Consteel continuous scrap feeding and iRecovery

Ori Martin has completed the revamping and modernisation of its Bressica Consteel EAF – the first such unit in Europe. The project scope included design advancements to improve operational efficiency and the installation of a heat recovery system on the primary off-gas line. This latter system is used to recover thermal energy in the gas for the production of steam used for district heating and to feed an ORC (Organic Rankine Cycle) turbo-generator to produce electrical energy.

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With the aim of increasing meltshop flexibility and reducing steel production cost, Ori Martin has successfully revamped and recommissioned its steel plant at Bressica, Italy, the site of the first European Consteel EAF unit, together with the installation of a heat recovery system on the primary off-gas line. The installation of the latest Tenova technologies has significantly improved the Consteel EAF performance and, thanks to the new iRecovery system, a significant amount of thermal energy is now recovered and delivered to the city of Brescia's district heating grid during the winter months or fed to an ORC (Organic Rankine Cycle) turbo-generator to produce electric energy for Ori Martin's internal use in the summer. The new installation has provided Ori Martin with one of the most environmentally friendly and energy efficient steelmaking plants in the world (*see Figure 1*).

Fig 1 The new revamped Consteel, connecting car side

THE NEW CONSTEEL PLANT

Following evaluation of operating results of the original plant configuration and the numerous tests carried out jointly by Ori Martin, backed by Tenova Engineering and Process departments, a number of goals were identified, including improving energy efficiency utilisation, environmental performance, product quality and plant flexibility, while keeping production focused on special steel grades.

The project was based on the following fundamental concepts:

- Rebalance the two main components of the melting unit (Consteel and EAF) to efficiently achieve the productivity goals
- Improve the thermal exchange between the EAF off-gas and the scrap in the different charging conditions (greater exposed surface and lower height of the scrap layer)
- Improve the distribution of scrap entering the liquid steel bath (larger surface area where scrap falls in the steel bath) to speed up the melting with a lower interference with the steel bath stirring
- Keep the connecting car pan inserted inside the EAF for any furnace tilting angle, so as to have the metallic scrap charging and the electrical power-on to the EAF electrodes starting together with minimal delays
- Reduce ambient air suction inside the Consteel and the primary off-gas line by increasing the efficiency of the Consteel seals and by better control of ambient air intake through the dynamic seal
- Maintain high temperatures of the EAF off-gas
- Reduce off-gas flow rate in the primary off-gas line and consequently reduce the electric consumption to the fume treatment plant
- Improve the conditions of the off-gas at the inlet of the heat recovery system installed on the primary off-gas line.

Process control is via a completely new and innovative system for supervision and control that is able to interact consistently with management systems of the other production units. This type of system is part of the global solution iSteel, developed by Tenova for the continuous ▷

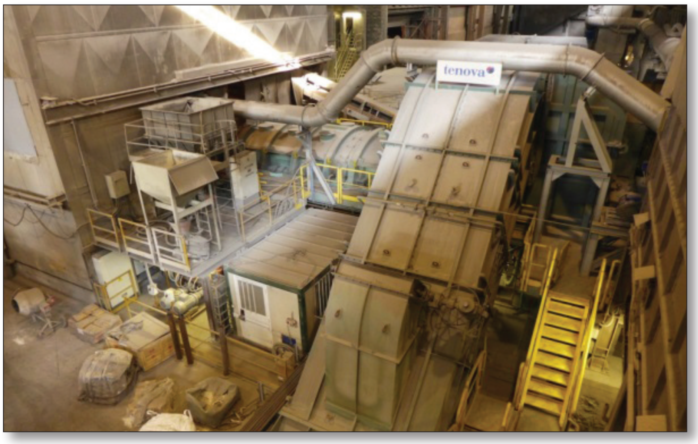

Fig 2 **The new revamped Consteel, off-take hood side**

Fig 3 **The new iRecovery system**

technological improvement of the steel production cycle. The automatic control of spillage TAT (Tenova Auto Tapping) has been implemented to control slag flow through the EAF eccentric bottom tapping (EBT) into the ladle and to minimise human intervention during this operation.

The melting process at Ori Martin is rather atypical when compared with the other Consteel EAFs as it employs only limited oxygen and carbon injection, leading to a modest quantity of energy in the off-gases. The main goal of the revamping project, therefore, was to maximise the recovery of the off-gas energy by improving the heat transfer to the scrap in the heating tunnel and by optimising the conditions of the gases at the tunnel's exit to properly feed the downstream recovery system.

The transfer of heat to the scrap is improved by increasing the scrap exposed surface through the installation of the widest possible conveyor (2,400mm) compatible with the existing EAF geometry. At the same time, the new Consteel drive allows the conveying speed to increase by 2m/min. These changes result in a reduction of the average scrap height from 800mm to 500mm, which boosts the average scrap charging temperature at the EAF.

The heating tunnel hoods have been completely redesigned, applying the results of a computer fluid dynamics (CFD) analysis on actual off-gas flow data. The aspect ratio of the hoods has been changed – they are wider and lower, while the overall section has been reduced by about 20%.

The efficiency of the energy recovery, both in the Consteel tunnel and in the downstream iRecovery, improves dramatically with increasing temperature of the gases.

Additionally, a completely redesigned set of seals has been employed to reduce air ingress to a minimum. The sealing chamber at the open end of the conveyor (a dynamic seal) has been reconfigured to achieve this result. To seal the gap between the heating tunnel and the EAF shell, a new circular flange, divided into two independent sectors, has been installed. The position of the upper flange can be regulated to adjust the quantity of post-combustion air to assure the complete combustion of CO and H_2 generated in the EAF. Both flange sections are retractable to give the necessary clearance for the shell changeover between campaigns. The improvement of the seals and the changes in the design of the dynamic seal allows significantly higher fume temperatures than the ones observed before, both inside the tunnel and at the tunnel's exit.

To reduce the dust load in the fumes sent to the waste heat boiler and improve the deposition of the metallic dust particles on the scrap layer, the offtake hood has also been redesigned, increasing both the horizontal section and the height to reduce the vertical speed of the fumes and increase their residence time (*see Figure 2*). The EAF

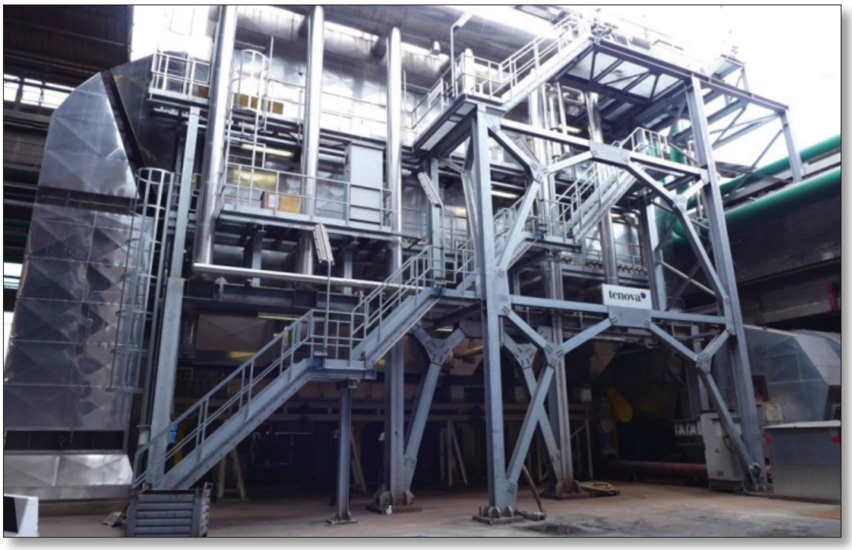

Fig 4 **The new iRecovery system, heat recovery section**

platform cradles were replaced to match the EAF tilting axis and the flange axis, and the connecting car was also improved so that it can be left inserted throughout the whole process, eliminating process delays.

iRECOVERY

The heat recovery system, iRecovery (*Figure 3*), has been running successfully since early 2016. This system, installed downstream of the new furnace, has the task of recovering part of the energy contained in the fumes generated during the EAF production cycle. The energy extracted from the fumes converts the recirculation cooling circuit water into steam. This is made possible thanks to the use of cooling water at boiling conditions that, by circulating and absorbing energy, will be subject to partial phase change generating saturated steam.

During winter months the steam produced is sent to a heat exchange unit dedicated to district heating for the town of Brescia managed by A2A Group. During the summer the steam is used to feed an ORC turbo-generator supplied by Turboden for the production of electricity for internal use.

The heat exchanger, generally called a waste heat boiler, consists of a single convective exchange unit, operating between fume temperatures of approximately 500-550°C down to a temperature of approximately 200°C. However, since the EAF process generates heat loads which are not constant over time (scrap melting, liquid steel refining and superheating, tapping, EAF preparation), the fume temperature varies significantly during processing. The recovery of heat and its transfer to the users is carried out according to a continuous cycle where water, coming from the degasser (see later), evaporates into the waste heat boiler, cools down in the heat exchangers and then ▷

Fig 5 **The new iRecovery system, A2A exchange section**

Fig 6 **The ORC turbo-generator (*courtesy: Turboden*)**

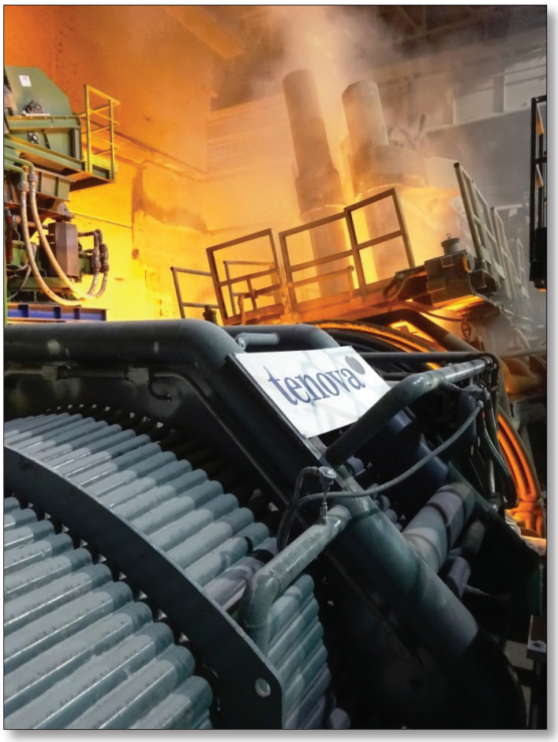

Fig 7 The new revamped Consteel EAF during tapping

is sent back in the form of condensate to the degasser, thus closing the thermal cycle.

The system is divided into the following sections:

Heat recovery section *(see Figure 4)* The new off-gas duct conveys the hot fumes through the heat recuperator and waste heat boiler to the primary existing off-gas line downstream of the quenching tower.

The waste heat boiler consists of a steam generator with natural circulation water tube bundles fitted with:

- A casing or fume flow chamber that contains the convective heat exchange units
- Evaporators which are essentially water containers through which bundles of vertical tubes carrying the off-gas cause the liquid water coming from the steam drum to undergo partial evaporation
- Steam drum which consists of a cylindrical pressure vessel installed above the recuperator in which the liquid water is in balance with the steam. Down-pipes come out from the bottom of the steam drum and go to the evaporators. The upward pipes, coming from the upper part of the evaporators, are connected to the upper part of the steam drum
- Economisers consist a water/steam drum containing water from the degasser through which pass bundles of vertical tubes containing the off-gas. The water temperature rises from about 105°C to a temperature close to the boiling point, at a defined pressure, in the steam drum, and resulting in a lower off-gas coming temperature
- Automatic recuperator cleaning system that allows the cyclical separation of dust deposited on the surfaces of the exchange units inside the waste heat boiler.
- Dust extraction system to collect and convey the dust separated in the recuperator up to a storage bin

Heat exchange section with A2A district heating system Here, the steam coming from the steam accumulation section transfers its energy to the water of the district heating grid. The unit comprises a condensing heat exchange unit consisting of two condensing heat exchangers operating in parallel, a flash tank inside of which all the condensate is conveyed, and an additional condenser which condenses the flash steam bringing it in exchange with the same district heating water (*see Figure 5*). All the condensate is subsequently sent to the degasser through a booster pump group.

ORC section This converts the recovered thermal energy into electrical energy and consists essentially of a turbo-generator (*see Figure 6*) with an ORC that uses the steam from the recovery section and converts the recovered thermal energy into electrical energy.

Water supply section This comprises a thermo-physical degasser with turret which has two duties: first, to ensure continuity of supply to the recuperator in case of non-supply of make-up water, second, to allow the elimination of gases dissolved in the make-up water.

The water in the degasser is drawn from a group of feed pumps and transferred to the recuperator steam drum. The pump group is provided with a level control valve that regulates the flow of water depending on the level of water in the steam drum.

Steam pressure accumulation and reduction section The steam produced by the recuperator is conveyed to a steam accumulator whose function is to accumulate the thermal energy. In its outlet on the delivery lines to the users, there are some thermal expansion valves to reduce and ensure the steam pressure at a value below the pre-set value. Additionally, between the steam drum and the accumulator there is a valve that prevents pressure in the steam drum falling below a predetermined value.

OPERATING RESULTS

Operating data analysis from start-up of the new Consteel EAF, through commissioning and start-up of the iRecovery system indicates excellent performance was achieved by these two integrated systems. The performances were measured by calculating a cost index that considers energy and material consumptions. The expected reduction of more than 8% of this cost index compared with the previous average values was confirmed.

The productivity of the furnace shown during tapping in *Figure 7* has increased by more than 13%, exceeding all expectations, so becoming an outstanding reference value for the production of steel via an EAF. Further developments and continuous improvement are ongoing, exploiting the high potential demonstrated by the system to exceed expected values.

The operation achieved with the new Consteel EAF is the base upon which the expected performance of the iRecovery system to recover more than 90kWh/tonne of good billets of thermal energy from the primary off-gas that will be available for district heating and the ORC turbo-generator. Thanks to a commitment to optimise plant tuning, the steam flow rate is now controlled based on the average thermal load of the fumes expected and can now be kept uniform over tap-to-tap time due to the thermal buffer of the steam accumulator. After more than one year of operation the results show that the amount of energy recovered from the off-gas is in line with the expected results.

CONCLUSIONS

The new Consteel EAF and the new iRecovery system have been fully integrated and the operation of the whole system is steady and consistent, enabling Ori Martin to be one of the most flexible, efficient and environmentally friendly steel making plants in the world. It also provides the company with the opportunity to exploit an additional lever for a more flexible and efficient operation of the plant. Furthermore, the potential already demonstrated by the system offers additional opportunities for the optimisation of performance and costs in many different scenarios. **MS**

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