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Energy efficiency in concrete block production

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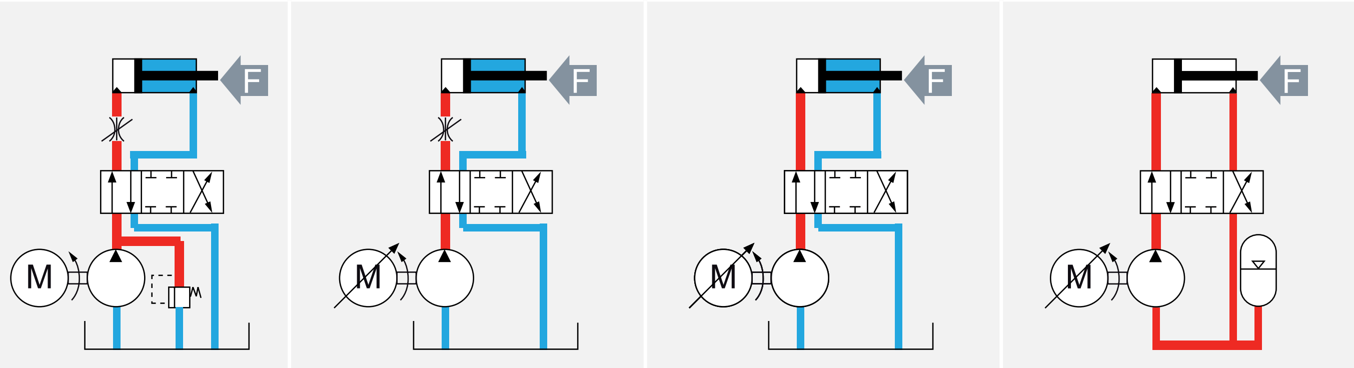
Masa GmbH from Andernach has been dealing successfully and innovatively with the topic of "energy efficiency in concrete block production" for several years. Apart from the possibilities to save energy costs, concrete block producers have a vested interest in analysing and improving the energy input and consumption of their plants, not least due to major amendments to the German Power and Energy Tax Act (which came into force on 01/01/2013) and the corresponding regulations. Requirements for good-quality energy audits were defined with the publication of the European standard EN 16247-1. In Germany, the execution of an energy audit in accordance with DIN EN 16247-1 represents for small and medium-size enterprises (SME) in particular a possibility to meet the requirements of the Power and Energy Tax Act for the surplus settlement. Within the scope of this topic, Masa has paid particular attention amongst other things to the areas of hydraulic pumps, drive technology and intelligent plant and control concepts, which will be dealt with below. At the beginning of 2016 at the 8th Works Manager Conference, Masa also presented aspects with which energy costs can be lowered, thus achieving possible relief from the energy and power tax.

System with a constant speed	System with frequency converter		
	Step 1 Elimination of the pressure limiting valve	**Step 2** Elimination of the flow control valve	**Step 3** Elimination of the directional control valve



System with a constant speed	Step 1	Step 2	Step 3
	✓ **Pure pressure control** ✓ Eliminates energy losses due to the pressure limiting valve ✓ Only the volume actually required is supplied ✓ Similar principle to volume-controlled pump	✓ **Pressure and volumetric flow rate control** ✓ Eliminates energy losses of the flow control valve Optional position control in the drive: ✓ High precision ✓ Relieves the PLC processor	✓ **4-quadrant operation („direction control“)** ✓ Saves directional control valves and tank ✓ Very high dynamics ✓ Very compact system ✓ Fully capable of energy recovery

Fig. 1: System with variable speed, step 2 without option, Source: Siemens, 2016

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Masa has a great wealth of experience and corresponding know-how in the area of "energy efficiency in concrete block production". In case of interest, Dipl.-Ing. (FH) Michael Dolon (head of electrical design), Dipl.-Ing. (FH) Karl-Josef Hauröder (head of mechanical design) and the team of development engineers offer assistance as competent contact persons.

Hydraulic pumps

Hydraulic concepts capable of energy recovery can be realised using variable displacement pumps with a variable speed drive. Heat losses are reduced, as a result of which less cooling power is required. The speed can be adjusted to suit the power requirement.

Classic hydraulic systems (fixed or variable displacement pump) use an electric motor with a constant speed and if necessary a bypass. Furthermore, classic systems consist of simplified valve technology. Furthermore, these systems contain the valves necessary for the control or regulation.

By contrast, innovative hydraulic systems use a variable speed drive in addition to the hydraulic pump (fixed or variable displacement pump). The new concept prevents energy losses through the use of short pipelines, the avoidance of throttle valves, bypasses and directional valves, and speed adjustment (power = pressure * volume). Since less energy is converted to heat, the cooling power can also be reduced.

The schematic shown in fig. 1 illustrates the different implementation steps to move from a system with constant speed to a system with variable speed, taking the fixed displacement pump as an example.

Further advantages are:

- Differential and synchronised cylinders can be combined.
- Several cylinders of different sizes can be used on one pump.
- No change in the direction of rotation is required for a to-and-fro motion.

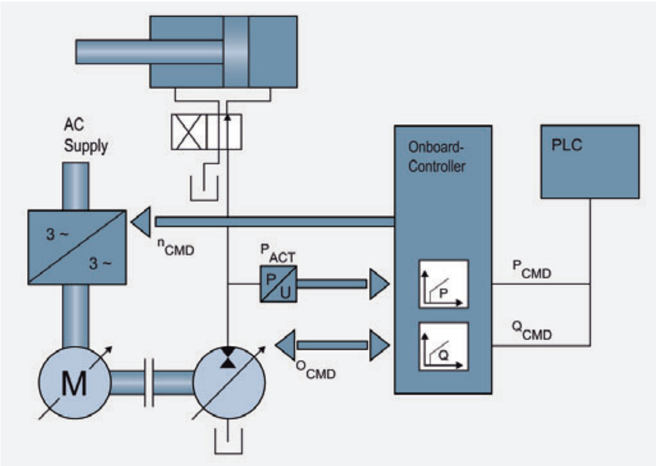


Fig. 2: Schematic illustration of the Masa prototypes with a pump as a generator and a pump as a motor

Fig. 3: Energy efficiency monitoring of the Masa XL concrete block making machine at the bauma 2016

Masa presented the prototype of a variable displacement pump at the bauma 2016 in Munich. This prototype was presented on the Masa XL 9.2 concrete block making machine within the scope of an experimental setup, in which the facing concrete feed box (shown in red on the monitor) and the core concrete feed box (shown in green) were each driven to and fro for 10 cycles. Whilst the facing concrete feed box was equipped with conventional hydraulics, however, the Masa engineers had fitted the new variable displacement pump prototypes to the (heavier) core concrete feed box. In a real-time comparison it was shown that the Masa prototype produced an energy saving of about 30% compared to the conventional hydraulics in relation to the selected speed.

Drive technology

With efficient drive technology and optimised systems, both energy and, after a corresponding amortisation time, money can be saved.

The efficiency-optimised drives are usually one series larger than a drive with the same output in a standard version. Copper losses (current heat losses) and iron losses (magnetisation losses) can be reduced through a change in material usage.

In the case of very frequent switching events and short running times, however, this can have a disadvantageous effect on the energy balance.

Intelligent plant concepts

Energy efficiency can also be improved through intelligent plant concepts. The approach extends thereby over the entire life cycle of the concrete block making machine. The conception, engineering and production phases of a plant each offer different points of contact for influencing the energy efficiency. Below, the core points of plant design, efficient components and energy recovery will be considered in more detail.

Is it worth replacing the old motor?

An old 30 kW motor with an efficiency of 85%, e.g. the mixer drive, is to be replaced by a new motor. An IE1 motor with the same output has an efficiency of over 90%. The efficiency of an IE3 motor is almost 95%.
Replacement of the old motor by an IE3 motor results in the following energy and cost savings, depending on the period of use:

	1-shift operation (5-day week)	**2-shift operation (5-day week)**	**3-shift operation (6-day week)**
Operating hours (h/year)	2000	4000	7000
Energy saving (kWh/year)	5200	10400	18200
Cost saving* (EUR/year)	780	1560	2730

*based on an electricity price of 15 cents/kWh including tax and duty, excluding VAT.

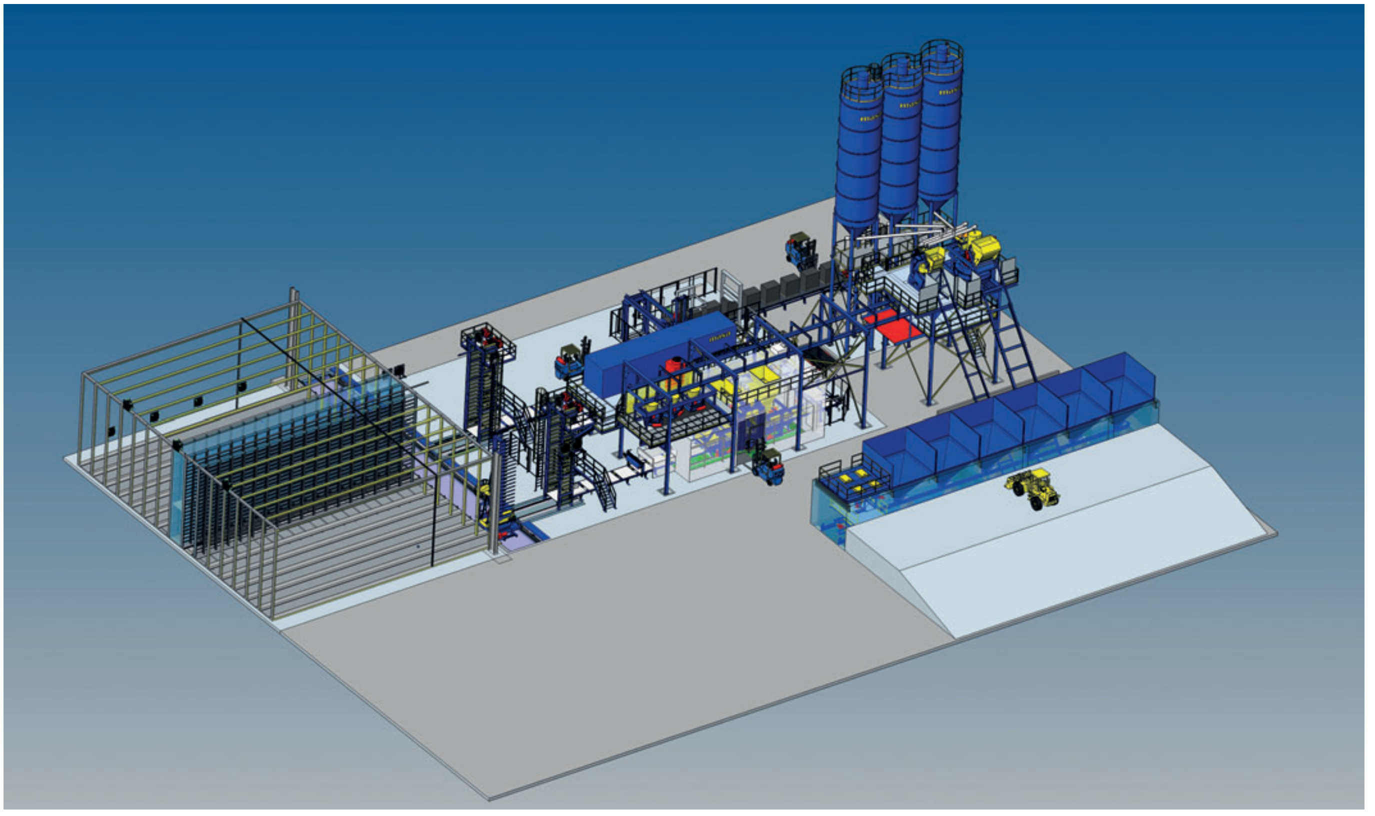


Fig. 4: Masa plant design: optimised energy efficiency through short routes in the energy distribution

Plant design

Apart from the selection of the right energy (air, oil, electricity), optimised energy efficiency depends above all on the spatial arrangement of the individual plant components. Short routes in the energy distribution are just as productive as short piping distances for hydraulics and pneumatics. Masa has therefore developed various standard layouts that optimise precisely these routes.

The Masa Powertainer with the power cabinets for the respective plant sections is located centrally. The hydraulic console is located directly adjacent to the concrete block making machine. In addition, short routes are planned for the material flow (e.g. raw materials).

Apart from the spatially optimised component arrangement, the intelligent plant design also takes into account the optimised dimensioning of the drives employed, since the best efficiency lies in the nominal operation.

Efficient components

Masa also concentrates on increasing efficiency when selecting the components to be used. For that reason either electrical drives (if possible) or efficient hydraulic drives are used. Pneumatics is used only with subordinate applications (e.g. scraper on the feed box).

As far as possible, toothed belts or chains with the best efficiencies (96 – 98%) are used for transmission gearboxes. Gearboxes with a high efficiency such as bevel gear transmissions (e.g. 98%) are chosen. Not only that, the reduction in weight of the components to be moved plays a not insignificant role.

Energy recovery

Energy is released when braking a drive. This energy can theoretically be fed back into the supply network or used by other drives.
There are various approaches to this:

- Intelligent control of drives
  Movements that produce generator power supply drives that require motor power. This solution is already implemented successfully by Masa in the cuber
  (Masa Cuboter).
  Further conceivable possibilities for this would be the elevator and lowerator, the lifting bucket on the mixer and all kinds of lifting gear. The elevator, for example, requires about 12 KWh of energy at 200 cycles per hour. This could be significantly reduced if the elevator and lowerator were to run simultaneously and the energy released by the lowerator were to be used for the lifting movement.

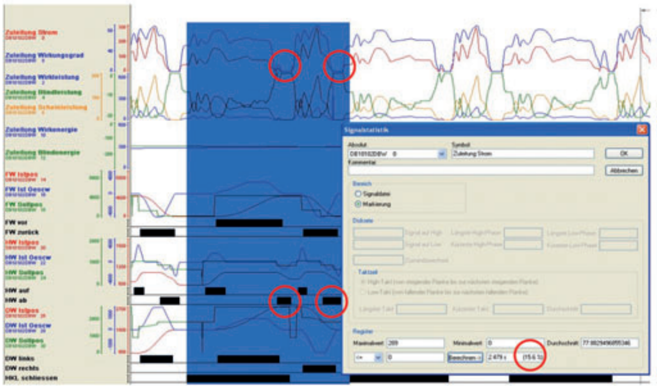


Fig. 5: Clearly visible are two operating points in the cuber cycle where no power is drawn from the mains. The lifting gear is moving downwards and generating at this moment. This accounts for about 15% of the cycle time.

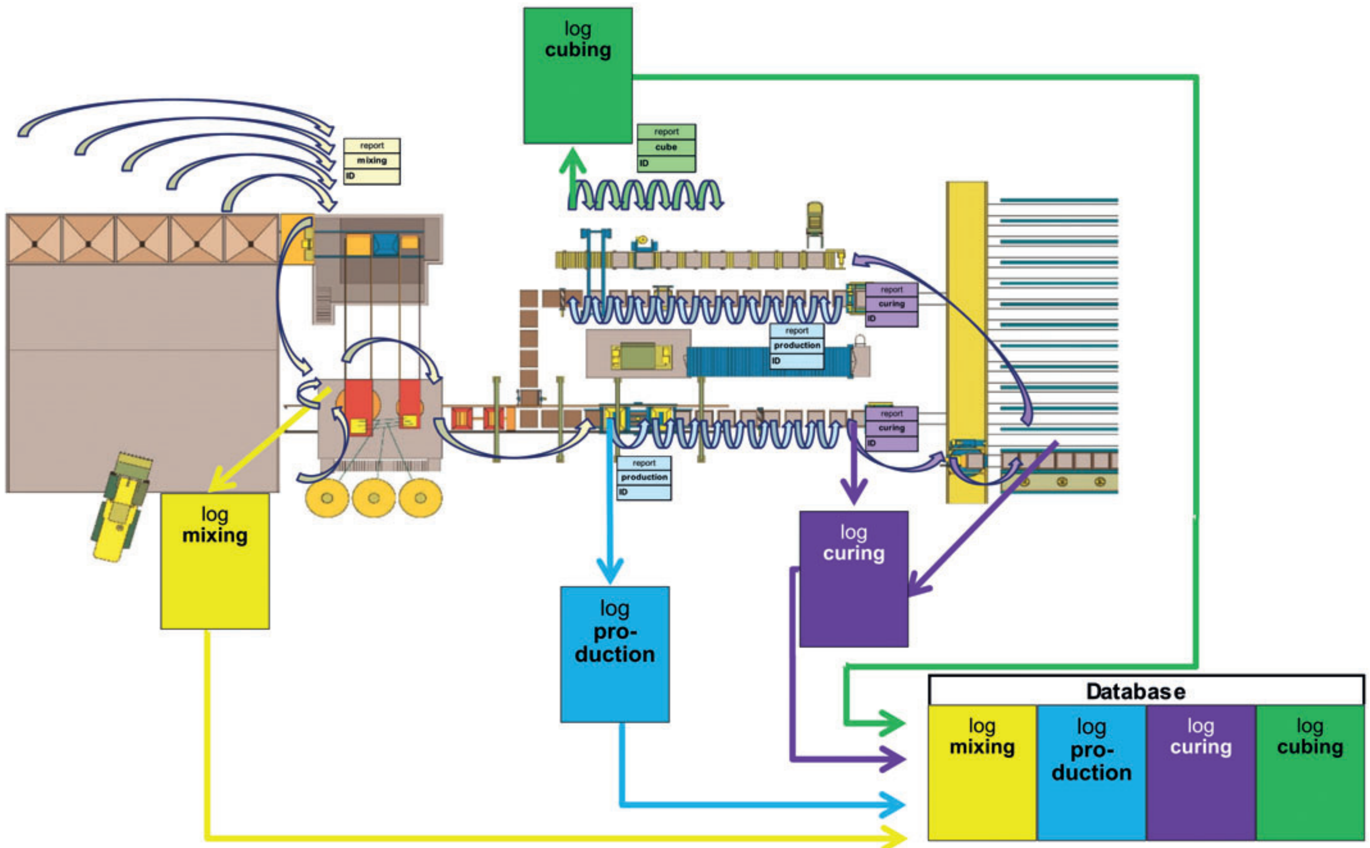
- Frequency converter capable of energy recovery
  The energy released by braking procedures could be fed back into the customer network through the use of frequency converters capable of energy recovery.

- Axle group of the frequency converters
  Through intelligent axle groups of frequency-controlled drives, an exchange of energy can take place between the individual connected functions. Masa uses this technology, for example, in vibration with amplitude adjustment and in the cuber (Masa Cuboter).

Intelligent control concepts

The energy balance can be optimised by means of an intelligent plant controller. The basic rule here is: energy is consumed only when it is needed. Standby times are to be avoided. The energy-saving mode is to be activated and energy-saving movement profiles are to be used. In particular with hydraulic pumps, for example, a lowering of the speed or the volumetric flow rate during the operating and idling times makes itself noticeable in the energy balance, since the power consumption increases quadratically with the speed when pumps and fans are in use. Energy can be saved if the hydraulic pressure is reduced to the value that is just required, since $W=Q*\Delta p$, i.e. it is the product of flow rate and pressure difference.

With its plant control software (Masa Fast Factory Automation Service Tools), Masa creates the necessary conditions for intelligent plant control. The plant is controlled by a single software, with which a holistic data concept is realised. Intelligent, energy optimised movements can thus be driven.



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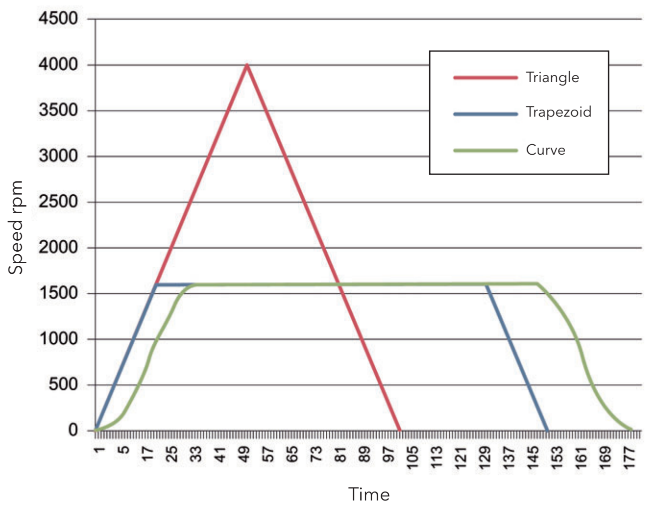

Fig. 7: "Speed/time" diagram

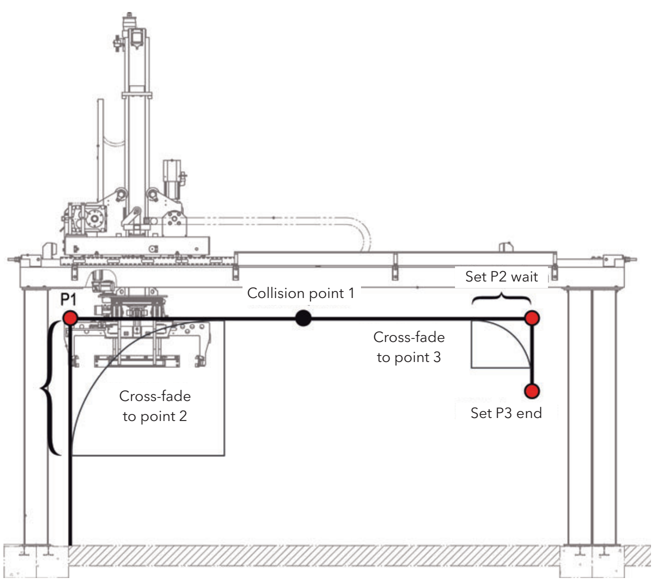

Fig. 8: Optimised movement sequence of the Masa Cuboter

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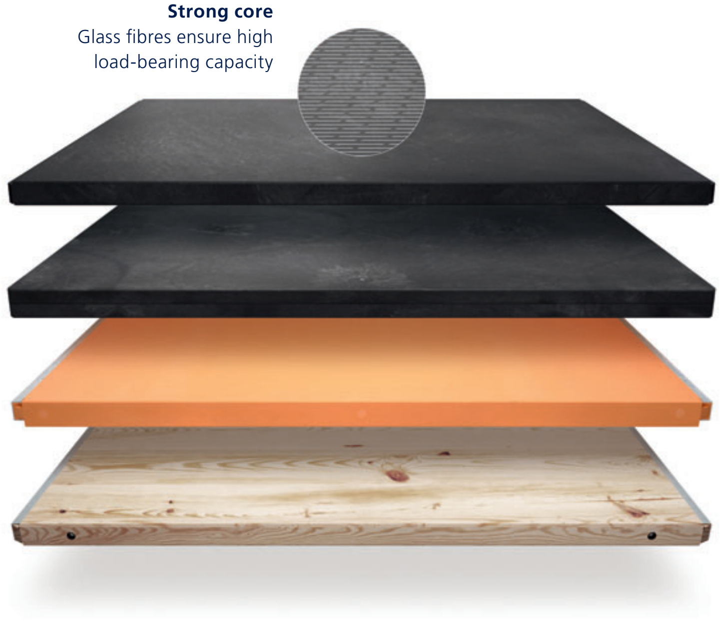

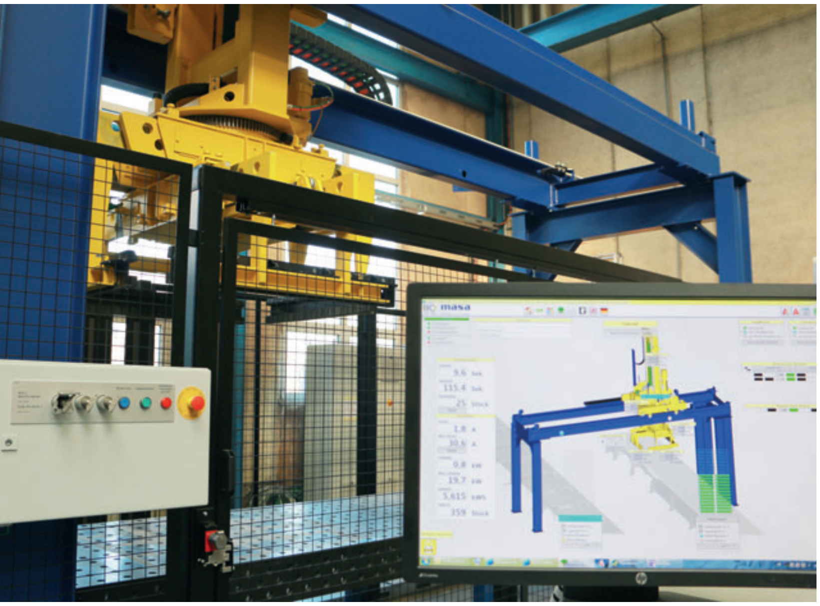

Fig. 9: A cycle time of 9.6 seconds was realised in the test setup

Energy-saving movement profiles

Within the concrete block making process, components such as the cuber (Masa Cuboter) must be continually repositioned. The fastest way to reach the respective position is described by a triangular movement profile.

However, this is unfavourable in terms of energy. The energy required is made up of the kinetic energy $W= ½ m*v^2$ and the work along a distance $W=F*s$. Since the distance remains constant, only the speed can be varied depending on the cycle time. The speed goes quadratically into the work. ½ speed thus means ¼ energy consumption. One example of this is the adaptation of the cycle time of the return transport on the dry side to match that of the cuber. If the cuber has a cycle time of 15 seconds, for example, then it makes no sense at all from the energy aspect to execute the transport with a shorter cycle time and then have to wait for the cuber.

In a further step the movement sequences can be optimised by co-ordinating movements with one another. In this way it was possible to optimise the movement curve of the cuber (Masa Cuboter) through the use of intelligent path control: The movements were co-ordinated in such a way that the original movement curve became a curve along calculated radii over the corner points. This curve is calculated from the stack heights (= varying removal or deposition heights) and the interfering points/obstacles to be driven around.

This produces the optimum path-time diagram of a harmonious movement. A curving of the ramps in the speed-time diagram leads to a more gentle movement and saves additional energy. With fast accelerations the drives have to summon up more power, which also means higher consumption and higher heat losses.

Prospects: The Masa Cuboter

Masa is ideally set up with the next-generation cuber, the Masa Cuboter. Dynamic-harmonic movements are realised with optimised Moviaxis controllers. The Cuboter has a high load-bearing capacity over long distances. It is energy-efficient, operating cost-optimised and of a robust design. The input power has been drastically reduced thanks to the high overload capability of the frequency converters. In the test setup an average cycle time of 9.6 s was realised and the energy consumption was around 5.615 kW/h. ■

FURTHER INFORMATION

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