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Condition Monitoring of Machine Elements using Magneto-resistive Sensors

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Summary:
Intelligent sensors are a key enabling technology for availability-oriented business models (e. g. “pay-per-use” models) in the manufacturing and power generation industries [1]. Intelligent sensors also provide data as a basis for “data as a service” business models [2]. Both these trends make use of sensors to provide information concerning the health or condition of machinery, which is used, in turn, to enable preventive maintenance and so ensure the high availability of the machines concerned.

Keywords: Condition Monitoring, Machine Elements, Sensors, Magnetic Sensors, Magnetoresistive effect

Many different methods are applied to gather information about the condition of machines. A classic approach is to measure vibration and acoustic emission is an associated technique. Furthermore temperature can be measured and wear monitored by analyzing debris in lubricants. However, most of these approaches are limited to applications in specific fields and are rarely used in broad industrial applications. Recently, two new approaches have gained in acceptance, namely the measurement of “Instantaneous Angular Speed” (IAS) [3] and “Motor Current Signature Analysis” (MCSA) [4]. Both techniques can use existing sensors, provided they are small, precise and robust, as well as featuring a high bandwidth and low power consumption [4, 5]. Machine and plant builders often have the additional requirement that they wish to use existing sensors or measurement points, rather than increase system complexity by adding additional sensors.

Magnetoresistive (MR) sensors are capable of fulfilling this complex set of requirements. The results of two recently completed BMBF-funded R&D projects demonstrate the potential of MR sensors for the condition monitoring of electro-mechanical actuators including gearboxes and other mechanical transmission elements, such as ballscrews [6, 7]. In both projects tooth sensor modules (see Fig. 1), based on the giant magnetoresistive (GMR) effect are used to monitor both the instantaneous angular speed of gears (see Fig. 2) as well as the wear of transmission components (see Fig. 3). Use is also made of current sensors based on the anisotropic magnetoresistive (AMR) effect for motor current signature analysis, by measuring the stator current of the electric motor (see Fig. 4). Even though the current sensors are mounted in the inverter of the electro-mechanical drive, it has been shown that the sensors are sensitive enough to measure the feedback from mechanical vibrations in the gearbox or ballscrew with high resolution.

These techniques are opening up completely new cost-effective and reliable opportunities for condition monitoring of machine elements as a basis for predictive maintenance models.

This paper will describe the basic functions of MR sensors and their specific advantages compared to other sensor principles. The results of the a.m. state-funded projects will be described alongside a number of industrial applications. The paper will conclude with an outlook concerning new methods of signal processing, such as machine learning, which are leading to even better predictions concerning machine condition [8].

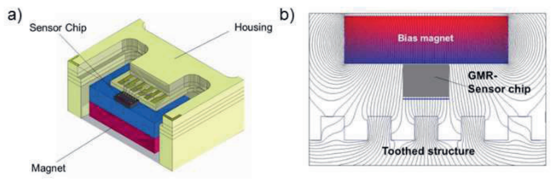

Fig. 1: GMR Tooth Sensor Module (Source: Sensitec GmbH)

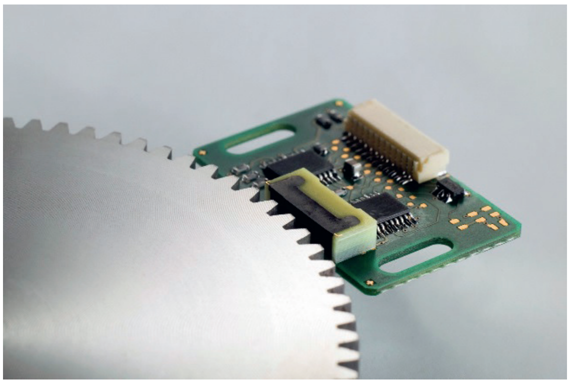

Fig. 2: Application Example (Source: Sensitec GmbH)

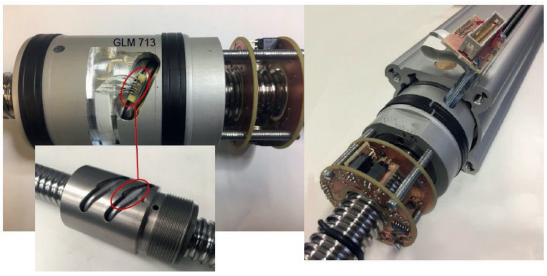

Fig. 3: Monitoring of ball and race wear in a ballscrew using a GMR sensor (Source: Sensitec GmbH)

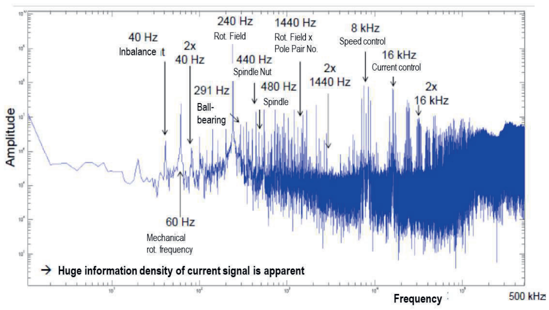

Fig. 4: Frequency spectrum for electro-mechanical linear actuator measured using an AMR current sensor in the inverter (Source: ZEMA gGmbH)

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