2019–2020 AIST President Ron O'Malley (right) presents a plaque of appreciation to Anders Persson (left), SSAB Borlänge, for hosting the study tour group.

by Alicia Gauffin

2019 AIST Sweden Long Products Study Tour

The AIST Sweden Long Products Study Tour was held 29 May to 5 June 2019. Together with Jernkontoret (the Swedish steel producers association), AIST's Long Products Technology Committee (LPTC) organized visits to seven facilities: SSAB Borlänge, SSAB Oxelösund, Sandvik Materials Technology, Erasteel Kloster Långhyttan, Ovako Smedjebacken, Fagersta Stainless and SSAB Virsbo.

The Swedish iron and steel industry has a long history dating back to the Middle Ages. Most steel companies in Sweden are found in the district of Bergslagen, which represents the "steel belt" located in the middle region of Sweden, where metal extraction was done as early as the Bronze Age. Even though there are no mining activities today, Bergslagen still has several remains of ancient ironmaking furnaces (Bessemer and Martin) and closed mines that are open for visitors. The iron ore deposits and mining activities are located today in the northern part of Sweden, in Kiruna, where the mining company LKAB is located. The annual iron ore

Left:
On the first day of the study tour, the attendees visited the Vasa Museum in Stockholm (left to right): Marcus Moore, Doug Durand, Chris Petrie, Ron O'Malley, Joseph Kemple, Ricky Adams and Alicia Gauffin.

Right:
The Old City in Stockholm (left to right): Aleksandr Taraso, Natalia Skrobot, Patrick Simonson and Volker Goedecke.

production there was 26.9 million metric tons in 2018.

Sweden has an annual crude steel production of approximately 4.7 million metric tons (2018). To maintain competitiveness in the global market, the Swedish steel industry has been focusing on niche product segments and specialty steel grades. Approximately 60% of the steel production in Sweden is special steel grades. This is significantly higher in comparison to other countries in Europe, which produce approximately 10% special steel grades. Around 60% of Swedish crude steel production is via blast furnace and 40% by electric arc furnace. There are a total of three blast furnace steel plants, 10 electric arc furnace steel plants, about 15 finishing plants in Sweden and approximately 1,000 foundries. Sweden exports about 3.3 million metric tons of finished steel products per year, almost 70% of which are exported to the EU; the rest are sent off to around 150 other countries.

The Sweden Study Tour was attended by 15 participants. The group included the 2019–2020 AIST president, Ron O'Malley from Missouri University of Science and Technology, and representatives from steel-producing companies. Those who were present were: Marcus Moore and Doug Durand of Nucor Steel–Berkeley; Chris Petrie from Steel Dynamics Inc. – Structural and Rail Division; Natalia Skrobot, Ilia Petenkov and Evgenii Shikhmetov of JSC Severstal; and Kirill Lutcenko and Aleksandr Tarasov of PAO Severstal. Joe Kennedy from Quad Engineering Inc. and Ricky Adams from Danieli Corp. represented the LPTC. From supplier companies, Antonio Ambra from AIC North America Corp., Volker Goedecke and Patrick Simonson of LAP GmbH Laser, and Joseph Kemple from Heiko Machine Tools LLC attended the study tour.

The Sweden Study Tour participants met on Wednesday, 29 May, at the Scandic Hotel in Stockholm. Stockholm is the capital of

The group met at the Scandic hotel in Stockholm (left to right): Patrick Simonson, Joseph Kemple, Marcus Moore, Evgenii Shikhmetov, Kirill Lutcenko, Ilia Petenkov, Aleksandr Tarasov, Ron O'Malley, Doug Durand, Alicia Gauffin, Joe Kennedy, Natalia Skrobot, Chris Petrie, Ricky Adams and Volker Goedecke.

Sweden and 1 million people currently live in the municipality. Stockholm is called the Venice of the North because it consists of 14 islands and is surrounded by the ocean. The group went on the hop-on-hop-off bus around Stockholm to see the beautiful city. One of the sightseeing locations was the Vasa Museum, which is located on the island Djurgarden. Vasa is a Swedish warship built between 1626 and 1628 by King Gustavus Adolphus as a military defense for the war with Poland and Lithuania. The Vasa capsized and sank in 1628 on its virgin voyage after sailing barely 1,300 m. After 333 years on the sea bed, the warship was salvaged. Today, Vasa is the world's best preserved 17th-century ship and the most visited museum in Scandinavia. The wood of the Vasa is held together with stainless steel bolts and nails produced by Sandvik Materials Technology.

On Thursday, 30 May, the bus departed Stockholm and drove to Borlänge. The following morning, the group visited SSAB in Borlänge for a tour led by Anders Persson. SSAB is mostly known for producing sheet, coil, plates and strips of high-strength steels and quenched and tempered steels (Q&T). Originally called Domnverket Jernverk, the mill was founded in 1878 and has been part of SSAB since it was formed 40 years ago. SSAB has production plants in Sweden, Finland and the U.S., and has an annual steel production capacity of approximately 8.8 million metric tons. SSAB Borlänge produces hot- and cold-rolled high-strength steel and is SSAB's largest strip rolling system. SSAB Borlänge receives slabs from SSAB Luleå and SSAB Oxelösund. There is approximately 40 km of railroad within the site area. On average, the plant produces 45,000 metric tons a week and there are a total 1,700 people working at the plant. The main product end-use areas are heavy transport, automotive, lifting, containers, etc.

The group then traveled to SSAB Special Steels in Oxelösund. The attendees were greeted by Per Rodseth, SSAB's former technical director who retired in 2004 and works today as a tour guide at the steel mill; Anders Stenberg, technician and an expert on steel-related history; and Tom Blomqvist, technician. The attendees were

Ron O'Malley presents a plaque to the SSAB Oxelösund tour guides (from left to right): Anders Stenberg, Per Rodseth and O'Malley.

served lunch at the steel plant and while they enjoyed their traditional Swedish "Wallenbergare" meal, Anders Stenberg explained the history of SSAB. SSAB was founded in 1978 following a government decision in response to the steel crisis in 1970. SSAB was a merger of several steel and mining companies, including Stora Kopparbergs Bergslags AB, Gränges AB, Norrbottens Järnverk AB and Tibnor.

After lunch, the attendees were divided into three groups and were guided through the blast furnaces (BFs), converter and ladle refining processes, continuous casting, and rolling mill. SSAB Special Steels in Oxelösund has approximately 2,400 employees. The plant has two blast furnaces: No. 4 BF with a capacity of 3,000 tons of hot metal/day and No. 2 BF with a capacity of 2,200 tons of hot metal/day. The Oxelösund operations produces Hardox® wear plate, Strenx® high-strength structural steel, Armox® protection plate, and Toolox® engineering and tool steel. The facility has other services such as coke production, pig iron production, post-treatment of the steel, continuous casting, formatting, quenching and tempering, and painting and marking. The deliveries of their product segments are done from their own deep harbor port. The production portion of the mill is around 4 km^2 in area.

After the BF, the hot metal goes though desulfurization by using CaC_2 injection in the hot metal cars. The mill has one basic oxygen furnace (BOF)/LD converter with a lance station, ladle and vacuum treatment, and two continuous casting machines for slabs and blooms. The plant is equipped with a Quarto plate rolling mill, which is one of the strongest mills in the world (10,000 ton/cm^2). The thicknesses can be 3–155 mm, with a maximum width of 3,500 mm and maximum length of 60 m.

SSAB is working together with LKAB and hydropower company Vattenfall on a project called HYBRIT. The project, which started in 2016, aims to replace coking coal by using hydrogen to produce direct reduced iron (DRI). If they succeed, it will be the world's first fossil fuel–free steelmaking technology with near-zero carbon emissions. The first pilot plant was constructed in 2018 in Luleå, Sweden. The goal is to have a solution by 2035.

On Saturday, 1 June, the attendees traveled to Sala Silvergruva, which is an ancient silver mine located in Bergslagen. The group went to the local cafeteria and had some coffee and various Swedish traditional sweets. It is Swedish tradition to take at least one break per day to get together and have some coffee and sweets — this is called "Fika." After the Fika, the group went on a guided tour of the silver mine. The guide was dressed in an old-fashioned outfit to resemble the time when the mine was still in production, from 1400 until its closure in 1908. The group was equipped with hard hats, which were put to good use due to the narrow pathways through the old mine. The guide explained the mine and its history, the workers and their lives, and the techniques to break the rocks in the mine. These different mining techniques were fire-setting, gunpowder and dynamite. During the Bronze Age, the mining technique was to put up a fire-setting overnight. The miners then went down to the mine the next day to break the brittle rocks that had cracked due to the heat from the fire. One fire-setting would mine 4 inches of rock. This was a very time-consuming process. The guide showed the attendees the largest mined cavity and sang a beautiful old song from the times the miners used to work there in the darkness. The Sala Silvergruva also has an underground hotel suite.

After the tour, the group traveled to Falun and had dinner at Banken Bar & Brasserie sponsored by LAP Laser.

On Sunday, 2 June, the group traveled to Kopparbergslagen, which is a copper mine. The copper mine is a World Heritage property and is protected under Swedish legislation. The mining activities in the area started around 700 and ended in 1992. During the Middle Ages, the mine

Left:
The guided tour of the Sala Silver mine.

Right:
The guided tour of the Falu Copper mine.

Right:
Ron O'Malley presents a plaque of appreciation to the guide Conny Fredriksson at Fagersta Stainless.

produced two-thirds of Europe's copper. The highest production was during the 17th century, when Sweden was a great power. During this time, the mine produced two-thirds of the entire world's copper ore and had more than 1,000 workers.

On Monday, 3 June, the group traveled to Sandvik Materials Technology in Sandviken. The group was greeted by Olle Sundqvist, research and development (R&D) expert metallurgist; Peter Karngren, rolling forging manager; Ebrahim Moosavi, R&D specialist, rolling and forging; and Fia Vikman, R&D engineer casting. The steel mill personnel gave a presentation about the company's profile and product segments. Sandvik Materials Technology is a leader in systems, equipment, tools for mining and construction industries, and high-value-added products and advanced stainless steels. Sandvik Materials Technology supplies products for highly demanding industries such as aerospace, automotive, nuclear power generation, oil and gas, industrial heating, chemical, and renewable energy. The product segments that are produced at Sandvik are tube, strip, bar, billets, hollow drill steel, resistance materials, etc.

The tour groups saw the electric arc furnace, ladle furnace, argon oxygen decarburization converter, continuous caster, bloom mill and bar mill. Lunch was served at the steel plant. After a meal and fruitful discussion, the group traveled further north to Erasteel Långshyttan.

The group was greeted by Jan-Erik Samuelsson, head of process developments; Erik Elfsberg, principal mechanical engineer; Bengt Nygren, process development engineer; and Avdulla Mazreku, engineer. Erasteel Långshyttan belongs to Erasteel Kloster AB, which is a manufacturer of high-speed steel and gas-atomized powder, high-strength steels, special steels, and tool steel. The company has approximately 400 employees at three different sites in Sweden: Långshyttan, Söderfors and Vikmanshyttan. The company is part of the French group Eramet, which mainly works with mining. Erasteel was formed in 1992 by the merger of Kinnevik-owned Kloster Speedsteel and French speed steel manufacturer Kommentryenne. Outside the steel plant

sits a Bessemer furnace from 1861, which had been in production at the site.

After the plant visit, the group had dinner at Tva Rum & Kok in Falun. The sponsor for the dinner was LAP Laser.

On Tuesday, 4 June, the group traveled to Ovako Smedjebacken. The group was greeted by Eva Friberg, steel mill manager; Annika Hibell, technical director; and Tomas Lind, rolling mill director. Annika Hibell gave a presentation about Ovako. The company has nine production sites around the world with a total of 3,100 employees. In June 2018, the company was purchased by Nippon Steel & Sumitomo Metal Corp. Ovako produces a wide range of special steels, including hot-rolled bars, round, square, flat, pre-components, hard-chromed plated bars and tubes, hydraulic cylinders, wire and bar-in-coil, seamless tubes and hollow bars, and rolled and forged rings.

The Smedjebacken site has a 125-ton EAF, ladle furnace, 6-strand continuous caster, roughing stand and bar rolling mill. They are currently installing a vacuum tank degasser (VTD). After the tour, the group was transported to a local restaurant for lunch. Everyone had a fruitful discussion over a traditional Swedish meal. The group then went on the bus and traveled to Fagersta Stainless in Fagersta.

At Fagersta Stainless, the group was greeted by Conny Fredriksson, technical director, and Per Jansson, production manager. Fagersta Stainless is a stainless wire rod and wire producer that is part of Outokumpu. It produces ferritic grades, austenitic grades, PH grades, duplex grades and customized grades.

At the entrance of Fagersta Stainless head building, sits the first-ever Brinell hardness testing machine. The Brinell harness testing machine was invented by Johan August Brinell, who worked as chief engineer at Fagersta Stainless from 1882 to 1903. During that time, he managed to double the production at Fagersta Stainless. The Brinell machine was displayed at the World Expo in Paris in 1900. More of the Brinell exhibition can be seen in a museum next to the head office.

After the plant visit, the group traveled to SSAB in Virsbo. The group was greeted by Hans Åkerblom, sales director for expandable rock bolts; Jan Beijbom, technical and quality manager; and Roger Berglund, engineer. SSAB Virsbo is part of the Specialty Products group within SSAB Special Steels. The plant produces long products, expandable rock bolts, tubes and bars. There are 56 employees at the facility and there are four lines for the production of expandable rock bolts and two welding lines for diameter ranges 20 to 133 mm.

The expandable rock bolts are folded tubes (C-section) that expand in a bore hole to secure the rock wall from caving in. The tubes are used to secure rock walls for mining and tunneling. SSAB was the first in the world to produce expandable rock bolts and has more than 40 years of experience

Ron O'Malley visited the first-ever Brinell testing machine, which is displayed at the entrance of the Fagersta Stainless headquarters.

Top:
Site visit at Kanthal.

Bottom:
The group met at Jernkontoret in Stockholm.

in their production and development. Hardox tube is used for transportation and handling of wear fluids and material. It has a diameter of up to 219.1 mm and thickness in the range of 3 to 6 mm. Strenx Tube 700 QLH are high-strength hollow structural sections. They are cold-formed and welded and quenched and tempered, and are designed to be used when weldability (uniform strength) is required and no residual stresses are allowed.

The group was guided through the heating furnaces, rolling mills, welding lines, and finishing and testing lab. After the tour, the group traveled to Vasterås. Dinner was held at Restaurant Limone. The sponsor for the dinner was AIC North America Corp.

On Wednesday, 5 June, the group traveled to Kanthal in Hallstahammar. Everyone was greeted by Roger Berglund, senior expert powder metallurgy R&D; Dilip Chandrasekaran, head of R&D and technology product area; Malin Borjeson, unit manager R&D; Stephanie Stockmeier, senior process development engineer; Johan Håkansson, engineer manager; and Enver Bajramaj, product manager metallic system.

Kanthal is a part of Sandvik Materials Technology. Kanthal has operations at two different sites in Sweden: Hallstahammar and Surahammar. The product segments at Kanthal are heating materials, resistance

heating and high-temperature alloys for temperatures up to 2,000°C (3,632°F). Another product segment is heating systems, products, components, systems and services for thermal processing. Kanthal also produces the broadest range of products and systems for industrial heating. The company handles everything from raw material of scrap, melting and processing to shipping of products.

After the tour, the group had lunch at the steel mill before they traveled to its last destination, the Swedish steel producers' association (Jernkontoret) head office in Stockholm. The attendees were greeted by Rachel Pettersson and Robert Vikman. The meeting started with a presentation about Jernkontoret and its diverse activities from education, research and development, publications and handbooks, to lobbying, conferences, etc. Ron O'Malley then gave a presentation about AIST's activities to promote the steel industry. The study tour attendees were then asked to speak about their own companies and product segments and their takeaways from the Sweden Study Tour.

After the meeting, the group went back to the hotel. Everyone met for the farewell dinner at Villagio in Stockholm. The sponsor for the dinner was Danieli Corp.

The Study Tour was concluded on Thursday, 6 June 2019. A reciprocal North America Long Products study tour will be organized in mid-summer 2020. ✦

Ron O'Malley presents a plaque of appreciation to Jernkontoret.