2011 OXYGEN STEELMAKING TECHNOLOGY COMMITTEE

Brazil Study Tour

The 2011 Oxygen Steelmaking Brazil Study Tour, organized by AIST's Oxygen Steelmaking Technology Committee, consisted of two segments: a primary study tour on 11–17 September and an optional tour on 18–20 September. The primary tour included four steelmaking facilities, a ferroniobium facility, a day-long technical discussion, an air separation facility and an AIST Brazil Member Chapter dinner. The optional tour included two additional BOF facilities and a dinner with the ArcelorMittal Americas BOF operators.

The primary study tour had 32 attendees, representing 11 steel producers, six students and 15 suppliers. Six countries were represented: Argentina, Brazil, Canada, Germany, India, Mexico and the United States.

The study tour began on 11 September at the Olegario Pizzeria with a meet-and-greet opportunity sponsored by Magnesita S/A. On 12 September, the delegation visited V&M do Brasil in Belo Horizonte, which produces pipe and tube products for the oil and gas industry.

Leandro Almeida, OSTC member and steelmaking manager of V&M do Brasil, welcomed the committee to the facility. He provided a summary of the steelmaking process at V&M, including their capabilities, products and markets served. He also highlighted the improvement of their safety performance indicators. During the tour, the delegation was guided through the facility by Marcelo Mercier, Dione Araujo and new OSTC member Hudson Asth. Throughout the tour, the guides were open to questions and provided extensive information regarding the steelmaking process at V&M do Brasil.

The steelmaking process at V&M do Brasil begins with an 80-tonne BOF which taps 22 heats per day. After tap, all heats proceed to the LMF and then either to the vacuum tank degassing station or directly to the continuous caster. At the caster, temperature and flow control are maintained via the tundish, which feeds four strands that cast round billets of 180–230 mm in diameter and 6–12 m in length. The finishing process at V&M do Brasil includes two rolling facilities, two quench and temper lines, a cold roll facility, a forge and an OCTG finishing line. The facility produces 700,000 tonnes per year of product. By utilizing 232,000 hectares of eucalyptus to produce a renewable charcoal source for their blast furnace process, V&M do Brasil is considered carbon-neutral through the continuous casting process. Additionally, they maintain 80,000 hectares of trees as a preservation area.

Upon completion of the V&M do Brasil tour, the hosts were given a token of appreciation for their time and the delegation boarded a bus to Ouro Branco. Lunch was sponsored by Siemens Ltda. at the Faz da Conta restaurant, where the group sampled many foods from the Minas Gerais region. When the delegation arrived in Ouro Branco, they were greeted at Gerdau Açominas by Eugenio Pacelli, steelmaking process consultant. A brief summary was given regarding the steelmaking facilities, and the tour of the facility was led by Laudenei Amorim.

Gerdau Açominas is the largest steel production facility under the Gerdau name. The plant produces 4.5 million tonnes per year of billets, slabs, blooms, rolled structural shapes with parallel legs and wire rod. The BOF produces 220 tonnes per heat and 52 heats per day. Two hundred tonnes of hot metal and 40 tonnes of scrap are charged into the converter and blown with oxygen for 17 minutes at 45,000 Nm^3/hour from a top lance. Six bottom elements provide additional mixing with argon and nitrogen. Chemistry and temperature are tested via a sublance system prior to the steel being tapped. Final steel chemistry is obtained via one of three stirring stations or from the ladle metallurgy facilities. For ultralow-carbon or interstitial-free grades, Gerdau Açominas has two RH degassers to achieve the necessary reduction in carbon and nitrogen content. Solidification occurs at either the 6-strand billet caster, 4-strand bloom caster or the newly installed slab caster. In 2009, the slab casting facility began to produce hot rolled coil, and in 2012, a heavy plate facility will begin production. Some final product requirements necessitate the production of approximately 500,000 tonnes per year of ingots.

The evening in Ouro Branco included a dinner with the Gerdau Açominas steelmaking representatives at the Caminho

do Ouro Restaurante e Petisqueira, sponsored by General Electric – Power Generation Division.

The OSTC Study Tour had been planned to coincide with the meeting of the Brazilian BOF Specialists. On 13 September, the OSTC delegation and representatives of the Brazilian BOF Specialists met in Ouro Branco for a technical exchange focused on improving tap-to-tap times and controlling mid-blow vessel eruptions (i.e., slopping). Otavio Sanabio, AIST Brazil Member Chapter chair, welcomed everyone to the technical exchange and thanked the day's sponsor, Luiz Amorim and SMS Siemag Servicos Industriais Ltda. Brian Bliss, AIST technology programs manager, highlighted AIST's mission and service activities to the steel industry, its educational programs for international forums, the launch of the AIST Process Benchmarker online steel process analytical tool, and the opportunities for the Brazil steel community to participate in both AIST and ABM through the AIST-ABM Combi-Membership.

Following introductions, each steel producer provided overviews of their programs for tap-to-tap improvements and yield improvements through controlling vessel slopping. The presenters were: Kamal Ughadpaga and Giyas Mohammed of Essar Steel Algoma, Ron Bannister of ArcelorMittal Dofasco, PN Rao of Vizag Steel, Hilton Lopes and Laudenei Amorim of Gerdau Açominas, Hudson Asth of V&M do Brasil, Walter Balante of Ternium Siderar and Bernard Chukwulube of ArcelorMittal USA R&D. Romao Baptista, a longtime steelmaker from Brazil, provided additional insight into improving these processes. Ana Christina Linhares, a student at Universidade Federal de Minas Gerais and a representative from Usiminas, presented recent work on a dynamic model for the BOF process. The technical presentations led to an extensive roundtable discussion on each plant's programs. The evening dinner was hosted by Gerdau Açominas at a country manor in Ouro Branco.

"AIST Oxygen Steelmaking 2011 Brazil Study Tour from 11 September 2011 to 20 September 2011 has been a great learning experience. It was organized in a very professional way and hospitality has been excellent. I cherish the experience and it will remain with me for a long time to come."

– MB Venkata Rao, Vizag Steel

On 14 September, CBMM hosted the OSTC delegates at their facility in Araxa, Minas Gerais. Marcos Stuart, chief technical officer, provided an overview of CBMM's mine and ferroniobium production. The CBMM facility in Araxa generates 80% of the world's commercial niobium, producing almost 90,000 tonnes of niobium each year. The facility supports the environment by recycling 95% of any water used in their process and by planting a tree for every tour hosted. Renata Menezes, Leonardo Silvestre and Marcos Stuart led the delegates through the mining area, the

flotation process, the submerged arc furnace (SAF) facility and the quality control lab. This was a unique opportunity to see the production process of one of the most costly alloying elements for the steelmaking process.

At the conclusion of the CBMM tour, the delegates traveled to Rio de Janeiro and eventually to the town of Volta Redonda. Upon arrival at the Bela Vista Hotel, they were greeted by the evening's host, Wagner Assunção of Danieli do Brasil Ltda., for a dinner at the hotel.

The next morning, Thursday, 15 September, included a tour of the CSN production facility in Volta Redonda. Wilson de Souza, steelmaking general manager of CSN, provided an overview of steel production at CSN, which first began in 1947. The BOF is capable of producing 7 million tonnes per year at 230 tonnes per heat, making it the largest steel production facility in Brazil.

The BOF facility consists of three converters, each with a fully automated blow system, the ability to blow independently, a sublance for testing, and sensors to detect and control slag slopping and carryover. The steel refining area consists of two bubbling stations, an LMF and an RH degasser. From the steel refining area, the steel is transported to one of three 2-strand continuous casters. The overall production averages 62 heats per day. The finishing capabilities in Volta Redonda include a hot strip mill, a cold strip mill, a hot-dip galvanizing facility and an electrolytic plating facility. Final products are shipped to the automotive industry, the canning industry, construction, appliance and other steel sheet customers.

"I would like to thank AIST for the opportunity to join the group in the Brazilian Tour. It was a great opportunity for increasing my knowledge and network."

– Pedro Kayser, Magnesita S.A.

The evening of 15 September included a reception and dinner with the AIST Brazil Member Chapter at the Fogo de Chao in Rio de Janeiro. White Martins Gases Industriais Ltda. sponsored the evening, which included a keynote speech by Marco Antônio Castello Branco entitled, "World Crisis: Challenges and Opportunities for the Brazilian Steel Industry." The speech highlighted the progression of regional steel capacity and world consumption in the last century, as well as the challenges Brazil faces in the future. Raw material, labor and energy costs are increasing for Brazilian steel producers, who must balance these increases with improvements in operations, technology and vertical integration toward raw materials to continue to satisfy Brazil's increasing demand for steel consumption in an efficient manner.

Upon completing his presentation, Dr. Castello Branco fielded questions concerning the opportunities for the Brazilian steel community. Special recognition was given to Dr. Castello Branco for his presentation by Otavio Sanabio, AIST Brazil Member Chapter chair. Mr. Carlos Frederico de Campos Martins, steel business director for White Martins Gases Industriais Ltda., was also honored with a token of appreciation as host and sponsor of the AIST Brazil Member Chapter event.

On Friday, 16 September 2011, the delegation traveled to the Santa Cruz area of Rio de Janeiro for the first-ever tour of ThyssenKrupp CSA, the newest integrated steel production facility in the western hemisphere. Humberto Marin, meltshop manager, greeted the delegation with a safety presentation and an overview of the facility prior to the tour. Dirk Gothelf, continuous casting manager; Luiz Otavio Haydt, primary metallurgy coordinator; Paulo Lascosqui, secondary metallurgy coordinator; and Vinicius Cravo, continuous casting coordinator, were also present.

ThyssenKrupp CSA is located on 9,000 square meters of land along the Atlantic coast, southwest of Rio de Janeiro. €5.2 billion was invested in the facility, which is owned jointly by ThyssenKrupp (73.13%) and Vale Industries (26.87%). Their vision is "to be the world's first choice for steel slabs, passionately produced in Brazil." The plant was built to be visually appealing and to blend with the local landscape. The facility has been a large boost to the local economy. During construction, more than 30,000 people were employed, with an additional 120,000 people indirectly employed. Once full operations began, the estimated impact was 5,500 directly employed positions, with an additional 14,000 indirect jobs for the local economy. ThyssenKrupp CSA has also provided the area with a school, a technical institute, a social program to keep children in school, accident avoidance seminars, and communication and environmental education courses. Projects for sustainable fisheries are also being developed. Environmentally, ThyssenKrupp CSA has created a 1.5 million square meter mangrove area and has planted 175,000 trees and 25,000 seedlings in the forest.

The Clean Development Mechanism Project instituted by ThyssenKrupp CSA has made the facility energy self-sufficient, generating 490 MW of power from offgas sources in the coke plant, blast furnace and BOF. Two gas silos regulate the flow of gas to the power plant. The three generation units at the plant produce enough power to supply the facility and provide 200 MW to the local community. Modern air pollution controls have resulted in a 90% reduction in coke plant emissions compared to other facilities. An on-site cement

Brazil Member Chapter Event

World Crisis: Challenges and Opportunities for the Brazilian Steel Industry

by Dr. Marco Antônio Castello Branco
Synopsis by Brian Bliss, AIST Technology Services General Manager

Dr. Castello Branco's speech began with a review of current crude steel capacity and consumption by regions in the world. China led all regions with the largest amount of capacity as well as the largest need for steel products, representing almost half of the global capacity and demand. The capacity and consumption by regions over the last century show how the maturation of regional steel production has developed over time and how raw material consumption has remained consistent as consumption in the individual regions waxed and waned. In the 1920s, North America led the way with consumption and capacity, followed by the European and Japanese reconstruction periods from 1940–1970. In the 1970s, Korea and Taiwan experienced sharp annual increases in steel consumption. During the 1980s and 1990s, the increase in steel consumption remained relatively flat — until the turn of the century, at which time the Chinese market saw a large increase in consumption. Looking to the future, raw material availability should remain a key component of the steel cost structure, as India is predicted to be the next large consumer of steel.

Reviewing the cost components of shipped steel in 1995 and 2000, China had low costs for raw materials and labor, giving them a cost advantage of more than 40% when compared to the rest of the world. This decreased to 25% in 2005 and to 9% in 2008 as their raw material costs began to increase due to internal steel demand, which strained resource availability. The result shows that when global steel demand increases, the costs of raw materials increases, thereby limiting the cost advantage of China to the global steel market as they are forced to use higher-grade ores to supplement production requirements. When demand wanes, China reduces consumption of their internal higher-grade ores to limit costs, while the rest of the world is forced to obtain raw materials from the global ore suppliers.

When comparing the value components of global hot rolled steel, in 1994, raw material costs made up approximately 18% of the value, while a steel company would retain the remaining 82%. In 2005, the raw material suppliers began to consolidate resources, which increased a steel company's raw material costs if they depended on external raw material sources. In 2008, coking coal and iron ore comprised 65% of the value, limiting the profits of steel companies. Dr. Castello Branco estimated that by 2015, this raw material value would be similar, at 56%, as raw material suppliers have learned how to balance supply to meet global demand.

In Brazil, the steel industry has endured increases in energy and labor costs over the last decade and must improve production efficiencies to limit the experienced increases. When compared to international benchmarks, the Brazilian steel industry can learn much from the international steel community to improve their production efficiencies to be competitive with the global industry. Even today, when compared to 2004, the Brazilian steel industry has been slowly losing their cost advantage over the rest of the world because of energy and labor increases. By utilizing the latest technology and improving production efficiency, Brazil can recoup some this advantage. Fortunately, the Brazilian steel industry maintains an advantage over international suppliers to Brazil for regional steel consumption, much of this due to international transportation costs and import duties and taxes.

As Brazilian steel consumption continues to increase, the Brazilian steel companies must recognize the challenges of world overcapacity, international raw material suppliers, degradation of exchange rates, technical disadvantages, and the fall of premium pay for local suppliers, which affects margins and investment capacity. The steel producers who can strengthen themselves through consolidation, vertically integrate themselves toward raw materials, improve their operations, and integrate into a value chain of local clients can meet the increase in Brazilian steel consumption and anticipate a strong future.

plant recycles 100% of the blast furnace slag, while a water treatment facility recycles 96% of the water used. To ensure compliance with local air pollution regulations, three air monitoring stations send information to the local governments automatically.

The steel plant began operation on 18 June 2010 and produced its first steel slab on 7 September 2010. Production capabilities include the 490 MW power station, a 1.9 million tonnes/year coke plant, a 5.7 million tonnes/year sinter plant, two blast furnaces producing 5.3 million tonnes/year iron and 1.3 million tonnes/year slag, two 330-ton BOF converters producing 5.2 million tonnes/year steel and 580 kt/year slag, and two continuous casters with a capacity of 2.55 million tonnes/year. Currently, all steel slabs produced are exported to Germany or the United States for further processing by ThyssenKrupp.

The tour of the BOF gave the attendees an opportunity to see a newly constructed facility with many advanced technology features. The two BOFs feed steel to two ladle treatment stations, a CAS-OB and an RH degasser before the steel goes to one of the two casters. Because the project originally considered only the recycling of internal scrap, the scrap yard is small and has only two excavators and five 60-ton scrap boxes. Hot metal is brought to the BOF shop via the hot metal ladles carried directly from the blast furnaces on rubber-tired, remote-controlled platforms. The ladles are lifted off the platforms and set into one of two desulfurization facilities. After achieving an average 30–40 ppm sulfur level in the hot metal, the metal is charged into the BOF.

The BOF utilizes an oxygen flowrate of 1,300 Nm^3/minute during the 20-minute blow. Eleven bottom-stirring elements inject nitrogen and argon during the blow to improve mixing, reaction and final chemistry. To control the process, the BOF is equipped with a state-of-the-art model integrated with an offgas analysis system. To improve accuracy and safety, the BOF has a robotic measurement system, which measures in-blow and end-blow temperature, EMF and a test sample. Upon tap, an infrared slag detection system and a pneumatic slag retention system limit any steelmaking slag from being carried over into the ladles.

The secondary metallurgy stations and RH degasser provide the proper final chemistry, while the CAS-OB facility can also provide chemical reheating prior to the heat advancing to the continuous casters. No stir plugs are installed in the ladles; therefore, any stirring is accomplished via stirring lances. The continuous casters are similar in design and operation. Each continuous caster has two strands, 12 segments plus benders (9,000-mm radius), air-mist cooling and a metallurgical length of 29,800

mm. The slabs are 255 mm thick and can vary in width from 800 to 2,000 mm. Scarfing is done for defects and dimensional adjustments. Final product lines include IF steel, low- to medium-carbon steel and tinplate grades.

Following the TKCSA tour and a lunch hosted by ThyssenKrupp, the delegation visited Air Liquide's air separation unit associated with the TKCSA facility. Fabio Nascimento, executive manager, and Eduardo Nonato, business development manager of Air Liquide Brasil Ltda., provided an overview of Air Liquide International, their activities in Brazil and the facility located at TKCSA. The TKCSA air separation unit supplies 2,900 tonnes/day of oxygen (35,000 Nm^3/hour at 30 bar), 600 tonnes/day of nitrogen and 21 tonnes/day of argon. In addition, it supplies 23,000 Nm^3/hour of compressed air and 580,000 Nm^3/hour of blast air for the blast furnaces.

Later that evening, Mr. Nascimento and Mr. Nonato hosted the delegation and Dr. Frank Arhenhold, TKCSA director of steelmaking, to a dinner at Porcao Rios. As this was the last evening of the primary study tour, appreciation was expressed for those who attended and the camaraderie that was experienced. All were encouraged to continue their involvement in the AIST OSTC to strengthen the international connection in the BOF community.

The optional study tour began on Sunday, 18 September 2011 for 10 delegates. In Santos, Sao Paolo, the delegates enjoyed an evening with representatives from Usiminas Cubatao sponsored by Küttner GmbH & Co. at Terraço Choop. The following day, they traveled to the Usiminas Cubatão steelmaking facility in Santos. There they were greeted by Paulo Leite, steelmaking technical manager, Carlos Alexandre Azevedo, steel plant operations analyst, and Antonio Malynowskyj, metallurgical engineer and technical steel plant support.

The Usiminas facility began production in 1986 with the start-up of two BOF converters. In 2001, a third converter was added, as well as an additional caster and ladle refining station. Total production of 4.5 million tonnes/year is achieved through the three BOFs, an RH degasser, LMF, CAS-OB and two argon stir stations that feed three continuous slab casters. Usiminas produces IF, API, peritectic and commercial grades, with the IF and API grades making up the largest portion. The BOF converters utilize sublance controls in the vessels for mid-blow testing and a dynamic blow control program. Bottom-stirring elements bubble nitrogen and argon during the blow for improved processing, and a slag detection system is coupled with a slag retention dart to limit vessel slag carryover during tapping. Vessel refractory life typically achieves 5,000–6,000 heats per lining without the use of slag splashing.

The optional study tour continued with a visit to ArcelorMittal Tubarão, Vitoria, Brazil. On 19 September 2011, the delegation joined the ArcelorMittal Americas BOF Committee for a dinner event sponsored by ECIL MetTec. Luis Antonio Freire, director and CEO, and Diego Soares, sales account coordinator, welcomed everyone to Vitoria. The ArcelorMittal delegation represented facilities from the United States, Canada, Mexico and Brazil. On 20 September, the representatives met at ArcelorMittal Tubarão's educational campus. Jorge Luiz Olveira, manager — steelmaking and hot rolled coil, provided a corporate overview of ArcelorMittal and the safety performance of the Vitoria facility. Francisco Dornelas, senior advisor and operations vice president, presented an overview of steel production at Vitoria and a history of ArcelorMittal Brazil. The Tubarão facility produces 7.5 million tonnes/year of steel. The operations have two cokemaking facilities (one utilizing the SunCoke non-recovery technology), two operating blast furnaces, three BOF converters, two RH degassers, an LMF and three slab casters. The finishing process consists of a single hot rolling mill with a capacity of 4 million tonnes/year, which requires ArcelorMittal Tubarão to sell 3 million tonnes/year of slabs. Further strip processing, including pickling, coating and annealing, is completed at the ArcelorMittal Brazil Vega facility. Final products are supplied to the automotive, appliance and construction industries.

"The study tours are a place to share experiences and knowledge, a place to learn and teach, where each one is a different opportunity from the other one, but all this makes new friends and strengthens the relationships between each person and each company. We think this is a place where we can extend our limits and look for new and more demanding objectives."

– Walter Balante, Ternium Siderar

"AIST's Oxygen Steelmaking Committee study tour of steel companies in Brazil was well attended, with attendees from Canada, United States, Mexico, India, Argentina and Brazil, making this tour a huge success. The hosting companies openly shared information. The interaction between the AIST members at the end of each day was exceptional, which turned out to be a wealth of knowledge sharing. In general, the Brazilian steel companies are updated with modern equipment, including their environmental systems, and are poised to provide steel to the world market. A tour such as this in invaluable to attendees through intimate contacts that are made along the way."

– Ron Bannister, ArcelorMittal Dofasco

An on-site co-generation facility at Tubarão generates electrical power from the coke oven, blast furnace and BOF offgases. Of the steel plant's power requirements, 112% is produced by the power generation facility, enabling ArcelorMittal Tubarão to contribute power to the local electrical grid. Tubarão also uses a dry quench practice in cokemaking for process steam production. Additionally, to improve process efficiencies, they will be revamping a blast furnace and installing a second hot rolling mill.

Following the tour and lunch at ArcelorMittal Tubarão, there was a tour of the education campus. Bernard Chukwulebe, ArcelorMittal Steel USA R&D steelmaking manager, thanked the attendees of the study tour. Additional appreciation was given to the hosts and sponsors for the efforts they put forth to welcome all attendees to Brazil. Dr. Chukwulebe wished everyone a safe trip to their final destinations and adjourned the study tour, at which time the ArcelorMittal Americas BOF technical meeting began.

The AIST OSTC has established study tours as an opportunity for members to increase their international network and to facilitate the lines of communication between steel producers. These study tours have also been established to encourage individuals who are not members of the committee to become involved in its activities within the global steel community. The OSTC will be considering a study tour to Eastern Europe in 2012, which will coincide with the Stahl 2012 event in Germany, once again allowing colleagues from the VDEh to participate. ✦