AIST ITALY
EAF STUDY TOUR

by Sam Matson, director of energy technology, CMC Americas

The Italy EAF Study Tour delegates visited Olifer ACP on Monday, 14 November.

The AIST Electric Steelmaking Technology Committee (ESTC) held its third international study tour in northern Italy on 14–19 November 2016. Among the 25 attendees, 14 represented steelmaking companies and eight attendees were from equipment and service providers.

The study tour focused on steelmakers in northern Italy with an extremely aggressive itinerary: visit nine meltshops and one refractory manufacturer in five days.

The overall tone of the study tour was of friendship and family in the steel industry. The group spent a significant amount of time together each day, on the tours of our host facilities, on the bus between our destinations, and at the dining table for breakfast, lunch and dinner. It was an intense trip but I expect it will pay dividends over many years as all of us go through our notes, share our "takeaways," and keep in contact with our new steelmaking brothers and sisters in Italy.

This summary was written with the intent to discuss the electric arc furnace (EAF) area of the operations in the most detail since

The 2016 Italy EAF Study Tour began at the Museo del Violino in Cremona, Italy.

the ESTC sponsored the tour. As a reader, you are encouraged to reach out to AIST staff or one of the tour participants for further details.

OLIFER ACP

On the morning of Monday, 14 November, the study tour made its first visit, to Olifer Acciaieria Cividate al Piano (ACP), located in Cividate al Piano (BG). We were immediately greeted warmly with signs reading "We Steel Love You." Our hosts discussed the history of ACP from its start in 1973 as a producer of billets for rebar and merchant bars up to its present-day operation as a specialty steel shop. The annual production at ACP has fluctuated over the past few years along with the economy, with production ranging between 125,000 and 200,000 tpy.

ACP's operation includes an EAF, two ladle furnaces (LFs), vacuum degasser (VD)/vacuum oxygen decarburization (VOD), continuous casting machine (CCM) and ingot casting.

Melting is performed with a 70-metric-ton AC spout-tap EAF. The EAF is 4.3 m in diameter and uses a 50-MVA transformer and 500-mm electrodes. The EAF is equipped with two porous plugs and four burner/injectors. The EAF lining is renewed every 300 heats, which is after approximately 3 to 4 weeks. The EAF has a machine for cleaning the slag door; measuring temperature, dissolved oxygen and carbon content; and collecting a steel sample. The meltshop operates with a slag pot practice.

Final chemistry adjustments and heating takes place at one of their two ladle furnaces equipped with 20- and 25-MVA transformers, 350-mm electrodes, porous plug stirring, wire feed systems, and automatic alloy additions. The VD/VOD is used in appropriate grades prior to casting into billets at the continuous caster or into ingots in the teeming aisle. The caster makes seven billet sizes, including squares and rounds, from 100 to 140 mm. ACP also has two annealing furnaces for treating its ingots.

ACP uses three different sizes of ladles and seven different refractory designs in order to optimize freeboard, costs and heat sizes from 35 to 95 metric tons.

Overall ACP is able to produce their special steels with a team of 83 employees and 30 outside contractors.

TENARISDALMINE

Our second stop on Monday was at TenarisDalmine in Dalmine (BG). TenarisDalmine produces seamless pipe for oil and gas end use and tubes for heat transfer and carrying water. The visit began with introductions and a lunch of traditional Italian food. We proceeded with the tour happy and with full stomachs.

The meltshop consists of an EAF, two LFs and two casters.

The EAF includes five oxy-fuel burners, three oxygen lances, three carbon injectors and two lime injectors. The EAF power system uses a 100-MVA transformer and produces a heat of 98 metric tons. Lime is injected and added through a roof top feed system. The EAF is equipped with three porous plugs used for argon bubbling. The Tenaris scrap mix uses about 10% pig iron. The EAF refractory and bottom stir plugs last about 4 weeks. The EAF tap-to-tap time is 35 minutes and the production goal is 35 heats per day. The EAF heat size is 88 metric tons for VD heats. Electrode consumption is 0.55 kg/metric ton.

Two porous plugs are used to homogenize the steel in the ladle.

The casters produce round billets from 145 to 395 mm in diameter. The larger-section caster is vertical while the smaller-section caster is curved.

The tour included a bird's-eye tour of the pipe mill from an observation level. The 5-m-long billets enter the rotary hearth furnace and are heated for about 3 hours before entering the mill. The billets are pre-heated using the waste gas from the rotary hearth furnace. A mandrel pierces the billet and its length and wall thickness are controlled as it passes down the 8-stand mill.

Depressed oil prices have resulted in reduced production levels at TenarisDalmine.

ACCIAIERIA ARVEDI

The third stop in the meltshop study tour was Acciaieria Arvedi in Cremona, a producer of flat-rolled steel. Arvedi produces its strip on two mills: In-line Strip Production (ISP) and Endless Strip Production (ESP). Arvedi was built in the early 1990s and has an annual production capacity of 3 million metric tons.

The meltshop consists of two EAFs, two LFs, and the ISP and ESP.

EAF No. 1 is a 120-metric-ton bucket-charge AC EAF with a 155-MVA transformer and 600-mm electrodes. The EAF is equipped with two oxy-fuel burners, six oxygen injectors and a consumable door lance. Heats typically use two buckets. EAF No. 1 has an infrared camera used during tapping. The tap-to-tap time for this furnace is 48 minutes and it produces

The Italy EAF Study Tour delegates visited TenarisDalmine on Monday, 14 November.

about 30 heats per day. Annual production from this furnace is 1.1 million metric tons per year.

EAF No. 2 is a 260-metric-ton Consteel® AC EAF with a 190-MVA transformer and 700-mm electrodes. The EAF is equipped with a 100-m scrap conveyor and four oxygen injectors. The furnace operates with a 90-metric-ton hot heel. Hot briquetted iron (HBI) is added to the furnace through the "5th hole." The tap-to-tap time for this furnace is 51 minutes and it produces about 28 heats per day. Annual production from this furnace is 2.2 million metric tons per year.

Electrode consumption for the Consteel furnace is 0.8 kg/metric ton. The Consteel furnace has four load cells to measure the weight of the shell, lining and steel contents. There is no bottom stirring in the EAFs.

Arvedi is preparing plans for waste heat energy recovery on both EAFs. One EAF will generate steam for use in the pickling process and the other will generate electricity using an organic rankine cycle (ORC) turbine.

DUFERDOFIN NUCOR S.R.L.

The fourth stop of the tour was at Duferdofin Nucor on Tuesday afternoon, 15 November 2016. Duferdofin Nucor is a joint venture between Duferco Group and Nucor. The facility melts and casts round, square, and rectangular billets and beam blank sections for sale or rolling at its other locations. The facility has an annual production capacity of 840,000 metric tons.

The meltshop includes an EAF, LF, VD, and a billet caster and a beam blank caster.

Ronald O'Malley (left), Missouri University of Science and Technology, and Stephan Ferenczy (right), Steel Dynamics Inc. – Structural and Rail Division, thanked Andrea Bianchi (center), manager head for process technology, Acciaieria Arvedi, for hosting the tour of Acciaieria Arvedi.

Giordano Streghi Montauti, Duferdofin Nucor plant manager, accepted a plaque of appreciation for hosting the tour (front row, left to right): Stephan Ferenczy, Ronald O'Malley, Montauti (Steve Jackson of Duferdofin Nucor is pictured behind Montauti), Michael Strelbisky and Dario Tornello, Duferdofin Nucor caster manager.

The EAF is a 105-metric-ton AC furnace with a 100-MVA transformer. The EAF is enclosed in a doghouse. It is equipped with three oxygen injectors, two carbon injectors and a lime injector. The tapping stream is visualized using an infrared camera for slag detection. This is one of the few EAFs that does not have any chemical energy additions through the slag door or porous plug bottom stirring. The slag door is cleaned using Motank®, and temperature, oxygen, carbon measurements are collected using Catfis® to minimize personnel requirements on the operating floor. The LF also has a simple sample-collecting robot to reduce personnel on the operating floor in that area.

Duferdofin Nucor S.r.l. has diversified its product offerings by adding specialty steels in order to differentiate itself in the market and maintain competitiveness.

DOLOMITE FRANCHI (RHI)

Our fifth tour took place Wednesday morning, 16 November 2016, at Dolomite Franchi (RHI), which is located near picturesque Lake Iseo in the foothills of the Alps. This tour included less-familiar equipment and processes since this operation mines dolomite and converts it into refractory bricks.

A large portion of the facility is located in the side of the hill near the lake. We quickly realized Dolomite Franchi's challenges in site logistics as we entered the facility and saw dozens of trucks being staged and directed through the facility.

The basic steps of the process include: mining, transport to the plant, crushing to desired sizing, removal of fine material, calcining and sintering in shaft furnaces, and then mixing with binder and pressing into brick.

The final stop in the facility tour was the palletizing area, where we saw several multi-axis robots preparing uniform stacks of brick for wrapping and shipping to customers.

FERALPI SIDERURGICA

Our bus then proceeded to our sixth tour destination at Feralpi Siderurgica. Feralpi is a long products producer and makes billets, reinforcing bars (rebar), wire rod, and wire mesh. Feralpi is a vertically integrated company with recycling facilities, steel mills and downstream fabrication.

The facility includes a scrap shear, shredder, meltshop and two rolling mills. The meltshop includes an EAF, LF and caster.

Stephan Ferenczy (right) presented a Helko Dettela (left), RHI AG plant manager, with a plaque of appreciation for hosting the Italy EAF Study Tour's visit to RHI AG.

and camera views throughout the shop.

Feralpi is finalizing installation of a scrap cleaning system that will remove dirt from the scrap before it is sent to the meltshop.

Feralpi was one of a few shops where we observed strictly defined walkways for personnel and even cages around the rolling mill stands in order to contain the process and protect employees. Alarms are triggered when a gate or cage is opened. We were also able to observe the operation of a multi-axis robot welding studs and product tags on finished bundles of rebar.

The EAF holds 105 metric tons of liquid steel, has a 124-MVA transformer and uses 700-mm electrodes. The power-on time at the EAF is 29 minutes and the tap-to-tap time is 41 minutes. Electrode consumption is 1.1 kg/metric ton. The EAF is equipped with four oxygen injectors, four oxy-fuel burners, two carbon injectors and two lime injectors. Four porous plugs in the EAF are used to stir and equalize bath temperatures. Feralpi uses an automatic door pusher, an automatic taphole sanding system with a camera and is testing an indirect bath temperature measurement system to reduce personnel traffic on the operating floor. The EAF is equipped with an extractive offgas analysis system that controls the chemical energy input. The EAF control room is elevated, has floor-to-ceiling windows, and includes five or more large-panel monitors to display EAF control screens, the status of all meltshop operations,

NLMK VERONA

Our seventh stop on the study tour was NLMK Verona. NLMK produces alloy and non-alloy ingots and heavy plates for end use in several areas, including shipbuilding, pressure vessels, oil and gas, automotive, and plastic molds. The annual production is about 360,000 metric tons.

The meltshop at NLMK includes an EAF, two LFs, VD, vertical slab caster and ingot teeming. Ingots can be forged on-site with their manipulator and forging press, and finished plates can be produced in their plate mill with quench and temper.

Maurizio Fusato (center), Feralpi Siderurgica director, welcomed the study tour group after the tour of Feralpi Siderurgica's facilities.

Marcello Calcagni (center), NLMK Verona chief executive officer, joined the study tour group on their tour of NLMK Verona.

The 70-metric ton AC EAF is equipped with three oxygen injectors, two carbon injectors and a lime injector. NLMK uses two porous plugs to promote stirring in the EAF. Energy input is 375 kWh/metric ton charged, and the electrodes are 500 mm with a consumption of 1.9 kg/metric ton. The EAF power-on time is 33 minutes and the tap-to-tap time is 50 minutes.

Changes in the economy have required NLMK to add grades, sizes and higher-value products in order to remain competitive in the market.

BELTRAME AFV

Thursday's second tour and our eighth overall was Beltrame AFV. Beltrame has six production plants, four EAFs and 10 rolling mills, for a total production capacity of 3.5 million metric tons per year with locations across Europe. The facility in Vicenza produces merchant and specialty bars.

The meltshop consists of an EAF, LF and two 6-strand continuous casters.

The 160-metric-ton AC EAF has a 130-MVA transformer and 700-mm electrode with an electrode consumption of 0.95 kg/metric ton. The EAF is equipped with four oxygen injectors, five post-combustion burners, four carbon injectors and two lime injectors. Four porous plugs are installed in the bottom of the furnace to stir the bath. The EAF uses offgas analysis to monitor the composition of the gases exiting the furnace.

The EAF has a power-on time of 32 minutes and a 45-minute tap-to-tap time. Electrical energy consumption is reported to be 400 kWh per metric ton billet. The EAF typically uses three charges to get to tap weight. The EAF lining typically lasts 400 heats before repair and renewal.

ABS (ACCIAIERIE BERTOLI SAFAU)

Friday's first meltshop tour was Acciaierie Bertoli Safau (ABS). ABS has an annual production capacity

Marcello Calcagni accepted a plaque of appreciation for hosting the Italy EAF Study Tour's visit to NLMK Verona (left to right): Stephan Ferenczy, Calcagni, Michael Strelbisky and Ronald O'Malley.

The Italy EAF Study Tour delegates visited AFV Acciaierie Beltrame on Friday, 18 November.

of 1.4 million metric tons and its products include billets, blooms, ingots, bar and wire rod. ABS is certified for ISO 9001 for quality, ISO 18001 for safety, ISO 50001 for energy and ISO 14001 for environment.

The ABS meltshop consists of one AC EAF, one DC EAF, two LFs, one VD and three continuous casters. Work is underway to automate the scrap yard.

The AC EAF is inside a doghouse and equipped with three carbon/oxygen injectors, one lime injector, and one oxy-fuel burner. The AC EAF adds three baskets of scrap totaling 110 metric tons and taps 100 metric tons through a spout. The EAF has three porous plugs in order to homogenize the steel. Temperature, carbon and oxygen content of the steel is measured using a Catfis. Electrical energy consumption for the AC EAF is 400–410 kWh per metric ton liquid and oxygen consumption is 28 Nm^3/metric ton.

The DC EAF is equipped with three carbon/oxygen injectors, one oxygen injector in the sump area, one lime injector, two oxy-fuel burners and a slag door oxygen lance. The charge basket is placed on a car and the furnace is charged automatically. The tap weight of the DC furnace is 107 metric tons. The DC EAF supervisory system monitors the laser-based offgas analysis and adjusts the chemical energy profile to reach the desired endpoint. Temperature, carbon and oxygen content of the steel are measured using an anthropomorphic robot. Electrode consumption of this furnace is 1.2–1.3 kg/metric ton. The furnace lining is repaired or renewed every 500 heats. Electrical energy consumption for the DC EAF is 390–400 kWh per metric ton liquid and oxygen consumption is 30 Nm^3/metric ton.

Michael Strelbisky (left) and Ronald O'Malley (right) presented Riccardo Turco (center), ABS chief of process engineering meltshop, with a plaque of appreciation for hosting the Italy EAF Study Tour's visit to ABS.

Caster No. 1 has four strands and makes billets for rounds and wire rod. Caster No. 2 has three strands and makes medium rounds. Caster No. 3 has two strands and makes "jumbo" rounds.

PITTINI FERRIERE NORD

Ferriere Nord produces rebar, rebar coils, wire rod, mesh and also processed slag branded as Granella®. Total production in 2016 for this location in Osoppo was 1.4 million metric tons while Pittini Potenza in southern Italy was 700,000 metric tons. Recruiting and training have been a core component of their success. Pittini has started a training center/school where employees and local residents are able to learn.

The Ferriere Nord meltshop consists of an EAF, LF and caster. The LF has a 32.5-MVA transformer and can heat at 4°C per minute. The caster has six strands, a radius of 7 m and casts 160-mm square billets.

The AC EAF is equipped with a 100+20% MVA transformer and 700-mm electrodes. The furnace charge weight is 167 metric tons and the tap weight is 147 metric tons with a heel that varies between 15 and 40 metric tons. The EAF uses three oxygen injectors, nine post-combustion burners, two lime injectors and four bottom tuyeres for oxygen. The offgas composition is measured and used to control the chemical energy package. EAF electrical energy consumption varies from 350 to 400 kWh per metric ton depending on the scrap and grade of steel being made. Electrode consumption is 1.0 kg/metric ton.

The EAF power-on time is 41 minutes and the tap-to-tap time is 47 minutes. During the tour, we observed a bucket charge operation that took 50 seconds from start to finish. The EAF averages 30 heats per day and 4,400 metric tons per day.

SUMMARY AND CONCLUSIONS

Overall the trip was a valuable experience for all of us. Seeing 10 facilities in five days was an aggressive plan, but it worked out to near perfection. Some of the major things observed during the study tour were: removal of personnel from the operating floor using cages, robots and automatic sampling devices; the widespread use of bottom stirring with porous plugs; the common practice of keeping scrap under roof; adaptation to the global economy by increasing product mix; and the interest and openness to share their practices and experiences with others.

ACKNOWLEDGMENTS

Special thanks to Pat Philbin of AIST and Mike Strelbisky of Tallman Bronze for organizing the tour and helping to keep order during the trip. Thanks also to Jessica Yurko of AIST for arranging all of the reservations and registrations.

The meltshop study tour had several opportunities for fellowship and a little sightseeing. Prior to the start of our tours, Magnesita sponsored our visit to the Museum of the Violin in Cremona, Italy. Inside we saw several of the most valuable violins in the world, including the Stradivarius "Messiah" violin.

Special thanks to the activity and dinner sponsors: Mineral Technologies, Magnesita, AMI/GE, CEBA, Tenova, SMS group, Danieli and Nalco. ✦

The ESTC would like to thank Mauro Milocco, SMS group S.p.A. head of development and product design steel making, for serving as tour guide (left to right): Stephan Ferenczy, Milocco and Michael Strelbisky.