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CONTROL AND MONITORING SYSTEM OF THE MINERAL WOOL PACKAGING PROCESS

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Abstract: This paper presents the control and monitoring system of the mineral wool packaging machine. The machine works synchronized with the final part of the mineral wool production plant. After the wool passes under the horizontal and transverse saws, the molded pieces of wool come in the packaging machine via the transporter system. Shrink foils dosage, transporter launching, packages managing, foils welding and packages treatment in the thermal chamber is automated. The packaging machine is controlled by PLC. Setting and review of the parameters, such as temperature of thermal chamber and weld of foil width and temperature, are done on a TOUCH terminal connected with PLC. The control system is connected to a plant SCADA system.
Keywords: packaging machine, mineral wool, shrink foil, control, monitoring

INTRODUCTION

The production of mineral wool takes place in a complex plant which consists of a number of technical and technological units: a raw material warehouse (coke, stone, dross and brickets), raw materials transport to the beam scale for measuring and dosing unit, a cupola furnace, filtration systems, centrifuges, binders preparation, fuels storage (heavy oil, oil, gas), burners, compressor stations, poly condensation chamber (PC), saws for longitudinal and transverse cutting of the wool, the ventilation and dust collection system, packaging and transportation lines of final products in the warehouse. Technological scheme of the plant is shown in Figure 1 [1].
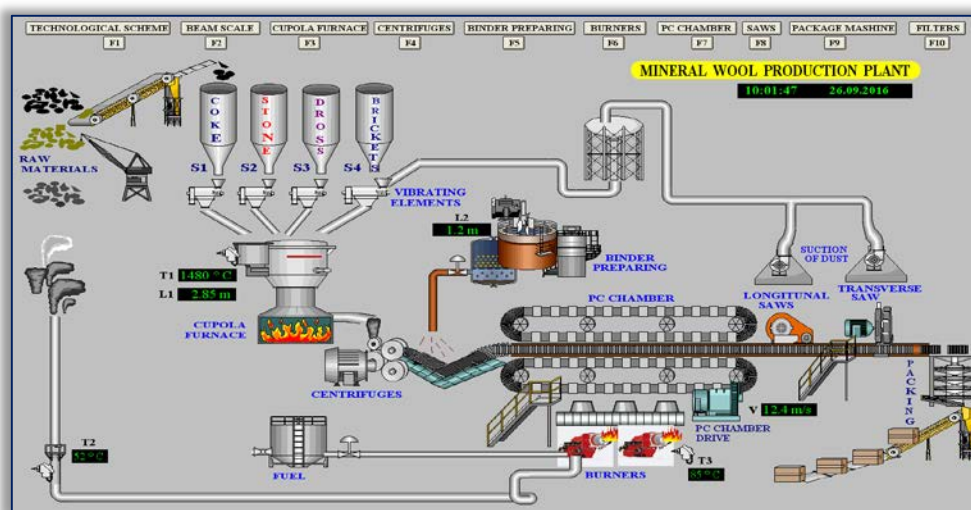

Figure 1. Technological scheme of mineral wool production plant (a SCADA screen).

The subject of this work is the packing machine used for packaging of mineral wool in shrink foil. It can be also applied in flat packaging of other similar products. The machine can work independently or as a part of a mineral wool production plant. When the machine is operating within the plant, its operation is synchronized with the operation of the plant. Namely, the packer control unit and the control units of

the system saws and poly condensation chamber (PC) are in communication. The saws are used for longitudinal and transverse cutting of mineral wool in given size panels. The polymerization of phenol-formaldehyde resin is performed in PC under the effect of the circulation of hot air. As a result of that, water evaporation occurs as well as fixation of binder which is added in the mass untwisting phase when so-called felts produces. E.g. if the assortment of 10 cm thickness plate is produced, the packaging machine control unit forms 5 plate packs so the height of package is 50cm. In case of producing a 5 cm thickness plate, the packer automatically forms10 packs of mineral wool plate. PLC (programmable logic controller) control unit in conjunction with a TOUCH SCREEN panel provides the automatic operation of the packer. Monitoring and parameters settings are performed on the TOUCH SCREEN panel. The operator has a role in monitoring of the machine operation and in the replacement of rollers with foil [1, 2].

2. CONTROL LOGIC

Control block diagram of packaging machine is shown in Figure 2. The control unit is PLC Omron CJ1M with a processor unit CPU 21, which has 10 integrated digital inputs and 6 integrated digital outputs.
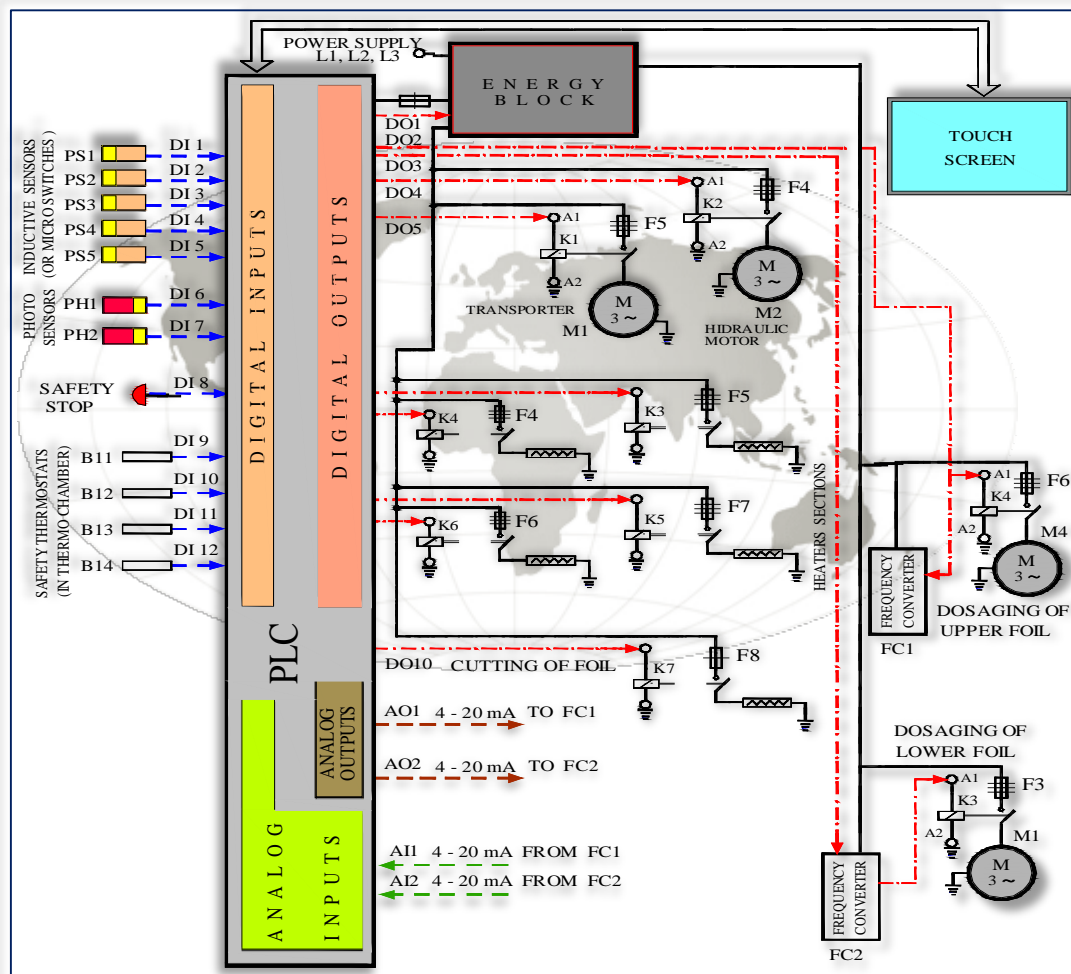

Figure 2. Block diagram of control mineral wool packaging machine

There are also used one digital input module ID 211 with 8 inputs, one digital output module OC 211 with 8 outputs, two analog modules: module ADO41 - V1 with 4 analog inputs and DA081 module with 8 analog outputs. Corresponding outputs of frequency converters (data of speeds - signals 4 ÷ 20mA) are connected on the analog inputs, and the 4 ÷ 20mA signals are lead from analog module output, which sets the engine speed for unwinding foil. The status of all switching elements in the system (circuit breakers, fuses, over current motor protection, safety thermostats, micro switches, photo sensors, inductive sensors) is linked on PLC digital inputs. The signals for starting the dispensing foil motor and transporters, heaters in thermal tunnel heating sections, heaters for cutting and welding of shrink foils, signals for launching the pusher and devices for sticking a label with the product type and the barcode come out from digital inputs. The power source (AC/DC module) is PA 202. The communication protocol is SYSMAC WAY. The control program is written in the CX - Programmer. Communication with the testers control unit and PK is realized via PROFIBUS. The control logic enables a synchronized operation

of all the packer elements [1 - 4]. TOUCH panel NS8 TV01 - V2 (Omron), which is installed in the distribution cabinet, has been applied as a control console. The mentioned panel is powered with a voltage source AC/DC 5V, 1A (Omron). The panel is connected with PLC via RS 232 communication. Several screens are realized and two of them are shown in Figure 3 and 4.Entering and reviewing the packer parameters are enabled for the operator through this screens. For the functioning of the packaging system it is important that the packaging machine work is synchronized with the production line. The packaging machine control unit, blade control unit and PC are in constant communication. The LED on the panel lights up green when there is synchronization between the two control units. LED flashes and colored red with a text message if there is no synchronization. Setting the parameters of packaging machine is controlled via buttons on the screen: "TRANSPORTERS", "HEATERS", "PACKAGES", "ALARMS" or by the indicated function keys. For example, by pressing the "HEATERS" or F2 key, the menu with the settings of working and the alarm temperature values of thermal tunnel heating sections is open (shown in Figure 4). The shrink foils temperature welding regulation is also performed here, by adjusting the voltage and current of the cutting heaters and welding foils. There are two work modes: manual and automatic. Entering the automatic mode, the database list of shrink foils types is provided to the operator. The temperature value is automatically set by clicking on a particular type of foils. During work, if necessary, these values can be adjusted [1, 5, 6].

3. ELECTROMOTORDRIVE

Five three-phase asynchronous motors are installed in the packaging machine:

» drive transporter 1 (motor - M1).This transporter is a part of the table for mineral wool plate accepting,
» drive transporter 2 (motor – M2).This transporter is a part of the thermal tunnel,
» drive up/down(motor – M3),
» dosage of lower shrink foils (motor – M4),
» dosage of upper shrink foils (motor – M5).

Electro hydraulic motor M3 is used for lowering and lifting mechanism associated with a table for receiving plates that come with the mineral wool production lines.

If the initial state is the upper position of the table, after the arrival of the first plate of mineral wool, the table is lowered for plate thickness by a motor M3, which makes room for another plate. Determination of electro hydraulic motor steps is performed by control unit according to the algorithm and based on the thickness range of wool on the line. The final positions of the table (upper and lower) are registered in the final position switches (inductive sensors). Depending on the plate assortment thickness, which is on the line, the package is formed, the table goes down into the lower position and the transporter driven by motor M1 starts. Stopping the transporters is performed by photo sensors (transmitter - receiver), which register the absence of a stacked plate on the transporter. This transporter with a roller is a part of the table and it leads stacked plates to the thermal tunnel entrance, where hydro pneumatic pusher works, and pushes the plate to the middle of the tunnel. This is where the cutting and simultaneous welding of the lower and upper shrink films occur. These foils are unwound by the motors M4 and M5 which have a frequency regulation (regulators FC1 and FC2). The regulators are coupled with the control unit, which also controls the operation of the heaters for cutting and welding foil. The time and temperature of welding can be adjusted. A formed package is accepted by another transporter (which is the part of the thermal tunnel) rotated by a motor M2 [1, 2].

4. THERMAL CHAMBER

In the thermal chamber (thermal tunnel) package wrapped with shrink foil is exposed to heat by using an electrical heater. There are four heating sections: on the ceiling, on the floor, on the left and right side of the chamber. The heaters operation is regulated by the control unit. The temperature measurement in sections is done by using Pt100 probes. As security elements limit thermostats were installed. The temperature is regulated up to the 220ºC.

The temperature is automatically adjusted according to the type of the available shrink foil. For practical reasons, the possibility of manual adjusting of the heating section temperature is also provided via the TOUCH panel (Figure 4). Passing through a thermal tunnel, the foil shrinks in the vertical and horizontal direction, forming a solid package which is ready for further transport. The control logic regulates the work of the transporter drive that passes through the thermal tunnel (motor M2). M2 starts after the expiration of the time which is needed for thermal foil collection. After the expiry of the preset time (that is different for each type of foil), the motor M2 is started and the package comes out of the tunnel, cools and goes into the warehouse. At the exit from the tunnel the control unit activates the device for sticking

labels and counting packages. Processing speed of 6 packs per minute satisfies the needs of the plant for mineral wool production [1].
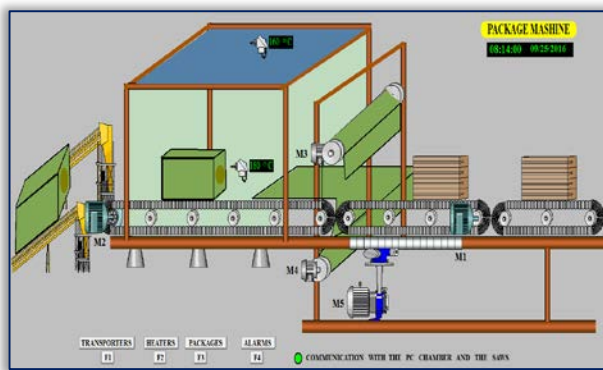

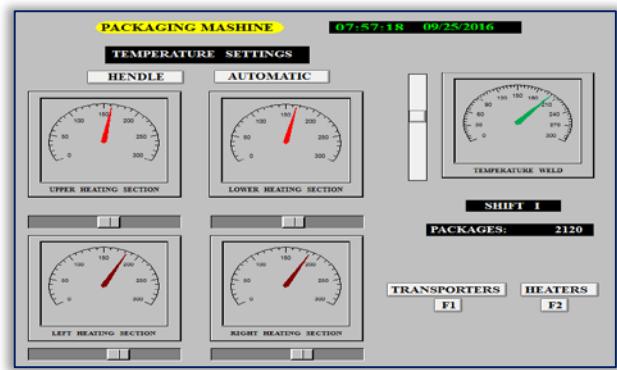Figure 3. Packaging machine SCADA screen

Figure 4. The touch panel screen for monitoring and adjusting the heater temperature

5. ALARMS
In case of excess temperature in heating sections, in a certain percentage which is defined as a pre-alarm status, the yellow lamp on the panel lights up with the corresponding text message which shows the percentage of the overrun. The alarm occurs also in case the temperature is below the appropriate value. In case of reaching critical values, the corresponding lamp is colored red and the sound alarm starts. The alarms also turn on when there is an activity of the fuses, over current protection of the transporter motor, safety thermostats or other safety elements that are connected to the control unit. The alarm statuses from the frequency regulators are also transmitted to the panel. The operator receives a text message with a sound alarm when it is necessary to replace the rollers with shrink foils. Alarm also starts in the case of deviation from normal state of current welding foil heater [1].

6. CONCLUSIONS
This paper describes the work of the automatic machine for mineral wool panels packaging into shrink foils. Compact packages, which can be further transported, are received at the exit of the machine. The packaging speed of 6 cycles per minute fully satisfies the requirements for the mineral wool production plant. The touch panel allows easy parameter settings and monitoring. Based on the entered data about the available types of shrink foils, the control system adjusts the power of the heater in thermal tunnel heating sections, which enables the optimal time to form a package. The heater power and time cutting and welding foil are adjusted. Frequency converters of motors perform optimally shrink foils unwinding from the rolls. Adjustment of the steps of pickup plate lowering is automatically synchronized with the production line, based on the data of mineral wool assortment that is produced. It is made possible to attach the labels on each package and to count packages. The thermal tunnel temperature data, welding temperature data and the packets number are transmitted by communication to the central SCADA system.

Note: This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016.

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