2015 Germany Caster Study Tour Report

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Pictured is the 2015 Germany Caster Study Tour group, representing nine international steel companies with 29 AIST members, at the start of the Völklingen Iron Works historical tour.

The AIST Continuous Casting Technology Committee (CCTC) is one of the largest AIST Technology Committees in terms of number of members and their participation in the committee meetings. Almost all producers and suppliers that have something to do with continuous casting are represented on this committee. Therefore, when the idea of organizing a first-ever caster study tour came up, the first part of a successful tour — favorable participation in the event by the members — was ensured. The second part of a successful study tour is the correct selection of operations to visit that would be of interest to all CCTC members. The AIST Oxygen Steelmaking Technology Committee (OSTC) held a successful study tour in Germany when it visited the country's basic oxygen furnace (BOF) steelmaking shops in 2007. Therefore, it was thought that Germany should be selected as the first CCTC study tour site; in fact, the negotiated study tour plan generally duplicated that of the 2007 BOF study tour.

Twenty-nine attendees, representing companies such as ArcelorMittal, United States Steel Corporation, Gerdau Long Steel North America, Charter Steel, AK Steel Corp., Steel Dynamics Inc., and special guests from JFE Steel Corp. (Japan), Tata Steel (U.K. and India) and Ternium Siderar (Argentina), obtained approval to visit and benchmark the most modern steel shops in Europe. The main focus was on caster operations. Five U.S. supplier representatives attended, along with U.S. producers. The delegates would like to recognize the two chairs who worked hard to organize the trip: Michael Strelbisky from Tallman Bronze Co., who organized the technical exchange, and Ronald O'Malley from Missouri University of Science and Technology. In addition, Jürgen Cappel from Cappel Stahl Consulting in Germany joined the group.

The locations of Germany's steelmaking facilities are illustrated in Fig. 1. The study tour focused on two areas where integrated metallurgical plants

Fig. 1: Locations of Germany's steelmaking facilities.
Source: WV Stahl.

are mainly located — Völklingen/Dillinger and Duisburg.

On Sunday, 8 November, the participants met in Frankfurt to begin their journey, which included visits to six steelmaking facilities, one conference, a technical exchange with the VDEh Steelmaking Committee and a visit to an OEM supplier.

Völklinger Hütte World Heritage site at Völklingen (UNESCO listed from 1994) was visited on Sunday evening. The Völklingen Iron Works in western Germany, close to the border of France, covers 14 acres and is a unique monument to pig iron production in Western Europe. No other historic blast furnace complex has survived that demonstrates the entire process of pig iron production in the same way, with the same degree of authenticity and completeness, and is underlined by such a series of technological milestones in innovative engineering. The Völklingen monument illustrates the industrial history of the 19th century in general and also the transnational Saar-Lorraine-Luxembourg industrial region in the heart of Europe in particular. The iron works are a synonym for and a symbol of human achievement during the First and Second Industrial Revolutions in the 19th and the beginning of the 20th centuries. The ironmaking complex dominates the townscape of Völklingen. It contains installations covering every stage in the pig iron production process, from raw materials handling and processing equipment for coal and iron ore to blast furnace iron production, with all the ancillary equipment, such as gas purification and blowing equipment. The installations are exactly as they were when production ceased in 1986. The overall appearance is that of an iron works from the 1930s, since no new installations were added after the rebuilding of the coking plant in 1935. There is considerable evidence of the history of the works in the form of individual items preserved substantially in their original form. Large sections of the frames and platforms of the blast furnaces, for example, have not been altered since their installation at the turn of the 20th century. Much of the original coking plant survives, despite the 1935 reconstruction, notably the coal tower of 1898. Six of the gas-blowing engines, built between 1905 and 1914, are preserved, as are the suspended conveyer system of 1911 and the dry gas purification plant of the same time (Figs. 2a and 2b). To complete the first day, the group gathered for traditional Saarland dishes at Stiefelbrau Restaurant, hosted by Darrell Sturgill of IMERYS (formerly Stollberg).

On Monday, 9 November, the group visited the first operations site, Saarstahl AG. Senior division manager of continuous casting operations Gerhard Ney made an introductory presentation about the company history, its product portfolio, the steel plant

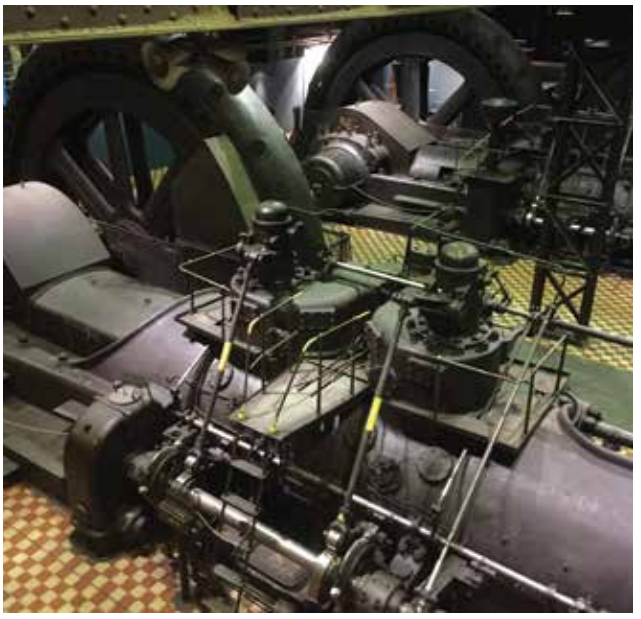

Fig. 2a: Gas-blowing engines.

Fig. 2b: Suspended conveyer system.

operations and recent modernization upgrades. The Völklingen site is Saarstahl's only steel production site. Fig. 3 shows another two locations where rolling mill facilities are located. ROGESA is an ironmaking joint venture with AG Dillinger Hütte. In 2014, the company's steel production peaked at 2.7 million metric tons, the highest volume of crude steel production in the last five years. The company has 4,000 employees, while the Völklingen site employs 2,600 people. Saarstahl AG sales consist of 68% wire rod product, 26% bar product and the remainder is billet product. They export around 8% of total production into the NAFTA region. The R&D department has a total of 60 employees with four personnel (three engineers and one technician) who are dedicated to casting issues.

The steel shop is currently operating two BOF vessels (total of three vessels) with a 5–8% scrap ratio in the charge. Because the product mix includes high-alloyed grades, two induction furnaces are available for pre-melting ferroalloys (FeCr and FeMn). When the new secondary steelmaking facility was commissioned in 2013, the utilization of these induction furnaces decreased significantly. The new secondary steelmaking facility includes two twin-ladle furnaces and a new RH degasser unit. This was a €25-million modernization project.

Other production facilities in the shop are three hot metal desulfurization stations and two injection stations for steel treatment. Steel production is around 50 heats per day with a ladle size of 180 metric tons. The casting operation has three billet casters and one bloom caster available. Originally, the shop had five casters, but one is currently idled. An overview of the operating casters is given in Tables 1 and 2.

Continuous Bloom Caster	3
Start-up	2009
Manufacturer	SMS Concast, CH
No. strands/machine type	5/Curved
Bloom size, thickness x width or diameter in mm	240x240 and 265x340
Nominal capacity	960,000 t/a

Table 1: Operational data for Saarstahl AG bloom caster

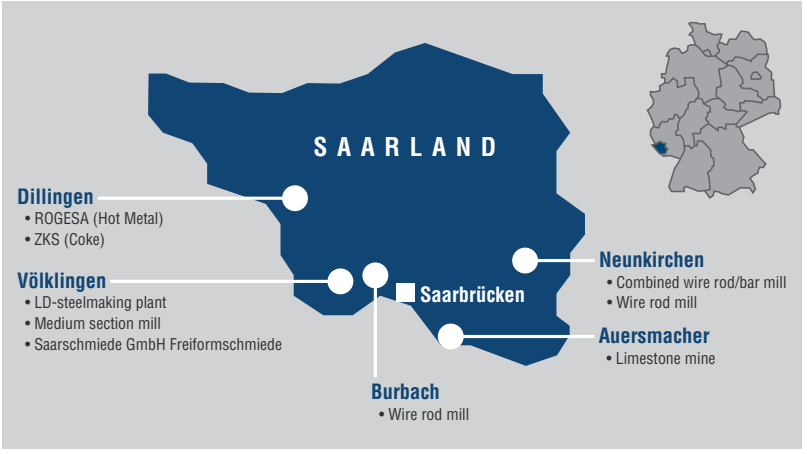

Fig. 3: Saarstahl's various operation locations.

Continuous Billet Caster	0	2	4
Start-up (last modernization)	2004	1981	1981 (1998)
Manufacturer	SMS Demag, DE	Mecan-Arbed, LU	Mecan-Arbed, LU
No. strands/machine type	6/Curve Convex®	6/Curve (bow)	6/Curve Convex®
Billet size, min.–max. in mm	150–180	125–125	150–150
Nominal capacity	120,000 t/a	840,000 t/a	960,000 t/a

Table 2: Operational data for Saarstahl AG billet casters

Continuous Slab Caster	3	4	5	6
Start-up (last modernization)	1968 (2002)	1975 (2003)	1998 (2010)	2014
Manufacturer	SMS, DE	SMS Concast, CH	SMS, DE	SMS Siemag, DE
No. strands/machine type	2/Vertical with solid slab bending	2/Vertical with solid slab bending	2/Vertical with solid slab bending	2/Vertical
Slab size in mm/thickness x width (range in mm)	200–300 x 860–1,600	200–350 x 1,600–2,200	300–450 x 1,400–2,200	300–450 x 1,400–2,200
Nominal capacity	1,200,000 t/a	1,200,000 t/a	1,400,000 t/a	1,500,000 t/a

Table 3: Operational data for Dillinger Hütte slab casters

On Monday afternoon, the members traveled to Dillingen for the Dillinger Hütte steelmaking facility visit. This was one the most anticipated visits due to the nature of the casting operation units. Ralf Bruckhaus, steel plant general manager, welcomed the participants, provided an introduction to Dillinger Hütte and described the steel plant in detail. Dillingen was the site of the first plate mill in Europe, and in 1961, Europe's first continuous caster was built here. In 1969, the current BOF facility was started. In 2014, the plant produced approximately 2.4 million metric tons of crude steel with around 5,000 employees. The plant is currently operating two BOF vessels, two stirring stations and has four vacuum tank degasser (VTD) stations available. Two of the VTD stations have the capability to reheat steel with oxygen. All produced heats are treated at the degassing station. A small portion of production (4%) is cast into ingots. The plant produces 40 heats per day with a heat size of 185 metric tons.

The visit focused on the No. 5 caster operations from the tundish, mold and through the unbending area, finishing at the torch machine area, with detailed descriptions of each part of the caster. A more detailed overview of each caster is given in Table 3.

Casters 3, 4 and 5 are vertical casters with solid-slab bending into horizontal position. The new No. 6 caster is a completely vertical caster even through torch cutting of the slab. The total height of the caster is 55 m, with 40 m below ground level. There are two main benefits that can be derived from the vertical machine: better inclusion flotation from the steel without entrapment in the top sub-surface of the cast slab and no bending or straightening of the slab, which means the slab surface never undergoes these steps in the critical ductility trough region.

Ralf Bruckhaus (center), steel plant general manager, Dillinger Hütte, received a plaque of appreciation from Ron O'Malley (left), technical chair of the CCTC, and Michael Strelbisky (right), study tour chair.

Sven Karrasch, head of continuous casting senior manager (center), ThyssenKrupp Bruckhausen, received a plaque of appreciation from Michael Strelbisky (left) and Ron O'Malley (right).

The newly expanded mold and segment shop was visited for a detailed look at the molds, segments and copper designs.

The day concluded at the Undine Saarbrucken restaurant, and dinner was generously hosted by Harriet Dutka from Magnesita Refractories.

Tuesday, 10 November was dedicated to visiting both steelmaking plants of ThyssenKrupp Steel Europe, one of the premium steel producers in Europe. An overview of the company and a safety video were presented in the new visitor center. ThyssenKrupp Steel Europe operates two steelmaking facilities, Bruckhausen and Beeckerwerth, which are just a few miles apart. ThyssenKrupp Steel Europe produced around 9.1 million metric tons of crude steel in these two steelmaking facilities in 2014.

The Bruckhausen plant was visited first, and due to time constraints, the BOF and CSP parts of the plant were skipped and the delegates went directly to the slab caster area. The plant operates two BOF vessels, an RH degasser and CAS-OB ladle treatment station. Liquid steel can be cast at two different casting facilities — the CSP route and a regular slab caster. The CSP facility includes a ladle metallurgy furnace (LMF) and a 2-strand, thin-slab caster. The 2-strand slab caster is a straight-mold caster with a 9.6-m machine radius. Produced slabs can have widths between 1.8 and 2.6 m. The caster has in-line slitting capability. Four stations are available to slit the slab longitudinally. The majority of steel grades produced in this plant are tinplate, electrical steels, structural and high-carbon grades. Production capability of this plant is 5.5 million metric tons of crude steel with a heat size of 400 metric tons.

Beeckerwerth plant production capability is 6 million metric tons with a heat size of 265 metric tons. The plant is equipped with three BOF vessels, two RH degassers, one ladle treatment station with reheat capability and two slab casters (two strands each). Caster 1 is a curved mold caster and was completely upgraded in 2014. Upgrades included an increased number of thermocouples in the mold, increased number of segments, air-mist cooling capability, increased number of unbending points and also increased tundish size. Caster 2 has a straight mold. Product mix is mainly ultralow-carbon steels and advanced high-strength steel grades.

Ingo Knopp (right), head of slab production senior manager, ThyssenKrupp Beeckerwerth, received a plaque of appreciation from Michael Strelbisky (left).

Slab Caster	1	2	3
Start-up (last modernization)	1967 (2013)	1967 (1990)	2000
Manufacturer	MDH, DE	MDH, DE	SMS Demag, DE
No. strands/machine type	4/Curved	2/Curved	2/Straight
Slab size in mm/ thickness x width (range in mm)	260 x 325–700	260 x 800–2,100	260 x 850–2,100
Nominal capacity	1,100,000 t/a	1,800,000 t/a	3,000,000 t/a

Table 4: Operational data for Hüttenwerke Krupp Mannesman (HKM) slab casters

Rounds Caster	1	2
Start-up (last modernization)	1981 (2002)	1984
Manufacturer	MDH, DE	MDH, DE
No. strands/machine type	6/Curved	5/Curved
Bloom sizes, diameter in mm	180/220/240	180/220/240/270/ 310/370/406
Nominal capacity	1,400,000 t/a	1,200,000 t/a

Table 5: Operational data for HKM rounds casters

Thorsten Bolender (center), division manager continuous casting, Hüttenwerke Krupp Mannesmann GmbH, received a plaque of appreciation from Ron O'Malley (left) and Michael Strelbisky (right).

After the tour, traditional German food was enjoyed at one of the famous Düsseldorf restaurants, Hausbrauerei Schumacher. Thank you to Jeff Brower of Primetals Technologies for hosting the dinner.

On Wednesday, 11 November, the Hüttenwerke Krupp Mannesman (HKM) plant was visited in the morning. Prior to the tour, a presentation about the company was given, and it was disclosed that the whole plant is undergoing an outage. This fact didn't discourage the participants, but actually increased their desire to see the plant even more. HKM's steelmaking operations produce around 5 million metric tons of crude steel yearly. The shop includes two BOF vessels, four vacuum tank degassers, three slab casters and two bloom casters. The two bloom casters are dedicated to casting round blooms for seamless pipe production. Slab casters 1 and 2 are small-radius casters (5 m) utilizing dry casting technology, where no secondary cooling is used. Caster 3 has been recently rebuilt (2015) to better accommodate production of peritectic and other crack-sensitive grades. Casters 1 and 3 have the capability of twinning slabs. The mold and segment shop was visited to take a detailed look into this newly designed twin mold. HKM doesn't have any downstream facility on-site, and slabs/blooms are sold as final products.

The delegates would like to thank HKM management for providing an excellent tour for such a large group, even under difficult conditions.

The afternoon was dedicated to visiting Stahl Zentrum, home of VDEh (Association of German Steel Manufacturers), where a technical exchange with members of the VDEh Steelmaking Committee was conducted. The aim of the Steel Institute VDEh, founded as a technical association for metallurgy in 1860, is to encourage the technical, technical-economic and scientific collaboration of engineers in the further development of processes for iron and steel production and the material steel itself.

The VDEh Continuous Casting Committee along with the AIST Germany Caster Study Tour participants during the technical roundtable discussion held at the VDEh headquarters.

Thomas Schramm (center), continuous casting manager, ArcelorMittal Ruhrort, received a plaque of appreciation from Ron O'Malley (left) and Michael Strelbisky (right).

The Steel Institute VDEh and the German Steel Federation, with their subsidiaries and associated companies, form the Stahl Zentrum in Düsseldorf as legally autonomous units. Competencies in the production and use of the material steel nationally in Europe and internationally are consolidated under this umbrella organization. The competencies of the Steel Institute VDEh also include initiation and support of research and development work, work in the field of process technology, steel characterization and application, and participation in the creation of standards and regulations. Similar to AIST, the Steel Institute VDEh is a steel cluster network supported by the joint work of the steel producers with suppliers, as well as with the further processors and end customers of the steel industry. The numerous value-creation chains of the material steel — from production to commodities and their recycling — are reflected in the work of the committees. The committee system is a central component of the institute's work. Feedback from the member companies within the framework of committee work is indispensable. The study tour delegates joined the regular meeting of the VDEh Steelmaking Committee to discuss previously agreed-upon topics, which included caster modernization strategy and new continuous casting plants, and process technology. Each producer representative from the study tour group was prepared to make a presentation on these two given topics. In total, 20 presentations were given. The day concluded with dinner in an Italian-style restaurant, Trattoria Gigante, generously hosted by Bill Emling of SMS group.

On Thursday, 12 November, the study tour participants attended the Stahl 2015 conference, held at Düsseldorf Conference Center. During the day-long event, 17 presentations were made in three parallel sessions. The general theme of the conference was future improvements toward reduction of CO_2 emissions from ironmaking/steelmaking production, latest improvements offered by various suppliers, and steel imports into the European Union, especially from China. The message of the day was that even though domestic (EU) demand is high, steel production in Germany's plants isn't reaching maximum levels due to increasing imports.

On the last day of the trip, the delegates visited ArcelorMittal Duisburg in the morning and SMS group headquarters in the afternoon. ArcelorMittal

Duisburg is a long products producer operating a BOF shop. Hot metal is supplied from nearby ThyssenKrupp Steel Europe. ArcelorMittal purchased the Duisburg mill from ThyssenKrupp in 1997. The plant is equipped with two BOF vessels and a unique secondary metallurgy station which includes a VD degasser, RH degasser, LMF and stirring station. Selection of the proper treatment route depends on the steel grade being produced. After the secondary metallurgy treatment, liquid steel is transported to the second building, where two continuous casters are located. Caster 1 is a 6-strand billet caster with a cast size of 155 mm square. Bloom caster No. 2 is capable of casting a section 265 x 385 mm and was recently upgraded to cast 320-mm square format. One of the main products is leaded steel, which is around 30% of total production.

The last part of the trip was to visit SMS group headquarters in Düsseldorf. The continuous casting group prepared six stations at which the delegates were able to learn various new technologies that are being introduced to the market.

- Virtual reality — How virtual reality can help during initial caster design and final approval discussion before actual caster manufacturing and construction.
- Caster portfolio — Complete portfolio of various caster designs.
- HD mold — Mold monitoring with fiber optics installed inside mold copper.
- HD scan — Ultrasonic testing and characterization of steel samples.
- STEC rolls — New caster rolls with improved internal cooling.
- Belt caster — New approach to cast new generations of advanced high-strength steels.

The day concluded with a dinner in a Düsseldorf Old Town restaurant called Brauerei Zum Schiffchen, which was generously hosted by Eric Rosenow of Nalco.

The AIST Germany Study Tour is now over, and all of us are back into our day-to-day work routines, but the plants visited and the interaction with fellow tour members will be not forgotten easily. The main value of the study tour is the direct application of the knowledge we gained from the tour for implementation into our individual companies. If AIST aims to encourage member interaction and technical exchange, then the tour was an excellent example of this and we are looking forward to welcoming the VDEh Steelmaking Committee members to our North America operations in 2017.

All participants would like to thank the companies visited for the opportunity to tour their caster operations. We would especially like to express our gratitude to all of our tour guides for their informative explanations of each of the operations we visited. ✦

Lothar Fischer (center), general manager continuous casting sales, SMS group, received a plaque of appreciation from Ron O'Malley (left) and Michael Strelbisky (right).