Application of steel slag as sensible thermal energy storage for continuous operation of a waste heat energy reuse plant

Jaime Lozano-Carmona[1], Peru Arribalzaga[1], Íñigo Ortega-Fernández[2] and Daniel Bielsa[1]

[1]*Centre for Cooperative Research on Alternative Energies (CIC energiGUNE), Basque Research and Technology Alliance (BRTA), Alava Technology Park, Albert Einstein 48, 01510, Vitoria-Gasteiz, Spain*

[2]*Transición Energética, Climática y Urbana, Tecnalia, Basque Research and Technology Alliance (BRTA), Gipuzkoa Technology Park, Mikeletegi Pasealekua, 2, 20009 Donostia- San Sebastián, Spain.*

This study analyses the real behaviour of steel slag, a low-cost by-product of electric arc furnaces (EAFs) as thermal energy storage (TES) material, within a waste heat recovery and reuse real industrial environment. Under the scope of LIFE HI4S project [1], a dynamic model of the application has been developed to analyse and optimize the TES system. Solid steel slag particles, in the centimetre range, is used in a 3 m^3 packed bed configuration. Packed bed TES systems have gained significant attention of the research community due to the notable prize increase of fossil fuels.

The thermal properties of steel slag heavily rely on the specific source and process of its origin [2]. This research contributes to the understanding and optimization of steel slag as a viable packed bed TES filler material, considering its interaction, with a given heat source and heat sink. The steel slag used in this project comes from the steelworks of Arcelor Mittal in Sestao (Spain). Figure 1**: thermal properties of the slag. Thermal conductivity (left), specific heat (right)** illustrates the thermal characteristics of the steel slag. These properties and the performance will be assessed, in a waste heat recovery application of the off gas generated in the EAF

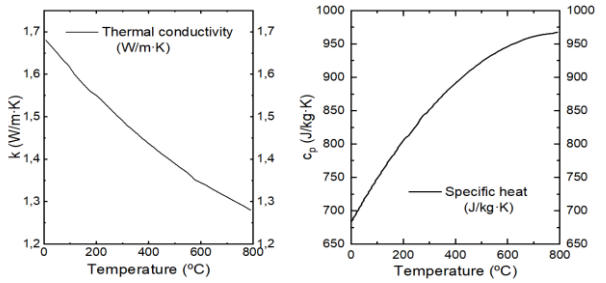

Figure 1: thermal properties of the slag. Thermal conductivity (left), specific heat (right)

in this same plant.

As important as the heat recovery is the applicability of the recovered heat. A potential application, addressed in the European-funded project LIFE HI4S [1], is to valorise the captured heat to simultaneously produce a clean heat source to preheat steel scrap and electricity through a low temperature organic Rankin cycle (ORC). To do so, a pilot plant has been designed and is under construction in the aforementioned steelworks.To cope with the intermittency of the gas stream in terms of temperature and availability (EAF is a batch process), the steel slag-based TES is proposed to keep providing energy during low temperature periods or even under periods with lack of heat source. The operation temperature range is considered between 385 and 400ºC, the limit temperature of the high temperature filtering system.

To design the pilot plant and to scale up the technology a dynamic model has been developed on the software TRNSYS, employing predefined and specific validated subroutines for the packed bed and the scrap pre-heating system. The model allows the simulation of the thermodynamical behaviour of the preheating scrap on a dynamic environment. To assess the benefits of the steel slag packed bed TES, simulations has been performed with and without TES. The results of energy and inlet temperature to the preheating are shown in Figure 2.

The results show how the plant is able to get a continuous heat supply at around 400ºC to the scrap during the whole casting, even when the off gases are under 385ºC, thanks to the TES, increasing the total energy reused in 30 kWh per casting.

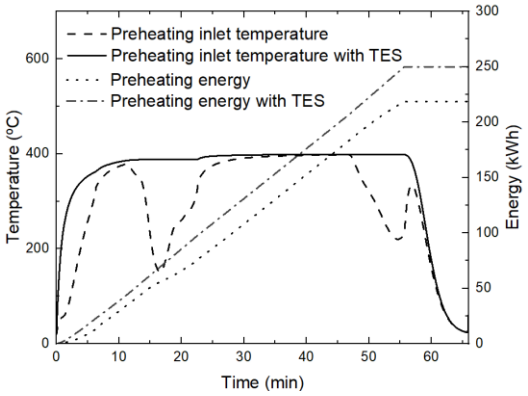

Figure 2: Preheating inlet temperature and reused energy, both with and without TES

References

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Mechanical and industrial design engineer by the University of Málaga. Studied a research focused Master in Aero-hydrodynamics in the University of Málaga and Granada. Project Engineer in the Systems Engineering and Technology Transfer department at CIC energiGUNE. Performs thermal studies, with Computational Fluid Dynamics (CFD) and 1D tools, in topics such as energy recovery systems, battery thermal management and thermal energy storage.

Presenting author: Jaime Lozano Carmona, e-mail:jlozano@cicenergigune.com tel: +34 653345133