Cogeneration With ORC at Elbe-Stahlwerke Feralpi EAF Shop

In 2012, Elbe-Stahlwerke Feralpi (ESF) installed the world's first EAF waste heat recovery plant with cogeneration based on organic Rankine cycle (ORC) technology. The background for the investment and the technological choices are explained, along with project milestones, commissioning and first operational results.

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Reducing energy consumption has been a constant concern of steelmakers over the years; making one ton of steel today uses about half of the energy used in the 1970s.[1] These efforts must continue, as further reductions are required in the steel industry as well as in other energy-intensive sectors to minimize costs and to respect policies on greenhouse gas emissions. This is a major challenge to meet, particularly in Europe, where the price of energy is high, CO_2 reduction targets have been set by the European Union (EU) and the steel industry is still suffering the impact of the economic crisis.

In electric steelmaking, which is gaining a growing percentage of world steel production, process optimization and control technologies and best practices — ever more shared by EAF operators — have substantially raised the benchmark productivity and energy efficiency of scrap-based mini-mills. In this area, a further energy efficiency improvement seldom considered, due to the perceived complexity of the application, is the re-use of the waste heat from the EAF exhaust gas for power production.

The challenging conditions of EAF scrap melting (a batch process with extremely variable offgas flow in a harsh environment) require robust, flexible and automatic systems capable of recovering the offgas heat and converting it to power, leaving the EAF operator concentrated on its main job. One key component that can fully meet the required duty is an organic Rankine cycle (ORC) power unit coupled with reliable primary heat capture equipment. ORC power units have demonstrated their unique properties in hundreds of biomass-based power plants and in waste heat recovery in cement, glass or downstream of gas turbines and large reciprocating engines. Key advantages of ORC systems are high reliability, ease of operation, good efficiency, and low operation and maintenance (O&M) costs.

The following is an example of a new heat recovery system from EAF offgas with ORC power production recently installed by Elbe-Stahlwerke Feralpi GmbH (ESF) in Riesa, Germany.

Elbe-Stahlwerke Feralpi

Riesa Steel History and Feralpi Group — Steel production started in Riesa in 1843 and continued while Germany and Europe went through many different events, including two wars.

In the 1980s, Riesa steel works, integrated into the planned economy of the German Democratic Republic, reached 12,000 employees. However, after the German Reunification, the plant risked closure because of high production costs and environmental issues. In 1991, the Italian steel producer Feralpi acquired the steel works, investing to build the present installations and creating Elbe-Stahlwerke Feralpi GmbH.

Founded in 1968, the Feralpi Group is a leading manufacturer of steel products for the construction industry, with a capacity of 5 million tons per year of steel and finished products. Feralpi plants, employing a total of 1,300 people, are located in Italy, Germany, Czech Republic, Hungary and Romania.

ESF Elbe-Stahlwerke Feralpi GmbH: Plant, Process, Production — ESF produces reinforcing steel in the form of bars and coils. The ESF steel plant consists of a steel shop for steel billets as semi-finished product and a hot rolling mill for further processing of steel billets to rebars and coils. ESF produces up to 1,000,000 metric tons of steel billets and up to 800,000 metric tons of reinforcing steel per year.

Figure 2 shows schematically the actual flow of materials at the ESF plant. The feedstock for steelmaking at ESF is steel scrap, which is melted in an electric arc furnace at approximately 1,600°C (2,910°F) to liquid steel that is cast to billets in a continuous casting machine. The hot rolling mill includes a walking beam furnace that reheats the steel billets up to a rolling temperature of approximately 1,200°C (2,190°F). The reheated billets are passed to the rolling mill, which can produce either round steel or wire rod by varying the number of rolling stands and cylinders and by choosing different paths of cooling and tying (as coils or bundles).

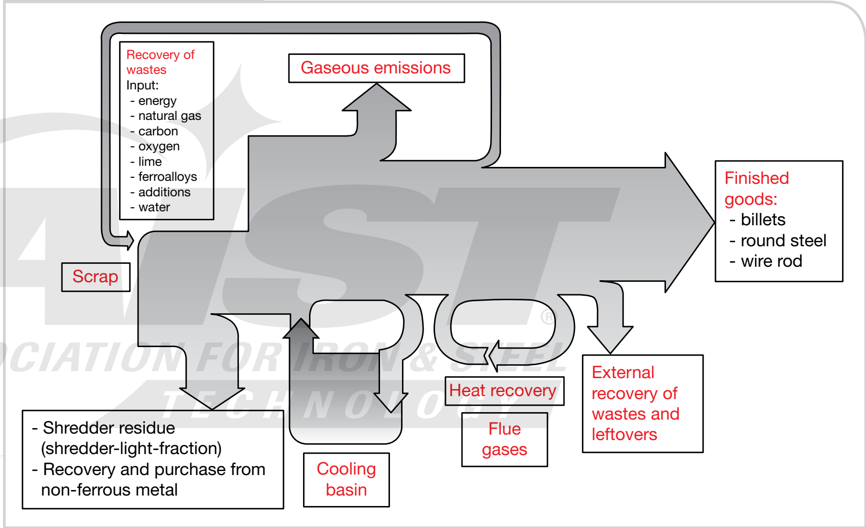
A specific feature of the ESF installation is the possibility of a direct feed of hot billets from continuous casting into the walking beam furnace (Figure 3). Billets can be fed to the furnace at temperatures up to 900°C (1,650°F): this leads to high energy savings at the furnace, since it has to increase the temperature by only about 300°C (540°F) to reach the feed-in temperature of the rolling mill. Nevertheless, ESF needs around 550 GWh of electricity and the equivalent of 230 GWh from natural gas per year.

EMAS Certification — Because of cost intensity issues, as well as its environmental responsibility, in 2012 Feralpi Group decided to establish an environmental and energy management system under the European "Eco Management and Audit Scheme" (EMAS), including all companies located at the Riesa site; in addition, Feralpi Riesa regularly publishes a sustainability report of the previous two years.[2] According to the policy of the management system, ESF continuously improves its environmental protection and energy efficiency. The installation of the EAF waste heat recovery is one of the key measures of

Figure 1

Elbe-Stahlwerke Feralpi GmbH (ESF) plant.

Figure 2

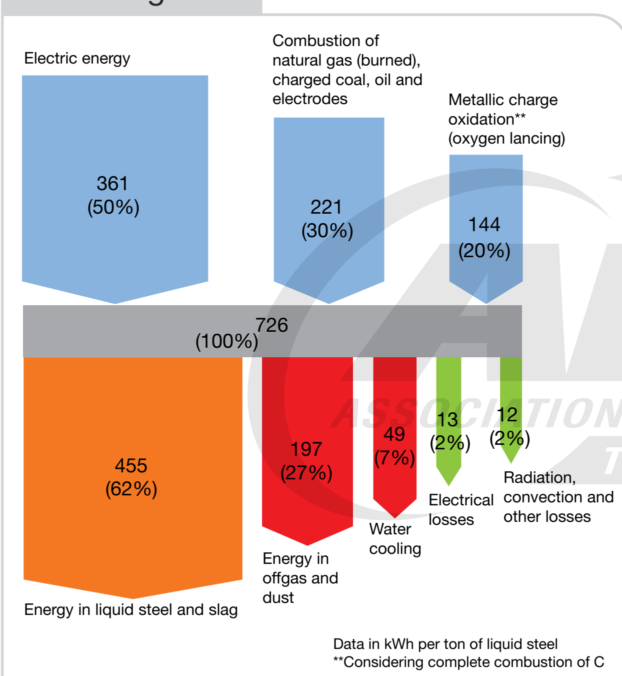


Material and energy flows at the ESF plant.

Figure 3

EAF (left) and continuous casting machine (right) at ESF, Riesa.

Figure 4



Typical energy balance for top-charged scrap-based EAF (Tenova).

energy savings and of environmental protection (CO_2 reduction) as well, due to a correspondent reduction in the use of fossil fuels.

Heat Recovery to Power From EAF Project

Feralpi Objectives — The Feralpi Group, continuously striving to improve the productivity, energy efficiency and environmental performance of its facilities, started considering the possibility of installing a waste heat recovery system with power production at one of its electric steelmaking plants back in 2008. The objective was to further improve energy efficiency of scrap-based steelmaking, thereby lowering the EAF specific electric energy use and CO_2 emissions, with no reduction in overall plant availability and no additional personnel cost.

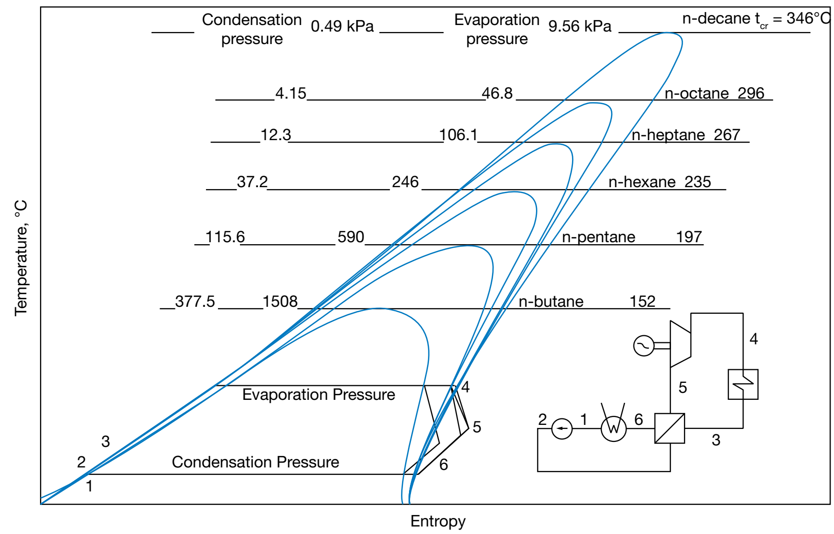
The identified waste energy source to be recovered was the sensible heat of the hot combusted gas stream from the EAF, normally conveyed through low-temperature water-cooled ducts to the primary fume treatment system, with quench tower and baghouse filtering. This waste stream, typically representing more than 25% of the total energy input,[3] is the most important source of waste energy in EAF steelmaking.

Process Choice: Steam Turbine vs. ORC — Many existing waste heat to power (WHTP) systems used in energy-intensive industries with continuous high-temperature processes use steam turbines to convert heat to power. Waste heat recovery boilers capture the valuable energy of the hot exhaust gases generated by the primary process to evaporate water and produce saturated or superheated steam. Steam is then expanded in a steam turbine and eventually condensed back to water. This is the classical Rankine cycle, employed, for instance, in the chemical industry, non-ferrous metal making and the production of ferroalloys.

These traditional water-steam systems are typically employed in industry for plants over 10 MW and extending up to 50 MW and above. In these cases, and where the primary calcining or metallurgical process generates a steady flow of high-temperature exhaust gas, superheated steam cycles are employed to maximize efficiency in converting heat to power. Superheated steam systems require costly equipment (high temperature and pressure demand more sophisticated equipment and materials) and high O&M costs (operators must be certified steam engineers, water quality requires special care, etc.). Due to the capital and running costs, superheated steam cycles are seldom convenient for WHTP plants below 15–20 MW.

At smaller capacities, less costly, non-superheated (saturated) steam Rankine cycle systems have been employed; however, in these cases, local codes also typically require the continuous presence of certified steam engineers, thereby increasing operating personnel costs to unacceptable levels. In addition, when the process heat source is discontinuous or highly

Figure 5



Saturation curves for several organic fluids (Turboden).

variable, steam turbines running on saturated steam cannot be easily employed.

Due to all these factors, Feralpi decided to rule out the traditional Rankine cycle based on water-steam boiler and direct expansion steam turbine, and to consider instead using the ORC. In fact, the ORC technology, widely employed in hundreds of renewable energy plants in Europe and North America (mostly in biomass-based generation and in geothermal applications) was successfully proven in various WHTP installations in the industrial environment.[4,5]

These ORC units, operating in cement plants and other energy-intensive industries, convinced Feralpi that the ORC would be the most appropriate alternative to handle the discontinuous, extremely variable waste heat of the EAF exhaust gases, guaranteeing flexibility, ease of operation and minimum O&M.

Feralpi had one concern about the ORC technology, namely the use of thermal oil as a heat carrier between the primary heat source (EAF offgas ducting) and the ORC proper. Despite the fact that thermal oil is widely employed in the oil and gas or marine industries, Feralpi objected to have thermal oil near the EAF. The issue was overcome after discussing it with Turboden, the supplier of the ORC system, and verifying that saturated steam could well be used to convey heat from EAF offgas to the ORC evaporator. In fact, studies and proposals done by Turboden in 2009 showed that saturated steam at about 20 bar·g, as produced at the Georgsmarienhütte EAF steel shop,[6] was a good heat carrier/source for an ORC system.

ORC Technology Explained — As the name suggests, the ORC is a thermodynamic cycle based on the classic Rankine cycle, performed with an organic fluid instead of water. The most widely used organic fluids are hydrocarbons (e.g., pentane), siloxanes (employed also in cosmetic products) and refrigerants (more common in HVAC systems and refrigeration). In Figure 5, saturation curves for several organic fluids are reported: as the shape of the curves suggests, if compared to water, organic fluids do not need to be superheated to avoid condensation in the turbine during the expanding stage; moreover, the organic fluids have higher molecular weight than water. All of these features lead to some very important technical advantages compared to conventional steam cycles in some specific cases:

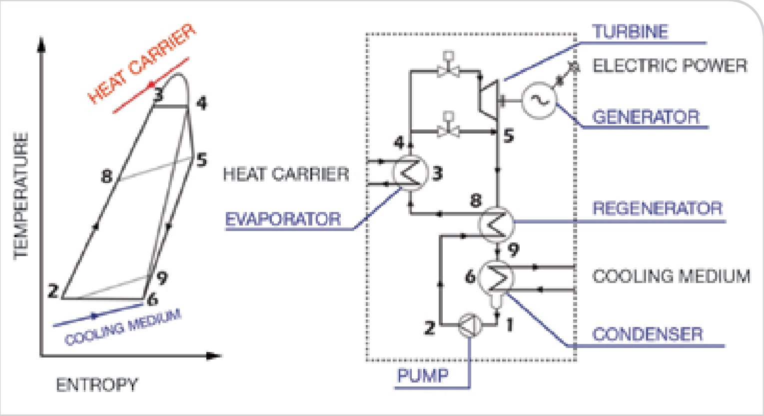
- High turbine efficiency (around 85%).
- Low mechanical stress on the turbine (low tip speed, moderate temperature).
- Low turbine rotational speed, allowing direct drive generator (no gearbox).
- No blade erosion (no liquid particles during expansion because of the shape of saturation curve).
- No oxidation (some organic fluids can even be considered as lubricants themselves).
- High efficiency with low and moderate temperature sources (e.g., 24% with 300°C (570°F) hot source).

As a consequence, ease of operation is characterized by:

- Simple start-stop procedures, with quiet running and automatic and unattended operation.
- High availability.
- High flexibility (good efficiency at partial load, with turndown to 10% or less of nominal power).
- Long life and minimum O&M requirements.

These advantages stem from the fluid characteristics, which allow one to design and build relatively large and slow rotating (thus efficient and reliable) turbines, making ORC one of the best choices for

Figure 6



Typical ORC scheme and thermodynamic cycle.

small-scale applications (up to 5–10 MW). On the other hand, the turbine size causes the ORC technology not to be cost-effective for most common larger applications, where superheated steam cycles are the natural choice. For this reason, the ORC technology has ever-growing applications for distributed generation in geothermal power, other renewables (especially biomass-based), in small combined cycles (bottoming gas turbines or internal combustion engines) and for waste heat recovery in industrial processes.

The actual configuration of ORC systems can be different depending on the specific application and site conditions, such as type of heat source, demand for low-temperature heat, availability of water, space constraints, etc.

Usually, when the primary heat source is hot, dusty combustion gases and cooling water is available, the heat recovery systems consist essentially of a primary heat exchanger, the ORC unit, and a cooling system for dissipating heat of condensation downstream from the ORC turbo-generator. The primary heat exchanger feeds the ORC turbo-generator, transferring part of the waste heat from the exhaust gas to the ORC unit by means of a heat carrier (typically thermal oil, pressurized water or steam). The ORC unit converts the incoming thermal energy into electricity and heat at low temperature. The heat discharged from the cycle of power during condensation is released to the environment by means of an intermediate water circuit (or mixture of water and glycol to prevent freezing in winter), when low-temperature heat is not usable. The dissipation of this heat can be in the form of a dedicated system: this can be either a dry system with air coolers or a wet system with evaporative cooling towers.

Figure 6 shows a simplified scheme of the ORC. Following the cycle step by step, the working fluid is pre-heated (8-3) and evaporates (3-4) by means of the heat carried (thermal oil, hot water or steam), and then expands in a turbine (4-5), which is usually directly coupled to the generator. The condensation (9-1) can be performed by a cooling medium (air or water). The cycle closes when liquid from the condenser is pumped (1-2) to reach the evaporation pressure. An internal heat exchanger (the so-called "regenerator) is placed downstream of the turbine in order to achieve higher efficiency (5-8, 2-8).

Site Selection — Feralpi Group, considering the high cost of electricity in Italy because of the nature of the installed power generation capacity in the country (no nuclear and only about 15% coal), initially considered installing an EAF waste heat recovery system in one of its scrap-based mini-mills near Brescia. The project would have benefitted from the Italian incentives on energy efficiency improvements employing an innovative technology. These incentives are generally a premium equivalent to €0.06/kWh added to the price of high-voltage electricity. The value of this premium (the so-called "white certificates") is defined by a market mechanism where the electricity distributors must meet commitments to improve every year the average efficiency of their clients. The white certificates system is one of the measures established by Italian legislators to meet the energy efficiency and greenhouse gases reduction targets fixed by the European Union. Notwithstanding the important savings on electricity costs, the payback time for a waste heat recovery to power system at the Italian site was considered too long.

More favorable conditions existed at the Elbe-Stahlwerke Feralpi plant in Riesa, where the local utility Stadtwerke Riesa GmbH was interested in acquiring directly as steam an important portion of the energy, recovered with the new installation, for one of its clients at the adjacent industrial park. The expected revenue of the steam exported, together with the saved cost of electricity expected after installing the ORC unit, gave an acceptable payback for the investment.

ESF Steel Shop Waste Heat to Power System — At the end of 2011, ESF agreed with Stadtwerke Riesa GmbH to supply about one-third of the heat recovered from the EAF offgas (i.e., 10 tons/hour of saturated steam at 26 bar·g), to be used by the plant of Goodyear Dunlop Tires Germany GmbH, located nearby. ESF then decided to go ahead with its cogeneration project based on recovering heat from the electric arc furnace offgas, generating saturated steam and conveying this steam partly to the thermal user

(Stadtwerke Riesa) and partly to the ORC power plant to produce electricity.

The first installation of this type was developed with the support of the European Commission (LIFE program, HREII Demo project), who co-financed a small part of the investment, highlighting the relevance, innovation and environmental benefits of the project.[7]

The plant to be built included a new EAF fume treatment and heat recovery system with evaporative cooling and saturated steam production contracted to Tenova, and a 2.7-MW ORC power plant fed with saturated steam contracted to Turboden. The simplified scheme and energy flow of the plant are shown in Figures 7 and 8.

It is well known that the steel melting process in the EAF is a batch process: offgas thermal flow from the EAF roof or side opening varies during the melting cycle. During tapping and when the roof of the furnace is open, for bucket scrap charging or for repairing, the thermal power at the primary offgas duct is close to zero.

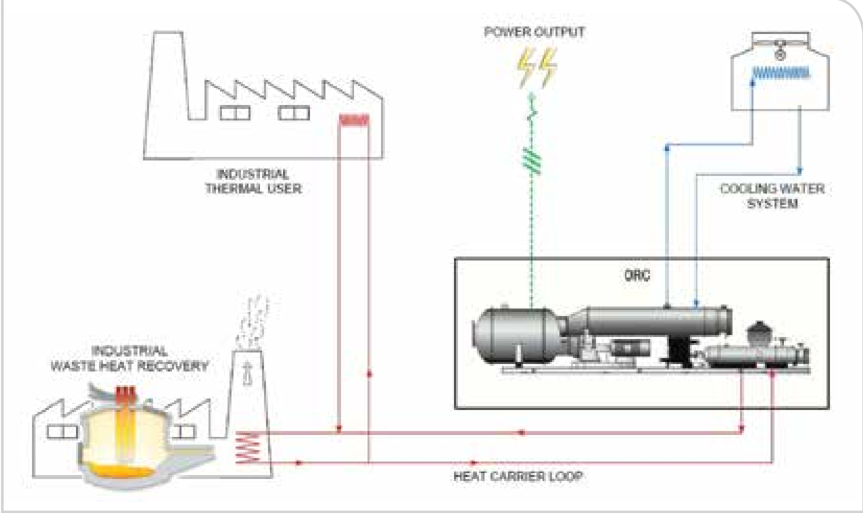
A typical EAF melting cycle at ESF is described in Table 1.

The significant values for the fume treatment and WHTP system design are:

- Tap-to-tap time: 48 minutes.
- Longest power-off time: 11 minutes.
- Average power during power-on: 70 MW.
- Total power-on time: 33 minutes.

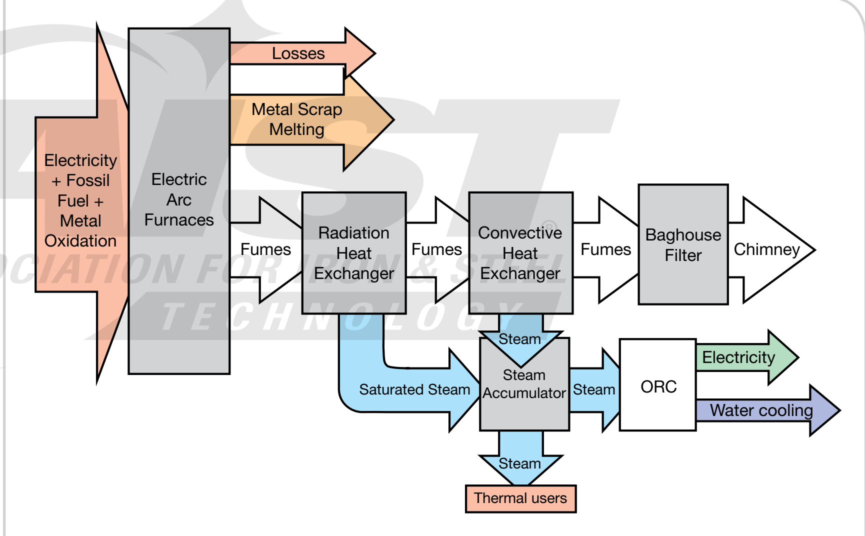
EAF Heat Recovery With Evaporative Cooling System — Since the EAF offgas has a discontinuous, highly variable heat flow, the evaporative cooling system (ECS) used for primary heat recovery must include a buffer, necessary to ensure that the

Figure 7



Simplified cogeneration waste heat recovery scheme, as applied in Riesa.

Figure 8



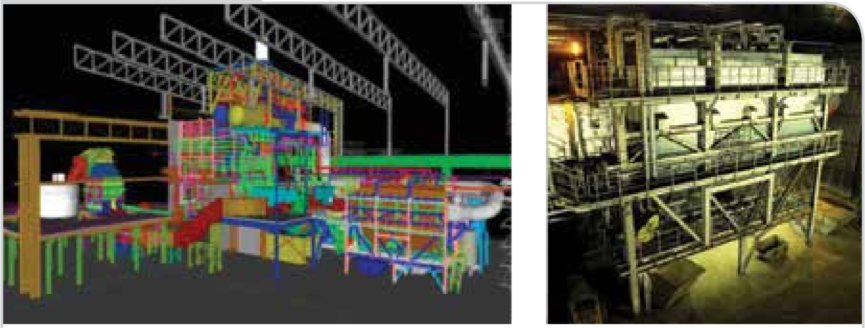
Heat recovery system with ORC technology from exhaust gas of EAF, as applied in Riesa.

Table 1

ESF Electric Arc Furnace Melting Cycle Data

Melting phase	Power-on time (minutes)	Power-off time (minutes)	Average power (MW)
1st scrap bucket charging		2	
Melting	10		70
2nd scrap bucket charging		3	
Melting	10		70
3rd scrap bucket charging		3	
Melting and refining	13		70
Tapping and repairing		7	

Figure 9



(a) (b)

Waste heat steam generator rendering (a) and installed equipment (b) at ESF plant, Riesa.

Table 2

ORC Design Data for ESF Electric Arc Furnace Heat Recovery Plant

Heat recovery system supplier	Tenova (Comeca sub-contractor for heat exchanger parts)
ORC supplier	Turboden
Hot source	Saturated/superheated steam @ 26 bar·g
Inlet thermal power to the ORC	13,517 kW
Steam temperature in to ORC	228–245°C (442–473°F)
Condensate temperature out from ORC	100°C (212°F)
Thermal power to the cooling water	10,640 kW
Cooling water temperatures (in/out ORC)	26°C/44°C (79°F/111°F)
Gross electric power output	2,680 kW
Net electric power output	2,560 kW

steam conveying the recovered heat is always available, and varies within a certain range of pressure and temperature. In the case of ESF, where steam is both exported and used internally for power generation, the buffer is sized to use as much as possible the generated steam, guarantee the agreed-upon constant steam flow to the external steam client (Stadtwerke Riesa) and guarantee at least the minimum steam flow (about 10% of the design flow) to keep the ORC always in operation, thereby producing electric power. In practice, the steam produced by the ECS in the primary offgas line and separated in the steam drum has peaks of 70 tons/hour. After the steam accumulator, the average output of steam to users is equalized to approximately 30 tons/hour.

The heat recovery system has two separate sections. The first section, where the offgas has peak temperatures of 1,600°C (2,910°F), works as a radiation heat exchanger, replacing the existing system (cold water-cooled ducts and settling chamber) with a completely new system using steam boiler tubes of small sections for evaporative cooling. This new offgas handling and cooling section with evaporative cooling was supplied by Tenova, based on the experience gained in more than three years of operation at the Georgsmarienhütte steel shop.[6]

The second section, installed bypassing the existing water quench tower, is a convection waste heat steam generator (WHSG) with evaporators, superheater and economizer mounted in sequence, following the gas flow on compact modules. While the layout is similar to a classical WHSG used elsewhere, the design was made considering peak loads in flow and temperatures and high dust load (20 g/Nm^3). The vertical plain tubes are cleaned automatically.

The offgas coming from the ECS cooled waste gas duct (radiation section) crosses the WHSG bundles horizontally. The dust separated inside the heat exchanger is collected and discharged into bins by means of a chain conveyor.

In the evaporative cooling system, the cooling water at boiling point is fed from the steam drum by recirculation pumps to the evaporators, which are in fact the offgas duct surfaces in the radiation section and the evaporator bundles in the WHSG. Once past the evaporators, a part of such cooling water evaporates, producing a water-steam mixture. The water-steam mixture returning to the steam drum is separated in two phases: boiling water, which is recirculated to the cooling system, and saturated steam, delivered to the heat users, Stadtwerke Riesa (10 tons/hour) and ORC power plant (up to 20 tons/hour).

Additional benefits of the new cooling system, other than recovering energy, are due to the fact that the (hot) evaporative cooling system extends the life of the offgas ducting for several reasons:

- Normal working temperature at the internal surface of the exhaust gas path/ducting is high

Figure 10

(a) (b)

Organic Rankine cycle unit at ESF plant, Riesa: overview (a) and turbine detail (b).

and far above dewpoint; therefore, ducts and heat exchangers are protected against acid corrosion.

- All cooled parts are continuously at the same nominal temperature or exposed to a low variation of temperature. Constant, uniform temperature minimizes thermal mechanical stress to offgas ducts.
- Through the evaporation of water, the system easily absorbs energy peaks.

ESF Steam to Power System With ORC — The specific features of the waste heat recovery installation at ESF Riesa, designed to export steam to the nearby industrial user, dictated the choice of the heat carrier employed to convey heat from the EAF fume treatment and heat recovery plant to the ORC.

The use of steam, instead of the more usual thermal oil as heat source, required several changes to the "hot" heat exchangers (pre-heater and evaporator) of the ORC, but, in practice, the steam-fed ORC unit of ESF looks very similar to other ORC systems using different heat carriers.

Using saturated steam at 26 bar·g and 228–245°C (442–473°F) as a heat carrier implies a small reduction in ORC efficiency compared to systems fed with thermal oil normally at higher temperature (280–310°C (536–590°F)).

On the other hand, as mentioned before, while thermal oil is appreciated in other industries like oil and gas, cement and biomass power, steel shop operators are not familiar with thermal oil and may like not to use it in the EAF environment.

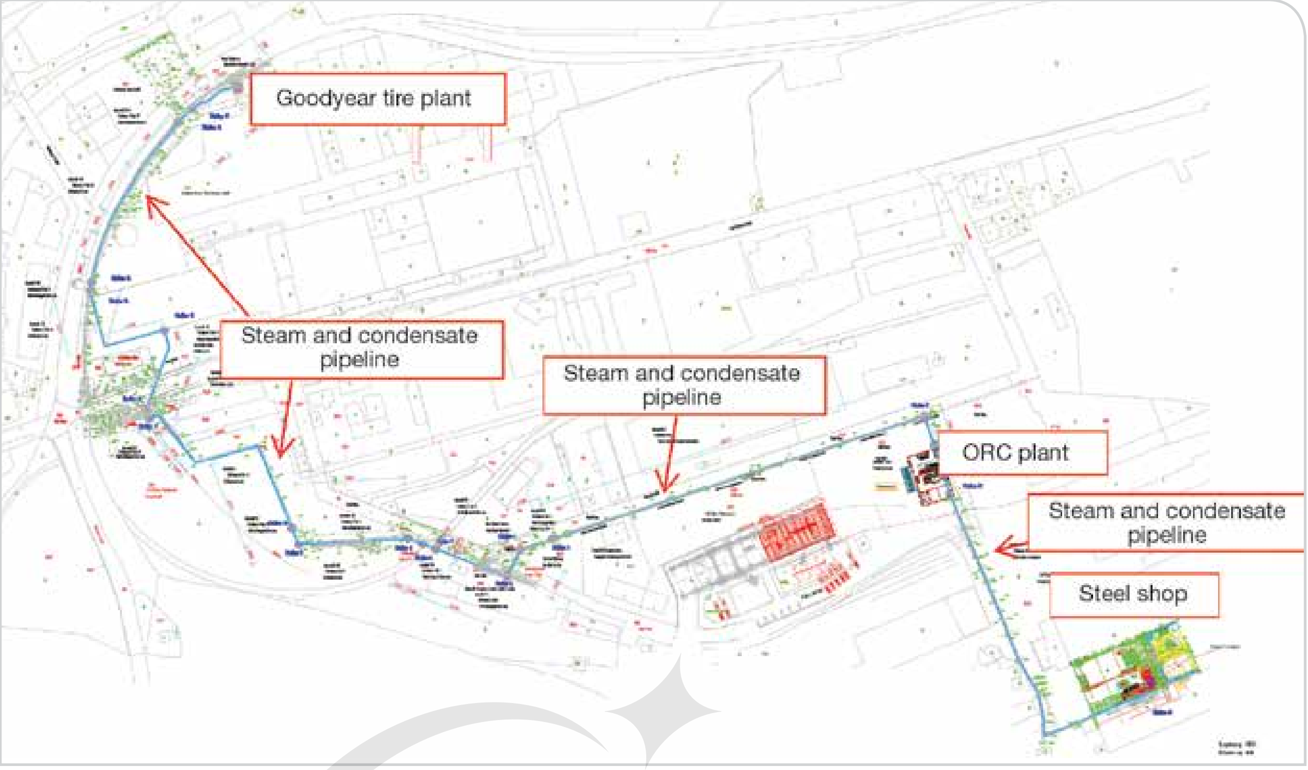
Feralpi was reassured in its decision to go ahead with a steam-fed ORC after the experience of Tenova at the Georgsmarienhütte steel shop,[6] where Tenova supplied an EAF waste heat recovery system producing saturated steam with similar parameters.

It is important to note that the saturated steam conveying heat to the ORC does not expand like in a traditional steam turbine. In this case, the saturated steam just transfers heat to the ORC working fluid through surface heat exchangers, is cooled down and condenses with a small pressure drop, returning as condensate to the steel shop fume treatment to be heated and then evaporates again.

The heat carrier loop with steam at 26 bar·g and 228–245°C (442–473°F) on the hot side, and 3–7 bar·g and 105–170°C (221–338°F) condensate on the low-temperature side, is much less demanding than any conventional superheated steam cycle with direct expansion. The closed-loop steam/condensate system is much easier to operate and maintain compared to a steam cycle with direct expansion.

The overall layout of the ESF installation, shown in Figure 11, was dictated by the location of the export steam and condensate return lines, connecting the offgas evaporative cooling system, the ORC power plant and the delivery point of steam to the Stadtwerke Riesa network and eventually the Goodyear Dunlop plant. In fact, the ORC power plant and auxiliaries are located near the delivery point of steam and return of condensate at the boundary of the ESF property. The steam and condensate return pipelines run for approximately 1,300 m (0.81 mile), partly on an existing pipe rack to connect the convection heat exchanger of the fume treatment plant with the ORC power plant.

Figure 11



Steam and condensate pipelines overall layout at Riesa.

Project Schedule and Start-Up — The contract for the supply of the ORC unit was signed in December 2011. During 2012, all the components were designed and manufactured, and in February 2013 the ORC unit was transferred to Riesa. Erection and cabling of the ORC took place in June and July; in August the convection steam generator was installed and the cold test of the ORC was performed. Finally, in November the radiation heat exchanger was installed during the yearly shutdown of the steel shop.

The start-up of the new waste heat recovery installation at Elbe-Stahlwerke Feralpi in Riesa occurred immediately before Christmas in 2013, with some delay with respect to the original plans, mainly due to the constraints to the site construction activities dictated by the priorities of the steelmaking shop operation.

Figure 12

Steam and condensate pipeline inside ESF plant, Riesa.

Conclusions

The revamped steel shop at Elbe-Stahlwerke Feralpi in Riesa, with new waste heat recovery installations, was back in operation on 18 December 2013. The following day, the ORC reached its nominal power.

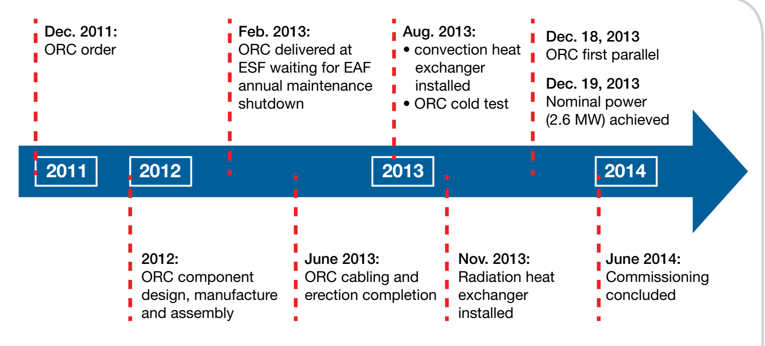
The commissioning activity was completed in June 2014, demonstrating that the EAF offgas treatment plant with evaporative cooling, the steam production and transport system and the ORC power plant met all the expected performance targets, with continuous operation following the normal ESF steel shop routine. Necessary improvements and adaptions executed through the cooperation of all parties led to a successful commissioning.

The ORC, for the first time coupled to scrap-based steelmaking, is confirmed as a best-in-class technology in challenging conditions, recovering and converting the variable energy of the EAF offgas, and thereby improving energy efficiency and reducing CO_2 emissions.

Ease of operation and flexibility of the system, capable of automatically adjusting to the EAF melting cycle, are key features greatly valued by steel shop operators. However, the system still possesses potential for optimization.

The economics of the installations are site-specific. In the case of ESF, the possibility of selling part of the heat recovered to a steam user was a major factor for a good payback time.

Figure 13



Project timeline of waste heat recovery installation at ESF plant, Riesa.

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Did You Know?

International Surface Inspection Summit 2015 Held in Pittsburgh

The International Surface Inspection Summit 2015 was held at the David L. Lawrence Convention Center in Pittsburgh, Pa., USA, on 17–18 March 2015. The event focused on the latest developments in surface inspection systems (SIS), in particular, advancements in automatic surface inspection systems (ASIS). The two-day conference attracted more than 100 attendees from 15 different countries representing more than 50 different companies.

Tuesday morning's keynote session was kicked off with a welcome by Günter Bleimann-Gather, owner of TEMA Technologie Marketing AG, which hosted the conference. Brian W. Smith, chair of AIST's Electrical Applications Technology Committee Sensor Systems Subcommittee, presented an overview of the history of surface inspection technology. Bin Wu, from Purdue University Calumet's Center for Innovation Through Visualization and Simulation (CIVS), followed with a presentation of CIVS' virtual reality simulation software and its practical applications.

The second half of the keynote session included a presentation by Matthew Fairlie of Novelis Global Research & Technology Center, who provided a retrospective of his 30 years in the aluminum industry and how ASIS has allowed the aluminum industry to move into previously inaccessible markets, including exterior automotive. Martin Beaver, United States Steel Corporation, spoke from an operations perspective. He stressed how the steel industry as a whole is experiencing a culture change as interest shifts from quantity toward quality, and how surface inspection technology is vital to address these changes. The keynote sessions were then followed with presentations by representatives from ArcelorMittal Global R&D Center – East Chicago, Steel Dynamics Inc., Primetals Technologies USA LLC and ISRA VISION Parsytec.

The second day of the conference was devoted to developments in imaging, classification, data analysis and calibration methods, and included a panel discussion. Fives Keods, one of the sponsors of the conference, presented on two of its software innovations: Eyeron™, an all-in-one quality management tool, and AbSIS™, which lets the user see an overview of upstream and downstream maps with traceability information.