Patrick Mayne – Third Year EngD

Academic Supervisors – Professor Cameron Pleydell-Pearce

Professor Chenfeng Li

Industrial Supervisor – Matthew C Davies (Tata Steel UK)

Swansea University
Prifysgol Abertawe

Development of Refractory Systems to Support the Steelmaking Process

Project Aims - To support the steelmaking process through:

- Monitoring performance and behaviour of existing refractory linings.
- Optimise the refractory selection using computer modelling to maximise conservation of thermal energy within ladles and reheat furnaces.
- Validation of three-dimensional Finite Element Method (FEM) models of refractory lined assets via industrial trials.
- Trial and assess refractory lining materials where appropriate.
- Avoid temperature losses that can have a significant impact to the business in terms of process, quality and conversion costs.

Real time thermal monitoring of castable refractories: An industrial study

Weighing in at around eleven tonnes and with a diameter of five metres, refractory lined ladle lids are used to conserve the temperature of both the liquid steel and the ladle refractory lining during the steelmaking process (figure 1).

An industrial study was undertaken to monitor the temperature of the refractory linings used in ladle lids, where the refractories are exposed to the atmosphere and undergo repeated high temperature thermal cycling.

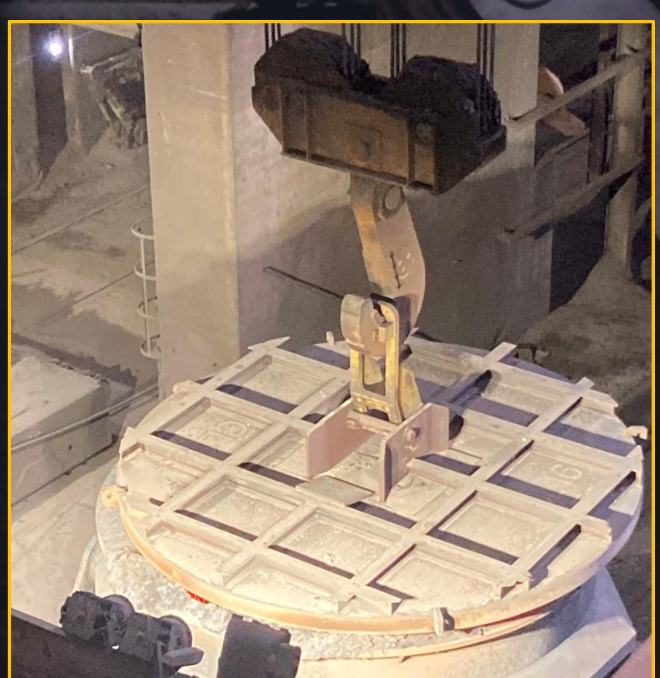

Figure 1, Left: A lid used in the steel plant to reduce heat loss from ladles.

Background Image: A ladle undergoes heating at a flare station using a specialised lid.

Thermal measurements of the refractories were taken using infra-red thermal imaging (figure 2) and installed thermocouples.

Long Range Radio Wireless Area Network (LoRaWAN) devices, encapsulated within high temperature insulation board (figure 3) were mounted on the lid and connected to the thermocouples to transmit the data.

These signals allowed for real time monitoring of the thermal data from any computer with an internet connection and running a suitable Python script (figure 4).

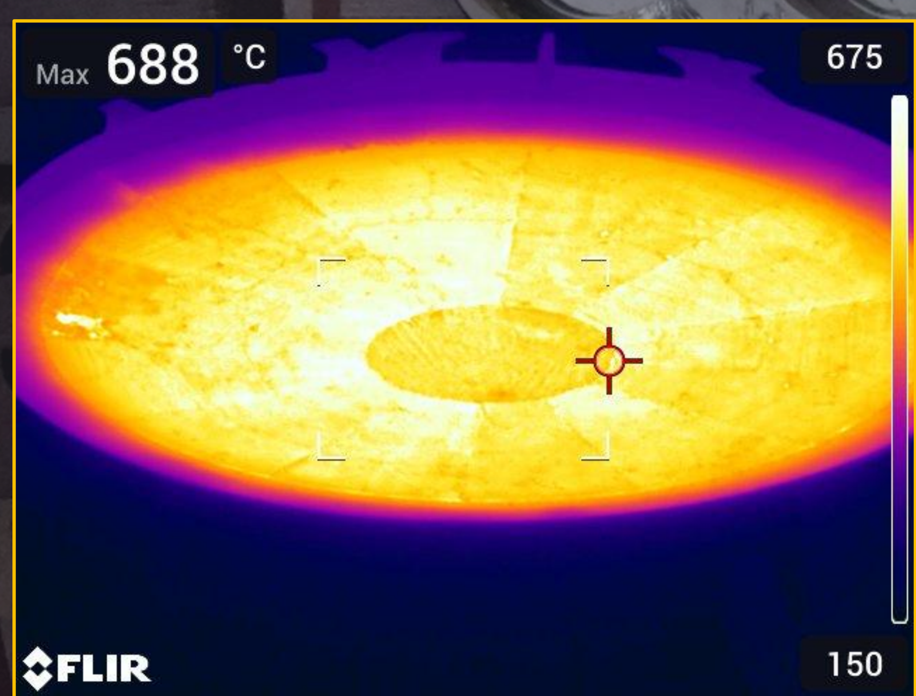

Figure 2: IR thermal imaging is used to measure the refractory hot face temperatures.

The collected data provides a recorded thermal history of the refractory lining, incorporating the rates of heating, cooling, and the peak recorded temperatures within the various parts of the lid (figure 5).

The data will allow for the assessment and validation of the developed FEM model (figure 6), improving the quality and accuracy of the output from the model.

Figure 3: Two LoRaWAN units are installed on a caster lid. Inset Image: A unit encased in insulation board.

Acknowledgments: Thanks to David Smart (Materials Processing Institute) and Colten Jones (Tata Steel) for their support on this project.

Figure 4: LoRaWAN gateway receiving signal data from lid transmitters. Inset Image: Initial data being received on a laptop.

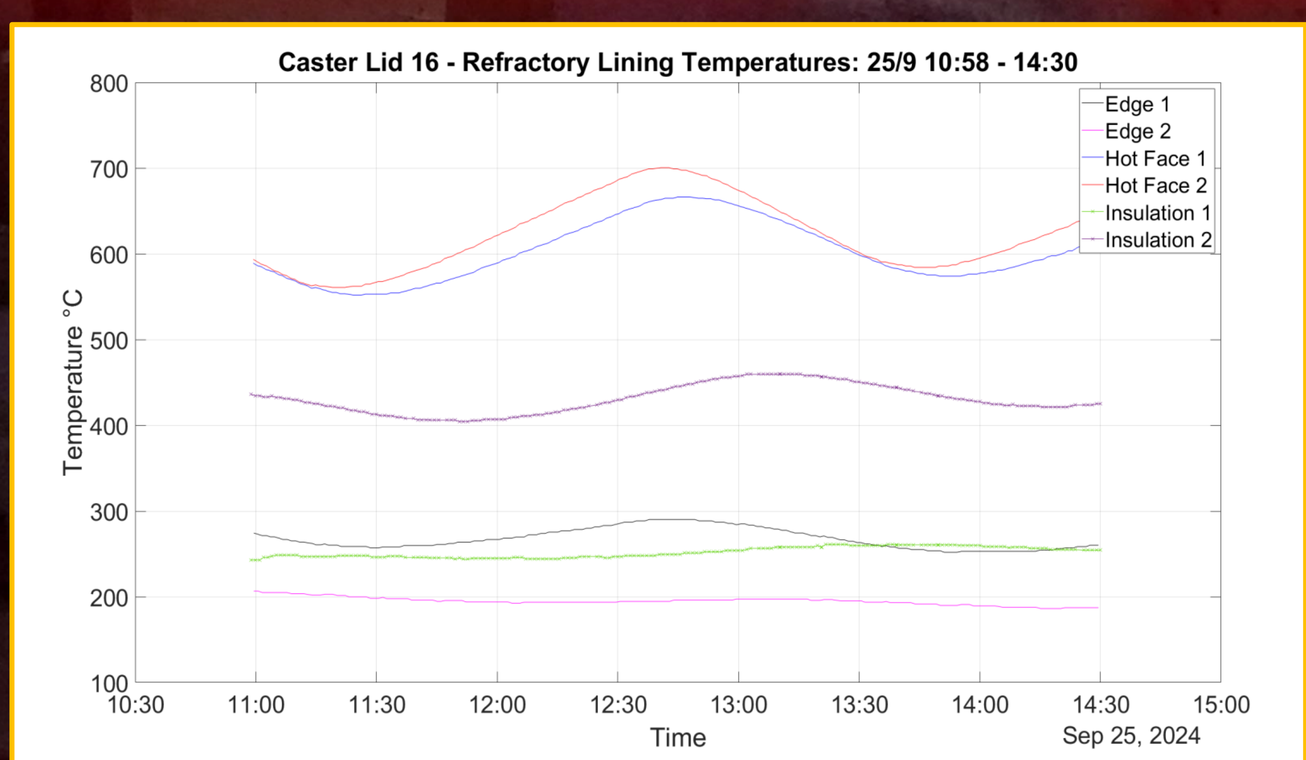

Figure 5: Temperature profiles of lid refractories plotted using thermocouple data.

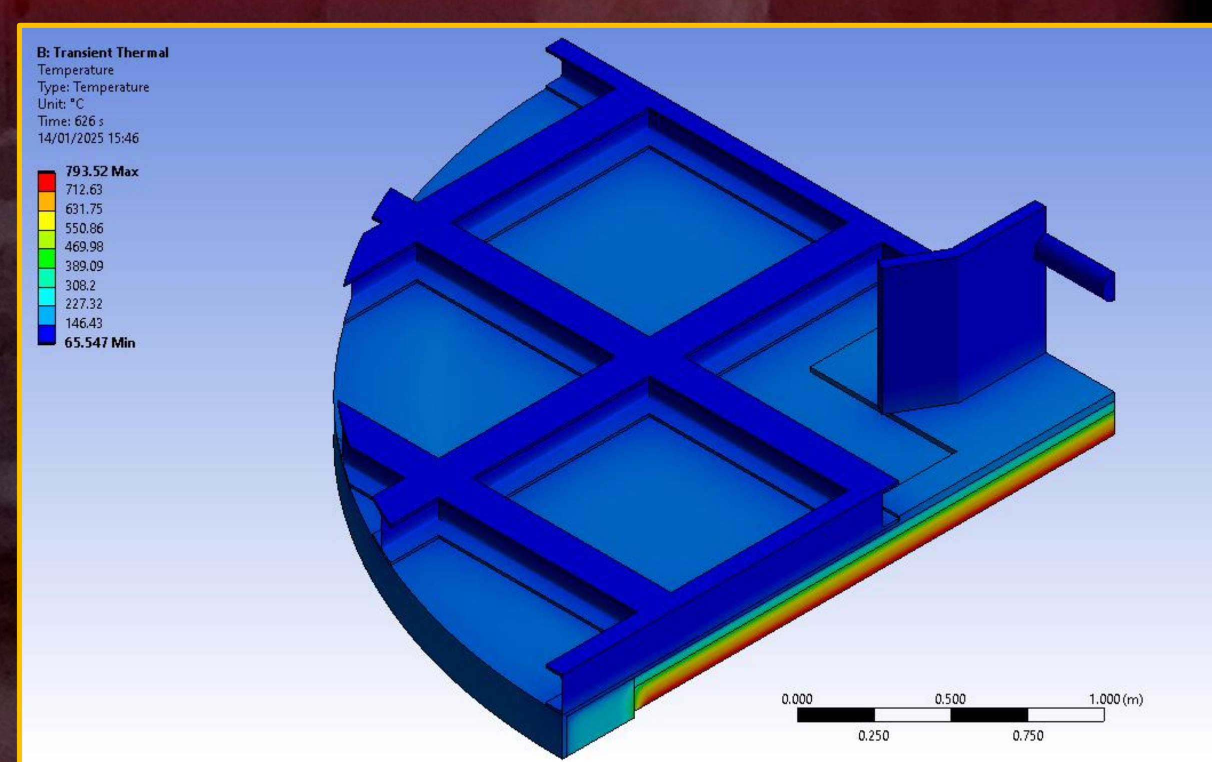

Figure 6: Transient thermal simulation of the refractory linings and structural steelwork of a caster lid as used at Port Talbot.

M2A COATED

UKRI Engineering and Physical Sciences Research Council

sustain future steel manufacturing research hub

TATA STEEL