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Knowledge about temperature development in gas stirred ladle treatment batch process

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

CONTENT

1 Monitoring of melt temperature evolution during gas stirred ladle treatment

1.1 Fibre optical measurements

In D3.7 a demonstrator for fibre optical measurements of the melt temperature was developed which was successfully applied also during vacuum degassing (D7.2). Here, the sensor was used to measure the melt temperature evolution in the ladle during Ar stirring at tkSE. It has been decided by the involved partners to perform the trials directly at the 265 t ladle rather than down scaling the stirring lance as originally envisaged, so the device was installed at the Ar stirring stand (**Figure 1**). A stirring lance was adapted to allow fibre feeding into the melt through the purging gas tubing (**figure 2**).

Figure 1: Photograph of the demonstrator for fibre optical temperature measurements installed at the Ar stirring stand of TKSE

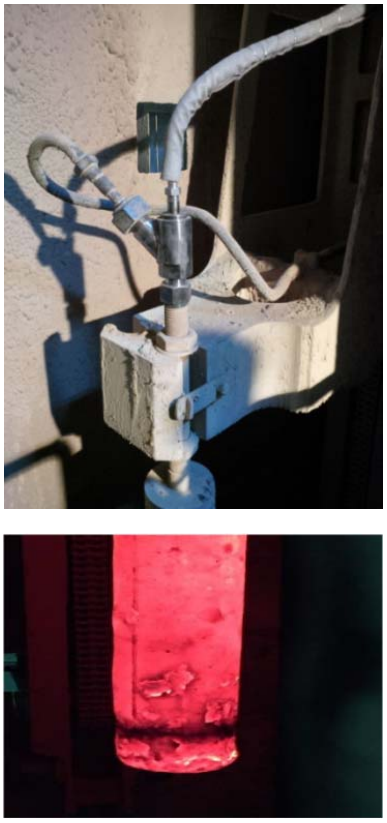

Figure 2: Photograph of a y-junction at the cold end of the stirring lance and the blowing nozzles at the hot end of the stirring lance

With the flexible tube connected directly to the lance, it was possible to perform a first continuous inline temperature measurement during the entire stirring process. The measurement results are plotted in **figure 3**. The overall temperature decrease can be observed together with some minor fluctuations in bath temperature.

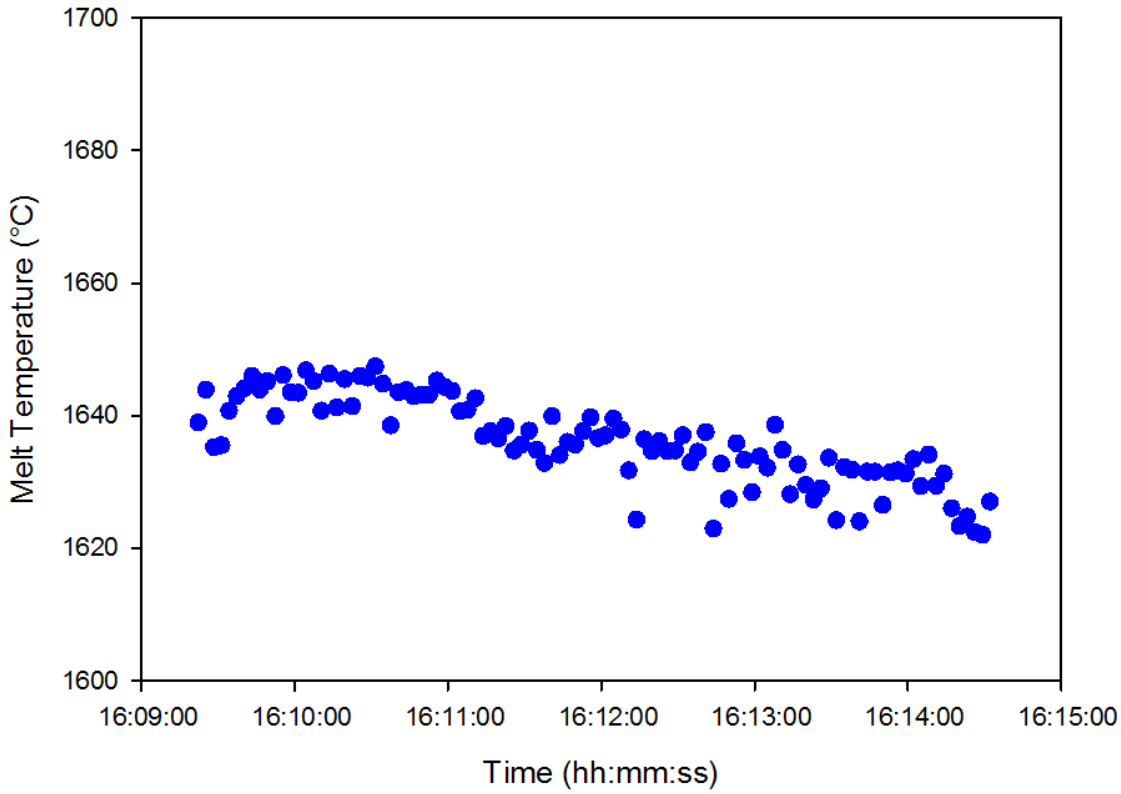

Figure 3: Liquid steel temperature evolution during gas stirring using the original stirring lance as measured by fibre optical system

1.2 Industrial trials

Using the fibre optical measurement technique, monitoring of the temperature evolution through the entire stirring process was realized. The stirring lance was adapted to allow temperature measurements independent on the gas stirring. Therefore the stirring lance was equipped with an additional steel capillary exclusively for fibre feeding.

Exemplarily, results of one measurement with 9 minutes duration are given in **figure 4**. Additionally three short term thermocouple measurements were performed. In total 12 measurements with a summed measurement duration of 73 minutes were performed. Thermocouple and fibre optical measurements are in excellent agreement.

The continuous measurements with high accuracy and dynamics allow for the first time to visualize the temperature evolution during the process. The effect of material additions is clearly visible by a rapid temperature decrease. The cooling effect and the homogenisation duration can be worked out. Also the temperature decrease during Ar stirring can be observed inline during the process. The width of the scattering band of about 10K allows to estimate the temperature fluctuations in the bath, which limits the accuracy of thermocouple measurements to 5K standard deviation.

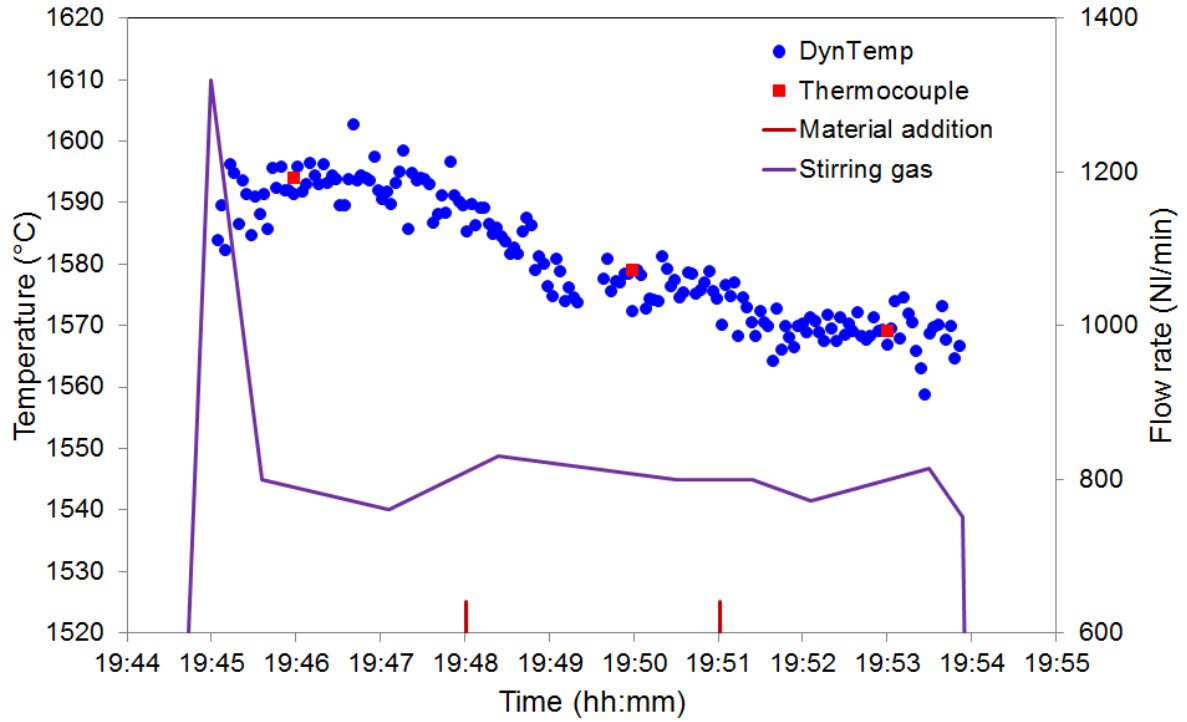

Figure 4: Liquid steel temperature evolution during gas stirring using an adapted stirring lance as measured by fibre optical and thermocouple measurements.

1.3 Conclusion

The fibre optical measurement was successfully applied at the Ar stirring stand of tkSE. Using an adapted stirring lance, the melt temperature evolution was continuously monitored during the entire gas stirring. Effects of stirring gas flow and material additions on the melt temperature can clearly be seen. Thus, the results of fibre optical measurement can also be used for tuning the parameters of dynamic process modelling to account for the temperature loss rate under varying process conditions like stirring gas flow rate, batch cover, and quality and mass of heat.