Applications of wireless SAW sensing in the steel industry

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Summary

Surface acoustic wave (SAW) sensors are passive devices without the need of an internal energy source (e.g. a battery) and can be interrogated wirelessly via a radio link. They have been proposed for usage at elevated temperatures in harsh industrial environments for several years [1], but are rarely used so far. In this paper three novel applications of SAW sensor systems in the steel industry are presented: i) radio frequency identification (RFID) and temperature monitoring of slide gate plates, ii) monitoring of the temperature inside a lining of a metallurgical vessel and iii) RFID tagging of slag ladles. Starting from this motivation and the system requirements the specification of the sensor, the antennas and the reader unit are derived and design constraints are discussed. Results of field trials of the SAW sensor systems within the steel plants are presented and compared to laboratory measurements and analysis.

Motivation and Results

Ad i) Slide gate plates are refractory wear elements placed within slide gates used to control the liquid metal flow in the continuous casting processes. Failure (e.g. breakthrough of liquid metal) can cause severe damage. An RFID and temperature monitoring system allows the manufacturer better control over the usage and the logistics. The SAW transponder is protected and positioned within the slide plate by a ceramic body. These parts are completely integrated within the slide gate plate and fixed with mortar (Fig. 1). The system was tested in a steel plant during a steel casting process. The ID and the temperature could be correctly evaluated during the entire casting process (Fig. 2).

Ad ii) A metallurgic vessel for molten metal consists of an outer steel shell and an inner refractory lining. The refractory castable is mixed with water and applied to the vessel inside wall, where the castable has to be dried before it gets in contact with the molten metal, to prevent dangerous steam explosions. The SAW sensor inside the lining monitors the temperature to ensure that the castable is dried out completely. The sensor signal is transmitted through the steel shell of the vessel via a robust cable link from the sensor head to the transponder antenna (Fig. 3). Because the metallurgic vessel is transported through the metal production plant the sensor unit has to be wireless. The sensor unit has been tested in a drying sequence of a castable refractory lining (Fig. 4).

Ad iii) Recycling processes of slag coming from the converter and stored in special slag ladles strongly depends on its quality. A correlation of the casting process and the slag ladle is recommended. For an automatic transport logistics a SAW tag is placed directly on the ladle. The tag has to withstand temperatures of up to 350°C and heavy mechanical shocks during emptying of the ladle. An exemplary system configuration is shown in Fig. 5 and 6. In spite of the metallic surrounding and coexisting WLAN a readout distance of 5 m has been achieved.

References

[1] L. Reindl, G. Scholl, T. Ostertag, A. Pohl, and R. Weigel, "Wireless Remote Identification and Sensing with SAW Devices," IEEE 1998 MMT/AP International Workshop on Commercial Radio Sensor and Communication Techniques, pp. 83-96, 1998.

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