Crushing and screening digital system

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Abstract. The article proposes the structure of the Crushing and Screening Digital System (CSDS). A software implementation of a digital system for a cone crusher has been completed, which allows integrating a set of interfaced technological units in the control of one hardware equipment as part of the controller and installed at the operator station of the SCADA system. The most important functions of the CSDS are the continuous monitoring of the equipment condition of the complex of crusher mechanisms and aggregates in the process of work and the formation of a signal to regulate the productivity of the crusher. CSDS allows you to integrate in the control of one hardware as part of the selected controller and the SCADA-system server crusher installed at the operator station, a set of interfaced technological units, the efficiency of joint work of which is largely determined by the degree of coordination and the speed of two-way information exchange. In the event of malfunctions or abnormal situations, it will notify the operator. All accidents and crusher operation parameters are recorded in an electronic archive. The developed system provided a significant increase in the operator’s comfort, providing him with a single user interface for controlling the cone crusher from one operator station and an additional amount of information and services.

1. Introduction
Modern crushing and screening production of stone materials for constructions products and structures is a complex with a large set of technological operations [1, 2]. Technological operations include the delivery of the source material, its purification and preliminary sorting, crushing in several stages, with the sorting of the required commodity fractions by crushing stages, storage and transportation to the final consumer. Technological processes of crushing and sorting are among the most critical processes in the technology of obtaining building materials, but they are not highly efficient enough.

To increase the efficiency of technological processes for crushing and sorting stone materials, it is required to develop new methods and scientific approaches to the creation of a Crushing and Screening Digital System (CSDS), which is a complex multi-level system.

2. Materials and Methods
A set of CSDS technological equipment (Fig. 1) is a branched flow-transport system, in its simplest version, consisting, for example, of a storage hopper, a screen, a crushing plant and several belt conveyors, and in a more complex version, it has several dozen units of equipment linked into a single technological process and operating in automatic mode [3, 4].
The choice of the CSDS technological scheme depends on the type of processed raw materials, its physical characteristics, quality requirements and the purpose of the finished product. In addition, the technological scheme of the crushing and sorting plant also depends on the required ratio of cuboid grain, the planned capacity, as well as the readiness of the owner of the DSK to bear a certain share of the costs of restoring the operability of its working bodies.

Aggregates with jaw crushers (Fig. 2) are used for coarse and medium crushing of hard and abrasive rocks (granite, diabase, sandstone). Crushing is carried out by means of two “cheeks” - plates, one of which makes oscillatory movements.
Aggregates with cone crushers (Fig. 3) are most effective for medium and fine crushing of strong and highly durable rocks. In them, crushing is carried out continuously due to the rotation of an eccentric conical rotor - a "crushing cone" inside an external stationary cone.

In cone crushers, instead of vibrations, continuous rotation is used, and the gap is changed, in contrast to jaw crushers, not simultaneously over the entire width of the gap, but by its alternating change along its length. The working gap in a cone crusher does not change simultaneously over the
entire width, as in a jaw crusher, but continuously around a circle, contributing to an improvement in crushing quality. The inlet and outlet slots in the cone crusher are concentric rings. The maximum and minimum size of the exit slot is set by the adjusting device.

The size of the cone crusher product depends mainly on the size of the exit slot and the strength of the rock.

3. Results and Discussions

The power supply and automation system is built on a modular basis, which makes it possible to reconstruct or modernize production. Remote and local modes of operation are debug and repair modes. Visualization of the technological process is provided in various ways - by installing a control panel with a mnemonic diagram of the technological process, an operator's touch panel or a computer as part of an automated workstation (AWP) of a dispatcher [5, 6].

At the operator station of the SCADA-system [7, 8], a visualization project was implemented with reference to the main video frame for monitoring the state of the crusher equipment. In the right part of the screen there is a tool-information panel (Fig. 4).

![Mnemonic diagram of the cone crusher control system](image)

**Figure 4.** Mnemonic diagram of the cone crusher control system

In the process of adjusting the system software, it was revealed that it was impossible to remotely control the hydraulic unit to rebuild the gap in automatic mode due to failures in the adjustment of the sensors of the hydraulic unit pressure switch.

When rebuilding the unloading slot in the local operating mode of the hydraulic unit, the maintenance personnel must proactively enter information about the size of the unloading slot from the operator station. The system monitors the fact of operation of the hydraulic unit and informs about the need to enter information on the actual size of the gap in a special information window.

The function of "optimal control of loading ore into the crusher" is realized only from a programmable logic controller (PLC) of Russian production OWEN PLC 150 (Fig. 5) and provides control of the drives of the feeding conveyor depending on the calculated value of the indicator "current value of the unloading gap", automatically generating a task for the amount of stone material fed into the crusher (Q, t/h).
Optimization of material supply as a function of the size of the discharge gap is performed only in the recommended technological range of values of this gap (8.5 - 10.5 mm). When the crusher is operating with a slot outside this range, the regulator processes the algorithm setting in a gentle mode. At the crusher operator’s station, information messages are generated about the need to tighten the gap.

The regulator implements control of the change in the supply of stone material to prevent the crusher blockage in the event of interruptions in the supply of material on the conveyor according to the following algorithm: in the case of a sharp decrease in the supply of ore (more than 70% of the steady-state value for 3 seconds), not due to the formation any control action from the control system, the setpoint of the material feed task is reduced.

4. Conclusion
A structural diagram of a CSDS has been developed, consisting of a set of elements, taking into account possible relationships; the features of the functioning of the elements of the scheme are determined, due to the need to automate the crushing and screening production.

The software implementation of the automated control system for the cone crusher in the SCADA system has been completed. This made it possible to integrate in the control of one hardware and technical complex as part of the selected controller and the SCADA-system server crusher installed at the operator station, a set of interfacing technological units, the efficiency of joint work of which is largely determined by the degree of coordination and the speed of two-way information exchange.

The developed system provided a significant increase in the operator’s comfort, providing him with a single user interface for controlling various technological units from one operator station and an additional amount of information and service services, and also confirmed its economic efficiency.

Figure 5. Programmable logic controller OWEN PLC 150
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