AIST 2019

Oxygen Steelmaking Study Tour

ArcelorMittal Ghent

The AIST Oxygen Steelmaking Technology Committee has held regular international study tours since it first started the AIST Study Tour program in 2007. The strength of these Study Tours resides in the interaction between producers from diverse backgrounds, discussing different operation practices, equipment designs and regulatory compliances. The attendees benefit from the Study Tours by expanding their global networks; learning about unfamiliar mill designs and process methods; discussing different safety standards and regulations; recognizing environmental restrictions outside their region; comparing man-hours-per-ton utilization; seeing different quality innovations and product traceability practices, raw material programs, and steel process bottlenecks and preventive maintenance programs; and future development planning.

The 2019 BOF Study Tour was conducted over the period of 6–11 October 2019. The tour would see the delegation travel from the Netherlands, through Belgium and Finland, to its conclusion in southern Sweden. Included in the study tour were four BOF facilities and two steel research facilities. Seventeen attendees representing 12 steel facilities from nine countries participated in the tour, making it the most internationally diverse AIST Study Tour to date. Representatives came from North and South America, Europe, and Asia, providing a broad and deep pool of experiences and backgrounds.

Tata Steel Europe IJmuiden, 7 October 2019

General Information:

- Built: 1968, with a converter revamp in 1984.
- Steel production: 7 mtpy total (5.5 mtpy slabs, 1.5 mtpy direct sheet plant (DSP)).
- Sinter plant.
- Coke plant.
- Two blast furnaces.
- Two hot metal desulfurization stations.
- Three BOFs (330 tons).
- Two ladle treatment stations.
- One RH degasser.
- Two ladle metallurgy furnaces (LMFs).
- Three slab continuous casting machines (CCMs).
- Product mix: high-strength steel (HSS); high-strength, low-alloy (HSLA) and electrical steel.

Safety and Environment:

- LED-lighted caution areas are displayed in hazardous operation areas.
- HISARNA pilot plant being built to produce hot metal without CO_2.

Automation:

- Hot metal ladle movement, BOF tilting, scrap charge and hot metal charge are fully automated with one-button operation.
- BOF blow process is fully automated.
- BOF tapping is semi-automatic; requires one operator.
- A smart camera is used under the BOF to monitor for slopping severity. If slopping is detected, oxygen is reduced by 15% and the lance is lowered.

BOF:

- Three BOFs (330 tons), operating philosophy based on a two-BOF operation with one spare BOF.
- Blowing time: 18 minutes.
- Samples are taken in-blow (carbon) and at the end of the blow (temperature, carbon and oxygen).
- In-blow slag and steel samples are taken with a sublance sampler.
- A camera is used for tap monitoring. The software recognizes when the dart impacts the tap stream.
- Six bottom tuyeres are used, with two spares.

Tata Steel IJmuiden

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> Lining life: 3,500–4,000 heats.
> Dynamic prediction of carbon using input material data triggers sublance moment.
> O_2 lance life is 250 heats. Change is determined by visual inspection and by FeO change.

ArcelorMittal Ghent, 8 October 2019

General Information:

> Built: 1976, revamp in 2003 and 2018.
> Steel production: 5.6 mtpy as slabs.
> Production: advanced high-strength steel (AHSS), ultralow carbon (ULC), interstitial-free (IF) grades.
> Two hot metal stations.
> Two BOFs; 330 tons/heat.
> Three LMFs equipped with skimming. Built for future HSS production.
> Twin-station RH degasser.
> Continuous Caster #1: Curved machine, hot slab slitting machine, high-strength steels.
> Continuous Caster #2: Vertical bending machine, ULC steels.
> Benchmark improvements in safety, environment, cost, productivity and quality.

Safety and Environment:

> RFID control of operators in all levels of steel plant.
> Gas recovery system to utilize the gas for other applications.
> Dust handling: Primary sludge (wet system) sent to a briquetting press after press-filtering, Zn is controlled in batches, fine dust goes to sinter plant. For high-zinc campaign, dust is sold outside.

Automation:

> Models include scrap, automated blowing of oxygen and dynamic end blowing models.
> Automatic tapping and a pneumatic slag stopper resulted in a 10 kg/ton improvement in yield.
> CCM: Ladle shroud robot. Automated tundish exchange.

BOF:

> 60 heats/day. Two-BOF operation 305 days/year. One-BOF operation 60 days/year (maintenance).
> Tap: 22 minutes in 2/2 operation (44 minutes/BOF).
> During one-vessel operation, tap-to-tap time is 29 minutes/heat; simultaneous blowing not possible, but simultaneous reblow and blow can be operated.
> Bottom stirring: 17 positions for elements but only nine plugs operate.
> Refractory is relined as scheduled. Reline is not determined by brick status. If the lining still shows acceptable thickness close to the scheduled reline, the slag is made to be more fluid during operation.
> Oxygen flow 950 Nm^3/minute; no sublance but drop sensor used as well as sampling during tapping.
> Tap weight increased in 2018 (all ladles changed).

SSAB Europe Oy Raahe, 9 October 2019

General Information:

> Built: 1964 (blast furnaces); 1967 BOF shop (revamp in 2016) and heavy plate mill. Formerly Rautaruukki Oy.
> Production: 2.5 mtpy, heavy plate, high-strength steel, carbon steel.
> Coke oven.
> Two blast furnaces.
> Three BOFs.
> One LMF.
> Three CAS-OBs.
> Tank degasser.
> Three CCMs.

Safety and Environment:

> BOF slag is recycled to the blast furnace.
> 11 wind turbines on-site.


SSAB Oy Raahe

Automation:

> Automatic tap program is 50% complete, utilizing vessel position, cameras, scales and car positioning sensors.
> Models used for temperature, alloying and scheduling.
> All sensors have been developed internally.

BOF:

> Two vessels always in operation with one on standby.
> Tap weight: 125 tons.
> Blow time: 18 minutes.
> Tap-to-tap time: 40 minutes.
> Three BOFs can blow at the same time, but flux addition is for two systems only.
> O_2 blow rate is 350 Nm^3/minute.
> Lance life was 150 heats — improvements to backpressure increased life to 500 heats.
> Bottom stir: Max. 1,600 L/minute per plug. Eight plugs used. Camera watches the bottom plug status and a picture is taken after each heat.
> Bath level: Calculated from laser scans, laser is done each shift from a fixed installation.
> Drop sensor, pneumatic slag stopper, infrared camera and slag detection used.
> 2,000 heats per lining lifetime. Steel shop philosophy is to have 100% bottom stir during the campaign.


SSAB Luleå

SSAB Europe Luleå, 10 October 2019

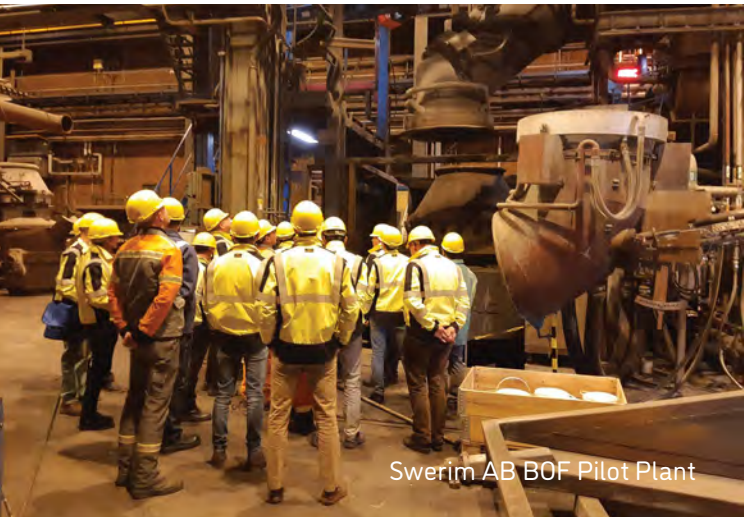
General Information:

> Built: 1940 but BOF steel production began later.
> Site capacity: 2.5 mtpy.
> Production: 2.5 mtpy, heavy plate, high-strength steel, carbon steel.
> Lime kiln.
> Coke plant.
> Single blast furnace.
> Two hot metal desulfurization stations.
> Two BOFs (130 tons each).
> Two CAS-OBs.
> One RH degasser.
> Two CCMs.

Safety and Environment:

> Slag and sludge dust are dumped or converted to self-reducing bricks. Stonemaking plant produces briquettes for blast furnace.

Swerim AB


Swerim AB BOF Pilot Plant

> BOF gas recovery: Offgas recovery heat is used for heat and electricity to local district.
> Hydrogen-based HYL-DRI reduction pilot plant with LKAB planned to start up in 2022.

Automation:

> Auto-tapping since 1998, internal development. Tapping is controlled from control room by the BOF operator.
> Automation features: Auto-tap, auto-deslagging, semi-automatic cranes, automated laser scanning, automated ladle sanding, automated ladle lid handling.
> Scan uses fixed LACAM, 2- to 3-minute scanning time. The laser measurement is also used for lance blow height setup.

BOF:

> BOF lance: 4-hole, 8°, 340–360 Nm^3/minute flowrate. Lance life: 700–900 heats. Lance blow pattern is based on silicon level.
> Slopping detection by camera focused on the pit under the vessel.
> Bottom stirring: Six plugs with N_2, Ar. Goal is to have 100% stirring during campaign. 3,000 l/minute rotating four out of six plugs every heat.
> Lining life is 2,000–2,500 heats.
> Reline is scheduled one year in advance. Outage is for 64 hours from stop blow to start blow. Lining work is done by two groups per shift. During the reline, the blast furnace is stopped for a total of 12 hours.
> Tapping: Slag stopper, bottom stirring in the ladle during tapping.
> Endpoint decision is made by model calculation and observation.

Swerim AB, 10 October 2019

General Information:

> Started in 1966 as MEFOS; merged in 2019.
> Goal is to bridge lab scale to the industrial scale to minimize risks and expenses.

Expert Areas:

> Minerals through rolling and forming.
> Additive manufacturing.
> Environmental life cycle research.
> Fossil-free production.

Priority Projects:

> Fossil-free and CO_2-neutral industry.
> Circular economy.
> Raw material and energy.
> Large-scale pilot and demonstration facilities.
> Process integration digitalization measurement technology and modeling.

Pilot Facilities:

> Two EAFs (AC and DC).
> Universal converter (10- to 12-ton capacity), 1966.

Luleå Technical University

> Ladles for transport.
> Gas cleaning.
> Induction furnaces.

Recent Investments:

> Hydrogen infrastructure (electrolysis unit).
> Subcontractor with HYBRIT to do testing on the HYBRIT pellets.
> Vacuum induction furnace.

Oxygen Steelmaking Research:

> Three different converter bodies to change which converter they use.
> Uses a one- or three-hole lance plus bottom stirring plugs and side tuyeres.
> Three offgas systems have electric static filter, wet venture scrubber or bag filtration.

Luleå Technical University, 11 October 2019

Main Strategies:

> Engineering Materials:
  – Started research on carbide-free bainitic steels, 2001.
  – Additional research on austempering, quench and partitioned steels, and crack formation during casting.
  – Current project is cracking in cast slabs of microalloyed steel.
> Solid Mechanics:
  – Modeling of materials processing and product functionality.
  – Press-hardening steel research: Invented in Luleå 40 years ago. Simultaneous forming and quenching of a steel component.
> Machine Elements:
  – Research on friction, wear and lubrication.
  – High-temperature tribology.


Jens Hardell, LTU associate professor, demonstrates an engine model for lubrication analysis.

For the attendees, a primary focus for the 2019 Study Tour was the technical discussions on subjects that have a strong history in the regions visited. These discussions would provide an equitable exchange of experiences and ideas between many different regions. The technical subjects discussed during the visits included steelmaking automation, environmental practices, BOF refractory maintenance and differences in BOF process operations. With the age of digitalization upon the steel industry, the strongest interest was in different automation systems being utilized by BOF operations.

A special note of appreciation to TML Technik GmbH and RHI Magnesita Europe for supporting the Study Tour by sponsoring dinners during the week. These dinners, as with other dinners sponsored by the steel facility hosts, provided additional time for the attendees and hosts to discuss technical matters and compare operating practices outside the confines of the steel mill. ✦