Heat recovery potential in reheating furnaces

Reheating furnaces are used extensively in steel making to bring a feedstock up to temperature before mechanically forming it to a specified profile. The temperature in the furnace is usually maintained at 1100-1300 °C, depending on process requirements. Between 10 and 17% of the primary energy input to the reheating furnace is lost to cooling water in the skid pipes, that support the feedstock within the furnace.

Skid pipe cooling is typically performed using water from a cooling tower. The temperature of this cooling water is usually not a matter of active choice but decided instead by the cooling tower specification and is typically in the range of 10-40 °C.

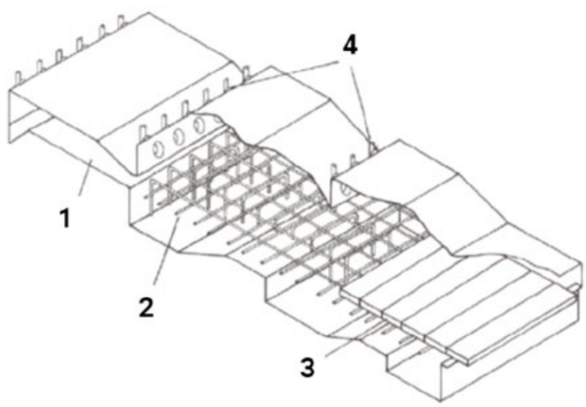

Figure 2 - sketch of reheating furnace showing: (1) Soak zone. (2) cooled skid system (3) stock (4) burners

Table 1 highlights the potential for heat recovery from a walking beam furnace. Nominally, a reheating furnace with a material throughput of 150 ton/h loses between 5 and 11 MW of the primary energy input to skid pipe cooling, depending on the state of the refractory lining.

Energy balance for a reheating furnace	Energy MW	%
Required burner power	51.5-63	100
Energy transferred to steel	37	59-72
Losses to skid system	**5-11**	**10-17**
Losses in off-gas stream	7.5-12	14-21
Other losses	2	4

Table 1 - Energy balance for a reheating furnace

Power production from hot water

The rejection of high temperature heat to low temperature cooling water represents a lost opportunity to recover high quality energy. Little to no focus has been placed on this area, primarily because of a lack of commercially viable low temperature energy conversion technologies.

Traditionally, waste heat recovery solutions require temperatures between 150 °C and 600 °C with technologies such as steam turbines and high temperature ORC (organic rankine cycle) systems to generate electrical power. However, recent developments have lead to the commercialization of conversion technologies that can operate at lower temperatures, down to 70 °C.

The biggest challenge while working with temperatures below 100°C is the low quality of energy within this temperature range, dictating that the process must be extremely efficient with little to no losses to facilitate profitable conversion.

Often, the parasitic load associated with the generation of power from low temperature heat makes this an economically unfeasible option. Climeon’s Heat Power technology has been designed to maintain a low parasitic load while ensuring minimal losses through all stages of generation, resulting in a highly efficient system with twice the efficiency of conventional low temperature ORC systems.

Heat recovery integration

When liquid water is used in the skid pipe cooling loop, the requirement is that it should remain in liquid phase at all times. Figure 3 shows a typical cooling arrangement . Heat accumulated in the skid pipes is rejected to a cooling circuit that is often separated from the cooling loop of the furnace using a heat exchanger. The temperature in the reheating furnace is between 1100 and 1300 °C while that of the cooling water is typically under 50 °C. This represents a significant wastage of high grade heat to the surroundings.

Table 2 shows the impact on the cooling flow when increasing the temperature in the secondary loop. It is evident that the that there is no change in the cooling flow requirement when increasing the cooling temperature from 20 to 100 °C. This is because liquid water has essentially the same capacity to cool, regardless if the temperature is as low as 10 °C or as high as 100°C. If the temperature of water can be increased to over 70 °C, the water leaving the heat exchanger will be sufficiently hot for power generation.

This can be achieved with minor modifications to the skid cooling circuit, as illustrated in figure 3:

Step 1: Water in the secondary loop is circulated through the Climeon Heat Power system while the system is not operating (“off” mode). As no heat is extracted from the secondary loop at this stage, the temperature of the water flowing through the secondary loop increases.

Step 2: When the temperature of water leaving the heat exchanger is sufficiently high, the heat power system is automatically started. Heat is extracted by the system, which cools the water in the secondary loop. A part of the extracted energy is converted to power, while the rest is rejected to the existing cooling tower. Nominally, 10 % of the wasted heat can be converted into useful electricity. This implies that the cooling requirement of the reheating furnace is reduced by 10 % which brings additional cost benefits to the steel manufacturer.

	Heat rate	Electricity produced	Temperature in second loop		Specific heat capacity	Cooling flow
			In	Out		
	[MW]	kW]	[°C]	[°C]	[kj/kgK]	[kg/s]
Initial	9	0	20	30	4.19	215
Raised	9	0	90	100	4.21	215
With WHR	9	900	90	100	4.21	192

Table 2 - Effect of waste heat recovery integration

Climeon Heat Power

Climeon’s innovative Heat Power technology converts the thermal energy contained in hot water between 70 to 120 °C to electricity. The unique design operates at low pressure and can be expanded modularly to the required capacity. This modularity ensures high performance even when the heat availability varies as a result of varying production rates, making it perfectly adapted to installation in the steel industry.

When working with fluctuating heat sources, Climeon’s adaptive control system automatically synchronises system behaviour to match the available heat. Further, the machine is fully automated and requires minimal human intervention to run.

Remote monitoring and preemptive maintenance are key features that ensure a stable and reliable production.

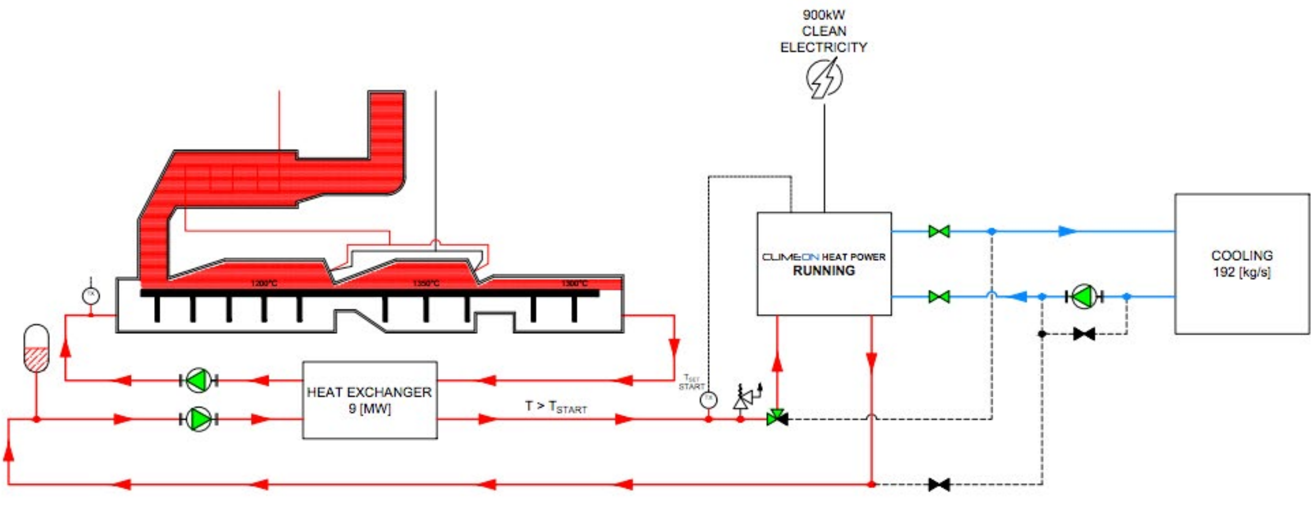

Figure 3 - schematic sketch of heat recovery process

Proven in field

At the SSAB hot rolling mill in Börlänge, Sweden, heat is recovered from the skid cooling system of the reheating furnace to supply heat to internal consumers and district heating to the city of Borlänge. The excess heat available is used to produce electricity. The installation of the Climeon Heat Power system was initiated in the spring of 2015 with a 100 kW pilot. Following the successful pilot, an additional module was commissioned at the site in 2016.

Dr. Rakshith Sachitanand
Head of Sales,
Industrial heat recovery
Climeon AB
rakshith.sachitanand@climeon.com

Daniel Eriksson
Technical sales engineer
Climeon AB
daniel.eriksson@climeon.com

Denise Conway
Head of Sales - Power
Climeon AB
denise.conway@climeon.com