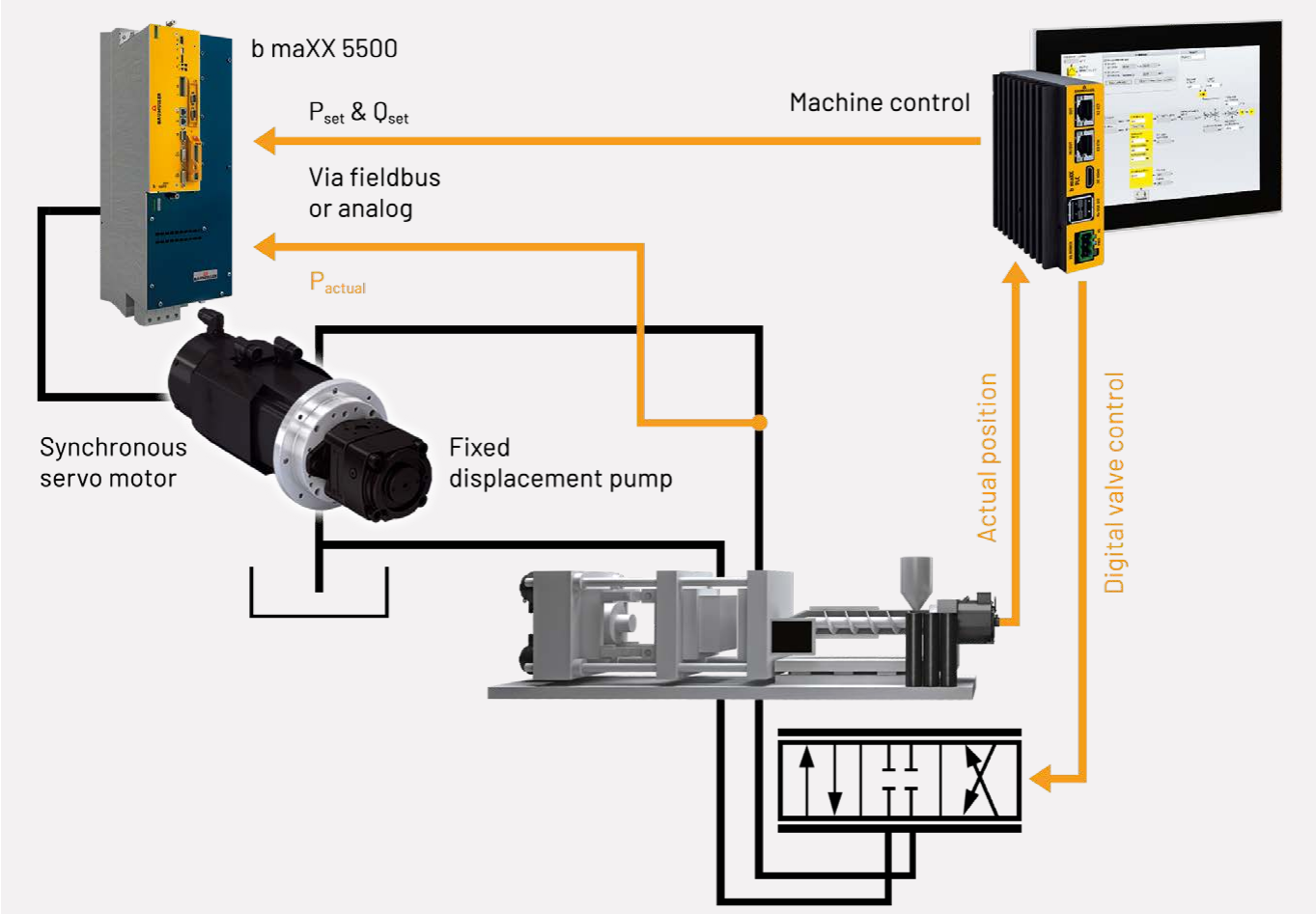
Expertise for your machine with hydraulic drive

Baumüller supplies innovative and optimized drive solutions for all sectors through years of intensive cooperation with mechanical engineers. Due to the integrated control in the servo drive, Baumüller servo pumps can easily be connected to your machine control systems. In the process, you reduce the energy consumption of your drive system significantly and also allow for shorter cycle times, greater accuracy as well as lower noise emissions. See for yourself and rely on the flexibility and power of innovation of Baumüller experts.

SERVO HYDRAULICS

The servo-hydraulic drive system

Example of the structure of a servo-hydraulic system in an injection molding machine



The servo-hydraulic system consists of a servo drive, which drives a synchronous servo motor. This motor drives a fixed displacement pump. The pressure and volume flow set values (Pset and Qset) are sent from the control unit to the servo drive. Pressure and flow rate are controlled on the servo drive by adjusting the speed. As in the conventional hydraulic systems with standard motors, the actual positions are read out via the machine control unit.

The machine builder provides the system supplier with the flow rate and pressure values required for the design of the drive system. Baumüller undertakes the design of the entire drive system, including the pump, motor, and the servo drive.

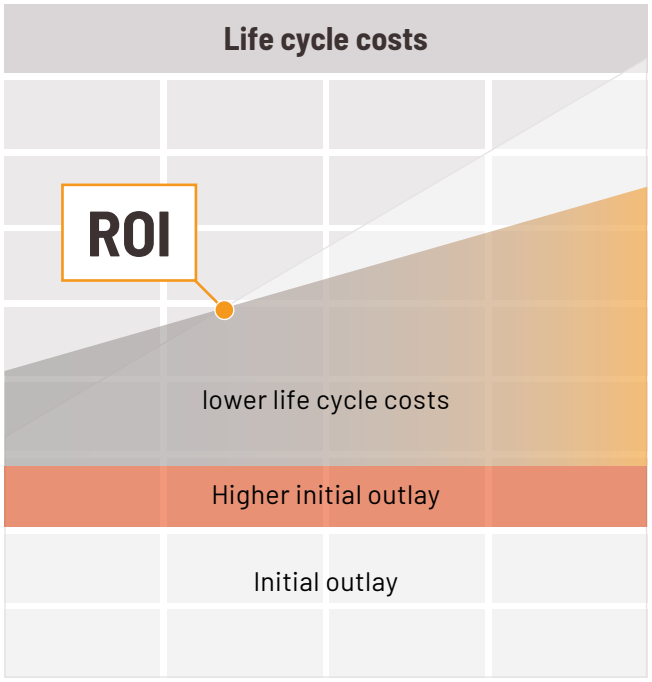
Energy efficiency and dynamics

Baumüller's servo hydraulic system combines the advantages of hydraulic power transmission with those of electric servo drive technology. Servo pump drives for the hydraulic supply consist of a fixed displacement pump and a servo motor. The quantity (flow rate) and pressure can be controlled precisely by highly dynamic changing of the motor speed. If neither flow rate nor pressure are required, the motor stops and does not consume any energy. The following applies to the pressure control: The motor turns at the lowest speed. It only consumes the energy necessary to maintain the pressure control.

The integrated Baumüller controller function enables simple linking to existing machine control systems. The actuation signals can be adopted directly from conventional hydraulic systems. This simplifies the machine integration and reduces commissioning times to a minimum.

The control of the drive and the low energy consumption of the components, especially in the partial load range, results in a highly energy-efficient and yet economical solution that you can use in your machines as a decisive competitive advantage.

Combine hydraulics and servo technology and save up to 50% on energy costs



Annual power cost for a conventional hydraulic machine at 300 days continuous operation and energy unit price of € 0.19 per kWh:

30 kW * 7,200 h * € 0.19/kWh = € 41,040

Typical energy consumption reduction of 30%:

€ 41,040 * 0.3 = € 12,312

Amortization of initial costs:

< 1 year

Not included in this analysis:

- ✓ Reduced cycle times
- ✓ Improved accuracy
- ✓ Less demand for air conditioning
- ✓ Smaller cooling system
- ✓ Longer service life of oil, etc.

Advantages

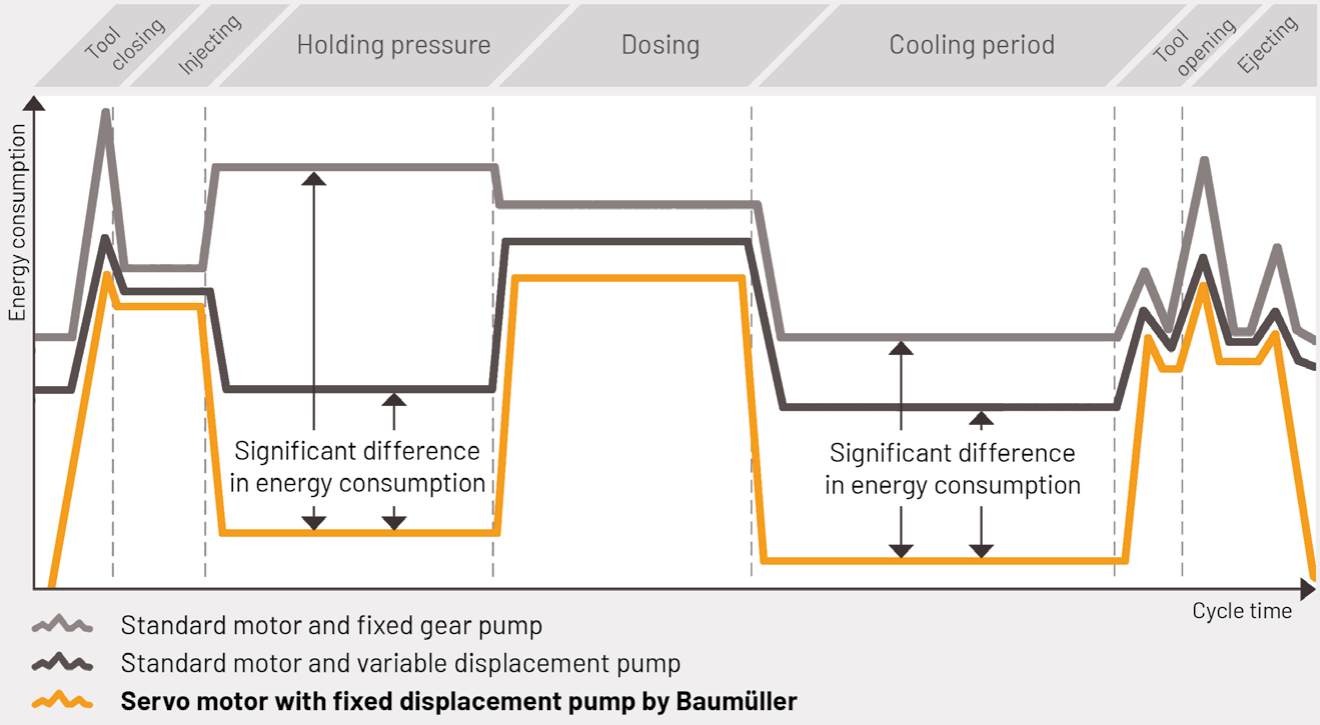
- ✓ Significantly lower energy consumption through control of the pump drive
- ✓ Lower noise emissions
- ✓ Higher process and product quality
- ✓ Downsizing of the drive components due to higher speeds -> compact drive system and smaller machine footprint

APPLICATIONS

Example injection molding

The principle of servo-hydraulics can be very well illustrated in the example of the cycle of an injection molding machine. The manufacturing of plastic cups or bottle stoppers consists of seven steps: Tool closing, injecting, holding pressure, dosing, cooling period, tool opening, ejecting. These production steps are very different, which means that within a process step the injection molding machine has a highly fluctuating power requirement. Closing and injection sequences require large quantities of hydraulic oil and a high volumetric flow. Cooling times, on the other hand, require no or just minimal output.

Example of a cycle of an injection molding machine



The difference in energy consumption can be clearly seen in the typical hydraulic system shown in the diagram. The high energy efficiency of the servo-hydraulic solution arises from a needs-specific pump output. When the machine is at rest, e.g. during cooling, then the motors will also be at rest and will consume no energy.

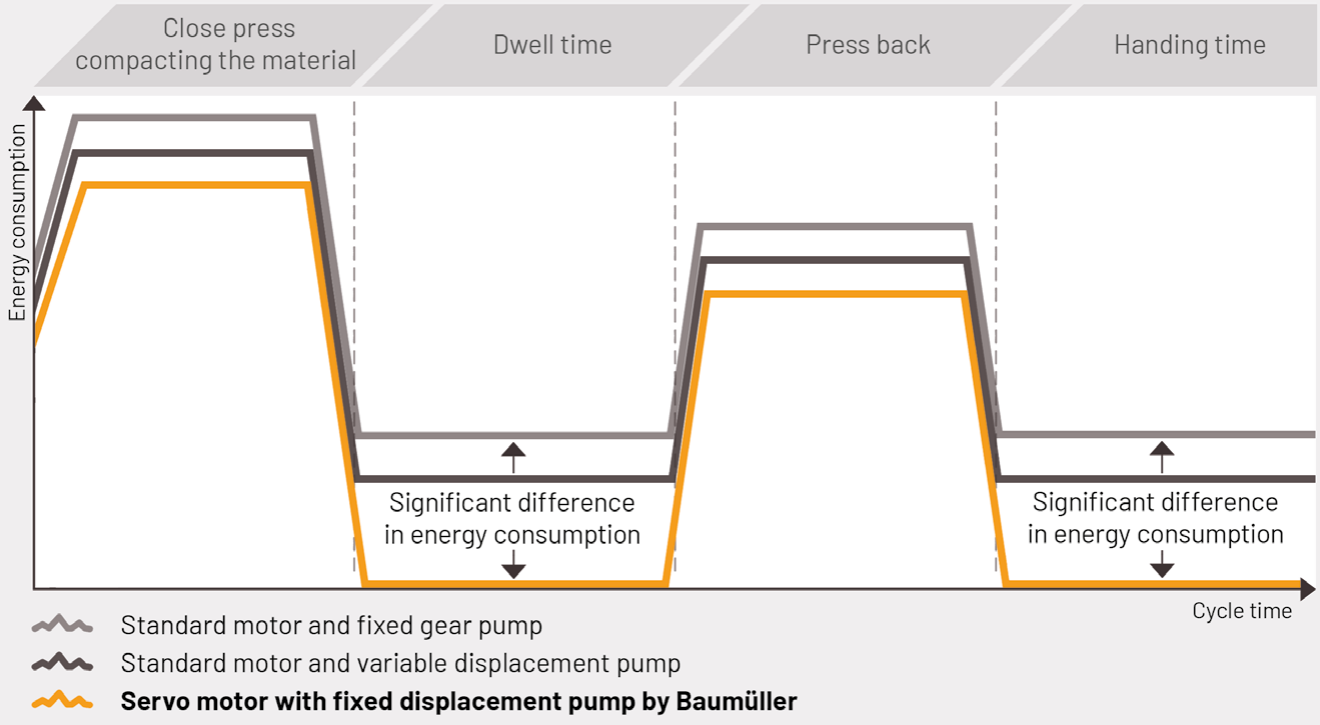
Energy calculator

You can calculate your potential savings directly online. Simply set the number of cycle segments, duration, pressure and flow rate and receive the energy consumption immediately:
www.baumueller.com/en/energy-calculator

Example press

An additional example is presses. The cycle in the figure is divided into four partial cycles: Close press (compacting the material), dwell time, press back and handling. The comparison of energy consumption between the three different systems shows that the servo-hydraulic solution in the individual partial cycles has a significantly lower power input and thus has a significantly lower energy consumption overall. Unlike conventional hydraulic systems, only the energy that is actually needed is used, while in the classic systems the losses are higher due to the constant rotation of the standard motor in rest phases, such as during the dwell time.

Example of a cycle of a press



Other application examples for servo-hydraulics

Injection molding machines and presses are not the only applications for servo-motor pumps. Anywhere that phases with high output requirements alternate with pause times in the machine cycle, the use of a servo-hydraulic system can make sense, such as in stamping and bending machines.

The advantages of hydraulic power transfer and electric power setting using servo technology combined, as an alternative to hydraulic pressure and volumetric flow control, yields an energy-efficient and cost-effective solution in the form of a dynamically controllable servo pump.

SOFTWARE

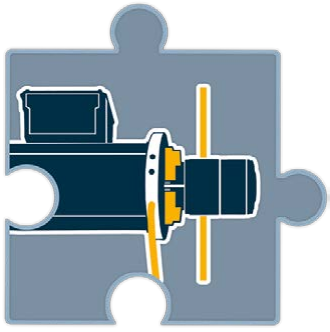
Intelligence in the drive

The servo hydraulic technology module is integrated directly in the servo drive and is fundamentally responsible for ensuring maximum utilization of the advantages of servo hydraulics. The heart of the software is the flexible pressure and flow rate control in a controller cycle time of only 125 µs for maximum dynamics and precision. Thanks to intelligent feed forward pressure controls, the control adapts itself to different hydraulic ranges and thus achieves outstanding pressure adjustment behavior.

Parameterization of the servo drive including servo hydraulic functions is fully embedded in the ProDrive user interface. The guided commissioning makes fast commissioning possible, even without in-depth programming knowledge or detailed servo drive technology know-how. The graphic user interface screens enable logical and clear operation.

The commissioning and optimization can also be undertaken as a service by the Baumüller experts, who have many years of experience in the application of servo hydraulics systems and thus integrate the system into the machine optimally.

In addition to the excellent control behavior and easy handling, the latest Baumüller V2+ software for servo-hydraulic systems also includes numerous protection and monitoring functions that further enhance the performance and reliability of the system.



Wire break monitoring, pressure sensor

Problem:
- ✓ Pressure sensor wire break

Function:
- ✓ Monitoring of the pressure signal at the servo drive
- ✓ Detection of a wire break
- ✓ Error message with definable error response

Benefits

- ✓ Schnelle Fehlersuche
- ✓ Reduzierte Stillstandzeiten

Pressure sensor comparison, monitoring and compensation

Problem:
- Aging of pressure sensors (zero drift)
- Damage to the pumpe

Function:
- Monitoring of the sensor signal by internal comparison routine
- Trigger by external signal
- Automatic compensation of the measured offset
- Adjustable warning and error thresholds
- Error and warning message with definable drive response

Benefits

- Condition monitoring: Early detection of a defective sensor
- High availability: Protection of the pump
- Optimum process sequence, even with sensor drift

Acceleration limit

Problem:
- Pump wear due to over-high acceleration

Function:
- Limiting of the acceleration in the servo-hydraulic system

Benefits

- "Soft machine behavior"
- Reduced wear and reduced down times

Leak determination, monitoring and compensation

Problem:
- Aging of pumps and therefore increasing leakage
- Reduced process accuracy

Function:
- Identification of the hydraulic system leakage
- Adjustable warning and error thresholds
- Error and warning message with definable drive responses
- Compensation of the measured leakage

Benefits

- Condition monitoring: Early detection of a defective pump
- Optimal process run even with increasing leakage

Basic pump protection

Problem:
- Dry running of the pump

Function:
- Detection of faulty states in the hydraulic system
- Monitoring of the pressure build-up time
- Error message with definable error response

Benefits

- High availability: Protection of the pump against dry running

Thermal pump protection

Problem:
- Thermal overload in case of overlong pressurization mode (zero flow)
- Wear and possible premature failure of the pump

Function:
- Protection against thermal overload **without** temperature sensor
- Calculation of the pump thermal overload depending on process parameters (pressure, speed, etc.)
- Optional: Activation of a hydraulic bypass on reaching a definable warning threshold to relieve the pump
- Error message with definable error response

Benefits

- Increase in availability: Protection against pump failures caused by thermal overload
- Condition monitoring: Display and monitoring of the current pump capacity utilization

HARDWARE

Performance boost for your machine

Fixed displacement pumps are generally used in servo-hydraulic systems. Baumüller can work with any of the standard pump manufacturers on request. Numerous manufacturers have their own series for variable-speed operation in their product portfolio that exactly meets the requirements of servo-hydraulic systems and is designed for high accelerations. Compared to an uncontrolled hydraulic system with a standard motor, the pump will be smaller because decoupling from the power supply frequency occurs. This allows a higher speed and smaller pump dimensions.

As a special feature, Baumüller offers three different options for the connection between the pump and motor.

In the **Standard Line**, the attachment is made using the conventional solution of coupling and pump support. This tried-and-tested option can be achieved with a standard motor shaft and motor flange and is flexible due to the separate components.

The second development stage, **the Advanced Line**, describes the direct attachment of the pump on the motor via internal toothing. There is no need for a pump support and coupling, so the system is more compact and robust. Omitting the pump support as a resonating body also reduces the noise impact.

In the third stage, the **Performance Line**, the hydraulic fluid is additionally used for intelligent circulating oil lubrication. For this purpose, connections were added not only to the motor but also to the constant pump, allowing the leakage flow of the pump to be used for the permanent lubrication of the toothing. This eliminates an otherwise necessary grease lubrication of the internal toothing, which would be due every 3,000 operating hours on average, also rendering the system particularly robust. Baumüller thus offers a patent-pending solution, which leads to significantly reduced service costs in operation.

Motor/pump combinations

Permanent magnet synchronous motors are used as motors in servo-hydraulic systems. The main criterion for selecting servo motors is good performance in terms of dynamics and overload capability.

Baumüller offers various motor series for use in servo-hydraulic systems, from the dynamic three-phase current servo motor DSD2 to the three-phase current synchronous motor DS2. All motors are available in an air-cooled and a water-cooled version. The servo motors sizes 45–132 are also available in an oil-cooled form. This is an advantage in the hydraulic system, since the oil is available in the machine anyway. Another advantage is that liquid-cooled motors have a higher power density and can therefore be dimensioned smaller.

Direct attachment is available for the Advanced and Performance Line models. The Standard Line, attachment via coupling and pump support, is possible with all the motors listed here.

Direct attachment with grease lubrication

Pump type		Motor size			
		56	71	100	132
Bosch PGH2	(5–8 cm^3)	✱	-	-	-
Bosch PGH3	(11–16 cm^3)	-	✓	-	-
Voith IPV3	(4–10 cm^3)	-	✓	-	-
Bosch PGH4	(20–50 cm^3)	-	✓	✓	-
Voith IPV4	(13–32 cm^3)	-	✓	✓	-
Eckerle EIPC3	(20–64 cm^3)	-	✓	✓	-
Voith IPV5	(32–64 cm^3)	-	-	-	✱
Eckerle EIPC5	(64–100 cm^3)	-	-	-	✱
Voith IPV6	(64–125 cm^3)	-	-	-	✱
Eckerle EIPC6	(125–250 cm^3)	-	-	-	✱
Bosch PGH5	(63–250 cm^3)	-	-	-	✱

Direct attachment with circulating oil lubrication

Pump type		Motor size			
		56	71	100	132
Bucher QXM23	(5–8 cm^3)	✱	-	-	-
Bucher QXEH(X)3	(10–16 cm^3)	-	✓	-	-
Bucher QXEH(X)4	(20–32 cm^3)	-	-	✓	-
Bucher QXEH(X)5	(40–63 cm^3)	-	-	✓	✓
Bucher QXEH(X)6	(80–160 cm^3)	-	-	-	✱

✓ available ✱ on request

Advanced Line

Performance Line

DSD2/DSC1/DS2 – Technical data

Type	P_N		n_N	J		M_0		$M_{0\,MAX}$	
	[kW]	[hp]	[min^{-1}]	[$kgcm^2$]	[lb in^2]	[Nm]	[lbf ft]	[Nm]	[lbf ft]
DSD2-045 ✓	0.7-7.6	0.9-10	3000-6000	1.0-1.9	0.34-0.65	2.7-13	2.0-9.6	12-28	8.9-21
DSD2-056 ✓ ✓	1.3-12	1.7-16	2000-6000	3.6-6.6	1.2-2.3	7.0-30	5.2-22	25-57	18-42
DSD2-071 ✓ ✓	3.0-25	4.0-33	2000-6000	12-19	4.0-6.5	17-73	12-54	53-105	39-77
DSD2-100 ✓ ✓ ✓	1.9-42	2.5-56	1200-6000	52-105	18-36	42-210	31-155	105-280	77-206
DSD2-132 ✓ ✓	16-150	21-201	1000-6000	290-760	99-260	175-770	129-568	380-1080	280-797
DSC1-045 ✓	0.5-4	0.7-5.4	2000-4000	1.4-3.2	0.48-1.1	2.7-12	2.0-8.9	8.7-26	6.3-19
DSC1-056 ✓ ✓	0.6-6.5	0.8-8.7	900-4000	4.4-11	1.5-3.6	6.2-26	4.6-19	16-49	12-36
DSC1-071 ✓ ✓	1.2-14	1.6-19	750-4000	12.6-31	4.3-11	12-58	8.9-43	27-82	20-60
DSC1-100 ✓	2.3-18	3.1-24	850-3000	46-101	16-35	23-105	17-77	42-125	31-92
DS2-100 ✓ ✓ ✓	5.3-47	7-63	1000-3000	100-200	34-68	48-165	35-122	120-340	89-251
DS2+-100 ✓ ✓ ✓	23-66	31-88	4000-4500	100-200	34-68	61-165	45-122	130-325	96-240
DS2-132 ✓ ✓ ✓	14-105	19-141	1000-3000	450-800	154-273	130-375	96-277	305-710	225-524
DS2+-132 ✓ ✓ ✓	56-123	75-165	4000-4500	450-800	154-273	180-365	133-269	340-680	251-501
DS2-160 ✓	30-155	40-208	1000-3000	1500-2500	510-850	320-695	236-513	690-1210	509-892
DS2-200 ✓	39-295	52-396	500-2700	4400-7900	1500-2700	570-1340	420-988	1130-2190	833-1615

Motors are suitable for ✓ Standard Line ✓ Advanced Line ✓ Performance Line

The values specified are maximum values. For details, please refer to the relevant technical documentation.

Subject to alteration.

b maXX 5000 servo controller family

The largest difference to the uncontrolled hydraulic system is the servo drive. It plays a key role in the selection of the appropriate system. The servo drive contains the software for pressure and flow rate control and for numerous other functions, e.g. the pump monitoring. In addition, the servo drive must offer the right interfaces to integrate the drive system in the machine.

The Baumüller b maXX 5000 servo drives have analog interfaces for the pressure sensors and interfaces for all common field buses, enabling a simple link to the central control unit. When switching from a hydraulic system with a standard motor, the requirements for the central control unit do not change, so mechanical engineers have the option of working with their customary control types. The motor and the servo drive are designed as a package tailored to the performance requirements. The cooling methods available are standard air and cold plate cooling, and push-through air, water and oil cooling. The advantage of oil cooling is that the medium is already available in the machine.

b maXX 5500 mono units – Technical data

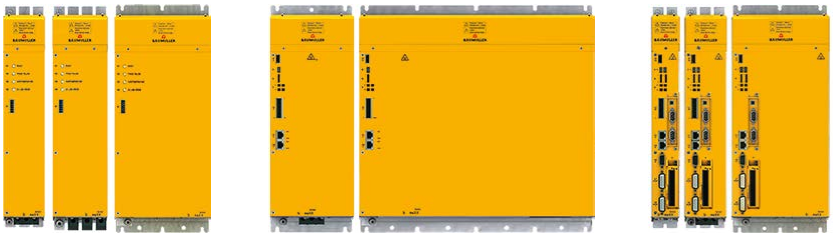
Type	Frame size	I_N	I_{MAX}	typ. motor rating		Overload factor	Dimensions WxHxD [1]
		[A]	[A]	[kW]	[hp]		[mm]
BM 5512	1	2.5	5	1.1	1.5	2	106 x 310 x 263 [4]
BM 5513	1	4.5	9	2	2.7	2	106 x 310 x 263 [4]
BM 5522	2	7.5	15	3.4	4.6	2	106 x 428 x 340 / 320
BM 5523	2	11	22	5	6.7	2	106 x 428 x 340 / 320
BM 5524	2	15	30	6.8	9.1	2	106 x 428 x 340 / 320
BM 5525	2	15	40 [2]	6.8	9.1	2.6	106 x 428 x 340 / 320
BM 5526 single phase	2	22.5	45 [2]	6	8.0	2	106 x 428 x 340 / 320
BM 5526	2	22.5	45 [2]	10	13.4	2	106 x 428 x 340 / 320
BM 5532	3	22.5	45	10	13.4	2	155 x 510 x 340 / 325
BM 5533	3	30	60	13	17.4	2	155 x 510 x 340 / 325
BM 5534	3	45	90	20	26.8	2	155 x 510 x 340 / 325
BM 5535	3	60	90	28	37.5	1.5	155 x 510 x 340 / 325
BM 5543	4	80	120	36	48	1.5	190 x 624 x 374 / 327
BM 5544	4	100	130	45	60	1.3	190 x 624 x 374 / 327
BM 5545	4	130	170	58	78	1.3	190 x 624 x 374 / 327
BM 5546	4	150	200	75	100	1.3	190 x 624 x 374 / 327
BM 5553	5	150	195	75	100	1.3	307 x 656 x 374 / 321
BM 5554	5	210	260	110	147	1.3	307 x 656 x 374 / 321
BM 5562	6	250	325	132	177	1.3	437 x 815 x 378 / 316
BM 5563	6	300	390	160	215	1.3	437 x 815 x 378 / 316
BM 5566	6	350	450	175	234	1.3	437 x 815 x 378 / 316
BM 5572	7	450	585	225	302	1.3	520 x 600 x 388 / 340
BM 5573	7	615	800	315	422	1.3	520 x 600 x 388 / 340

Supply voltage: 207–528 V ± 0% AC
Supply frequency: 50/60 Hz
Supply rated voltage: 400 V
DC link voltage: 540 V rated voltage
Chopping frequency: 2/4/8 kHz

Output voltage: 0–95 % of supply voltage
Electronics supply: external 24 V DC (diagnostic capability)
Fan connection: frame size 1–3: 24 V DC electronics supply, frame size 4–7: 230 V AC ± 10 %
Certification: CE, CSA, UL

1) Depth air cooling / depth water cooling
2) for 1 second 3) single phase 4) air cooling only
Height and depth w/o mounting brackets; depth incl. required bending radius of connecting cables

Subject to change



b maXX 5000/5100 supply units and regenerative units – Technical data

Type	Frame size	DC link power		DC link peak power [1]		Overload factor	Dimensions WxHxD
		[kW]	[hp]	[kW]	[hp]		[mm]
BM 5030	3	5	6.7	7.5	10.1	1.5	75 x 395 x 280 / 210 [2]
BM 5031	3	10	13.4	15	20.1	1.5	75 x 395 x 280 / 210 [2]
BM 5032	3	18	24.1	27	36.2	1.5	75 x 395 x 280 / 210 [2]
BM 5043	4	36	48.2	54	72.4	1.4	100 x 395 x 280 / 210 [2]
BM 5044	4	70	93.8	70	93.8	1.0	100 x 395 x 280 / 210 [2]
BM 5074	7	150	201	300	402	2.0	175 x 395 x 280 / 250 [3]
BM 5075	7	200	268	300	402	1.5	175 x 395 x 280 / 250 [3]
BM 5173	7	36	48.3	54	72.4	1.5 [1]	175 x 395 x 280 / 210 [2]
BM 5174	7	64	87	96	130.2	1.5 [1]	175 x 395 x 280 / 210 [2]
BM 5192	9	150	201	300	402	2.0 [4]	425 x 395 x 280 / 210 [2]
BM 5193	9	200	268	300	402	1.5 [4]	425 x 395 x 210 [3]

b maXX 5300 axis units – Technical data

Type	Frame size	I_N	I_{MAX}	typ. motor rating		Overload factor	Dimensions WxHxD
		[A]	[A]	[kW]	[hp]		[mm]
BM 5323	2	2x 3	2x 9	2x 1.6	2x 2.1	3	50 x 395 x 280 / 210 [2]
BM 5323 [5]	2	2x 4.5	2x 9	2x 2.4	2x 1.8	2	50 x 395 x 280 / 210 [2]
BM 5325	2	2x 6	2x 18	2x 3.2	2x 4.2	3	50 x 395 x 280 / 210 [2]
BM 5325 [5]	2	2x 8.5	2x 18	2x 4.6	2x 3.5	2.1	50 x 395 x 280 / 210 [2]
BM 5326	2	12	24	6.5	8.7	2	50 x 395 x 280 / 210 [2]
BM 5327	2	20	40	10.8	14.5	2	50 x 395 x 280 / 210 [2]
BM 5328	2	30	60	16.2	21.7	2	50 x 395 x 280 / 210 [2]
BM 5331	3	2x 12	2x 24	2x 6.5	2x 8.7	2	75 x 395 x 280 / 210 [2]
BM 5332	3	2x 20	2x 40	2x 10.8	2x 14.5	2	75 x 395 x 280 / 210 [2]
BM 5333	3	2x 30	2x 60	2x 16.2	2x 21.7	2	75 x 395 x 280 / 210 [2]
BM 5334	3	40	60	21.6	29.0	1.5	75 x 395 x 280 / 210 [2]
BM 5335	3	60	90	32.4	43.4	1.5	75 x 395 x 280 / 210 [2]
BM 5372	7	90	180	48.6	65.1	2	175 x 395 x 280 [3]
BM 5373	7	120	240	64.8	86.8	2	175 x 395 x 280 [3]
BM 5374	7	150	300	81	108.5	2	175 x 395 x 280 [3]
BM 5375	7	180	360	97.2	130.2	2	175 x 395 x 250 [3]
BM 5376 air-cooled	7	150	420	81	105.5	2.8	175 x 395 x 280
BM 5376 water-cooled	7	180	420	92.2	130.2	2.3	175 x 395 x 250 [3]

Supply voltage: 207 – 528 V ± 0% AC
Supply frequency: 50/60 Hz
Electronics supply: external 24 V DC
Certification: CE, cUL

Supply units and regenerative units:
Supply rated voltage: 400 V
DC link rated voltage: 540 V (supply unit), 640 V (regenerative unit)
Axis units: Chopping frequency: 4/8 kHz

1) for 120 seconds
2) depth air cooling / depth cold plate
3) depth water cooling
4) for 10 seconds
5) Load cycles as per EN 61800

Height & depth without mounting brackets; Depth including required bending radius of connecting cables

Subject to change

IOT & CONTROLS

b maXX PLC mc

If applications from the Baumüller SmartValue functions are required, they can be implemented with the help of the b maXX PLC mc. A typical application would be smart energy monitoring with which the required energy costs over a production cycle can be determined. If data is to be further processed with the help of mathematical algorithms, using AI (artificial intelligence) or with ML (machine learning) and the intelligence on the drive is not sufficient, this can be implemented on the PLC mc.

Alternatively, the b maXX PLC mc can establish a connection to any clouds via your connectivity. Further data analyses can then be undertaken here or can be presented on dashboards for visualization. To this end, various IoT world protocols are available, for example OPC UA. If necessary, m2m (machine to machine) connections can also be set up.

In addition to Baumüller SmartValue and IoT requirements, the b maXX PLC mc is also able to control complex movements, parts or the entire machine. To do this, it is programmable in real time to IEC 61131-3. By using Windows as an operating system, a large number of visualization, data processing, connectivity and IoT applications are available.

BAUMÜLLER SMART VALUE

EtherCAT

IEC 61131-3

Node-RED

OPC Unified Architecture

MQTT

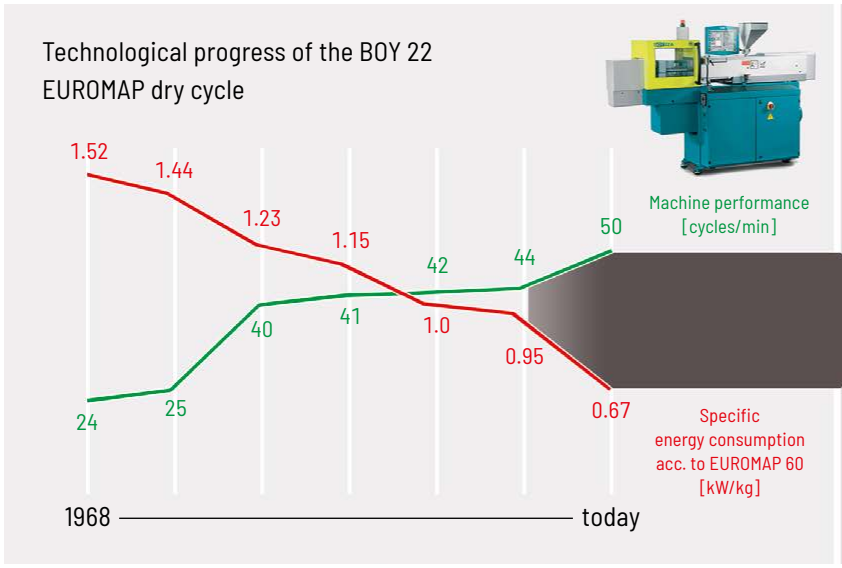
Service

As a system provider, Baumüller can take charge of the design and commissioning of a drive system, as well as support up to the readiness for start of production.

Baumüller supports mechanical engineers with its extensive experience and necessary know-how for system changeovers.

Cost-effectiveness analysis using the example of BOY injection molding machines

Change in energy consumption of an injection molding machine



Introduction to speed-controlled servo drives

Optimization in the hydraulic system (rapid traverse cylinder BOY 22/25)

Efficiency optimization
Increase in performance

Drive technology change – result

- more than 10% faster and more precisely controllable
- more than 20% reduced noise level
- approx. 50% less energy consumption

"Modern injection molding machines help to reduce CO_2 emissions."

Alfred Schiffer, Executive Partner of BOY

References

BOY Spritzgiessautomaten · ENGEL · Erlenbach Maschinen · HÜRMAK · HUSKY
KraussMaffei · LAUFFER PRESSEN · MAC ENGINEERING · maicopresse · VALMO ENGINEERING

HOUSE OF AUTOMATION

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