



Embedded PCs control hydraulic press:
Optimized production process through software-based PID control

Fast and precise pressure control increases quality of ceramic tiles

A boom in the real estate market and increased construction of large public buildings has triggered an increasing demand for high-quality ceramic tiles in China. Foshan Henglitai Machinery Co. Ltd. is among the largest manufacturers of ceramic presses in China. Henglitai has implemented a PC-based controller from Beckhoff in its newly-developed type YP4200 hydraulic press. Through the use of EtherCAT and the TwinCAT Hydraulic software library, the press is easier to adjust and produces more tiles in a higher quality than previous models.



The basic material for the ceramic production is clay, to which various other minerals are added. The production process for the ceramic tiles is roughly divided into grinding, compacting, sintering and polishing. The ceramic press from Henglitai is used for the press forming of the dry ceramic material: The prepared powder is filled into a frame, fed into the machine and compacted by a vertically incoming piston at high pressure. The pore volume is reduced using this procedure, wherein the air contained in the material is pressed out. After repeated de-aeration and compaction with increasing pressing power, the powder material is solidified into a tile blank, which is removed from the press and transported to the kiln.

Precise control of powerful forces

The ceramic press controller must master the following requirements: The exact movement and the precise pressure control of the press piston as well as the movement of the ejector.

The tasks of the press piston, which weighs around 10 tons, include the fast movement for opening and closing the press. This heavy weight has to traverse a distance of 150 mm in only 600 ms in order to drive accurately to the target position. For the de-aeration, the press piston must perform precise strokes of 0.5 to 2.0 mm with an accuracy of 0.5 mm.

The ejector is lowered with the powder packet into the working position and raised for the withdrawal of the pressed product. Since the tile has not yet been fired, it consists only of compacted powder and can very easily be scratched

or broken. In order to avoid this, the ejector must perform all movements both quickly and evenly. The demanded accuracy is 0.1 mm.

The production of each tile requires three to five pressing and de-aeration operations. Low, medium and high pressures are defined for this in succession for individually specified times with the aid of a proportional valve with a tolerance of 0.5 bar. (see figure 1)

The functions mentioned are usually digitally controlled and thereby attain a limited repeatability. The new press from Henglitai enables accurate movements of the press piston and the ejector as well as precise control of the pressing power and the time. The quality of the tiles can be significantly increased as a result.

Hydraulic axis control with "TwinCAT PLC Hydraulic Positioning" saves adjustment work

In order to achieve complete de-aeration, the movements of the press piston and the ejector are precisely controlled. The valve opening is thereby set by the cylinder position. For ceramic presses it is crucial to implement this interaction between cylinder movement and valve control with high accuracy.

The pressure control is provided by means of the fast, precise control of a proportional valve, in order to adjust the demanded operating points on the pressure curve of the valve opening. Oscillation around the set value is not permissible.

In designing the Motion Control algorithms, Henglitai decided on a concept that deviates from the usual PID structure. Classically, the PID controller adjusts

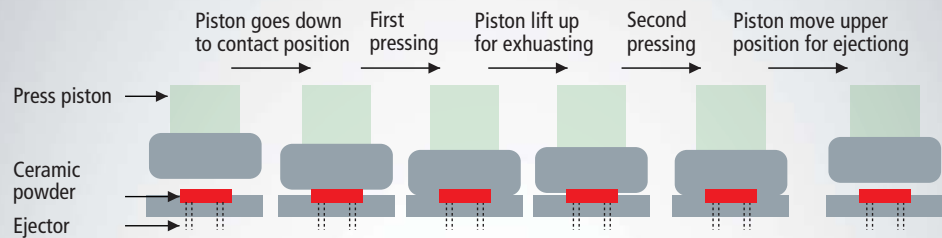


Figure 1: The production of each tile requires three to five pressing and de-aeration operations. Low, medium and high pressures are defined for this in succession with the aid of a proportional valve with a tolerance of 0.5 bar

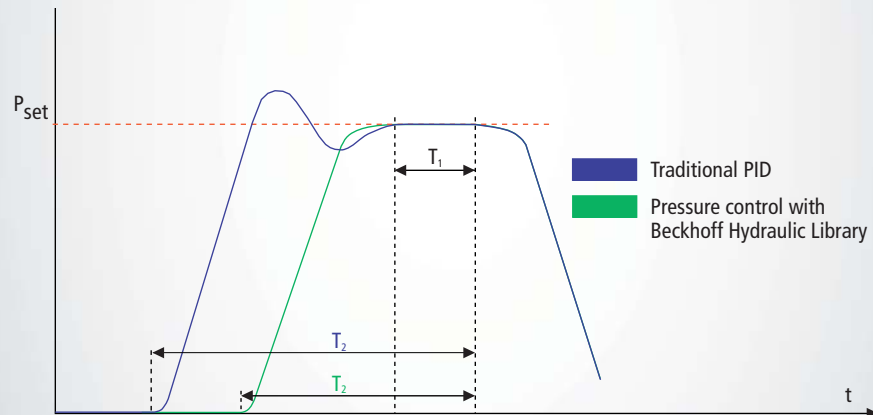


Figure 2: Actual pressure curve while changing the set pressure value (red). After changing the set pressure values, the plant can attain the set value with a deviation of < 0.5 bar during the current process cycle.

itself independently to the set value and works very precisely. However, it initially goes through a transient phenomenon, which often leads to overshooting. An overshoot-free behavior can be attained through the choice of suitable parameters, but this leads to sluggish control. (see figure 2) To make matters more difficult, the determination of suitable parameters requires great expert knowledge and is time-consuming.

The manufacture of ceramic tiles requires precise pressure control in a fixed and defined minimum time; falling short of this time leads to raw materials waste in the form of scrap. Therefore, the controller parameters are selected in such a way that the operator achieves the shortest possible cycle times without falling short of the necessary pressure values or minimum pressing time. The special pressure control modules developed using the Beckhoff "TwinCAT PLC Hydraulic Positioning" software library automatically calculate the parameters for controlling the proportional valve with each change of the set value. As a result, the machine operator is saved from having to perform the difficult and time-consuming setting of the parameters.

The open structure of TwinCAT and its integration with a standard Microsoft operating system allow the necessary leeway for future requirements. The acquisition of quality data or the integration of the press into a production cell or line can be accomplished comfortably. Integrated Condition Monitoring functionality for monitoring the oil quality and mechanical elements, such as the pump and other structural parts, is possible without external modules. Sensors are connected directly and the evaluation is performed by the machine controller.

EtherCAT improves accuracy and increases productivity

A Beckhoff CX1010 Embedded PC with integrated TwinCAT PLC control software serves as the control platform for the ceramic press. The controller needs only 39.5 μ s in order to execute 5000 lines of program code with mixed operations (including floating point calculation). Thanks to EtherCAT, the real-time Ethernet fieldbus, the signals from pressure sensors, the control signals of the proportional valve and other switching signals are updated within 100 μ s.

The test results show that the pressure control deviation of the new presses developed by Henglitai is less than 0.5 bar, in other words it has been reduced by 50 % compared to the earlier types of press (with smallest error: 1.0 bar). The complete execution of the stroke (150 mm) requires only 550 ms, which – compared with the 600 ms required until now – corresponds to an 8 % increase in productivity. At the same time, reducing the number of setting parameters has significantly simplified and accelerated machine operation.

Further Information:

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