2017

Ron O'Malley (left) presented a plaque of appreciation to Jun Eguchi (center), manager, steelmaking section, Chita Plant, and Masayuki Shiratori (right), associate senior engineer, steelmaking section, Chita Plant, Daido Steel Co. Ltd. for hosting the tour group.

AIST Japan Caster Tour Recap

By Rudolf Moravec

The Association for Iron & Steel Technology (AIST) and The Iron and Steel Institute of Japan (ISIJ), with their affiliated technology committees for continuous casting, worked together to prepare a study tour in Japan for the end of 2017. The tour included an interesting mix of flat and long product steel producers and a variety of plants using steel produced with the electric arc furnace (EAF) as well as the basic oxygen furnace (BOF) manufacturing processes.

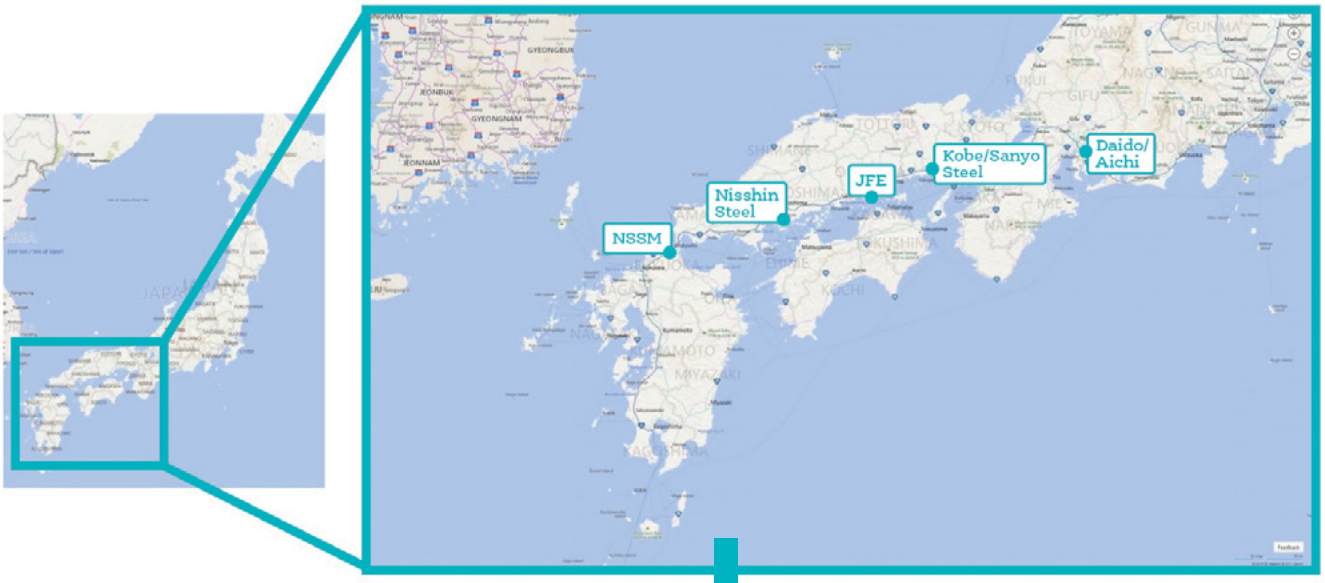

Fig. 1 — Travel map of the visited plant locations.

U.S.–based steel manufacturing companies have a long and interesting history of cooperation with Japanese steel industry firms. Some of them even today have joint-venture projects in the U.S. On the other hand, very little is published about the status of continuous casting technology in Japan, and therefore knowledge about trends in this area of steel production are not well known. All of these factors triggered a huge interest in this tour among U.S. producers. The final itinerary included three long product producers (Sanyo Special Steel, Daido Steel Co. Ltd. and Aichi Steel) and four flat product producers (Kobe Steel, JFE Steel, Nisshin Steel and Nippon Steel & Sumitomo Metal Corp.). Fig. 1 shows the locations of the plants visited.

A maximum of 23 attendees were approved by ISIJ, with only producers being allowed to participate. Among the participating companies, seven attendees were ArcelorMittal representatives, three from United States Steel Corporation, two from TimkenSteel Corp., two from Steel Dynamics Inc., two from Nucor Corp., two from Ternium Brasil and one from Stelco. In addition, there were two representatives from TMEIC, the organizer of the trip; one AIST staff member; and one representative from Missouri University of Science and Technology. The tour group was accompanied by a representative from the ISIJ.

On Monday, 6 November 2017, the first stop of the tour was Kobe Steel – Kakogawa Works. The plant is located around 50 miles east of Osaka on the east coast of Japan. Kakogawa Works is currently undergoing a modernization phase as well as increasing capacity. Kobe Steel decided to shut down primary operation sites at Kobe Works due to asset optimization in 2017. Among the US$600 million capital expenditure for this project was a new bloom caster. In 2016, Kakogawa Works produced 7 million metric tons of crude steel; 2.7 million metric tons were long products. The site currently employs 2,700 employees. Its product range includes plate, hot- and cold-rolled strip/sheets for automotive, construction and household appliances. The fully integrated mill includes three blast furnaces that supply hot metal to the pre-treatment plant. Desulfurization of hot metal is done at a Kanbara reactor (KR) station and dephosphorization of hot metal in a separate process to prepare hot metal for further steelmaking processing. Pre-treated hot metal is charged into one of three BOF vessels. Secondary metallurgy includes various treatment stations: two ladle furnaces, two composition adjustment by sealed argon (CAS) stations and four Rurhstahl Heraeus (RH) degassers. Steelmaking operations include five continuous casting machines, all of which were being used during the visit. A brand-new bloom caster, 6CC (start-up in early 2017), was the highlight of the tour. This 5-strand caster was designed and built by Kobe. The produced bloom has a size of 300 x 430 mm. The caster has a 63-metric-ton tundish and it is equipped with a stopper rod for start-up operation and a slidegate system for regular casting operation. The caster has a straight 1-m-long mold instrumented with thermocouples for breakout protection. The machine is fully segmented (33.4 m) to achieve superior surface and internal bloom quality. The annual capacity of this caster is 1.7 million metric tons. The steelmaking facility operates another bloom caster

(2CC), which started up in 1980 and has a bloom size of 380 x 630 mm. The slab casting building is in close proximity to the BOF shop and includes three continuous slab casting machines. The 2-strand slab caster (3CC) and 1-strand slab caster (4CC-1STR) are vertical bending–type and are mainly dedicated to strip production. The 4CC-2STR is also a vertical bending–type caster with one strand where slabs for plate mill production are being cast.

The next stop on the first day was long product producer Sanyo Special Steel. The production site was located just 20 miles south from Kobe Steel – Kakogawa Works. Sanyo Special Steel produces steel at two steelmaking facilities. The products range from bearing steel and tool steel to engineering steel. The steelmaking facility visited has a 150-ton EAF, ladle furnace, RH degasser and a 3-strand vertical bloom caster. Total yearly production is around 1 million metric tons. The continuously cast blooms are 380 x 530 mm in size with an average casting speed of 0.5 m/minute. One of the unique characteristics of this caster is that it uses a specially designed tundish (Sanyo New Refining Process or SNRP) with two separate chambers for better inclusion removal. The caster holds a record for casting 100 heats on one submerged-entry nozzle (SEN).

On Tuesday, 7 November 2017, the delegates visited JFE Steel – Kurashiki Works. This plant is part of JFE Steel Corp. West Japan Works, which has a total production capacity of 19.5 million metric tons. JFE was created in 2002 through the merger of NKK and Kawasaki Steel. Product portfolio of JFE Kurashiki Works includes electrical steel, plate, hot- and cold-rolled sheets, and seamless pipes. Two steelmaking plants are fed from two blast furnaces with a total capacity of 27,000 metric tons per day of hot metal. The tour group visited the No. 2 Steelmaking shop, where total steel production is around 6 million metric tons. All hot metal is processed through a pre-treatment center where silicon and phosphorus are removed directly in torpedo cars. The steelmaking shop is equipped with a KR station for hot metal sulfur removal, three K-BOP vessels, two twin RH (Kawasaki top blowing or KTB) degassers, ladle furnace and two 2-strand slab casters. The ladle size is 345 metric tons. The No. 6 CCM is a fully vertical caster for plate production, with nine segments. It has a 16-m metallurgical length and 1 m/minute average casting speed. It was impressive to observe the bending of the slab directly from a nearby observation deck. Slab thicknesses that can be cast are 215, 260 and 310 mm. The next caster visited was the No. 4 CCM. This is a vertical bending machine with a 3-m-long straight section. The caster is capable of casting up to 3 m/minute. Its metallurgical length is 45 m, with eight segments in the bow and 11 segments in the horizontal section. The tundish size is an impressive 80 metric tons. A hot tundish recycling

Ron O'Malley (left) presented a plaque of appreciation to Jin Yoshida (right), manager, steelmaking technology section, Kobe Steel Kakogawa Works.

Ron O'Malley (left) presented a plaque of appreciation to Kazuya Mishima (center), general manager, steelmaking department, Sanyo Special Steel.

technique is used for this caster. This technique allows the refractory lining to be used for up to 500 heats without any spray material.

After the tour at JFE Steel, the longest bus ride on the tour was to Hiroshima. The trip took around 3 hours. The schedule for the next day was a tour of Nisshin Steel – Kure Works. Kure Works is located 20 miles south of Hiroshima. The group utilized this opportunity and visited the Hiroshima Peace Memorial Museum and Atomic Bomb Dome site to pay their respects and remember the past.

Nisshin Steel – Kure Works has a very interesting location compared to the previously visited plants. It is located at the end of the bay area at Kure City, next to a shipbuilding yard. Nisshin Steel became part of Nippon Steel & Sumitomo Metal Corp. in early 2017. Kure Works operates two steelmaking facilities where each has one slab caster. Both casters were visited during the tour. Steel production capability for Kure Works is 3.5 million metric tons per year. Hot metal is produced in two blast furnaces with total hot metal production of 10,000 metric tons per day. The No. 1 Steelmaking shop has two 90-metric-ton BOF vessels and a ladle furnace. The 2-strand caster is a fully vertical type and it is dedicated to production of high-alloyed and stainless steel grades. It has a metallurgical length of 12.8 m with a slab thickness of 200 mm. After a quick visit at this vertical caster, the group moved to the No. 2 Steelmaking shop. A 185-metric-ton BOF vessel and RH degasser are producing steel for a 2-strand vertical bending–type caster. Total steel output for this shop is 2.7 million metric tons per year. The vertical section of this machine is 3.5 m. The majority of slabs produced at this caster are hot charged into the nearby hot mill.

Ron O'Malley (right) presented a plaque of appreciation to Takashi Yamauchi (center), manager Kurashiki steelmaking technology section, and Yusuke Watanabe (left), staff assistant manager, JFE Steel.

Ron O'Malley (center) presented a plaque of appreciation to Hideki Tanaka (left), general manager, steelmaking department, Nisshin Steel – Kure Works, and Masahiro Isobe (right), leader, technology team, steelmaking department, Nisshin Steel – Kure Works.

The next stop was in the northern part of Kyushu island where we were scheduled to visit Nippon Steel & Sumitomo Metal Corp. – Yawata Works. Yawata Works consists of three different plants — Yawata, Tobata and Kokura. Only the Tobata plant was visited. This plant includes No. 1 and No. 3 Steelmaking shops. Only the No. 3 shop was visited during the tour. The visit started unexpectedly at the cast floor of the blast furnace and caught everybody by surprise. However, this stop showed everybody how the company is serious about environment, safety and housekeeping issues. Even standing a couple yards from the tapping side of the blast furnace, no smoke, dust or flying graphite was visible, which was very impressive.

Ron O'Malley (right) presented a plaque of appreciation to Shinsuke Ikegami (center), general manager, vice head of works, Yawata Works, and Masato Kobayashi (left), general manager, head of Tobata Steelmaking Technical Department, Steelmaking Division, Nippon Steel & Sumitomo Metal Corp.

No. 3 Steelmaking shop is equipped with a hot metal mixer with a 2,000-metric-ton capacity and induction heating capability, desulfurization stations – KR and injection, two Linz Donawitz-optimized refining process (LD-OPR) vessels, two revolutionary degassing activator (REDA) degassers, and four CAS-OB stations where the heat size is 350 metric tons. The shop has four 1-strand casters. The No. 1 strand is a curved machine mainly dedicated to stainless steel, which is produced at the No. 1 Steelmaking shop. The 30-metric-ton delta-shape tundish is equipped with plasma heaters. The No. 2 and 3 strands are vertical bending machines with 2.5-m

Jumpei Konishi (right), general manager head of steelmaking technology division, Nippon Steel & Sumitomo Metal Corp., presented Ron O'Malley (right), second vice president of AIST and Continuous Casting Technology Committee study tour chair, with a plaque of appreciation.

straight sections. The No. 4 strand is a combo caster with a curved mold. Five different bloom sizes can be cast. No. 3 and No. 4 strands used the same type of tundish design, which is equipped with induction heating. One of the highlights was the superior cleanliness of steel production, where no tundish flux is used. The tundish is sealed and argon purged during casting.

After the tour, a lunch was organized to offer an opportunity for further discussion and a chance to listen to a little bit of the history of Yawata Works. Some of the parts are on the list of UNESCO World Heritage Sites.

A highly anticipated train travel followed immediately after the lunch. The group traveled from Kokura to Nagoya, the last stop of the tour, by high-speed bullet train. The journey of 500 miles took 3 hours with a maximum train speed of 180 miles per hour.

Before the last day of the tour, the delegates had an opportunity to meet with ISIJ Casting Committee members, who represented the companies visited during the tour. This banquet started with the ISIJ Casting Committee chair addressing past cooperation experiences and future possibilities. On behalf of the AIST Caster Study Tour participants, Ron O'Malley, AIST Continuous Casting Technology Committee study tour chair, thanked everybody for their effort to accommodate this group and invited them to visit the United States for a similar tour.

Two visits were scheduled on the last day of the tour. Daido Steel – Chita plant was the first stop. The production focuses on alloyed steel, free-cutting steel, bearing steel, spring steel and stainless steel. Total production of the plant is 140,000 metric tons/month. The steelmaking facility includes four 80-metric-ton EAFs and one 150-metric-ton EAF, three ladle metallurgy furnaces, three RH degassers, and an argon oxygen decarburization (AOD) converter. Casting capabilities included two bloom casters, promising hybrid caster (PHC) jumbo caster and ingot casting. The tour route included a visit to the EAF viewing room, where the 150-metric-ton EAF operations could be observed via a large window and all technical details about the plant could be seen. This EAF has a unique way to accelerate scrap melting without increasing energy cost. The principle is to rotate the EAF shell by 50° after the second scrap bucket is charged. The distance to the unmelted scrap from the electrodes is changed to a closer proximity and therefore final melting is faster. With this improvement, the energy power consumption was reduced by 5%. The next stop during the Daido tour was CC1, a 2-strand bloom caster with a bloom size of 370 x 510 mm. The caster is equipped with all three types of electromagnetic stirrers along the strand — MEMS, SEMS and FEMS. The bloom surface temperature is monitored with pyrometers, and if an anomaly occurs, hot scarfing is available to improve surface quality. CC2 was the last stop of this tour. CC2 is a fully vertical caster with four strands and with only one format to cast — a 350-mm round bloom. This caster is equipped with dynamic soft reduction, a plasma heater in the tundish, and mold and strand stirrers. One more thing that should be mentioned, even though it was not visited, was the PHC caster, which allows batch casting (two strands) of 650 x 850 mm blooms.

The last stop of the study tour was Aichi Steel, which is in proximity of Daido Steel. This plant was originally a Toyota plant for supplying the automaker with necessary steel parts. In the product portfolio, one can find all automotive components that can be made from steel. Two steelmaking shops are being utilized for production. The No. 2 shop was visited, where a 150-metric-ton EAF, ladle furnace and RH degasser are installed. The continuous caster visited is a 3-strand bloom caster with a casting size of 480 x 370 mm. The caster is equipped with a tundish plasma heater, dynamic soft reduction and hard reduction, which is applied to the fully solidified bloom. Unfortunately, there was a caster maintenance outage during the visit.

Aichi Steel was the final stop on the study tour.

Study tours are not only a great opportunity to visit manufacturing plants and learn different approaches to producing steel, but also to allow participants to interact among themselves. Another unique thing is experiencing different cultures. Traveling to the south of Japan gave the delegates an opportunity to visit some historical and cultural sites. While staying in Osaka, the group had a chance to visit two historical places in proximity of Kyoto, Nijo-jo Castle and Fishimi Inaru-taisha.

Very clear examples of how to approach environmental and safety topics were seen in each of the plants visited. Furthermore, a clear bond with the community was highlighted during each introductory presentation. If something was a little bit surprising, it was the minimal amount of automatization observed and lack of modernization viewed in the control rooms, where it appeared that time stopped several years ago compared to U.S. plants.

The study tour delegates thank their dinner sponsors, NALCO, SteelPlantech, ArcelorMittal, United States Steel Corporation, Steel Dynamics Inc. and TMEIC, for providing a dinner. This dinner not only increased participants' knowledge, but tickled their taste buds with real Japanese food.

Finally, the delegates are appreciative to TMEIC for the logistic planning. They did an excellent job with all the arrangements, not only for transportation and lodging but also with sightseeing stops to get a little bit of Japanese culture and history. Thank you Ippei, Kazuto and Thomas!

In remembrance of tour comrade, colleague and friend Chris Kennedy, 60, who passed away on 5 January 2018. ✦

AIST Caster Study Tour group enjoyed a dinner sponsored by TMEIC: Pat Philbin (right), AIST, with Ippei Shibata (left), TMEIC.