Energy recovery from steel reheating furnaces

Saving energy in a steelworks is both cost-effective and environmentally friendly. CMI designs and builds reheating furnace energy recovery systems which convert 'waste' heat into steam for re-use, providing up to 35% of a typical steelworks steam requirement.

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Well known as high energy 'consumers', reheating furnaces can become energy sources by recovering the heat generated during the process. Such energy recovery systems are increasingly included in newbuilds, but they can also be retrofitted to existing furnaces. The energy is usually recovered as steam which can be used elsewhere in the steelworks, however, if desired, the steam can be converted to power.

WATER/ STEAM PHYSICS

Water and steam can coexist at any pressure at the appropriate saturation temperature. Steam at a temperature above the saturation condition is known as superheated steam, and water at a temperature below the saturation temperature is called sub-saturated water.

At atmospheric pressure the saturation temperature of the water is 100°C. However, if the pressure is increased, this allows the addition of more heat per unit volume and an increase of temperature without a change of phase. Therefore, increasing the pressure effectively increases both the enthalpy of water and the saturation temperature, thus saturated steam is a high energy medium that can be used in other parts of a steelworks. There are two main ways to recover waste energy as steam: via a waste heat recovery boiler and via an evaporative recovery system. These will now be described.

WASTE HEAT RECOVERY BOILER (WHRB)

Modern reheat furnaces use a heat exchanger to use heat from the hot waste gases to preheat the combustion air. Since the waste gases exit the main heat exchanger at around 400°C, one way to recover this remaining heat of the waste gases is to install a WHRB in-line towards the stack as illustrated in *Figure 1*.

The hot wastes and cold water have a crossed circuit as follows: Hot wastes heat the overheated water in the super heater and generate steam. The remaining heat arrives in the evaporator where warm water arrives from the economiser where the cold water feed absorbs the remaining heat.

Figure 2 shows the water circuit and the way its steam is generated.

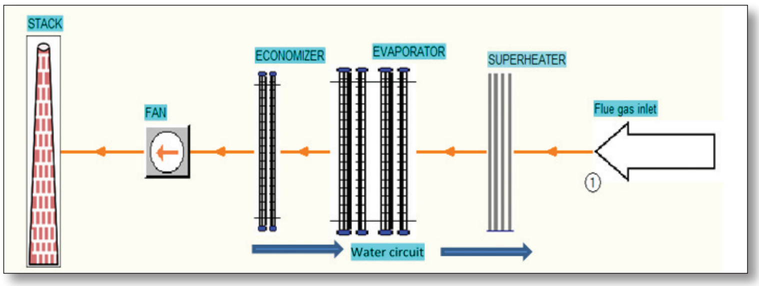

Fig 1 **Hot wastes circuit and cold water circuit**

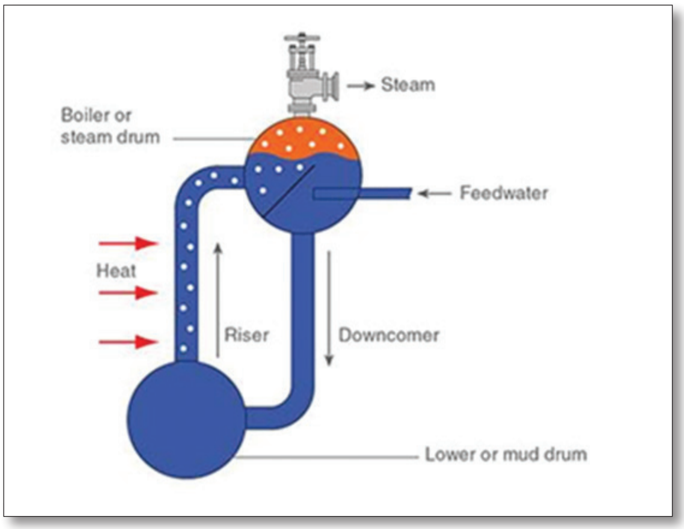

Fig 2 **WHRB principle**

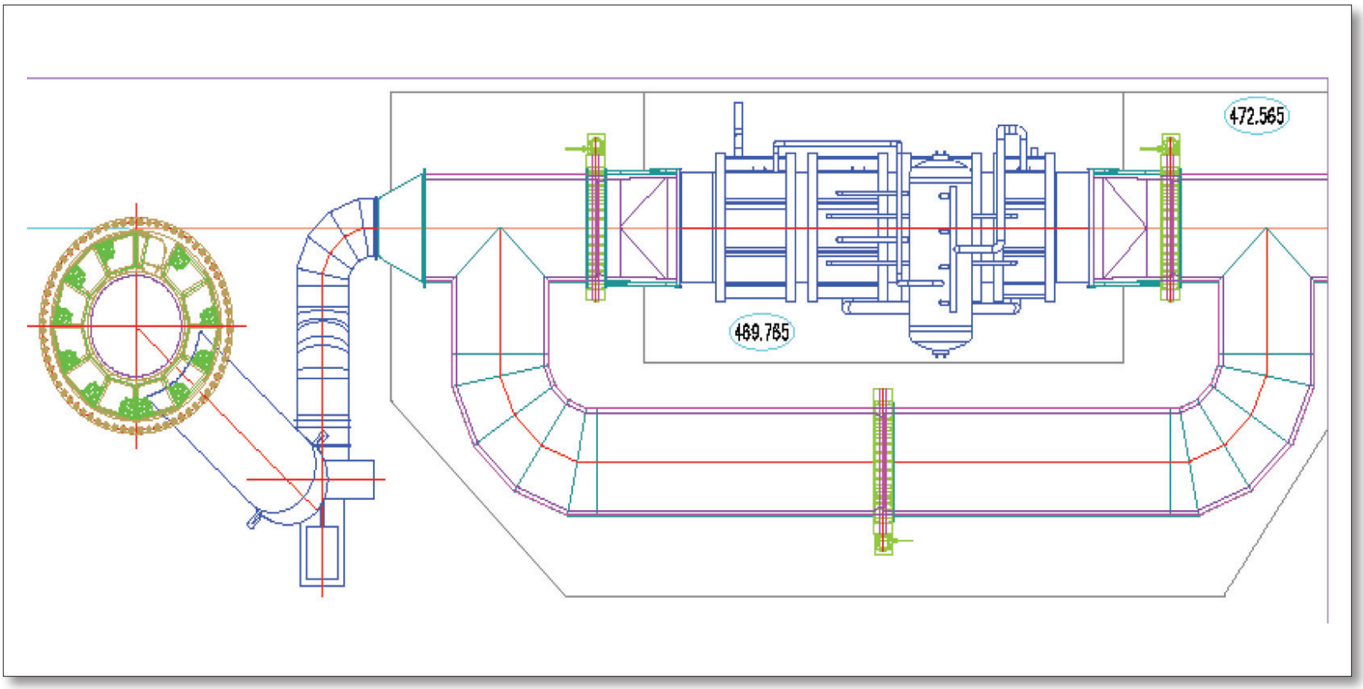

Fig 3 **WHRB with bypass**

Cold water is fed in on the right side and it descends through gravity towards the mud drum where it leaves any solids as sediment. Once heated, the density of the water diminishes and it rises towards the steam drum where it is overheated.

The main issues are that the pressure regulation of the furnace can be affected if the draft of the chimney is not well maintained, and that accessibility of the WHRB for maintenance can only occur during furnace stoppages. A draft drop at the chimney is very unlikely with the CMI approach and, in addition, an exhauster is installed to recover any draft drop and maintain the appropriate pressure in the furnace. Some customers prefer to have full access at any time to the WHRB without stopping the furnace. In this case, if the length of an existing waste gas tunnel to the stack or specific layout allows, a bypass can be considered. *Figure 3* shows an engineering drawing of such a system with the WHRB in blue at the top and the bypass line below.

EVAPORATIVE COOLING SYSTEM

The second approach to extract even more waste heat is to install an evaporative cooling system (ECS) for the skids and posts of the walking beam section of the furnace. Cooling of the skids and posts can be achieved either by the classical solution of circulating cold water in a closed loop in the tubes of the skids and posts or by an ECS that circulates a water/steam mixture at 105°C which is then heated to about 200°C through heat exchange between the furnace atmosphere and the skids and posts. The pressure under which the water/steam mixture circulates is around 15 bar(g) in order to allow the oversaturation.

The overheated water/steam mixture travels to a steam drum where the steam is separated from the water, which is re-sent to the system. Most of the steam is sent to the plant grid at a pressure required by the customer, and the remainder is used to preheat the completion water back to 105°C and hence back to the skids and posts. The water volume is permanently completed from a chemically treated water supply system.

As there is continuous contact between high temperature water and steel pipes, the quality of the water has to be thoroughly controlled and maintained so, before reaching the skids and posts, the preheated water is chemically treated and de-aerated through special equipment. The overall water flow system is illustrated in *Figure 4*.

As the system has to be especially watertight, a special design of swivel joints was conceived to follow the movement of the mobile skids and link the fixed and mobile skids in order to assure the continuity of the circuit. These swivel joints were developed by CMI through inhouse studies and are shown in *Figure 5*.

Since it works with high temperature saturated water, ECS has the additional benefit in producing lighter skid marks on the steel being heated. It is essential to well

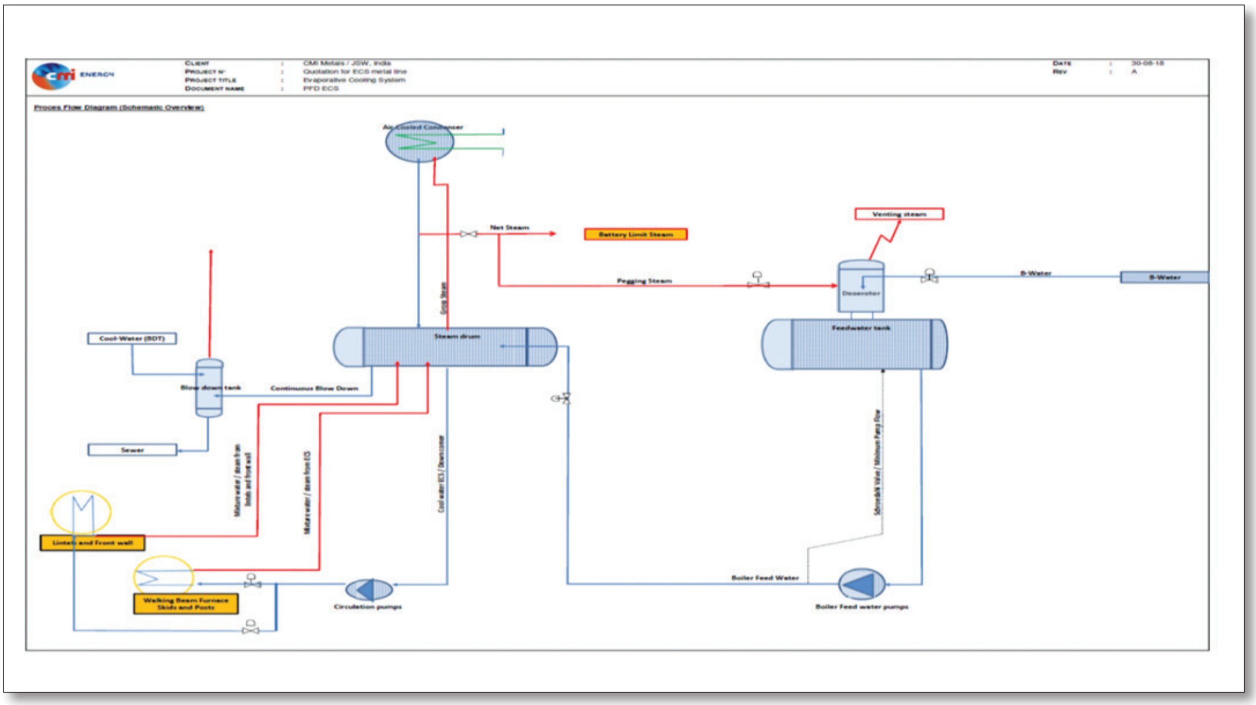

Fig 4 **Water/steam system for ECS**

maintain the refractory lining on the skids and posts in order to avoid the exposure of the metallic structure to the high furnace temperatures which may result in water leaks.

Since both WHRB and ECS systems need water at high temperature, they can be linked in order to provide only one source of steam to the plant network. As an example, for a 350t/hr capacity reheating furnace, a mixed heat recovery system (WHRB + ECS) can supply 31t/hr of steam at 20 bar(g) for 100% refractory lining of the skids and posts.

A complete energy recovery system from reheating furnaces can provide as much as 30-35% of the steam needed at a steelworks.

INDUSTRIAL APPLICATIONS

Despite general historical reservations against steam generation in reheating furnaces due to apparent non-reliability, the concept has already been installed at a number of our customers' works, and in all cases the feedback was positive. Such projects have been installed at AM Eisenhuttenstadt (WHRB) and AM Gent (ECS). A combined WHRB and ECS is planned for JSW Bellary India for three reheating furnaces. **MS**

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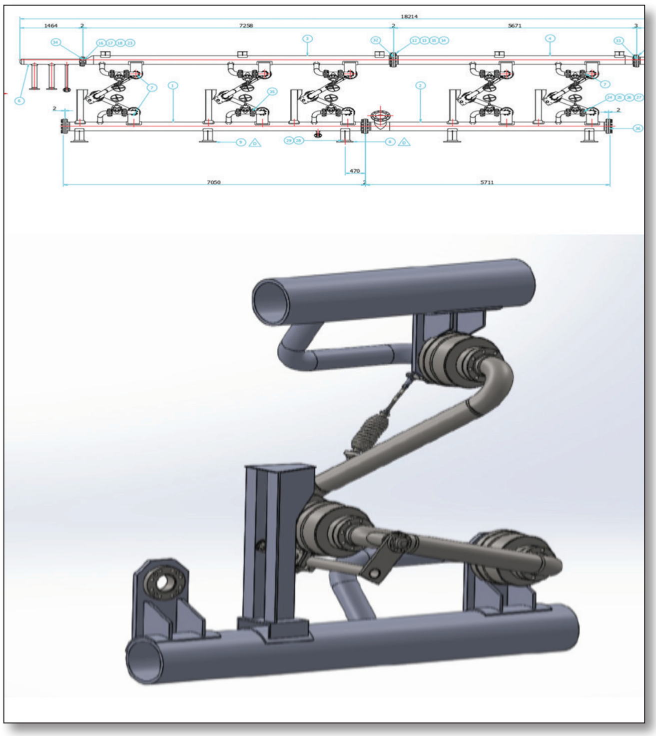

Fig 5 **Walking beam swivel joints**