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INTELLIGENT DRIVE INSTALLATION FOR BIOMASS CONVEYOR

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Abstract: On the market there are biomass conveyor solutions where the electric drive installation does not notice the imminent blockage in the conveyor piping, ensures only its stopping when overcoming an overload. The work presents the way in which the functioning of the motor reducer can be improved by operating it by means of a converter, with speed adjustment and anti–locking system, but without a monitoring based on a warning and parameter recording system during operation it is not known where the problems arise, what is actually the necessary torque, why the peak torque appears, how long does a peak last. It is necessary to perform predictive maintenance and eventually to integrate into a fully automatic system. This installation has been developed by INOE 2000–IHP together with S.C. CORNER PROD S.R.L. The solution can be applied both for individual equipment and for a large number of machines that can be monitored remotely on a smart phone or computer. The results are based on models developed by manufacturers of engines and reducers. All information is recorded and can be available in an easy–to–use way on the smart phone or computer app.
Keywords: intelligent drive, biomass, conveyor, automation

INTRODUCTION

Due to the dimensional inequality of the biomass passed through a conveyor, it can get stuck in its piping. This locking leads to excessive heating of the reducer, burning of the drive motor, destruction of the reducer seals, loss of lubricant, destruction of the gear reducer and breakage of its housing. Of course, a problem is the insufficient torque in the engine for the current mode of use, the time capable and the service factor too small at the reducer, but there may be other problems related to improper use, wear, lack of alignment, voltage variations, unbalanced phases or insufficient installed power. In case of such failures, the technological flow is interrupted, with major economic effects. To reduce the risk of blockages, the drives are greatly oversized. This solution is totally uneconomic, and when the blockage of the material occurs, the time required for weave is much longer.

In general, at low power, at this moment the problem is solved by oversizing the engines and reducers, but in the conditions in which it is necessary to use engines with premium efficiency (increased) to decrease the energy consumption, the oversizing approach is a matter of the past, especially as the energy is expensive and the reactive energy charges the bills even more. For this reason, it is necessary to monitor and optimize these drives.

Big problems occur in medium and large drives, where powers of over 3kW–4kW are common (Narayan, S., 2015). Depending on the type of conveyor, molten reducers are generally used for low power and especially for screw or inclined strips, pendulum reducers (cylindrical with parallel axes) for screw, conical–cylindrical reducers for strips, orthogonal reducers for operating biomass blenders (it actually has the role of bringing it to the biomass evacuation area at the same time as mixing).

In the working process of agricultural equipment, the supervision of their operation in optimal operating parameters is a complex process and requires for the operators extended working time, increased attention, concentration and knowledge in the field (Gandjbakhch, E. et al., 2020). However, they cannot notice the sensitive functioning problems (Caixal, G. et al., 2021) by which major defects can be avoided. Meeting the needs of reliable equipment with active assisted operation based on intelligent supervision (Hassan, M.M. et al., 2020) is a priority for researchers.

Luz E. et al. (2021) introduced an intelligent algorithm in the management of agricultural equipment. The monitoring system surveys the status of use and lease of the equipment. Good results have been achieved and work efficiency has been improved (Luz, E. et al., 2021).

MATERIALS AND METHODS

On the market there are biomass conveyor solutions where the electric drive installation does not notice the imminent blockage in the conveyor piping, ensures only its stopping when overcoming an overload. Researching the current situation of the market, we found that there is room for improvement which meets the needs of users (Stojanovic, N. et al., 2018)

There are extremely expensive general solutions. An example is the monitoring system using the vibration and temperature sensor QM42VT1. It is designed for monitoring pumps, compressors and engines of different sizes. Data can be collected from multiple engines, evaluated, centrally displayed and, if necessary, related to alarm actions for timely warning of imminent damage. Users can use radio technology to connect the vibration and temperature sensor QM42VT1 with the high–performance HMI TX700 device for this purpose.

The sensor, figure 1, detects vibration and temperature values. Changes in temperature or vibrations occur when in that transmission the screws through which the engine is fixed have been loosened, causing the wrong alignment of the shaft, it is a blocked bearing or an imbalance has occurred, mechanical vibrations can signal problems such as these.

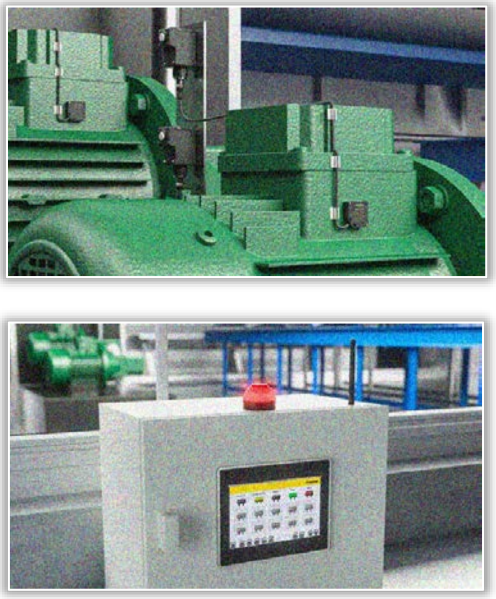

Figure 1 – Sensor mounting mode and data display

The QM42VT1 vibration and temperature sensor detects vibrations with a high level of accuracy. For this purpose, the compact sensor based on MEMS (micro–electromechanical system) is simply mounted directly on the engine block through a magnetic support. From there, it offers data on speed and acceleration on two dimensions in different frequency ranges. Changes to the measurement data can then be used to identify different problems in operation (Lacatus, P. et al., 2021).

Figure 2 – Optimal Schaeffler System

Measuring the temperature of the engines is also vital, since a significant increase in temperature could be an indication of insufficient wear or lubrication for the bearing. The IP67 sensor also detects working temperatures in the measurement range from –40°C to +105°C. Another very new system is Schaeffler OPTIME, which is now under testing at the Schaeffler factory in Brasov.

The Schaeffler OPTIME solution developed by the bearing manufacturer Schaeffler in collaboration with Siemens, monitors the behavior of the bearings in the machines by measuring vibrations and temperature at a distance of up to 500mm from the bearing, then transmits the data and its interpretation, taking into account the existing database for bearings.

THE CONSTRUCTIVE SOLUTION OF THE INTELLIGENT DRIVE INSTALLATION FOR BIOMASS CONVEYER

The solution developed and realized by INOE 2000 together with the partner company CORNER PROD aims to continuously monitor the state of the system (voltage, absorbed current, temperature, and power), developed for biomass conveyers of different types, recommended for a range of gear motors and reducers with speed between 2 rpm and 1400 rpm. The solution can be applied both for individual equipment and for a large number of machines that can be monitored remotely on a smart phone or computer.

The data collecting is done through sensors for monitoring the absorbed currents and temperature sensors, the wireless transmission of the collected data to the Gateway. The gateway receives the data sent by the sensors and transmits it to the cloud. In the cloud, data is continuously and automatically analyzed based on predetermined models and if it is necessary warnings or messages of imminent failuret are sent.

The results are based on models developed by manufacturers of engines and reducers. All information is recorded and can be available in an easy–to–use way on the smart phone or computer app.

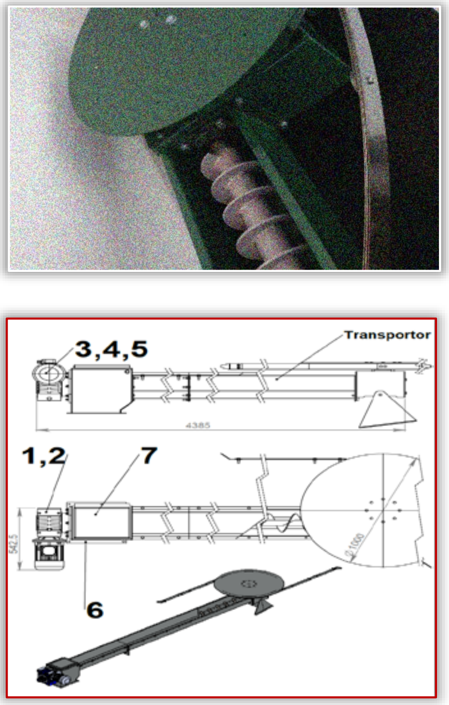

Figure 3 – Type of screw conveyor with additional action for homogenization and loading; 1,2 – reducers; 3 – temperature sensor; 4,5– engines; 6– Raspberry Pi4; 7 – Monitoring block

SENSOR SYSTEM

For the realization of the sensor module and the transmission of wi–fi to the gateway, the mounting below, Figure 4, is used.

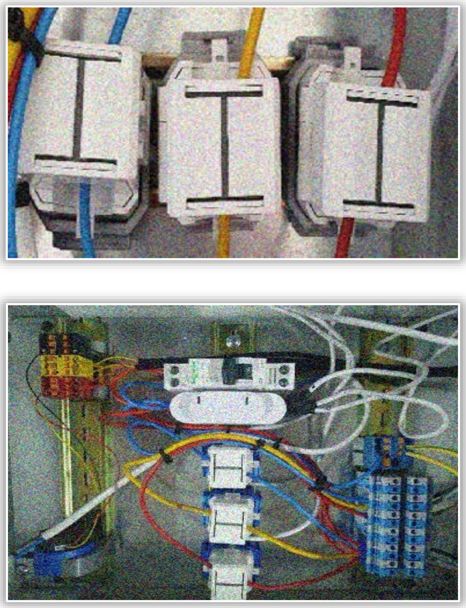

Figure 4 – Sensor module mounting

The sensors used in this application are sensors with WiFi communication produced by Shelly Cloud Bulgaria. In this application, two sensors are used. The first sensor, electrical, allows measuring the voltage in the three–phase network and the current consumed by each phase of the motor. The sensor acquires all six of these parameters with a cadence of one measurement per minute. The electrical sensor also makes calculations to indicate the power consumed on each phase and the power factor. The second sensor, thermally, is Shelly 1 with temperature measuring mode that allows the acquisition of three temperatures, in three points with semiconductor sensors of type 18S20 in cases with IP67 degree of protection. Temperatures are read with a cadence of one measurement per minute.

COMMUNICATION NETWORK

In order to achieve the data processing mode and the communication network, the assembly below, figure 5, is used. High–performance equipment for solar installations such as solar chargers or inverters have Serial, Ethernet, CAN or Modbus communication ports. These devices can be connected to the internet through gateways (Radoi, R.–I. et al, 2021)

The communication network used in the application is a local WiFi network, used only by the application components.

The network is controlled by the microtik Hap Lite RB941 Access Point swarm that ensures the management of network functions:

≡ Authentication of clients in the Wi–Fi network
≡ Automatic allocation of addresses in the local network through DHCP protocol
≡ Network Address Translation function to connect the local network to the internet
≡ Firewall function to protect the internal network from attacks from the internet
≡ Port forwarding function to make available resources from the local network to the Internet to allow access to data collected and processed by the system from the Internet.

All sensors connect to the WiFi network and automatically receive IP addresses from the Microtik router.

Figure 5 – Communication network assembly

Applying the Internet of Things (IoT) can improve the efficiency of the technology for monitoring the operation of agricultural equipment (Pi, J. et al., 2021).

DATA PROCESSING MODULE

The data processing module is implemented with a Raspberry Pi 4 with 4GB of RAM that provides all the necessary functions for the application:

≡ Data collection
≡ Storage
≡ Data processing.

On the Raspberry Pi runs the Raspbian operating system along with the applications necessary to ensure the above functions. In order to ensure a slight replication of the system, a solution was chosen to use docker containers with the necessary applications. Under these conditions, only a compose file for the Docker Compose application is required to replicate the application. The compose file that was written specifically for this application has the YAML format. It allows downloading from the internet the necessary Docker containers and linking them to ensure the operation of the application. The management of the installed containers can be done through the web interface of the Portainer–CE application.

The data collection function allows retrieving data from sensors with the cadence of one measurement per minute. Each sensor is programmed to transmit once a minute the data measured by MQTT protocol.

In order to use the MQTT protocol, it is necessary to use a Broker that takes the data published by the sensors and transmits it to the applications that have subscribed for receiving the data in question. The MQTT broker is provided by the open source Mosquitto application that runs in a Docker container.

Within the data collection function is also the node–red open source application that allows the graphic realization and running of Node JS applications. The function of the Node Red module is to connect to the MQTT Broker and process the primary data received from the sensors in order to be stored in a database in a unitary way (Lacatus, P. et al., 2021).

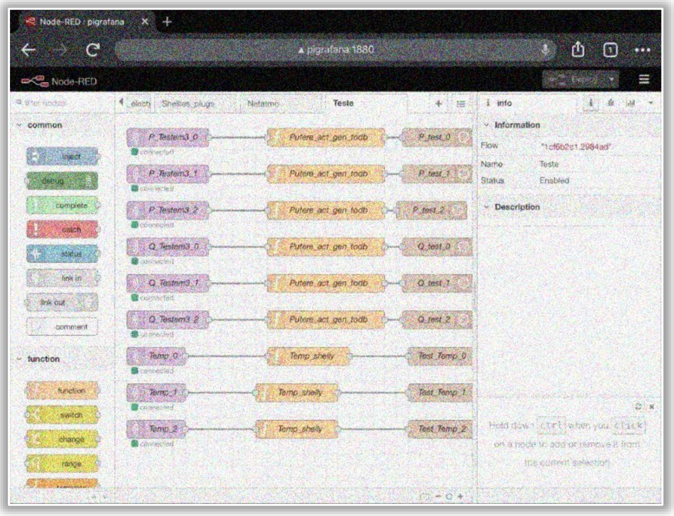

Figure 6 – Node–Red graphics application

INTELLIGENT DRIVE INSTALLATION TEST

For testing the prototype of the intelligent drive installation used for biomass conveyors, the conveyor belt equipment from the experimental model was used; the validated tests to the experimental model were repeated and the transmission of data and warnings of damage on the computer and mobile phone was followed.

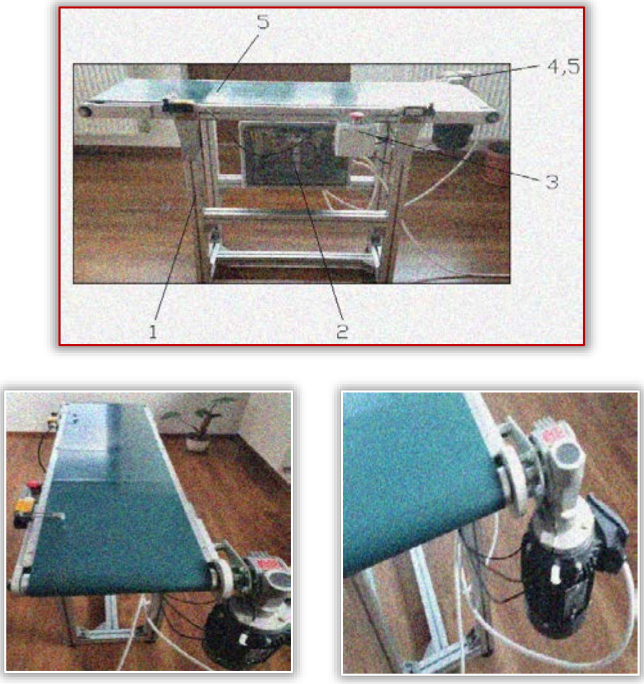

Figure 7 – Prototype testing installation
1–frame; 2– the way of recording and transmitting data; 3– crash button; 4– moto–reducer; 5– temperature sensors; 6– conveyor belt

The installation for prototype testing consists of a frame (1), a module for recording and transmitting data (2), a hazard button (3) the moto–reducer (4) with temperature sensors (5) and the conveyor belt (6) for simulating the load variation.

The monitoring module is located near the monitored motor assembly, and the connection of the motor is made through it to take over the electrical voltage current sizes necessary for the analysis.

The control module contains the router that ensures wi–fi communication with the rest of the monitoring modules and the Raspberry Pi 4 single board computer that stores the data and processes it according to the processing levels described above (Russell T., 2017).

The equipment monitors the behavior of the operation throughout the period of use and follows the following parameters:

- The current absorbed on each phase of the motor;
- The power absorbed on each phase;
- Voltage on each phase;
- The power factor on each phase;
- The temperature recorded in correlation with the other parameters in 3 strategic points on the engine and on the reducer (a sensor is also used to measure the ambient temperature)

These parameters are transmitted through the recording system, via wireless to the reception system that is connected to a computer. Thus, the intelligent drive installation stores the data recorded during operation and provides in real time error messages in case of exceeding the predetermined warning or damage values, so that the user can make decisions in the shortest time or establish the necessary changes to optimize the operation of the conveyor.

After the empty start of the installation, the loading of the conveyor belt is simulated by pressing with the hand.

Figure 8 – Mounting of the automatic control module

The data is automatically recorded every 5 sec and is transmitted via Wi–Fi by the monitoring module located near the conveyor belt to the control module located in another room that is connected to the central computer for data acquisition and interpretation in order to optimize the operation of the monitored system.

RESULTS

At the same time, this data is displayed on the mobile phone:

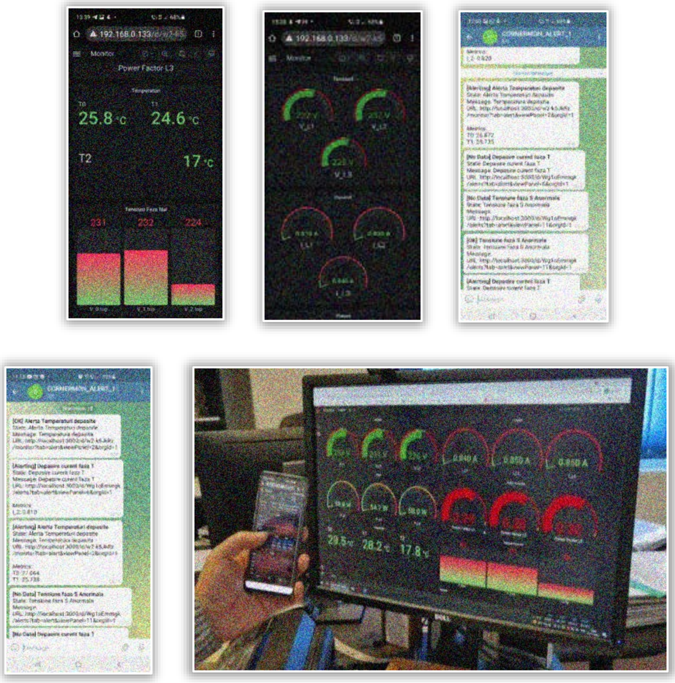

Figure 9 – Displaying the results on the mobile phone screen and on the computer screen

Data monitoring is displayed independently on both devices. The data is automatically recorded every 5 sec and is transmitted wirelessly by the monitoring module located near the conveyor belt to the control module connected to the central computer for data interpretation and establishing the decisions to be taken. The power outage was simulated and the installation sent an alert to the mobile phone.

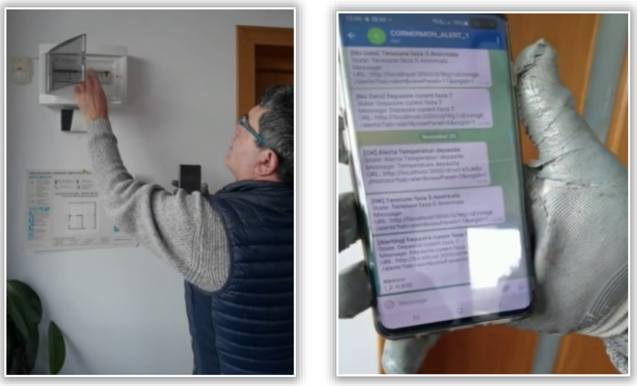

Figure 10 – Displaying the results

At the reboot, a new status change alert was sent. Higher load charges were simulated at the conveyor belt and the intelligent installation transmitted again on the monitor and on the phone alerts of exceeding the current and of the phase voltages at the monitored electric motor.

Figure 11 – Simulation at the conveyor belt

CONCLUSIONS

The prototype of "Intelligent drive installation for biomass conveyor" was tested in operating conditions in the laboratory, for monitoring, acquisition and data transfer of monitored parameters, via Wi–Fi from the conveyor belt equipment to the mobile phone and to the central computer where a dedicated program monitors and stores data for warning in case of failures or for the subsequent analysis of the monitored system.

It has been proven that it is possible to improve the operation of the motor by operating it by means of a converter, with speed adjustment and anti–locking system, but without a monitoring with a warning system and recording the parameters in the type of operation it is not known where the problems arise, what is actually the necessary moment, why the peaks appear, how long the peaks last. It is necessary to perform predictive maintenance and eventually to integrate into a fully automatic system. The same problems are encountered not only in the tracks but also in other types of conveyors, especially where the personnel using the installations do not check and do not comply with the conditions listed in the technical book, but where they can't be checked if the normal operating conditions have been observed.

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