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Cross-sectorial real-time sensing, advanced control and optimisation of batch processes saving energy and raw materials (RECOBA)

Start of the project: Jan 1st, 2015
Duration: 36 month

Pilot scale verification of AMLDS and selection of most suitable system

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Lead contractor for this deliverable: ELKEM

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Dissimination level

PU	public	☒
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CO	Confidential, only for members of the consortium (incl. the Commission Services)	☐

CONTENT

Pilot scale testing of radar as an automated metal level detection system (AMLDS)

1 Introduction

Real-time sensing to enable advanced control and optimise processes is a central part of the RECOBA project. Elkem is exploring the possibility of increased availability of sensor measurement in the ladle refining and casting process. The refining process is described in detail in RECOBA Deliverable 2.3.

The purpose of this document is to describe the pilot scale testing of a radar used for automated metal level detection. The benefit of having an online measurement of the ladle metal level is to enable remote monitoring of the tapping and refining process as well as to increase control of the process. Radar measuring offers a non-contact, direct observation of ladle metal level. It is also available in terms of compact, off-the-shelf equipment with a high degree of maturity.

Weight cells for indirect measurement of ladle metal level is a well-tested concept in Elkem. It is preferred to combine radar and weight measuring to allow for more flexibility, robustness and redundancy. The reason for selecting these two measuring methods for a pilot test is further described in RECOBA Deliverable 8.2.

2 Equipment information

2.1 Pilot plant

Bremanger furnace 2 (BRE2) is chosen as the pilot plant. This furnace already operates with weight measurement, which will give more redundancy to the radar test. The dust extraction system at BRE2, which is newly updated, might also give a more supportive environment for the radar. The alloy being produced in this furnace is a silicon alloy with about 25% iron, significantly more than what is described in D.2.3 but for the purpose of evaluation of sensor technology it is well within the scope of the project. Furthermore, this is the only Elkem furnace where ladle wagon load cells are installed.

2.2 Radar

The following issues have to be considered when choosing radar:

- Operating environment
- Cooling
- Mounting
- Logging of data
- Measuring range
- Accuracy
- Price

Several radar suppliers are contacted to find a suitable radar. However, as Elkem has a VEGAPULS 62 radar available in storage, this is chosen as the pilot. The VEGAPULS 62 radar has a measuring range up to 35 m and an accuracy of ± 2 mm. The maximum process temperature is 450 °C, while the maximum ambient temperature is 80 °C.

2.3 Casing/mounting

The radar is mounted in a metal casing. The bottom of the casing is covered with a glass plate, angled at 45° to minimise disturbance and reflection in the measurement. The casing is connected to an arm, which is fastened to the rod pushing machine and extended over the metal ladle.

The radar is continuously cooled with compressed air. The air hose and electrical cords run through the connecting arm, and are fitted with a fire sleeve where exposed.

The positioning of the radar above the ladle is shown in Figure 1.

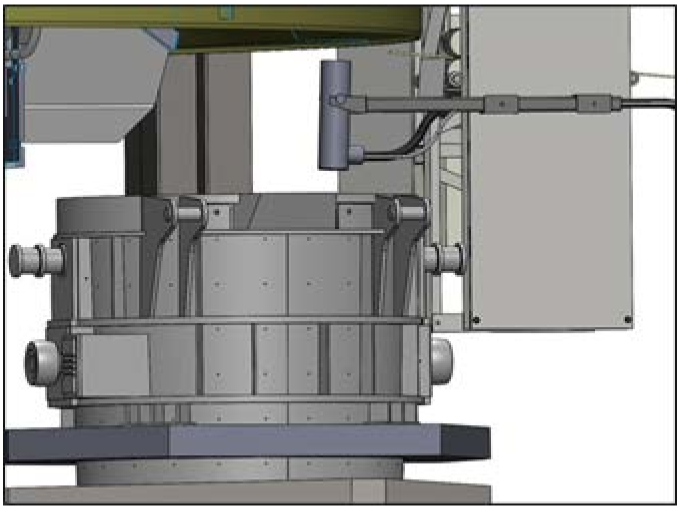

Figure 1 - Schematics of radar setup

2.4 Information logging

The radar is fitted with Bluetooth connection, enabling monitoring from any computer, smart phone or tablet. With the VEGA-DTM software and a Bluetooth USB adapter, it is also possible to do real time logging of the measuring information.

3 Test of radar

The main purpose of the test was to demonstrate that the combination of radar and load cells give precise information about the metal level in a ladle during tapping. Furthermore, the signals acquired by the sensor system should be registered automatically and allow future on-line processing of the information recorded. Since the test focus was on applicability, no significant effort was made to ensure robustness beyond what is required for a pilot-scale demonstration. This will eventually become a focus after the method itself has proven to be useful.

3.1 Results

Using known material properties of ferrosilicon as well as the ladle geometry, the metal level is calculated from the weight measurements and plotted with metal level from radar measurements in Figure 2.

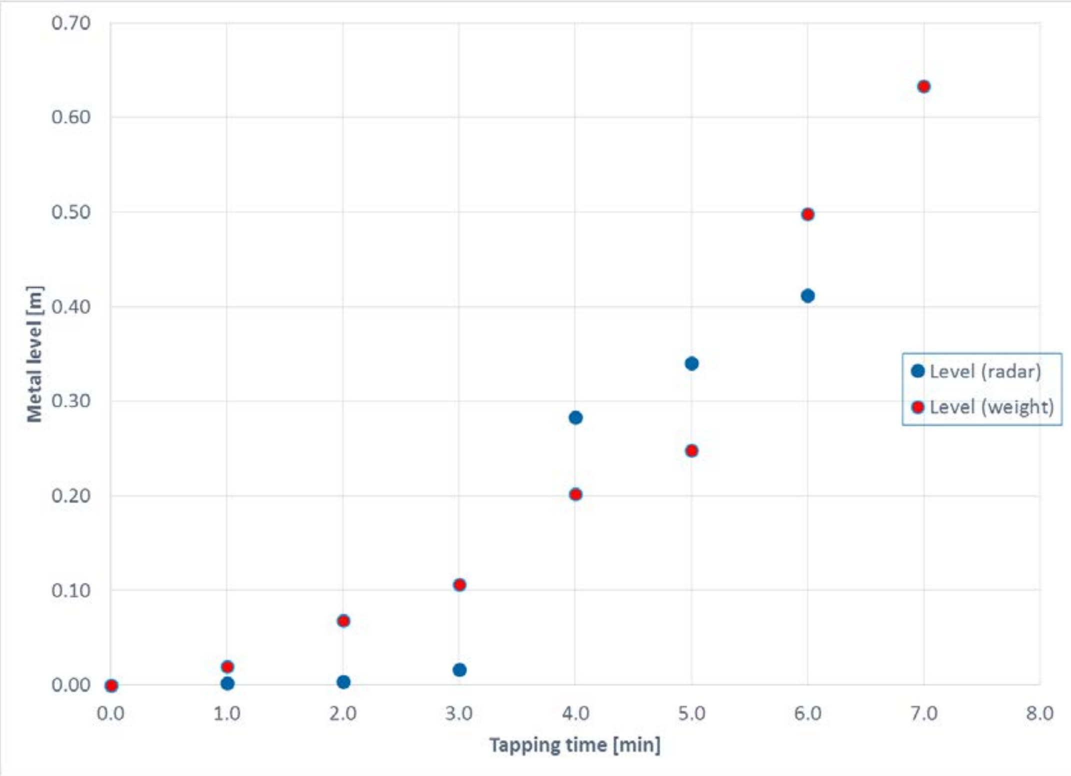

Figure 2 – Metal level in ladle from radar and weight measurements.

In the early stages of the tapping, the filter settings of the radar was too restrictive, causing an apparent low measured value for the metal level. The settings were changed after approximately 3 minutes, which resulted in a higher measured value more in sync with the weight measurement. It will be necessary to repeat the experiment to optimize radar filtering settings, but the initial result is promising. The weight measurements are stable and reliable, as can be seen from the entire time-weight curve in Figure 3.

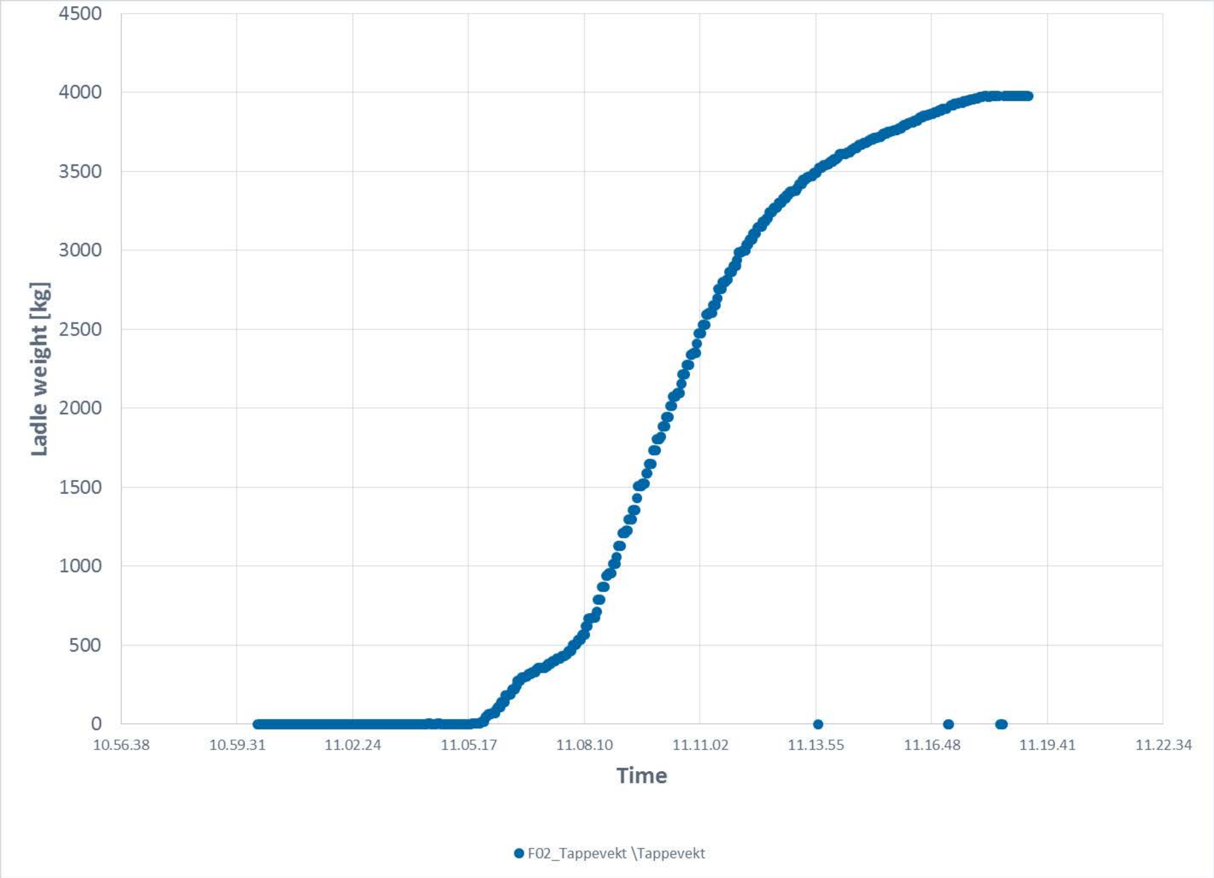

Figure 3 – Weight of ladle as measured during tapping.

4 Conclusion

The combination of radar measurements and weight measurements has been tested during tapping of FeSi75 into a ladle. This allows for a dynamic determination of the metal level in the ladle. The signals from the instruments were transferred by Bluetooth to a local computer, and can easily be made accessible to the main process control system for use in on-line models. Further testing is needed for optimization of the radar software filter.

5 Bibliography

Ref. no.	Title	Authors	Year
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[2]	RECOBA D3.1: Preliminary models for evaluation of sensor signals	Åslaug Grøvlen, Kjetil Hildal (Elkem), John Suberu, Andrew Flewitt, Alexei Lapkin (UCAM), Preet Joy, Johannes Knab, Adel Mhamdi, Alexander Mitsos (RWTH), H. Köchner (BFI)	2015
[3]	An automatic ladle level measurement system for monitoring ladle fill rate during tapping	A. Rödfalk, J.P. Nilsson, N. Brogden, P. Bloemer, A. Lyons, and O.J. Østensen	2014