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A universally applicable condition monitoring system for efficiency evaluation of low-voltage motors

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Summary:
A compact universal Condition-Monitoring-System for predictive maintenance and efficiency evaluation has been developed for monitoring low-voltage motors. The analysis for edge processing of glass sheets showed energy savings of up to 50 % and machine utilization of 30 %. This enabled unfavorable processes to be identified and improvement procedures to be initiated.

Keywords: Electric drives, Condition-Monitoring-System, Energy saving, Efficiency evaluation, Machine utilization

Motivation

As announced by the Federal Environment Agency in various publications, electric drives in industry and manufacturing consume almost two-fifths of all electricity in Germany. At the same time, this shows the great potential for savings in electric drives and driven units for pumps, fans, or ventilators, for example, as well as all types of conveyor technology. For driven pumps alone, the potential energy savings are estimated at five billion kilowatt hours [1]. A similar conclusion was reached by the German Association for Electrical, Electronic & Information Technologies (VDE) in its 2008 study "Efficiency and Savings Potentials of Electrical Energy in Germany," which shows the prospects and need for action up to the year 2025. The study showed that the key role in energy savings will be played by electric motors. The consumption focus here is seen in three-phase motors in the power range from 0.75 kW to 40 kW (related to electric drives of pumps, fans, and ventilators), as these have the greatest number of operating hours per year [2]. At the same time, in addition to energy saving, the maintenance of electric drives and driven units is of crucial importance, since sudden failures can have serious consequences for safety as well as high costs for repair or production downtime [3, 4]. Maintenance is based on permanent condition monitoring of electric drives [5, 6]. A universally applicable condition monitoring system was implemented for comprehensive monitoring of uncontrolled electric drives, which covers the two criteria of condition monitoring and efficiency evaluation. In this paper, the main focus will be on efficiency evaluation based on the energy data. This results from the comparison of the specified motor characteristics and the actual measured active power. The condition monitoring part was explained in [7].

Condition-Monitoring-System

The purpose of the Condition-Monitoring-System is the continuous monitoring of uncontrolled drives. For this purpose, the motor monitoring module is to be mounted on the terminal box of the drive. The recorded data is made available to the various user groups with the appropriate access rights via a gateway or a cloud (see Fig 1). The electrical contact of the motor monitoring module is made via the terminal board of the uncontrolled drive. The motor monitoring module consists of a measurement board and a communication board, which are connected to each other via plug contacts (sandwich construction). The measurement board contains the power supply for the module as well as all individual controllers and sensors for the acquisition of the electrical measured variables, the temperature (PT1000), and the acceleration (KX122). The individually acquired data is collected on a microcontroller and transmitted to the communication board. The W-LAN chip implemented on it transmits the data to a gateway or to a cloud.

Power determination

An energy measuring chip (power meter), which operates according to the Aron circuit [8], is used to record the energy data. Here, only two-phase voltages and two-phase currents are measured in a three-phase system to determine the power of the drive. The voltage is deter-

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mined directly and the current indirectly via two Rogowski coils. The two Rogowski coils used are induction coils in which a conductor wire is uniformly wound around a non-ferromagnetic core. The limiting factors of this measuring principle are the measuring range of the coils, which in the case shown is 40 kW, and the wire cross-section of the motor's connecting cable. The accuracy of the power determination is 5 %.

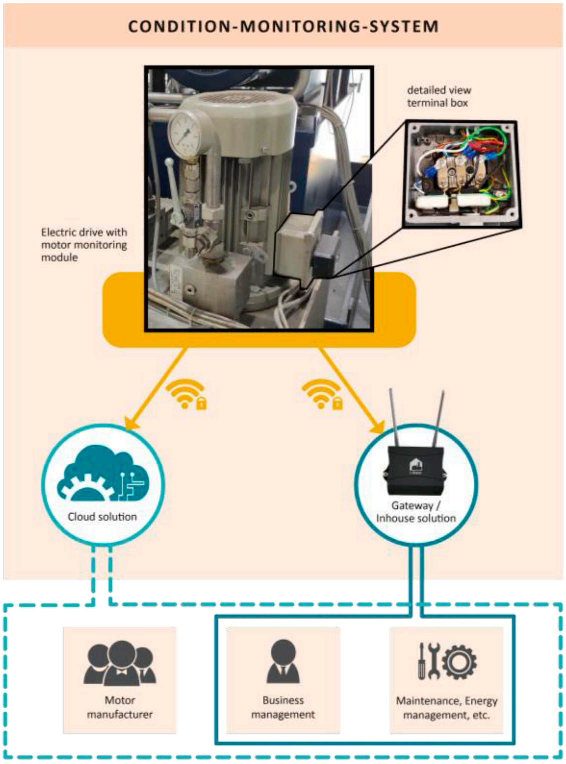

Fig. 1. Functional principle of the Condition-Monitoring-System.

Pilot study

For the pilot study, a machine for edge processing of glass sheets was equipped with the Condition-Monitoring-System. The aim was to determine the efficiency of the motor (P_{mech} = 3 kW), the actual processing time per work piece and the utilization of the machine.

Results

The energy analysis showed a motor idle power of 0.2 kW, an average active power in the tool engagement of 1.2 kW and a max. active power of 1.7 kW. Thus, an energy saving of 50 % can be achieved by using a smaller motor (e.g., 1.5 kW motor). With regard to the processing time, it could be determined that the glass sheets to be produced most frequently are processed between 13 s and 29 s. With this knowledge, conclusions can be drawn about the glass sheet sizes and considered in investment activities. The actual machine utilization was 30 %. Based on these findings, the peripheral processes were analyzed, unfavorable processes were identified and improvement measures were initiated.

Outlook

In the future, the Condition-Monitoring-System will also focus on controlled electric drives. Furthermore, the development of AI-based evaluation algorithms will be addressed.

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