Slab and Billet Reheat 'Thru-process' Temperature Profiling, the accurate Furnace Mathematical Model Validation Solution.

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In the steel reheat market mathematical modelling is crucially applied in furnace control systems. Such models allow accurate control of transient times and drop out temperature of steel slabs or billets during the pre-rolling, reheat operation. Critical to the success of such mathematical models is the availability of accurate actual product temperature profile data against which models can be validated or optimized.

The PhoenixTM 'thru-process' temperature profiling system has been designed specifically to allow comprehensive monitoring of the entire slab/billet through the entire furnace pre-heat and soak processes. Offering up to 20 thermocouple inputs using the PhoenixTM High temperaturePTM1-220-HT data logger(Figure 1) temperatures can be measured at the surface, centre and base of the product at various positions along its length.

The resulting temperature profile data (complete reheat process Figure 4)can be imported directly into the theoretical controller model to validate correct selection of process parameters and assumptions applied.

Passing through the reheat furnace reaching temperatures of up to 1300 °C / 2372 °F, for up to 8 hours, the data logger requires significant thermal protection. Such protection is provided by the specially designed TS07 thermal barrier range. Manufactured using graded insulation layers and an evaporative inner water tank, the phased evaporation of water maintains the logger temperature at a safe 100 °C/212 °F. The thermal barrier is placed on the slab/billet (Figure 2.2) or in circumstances where height clearance is an issue, located in a space machined out of the end of the test slab/billet, supported on hanger bars/plate welded to the slab.

Fig 1: PhoenixTM PTM1-220-HT data logger designed specifically for monitoring the most demanding of steel reheat processes. Providing up to 20 measurement channels with choice of type K or N thermocouple types with a data logger accuracy of +/- 0.3 °C.Designed to operate safely for extended periods at 100 °C / 212 °F.

Thermocouple Selection and Accuracy

For reheat processes typically mineral insulated (MI) thermocouples are chosen due to their robust operation above 1000 °C / 1832 °F. Generally, either Type K or Type N thermocouples are used but noble metal thermocouples (R & S) are also a possibility although

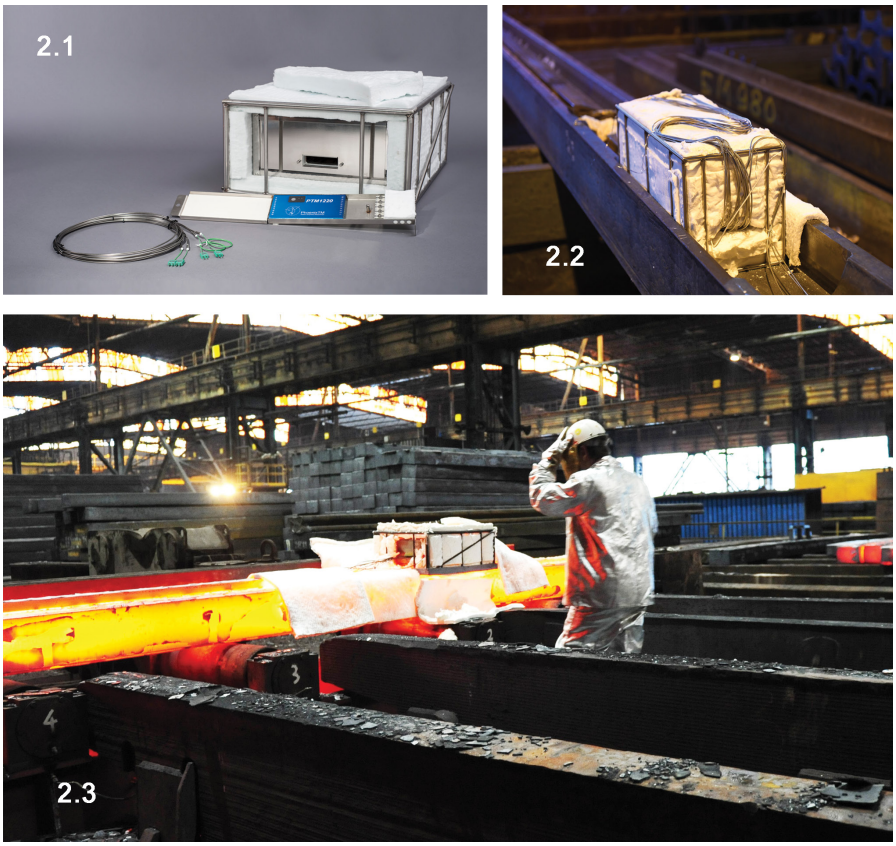

Fig 2: (2.1)PhoenixTM Profiling system showing typical thermal barrier design (thermal blanket insulated water tank) and data logger held in insertion tray. (2.2) System pre-run installed on steel blank. (2.3) System post reheat furnace. Thermal barrier (TS07-300-3 provides 3.2 hrs protection at 1300 °C / 2372 °F) loaded on cast steel beam blank reheated prior to rolling into structural metal work for buildings/skyscrapers. The PhoenixTM 1220 data logger at the core of the system stores data measured by the thermocouples inserted into the steel blank at varying depths along its length.

at a higher cost. Final selection is made considering accuracy and temperature range. Type N are more stable at high temperatures and therefore have better accuracy but have an upper limit of 1300 °C / 2372 °F. Type K in comparison has an upper limit of 1370 °C / 2498 °F. Having selected the thermocouple type the final choice is the diameter and length of the thermocouples to match the dimensions of the slab being monitored. Typically, 3 mm (0.12 inch) diameter MI probes are used to reduce the risk of break down of the magnesium oxide insulation and resulting risk of "shunt impedance" errors.

To maximize measurement accuracy in the slab process the PhoenixTM system offers the ability to apply both data logger and thermocouple correction factors to the temperature data automatically in the Thermal View operating software. These correction factors can be efficiently applied after creating correction factor files from the data logger (downloaded directly) and thermocouple calibration certificates.

Accurate probe positioning in slab/ billet

When considering measurement accuracy in a reheat application the choice of thermocouple, although important, is not the only consideration which needs to be made. Positioning of the thermocouple tip accurately at the slab depth required needs to be done with care. Drilling a 3 x 200 mm /0.12 x 8 inch hole to position the MI thermocouple is very difficult. To make this operation easier it is recommended that a 20 mm / 0.8 inch pilot hole is created which is then filled using steel bushes guiding the thermocouple tip to the required measurement point (See Figure 3).

Secure fixing of thermocouples over the slab

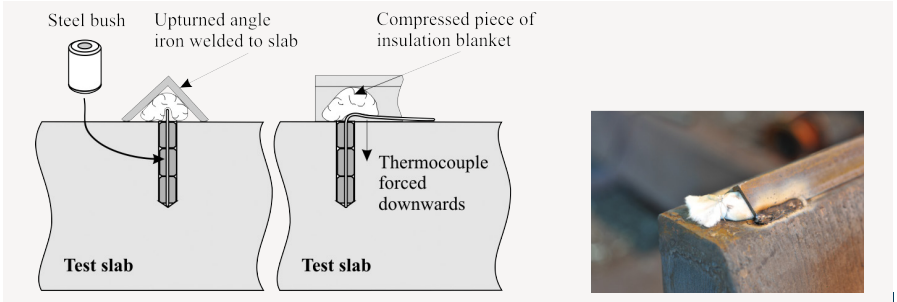

Fig 3: Thermocouple fixing methodology recommended to ensure that MI thermocouples measure accurately at the required depth in the slab/billet and secured in place during the profile run.

Mineral insulated thermocouples by their very construction have a residual springiness and therefore need to be held in contact with the slab being monitored to ensure that the measurement point of the thermocouple 'hot junction' remains in contact with the slab at the depth

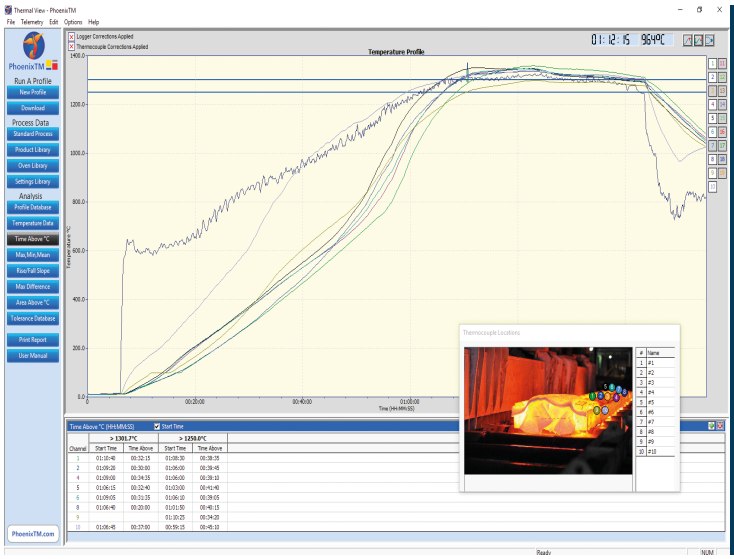

Fig 4: PhoenixTM Thermal View Plus Software showing a typical 'Thru-process' Slab/ billet temperature profile trace.The profile traces show the variation of temperature at different locations in the Slab/billet and also the furnace environmental temperature. Such data can be imported directly into a furnace controller model to allow optimization and validation.

required. It is recommended that they are held in position by packing insulating blanket beneath a piece of upturned angle iron and 'tack welding' this to the slab surface (See Figure 3). This action not only secures the thermocouple in place but can significantly reduce the risk of "shunt impedance" errors by reducing the temperature difference between the hot junction and thermocouple itself running through the furnace environment.

Applying 'thru-process' temperature data to validate mathematical models – the benefits

Applying accurate profile data to mathematical models, targeted roughing mill exit temperatures can be set to obtain a desired furnace drop out temperature throughout the product thickness. Accurate control of such variables allows a successful rolling operation with minimal scale build up maximizing mill yields, saving energy and maximizing production throughput. By accurate optimization and reduction of the furnace operating temperature, the furnace life can be extended. At the same time under temperature products can be prevented further protecting down-stream processing machinery.

Overview

The PhoenixTM 'Thru-process'Slab/ Billet reheat system offers an accurate, rugged and reliable solution for performing product temperature profiling of Slab/Billet reheat processes,providing the means to Understand, Control, Optimize and Certify the furnace and allow accurate optimization of mathematical models applied.