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AUTOMATED PROCESS CONTROL SYSTEM OF CONCRETE TWIN-LAYER PAVER AND BLOCK PRODUCTION

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ABSTRACT

The article proposes the concept of an Automated Process Control System (APCS) for the concrete twin-layer paver and block production. APCS designed by SMART Factory concept. APCS includes a set of technological equipment, information, and software for control the objects of the production line of concrete paving block and tile. The system is scalable and includes various local automated control systems for the preparation of concrete mixtures, molding of concrete products, warehouses of inert materials and cement, access control subsystems, and workplaces for management personnel. In accordance with the proposed concept, a complex automated system should provide an optimal level of automation for information collection and processing to form control signals and transfer them without loss and distortion to actuators in order to achieve efficient operation of the technological line for the concrete twin-layer paver and block production.

Keywords: concrete block, concrete paver, concrete block machinery making, concrete batching plant, SMART Factory, mnemonic scheme, Automated Process Control System (APCS), control, process.

1. INTRODUCTION

At present, the manufacture of concrete twin-layer paver and block is one of the largest industrial branches, in which huge factories and factories, as well as private manufacturing enterprises, operate. This development of the industry is justified, because paving slabs are products that are in demand by the consumer.
Producers are offered a rich and well-thought-out assortment of not only paver, but also curbs, spillways, steps, etc.

The production of concretepaver requires minimal human operator involvement, as modern production is fully automated. The equipment for making concrete blocks and paving slabs can differ both externally and by characteristics, but the essence of the process does not change.

Manufacturing high-quality concrete paver and block is impossible without the use of modern technological equipment and the introduction of automated control systems for technological processes production [1, 2].

2. BACKGROUNDS

Full automatic line for concrete twin-layer paver and block production include of a concrete batching plant[3– 11] with two planetary mixers, storage bins for inert materials and silo for storage of cement, Concrete block machine, circulation system pallets, stackers (stacking and stacking elevators), a forklift truck and a packer of concrete products. (Figure-1).

The concrete mix is prepared in two mixers for the main layer (calculated for a larger volume, for example, 2.25 m^3) and for the upper color layer (calculated for a smaller volume, for example, 0.75 m^3)

Receiving hopper concrete block machine for the mixture is located under the discharge funnel, which allows you to quickly unload the mixture into it without moving a long distance. From the receiving hopper, the mixture is fed to the forming part of the line, where the actual molding takes place.

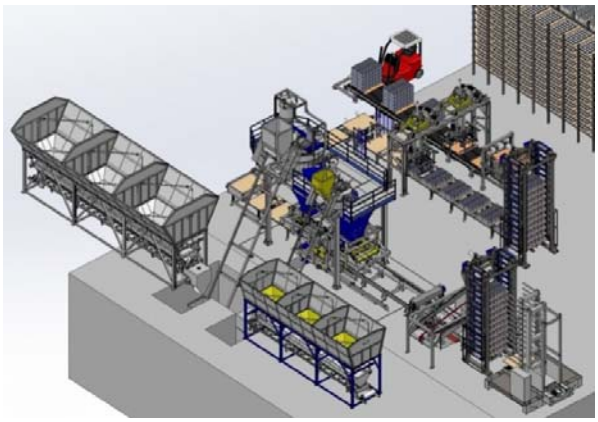

Figure-1. Full automatic line for concrete twin-layer paver and block production.

Concrete block machine squeezes the mixture in a mold under high pressure. The forming part of the concrete block machine is the matrix and the punch. The punch has on its surface a pattern that is imprinted on the face of the paving slab. The matrix is responsible for the molding of the walls of the produced tiles.

Then the mold is removed, and the compressed blocks remain on the pallet, which are then sent through the circulation system of the pallet to the steam chamber or to the warehouse where it undergoes natural drying, where within a few weeks they will gain the required strength. It should be noted that this will take at least 28 days.

The technological line is equipped with two stackers. They solve the problem of receiving and storing an appropriate number of production countertops with molded products, which in the subsequent stage of the

technological process will go to the rack system, in order to subject them to the introductory hardening.

The robot-loader in the technological line works together with the lower swivel platform, as well as elevators: for stacking and spreading, delivering or taking concrete products from a natural stabilized warehouse.

The finished products are packaged, labeled and loaded to the customer.

The technology of vibrating compression allows to reduce the consumption of plasticizer and modifying additives and significantly reduce the share of manual labor in production.

The organization of two-shift work, a shortened technological cycle with vibrating compression allows to sharply increase production output, while reducing overhead costs.

3. MODELS AND METHODS

3.1. SMART factory concept

SMART Factory is defined as an enterprise that, on the basis of context-aware knowledge, helps people and mechanisms perform their tasks. (Figure-2).

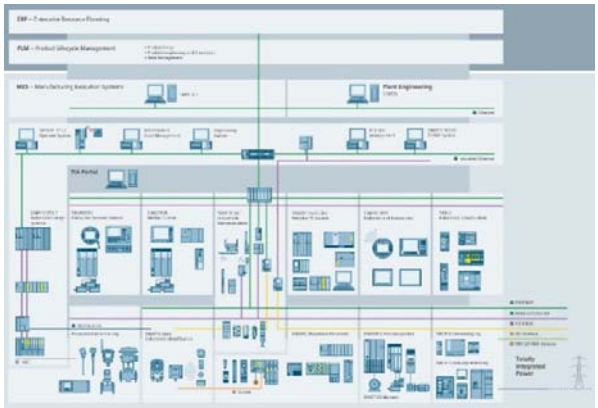

Figure-2. Siemens SMART factory.

This is achieved with the help of background-active systems, as well as taking into account contextual information in their work, for example, the position and status of the object. These systems perform their tasks on the basis of information coming from the physical or virtual world. Information from the physical world is, for example, the position or state of the instrument, and information from the virtual world can be electronic documents, blueprints or simulation models.

SMART Factory can be used for industries that are characterized by:

- complexity and dynamics of ongoing processes;
- uncertainty of supply and demand;
- individual approach to each manufactured product;
- frequent updates to the product range;
- production of small series of goods.

All this requires department heads to be highly responsive in making decisions and adapting plans when unforeseen events occur in real time. SMART Factory integrates existing Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) with the ability to adapt and adapt plans for real-time events, for example, from customers or from other control systems, from automatic line sensor sensors, tablet masters or touch screen workers to eliminate downtime and A shortage of resources or highly skilled workers. In the process of exploitation, a knowledge base is created about production processes, products and materials, equipment and workers to ensure an individual approach to each order or resource. This allows you to make plans more precise and executable at any events, such as the occurrence of a high-priority order, equipment failure, delays in the supply of materials, etc.

3.2. Industrial network

Automated Process Control System to be designed on the basis of Siemens SIMATIC equipment, which includes modern industrial Programming Logical ControllersS7-1500, industrial IPC computers, TP touch screens and ITP1000 tablet computers, using industrial network routers and wireless access points SCALANCE. (Figure-3).

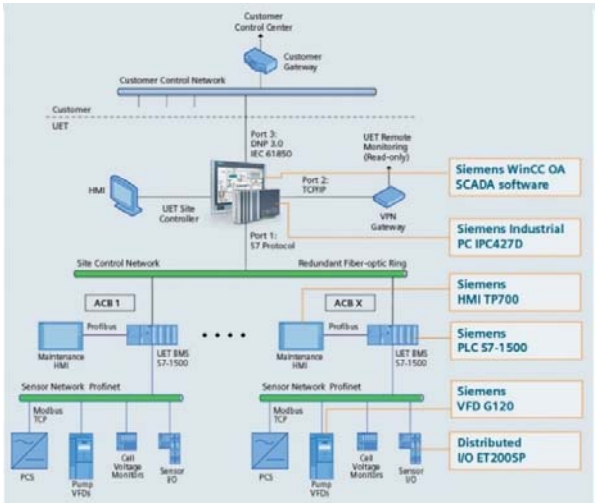

Figure-3. Logical structure of siemens ProfiNET.

4. RESULTS

4.1. Concrete block machine control system

Modern concrete block machines have high-precision dosing systems that completely exclude the human factor in the production process, automated lines of transportation and packaging of finished products, versatility (replacement of the mold allows for the transition to new types of products), high productivity, significant energy savings.

The high-performance MULTIMAT RH 2000-3 concrete block machine from HESS is easy to operate and fulfills high safety requirements, and also guarantees high

profitability in the manufacture of concrete products. (Figure-4).

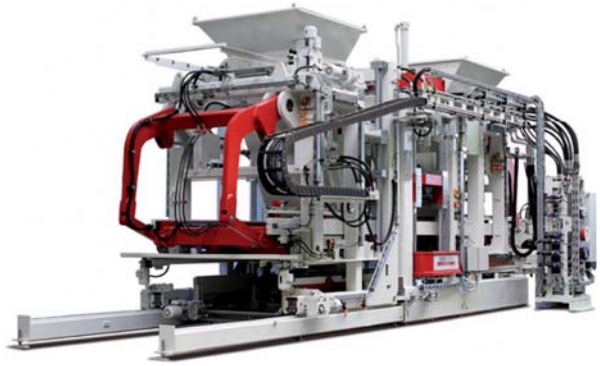

Figure-4. Concrete block machine MULTIMAT RH 2000-3.

The automated system allows controlling hydraulic and electric actuators in manual and automatic modes. A large number of technological parameters makes it possible to expand the range of manufactured products and significantly improve their quality. The touch screen provides convenient control of the system and allows you to quickly change parameters during the process cycle. (Figure-5).

Figure-5. Touch screen and control panel for a concrete block machine.

Industrial controllers perform operational monitoring of the equipment, thereby increasing the service life of the vibroforming machine, increasing the reliability of its operation.

Concrete block machine control system performs monitoring and analysis of specified operating modes (automatic, manual), gives warnings about emergency and technological situations, if necessary, can archive events. Special devices connected to hardware components allow you to quickly find errors and fix them. Finding the error, the computer stops the work process.

4.2. Concrete batching control system

In the production of concrete paver and block, planetary concrete mixers are used, which have some design features. It is equipped with a skip, must have a cement dispenser and the ability to add coloring additives. (Figure-6).

Figure-6. Planetary concrete mixer with skip and cement weigher.

Example of Mnemonic scheme of concrete batching control system for a concrete batching plant with two planetary concrete mixers implemented on the basis of SCADA [12]. (Figure-7).

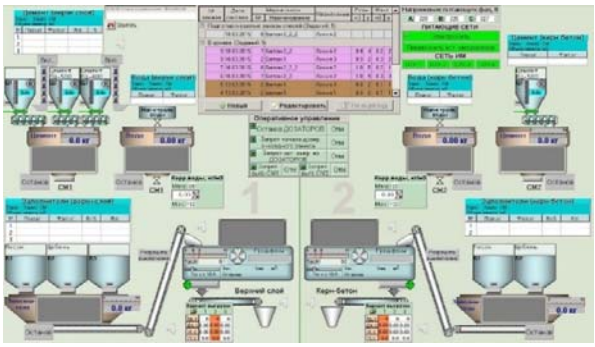

Figure-7. Mnemonic scheme of concrete batchingcontrol system.

This control system with a personal industrial computer provides dosing of individual components according to a preset recipe. Control is equipped with a visualization system, statistical programs, a printer, remote maintenance, etc.

Using the menu bar buttons, you can get more detailed information on each of the nodes and organize work with the lists of emergency and technological messages, which allows the operator to fully control the operation of the system, monitor the failures of technological equipment and prevent emergencies.

All actions of the operator and failures of the technological equipment are recorded. In addition, a database of dosing results for each order is formed, with information on the order execution time and the quantity of the dosed out raw materials.

In the event of failure of the operator station, a spare control channel is provided from the operator panel (console).

The system includes several flexibly adjustable parameters installed in the engineering settings window, with which you can fine-tune the various delay times, weight thresholds, dosing parameters, and so on.

5. DISCUSSIONS

A significant disadvantage of the proposed technical solutions for the automation of the production of concrete blocks and paving slabs based on the Siemens Smart Factory concept is a very high price, compared to technical solutions based on the application of Russian controllers (for example, OWEN).

However, the technical solutions of OWEN, although much cheaper and more reliable at the level of industrial controllers, and also provide import substitution, are much inferior to Siemens products in system integration and process visualization.

6. CONCLUSIONS

Further research and search for new solutions for the automation of industrial enterprises in the SMART Factory concept and their subsequent introduction, including the production of concrete paver and block, are needed.

This will increase the efficiency in making decisions and adapting plans in the event of unforeseen events in real time, as well as significantly improve the quality of the shipped product and reduce the percentage of rejects due to increased accuracy of dosing of the components of the concrete mixture and its preparation time, automatic control over the molding process.

The accumulation of a knowledge base on consumable raw materials and materials for different time periods will allow the introduction of intellectual analysis to control the turnover of raw materials, materials and finished products in the enterprise.

Expected increase in labor productivity and technological discipline, due to the exclusion of the operator's labor by replacing it with cyberphysical systems and automatic logging of events.

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