Iron & Steel in Canada

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IRON AND STEEL IN CANADA: A HISTORICAL INTRODUCTION

Hierro y acero en Canadá: Una introducción histórica

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RESUMEN

La producción de hierro en Canadá comenzó en 1733 durante el Régimen Francés de Quebec y se desarrolló aún más con la ocupación británica (1764-1867). Fue en Quebec donde se inventó el soplado de fondo con oxígeno en la fabricación de acero, que ahora se utiliza en todo el mundo. Canadá es también uno de los proveedores más importantes de mineral de hierro y tiene una de las plantas de peletización más grandes del planeta.

PALABRAS CLAVE: Acero, Canadá, Hierro, Historia de la Siderurgia.

ABSTRACT

Iron production in Canada started in 1733 during the French Regime in Quebec and developed further during the British occupation. It was in Quebec that the bottom blowing of oxygen in steelmaking was invented which is now used worldwide. Quebec is also one of the major supplier of iron ore and has one of the largest pelletizing plants.

KEY WORDS: Canada, Iron, Steel, Iron History.

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INTRODUCTION

Steel production in Canada involves the use of blast furnaces, direct reduction processes, and ilmenite partial reduction in an electric furnace (Tables 1 and 2). Pelletizing of iron concentrates for direct reduction became an important technology in Quebec (Figure 1). The electric furnace was used for the metallized pellets as well for scrap (Figure 2). Also, bottom blown oxygen process for steel making, invented in Canada, is used all over the world. The production of ferroalloys was a success story in Canada.

<table>
<thead>
<tr>
<th>Source</th>
<th>%</th>
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<tbody>
<tr>
<td>Blast furnaces</td>
<td>60</td>
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<tr>
<td>Scrap</td>
<td>30</td>
</tr>
<tr>
<td>Direct reduction</td>
<td>15</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>15</td>
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<tr>
<td>Total</td>
<td>100</td>
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Table 1. Steel production in Canada.
Tabla 1. Producción de acero en Canadá.

Scrap

On the average, the steel industry consumes 50% raw iron and 50% scrap. Steel scrap for steelmaking comes from two main sources (Figure 2):

- Local. This is scrap produced locally in a steelmaking plant during shaping. In a steel plant, about one third of the steel produced is returned as scrap.
This is old automobiles, farm equipment, railroad rails, ships, etc., that is purchased from outside sources. The use of scrap in certain steelmaking processes is necessary because it is used to control the temperature in the converter during steelmaking. As a result of oxidizing the impurities in the pig iron, the temperature rises because of the exothermic nature of the reaction. To prevent the rapid deterioration of refractories, scrap is added to cool down the change.

A certain quantity of iron is produced by direct reduction methods. This iron is not produced in the blast furnace but in less expensive equipment such as a rotary kiln, a static bed, or a fluidized bed. It differs from blast furnace iron in being not subjected to melting, and is suitable as a substitute for scrap. Usually steel produced from such iron is made in electric furnaces.

THE BEGINNINGS
Charcoal iron works

In 1733 François Poulin de Francheville (1692-1733), a French merchant from Montreal built the first furnace in Canada on the bank of Saint Maurice River near Trois Rivières located half way between Québec City and Mon-
Québec (Figure 3). The furnace was fuelled by charcoal to process local iron ore. Air was blown in the furnace by small bellows operated by a water wheel. The Saint-Maurice River is one of the largest tributaries of Saint-Lawrence River. The temperature of combustion in the furnace was not enough to melt the iron produced. Thus, a product called “bloom”, which was wrought iron mixed with slag, was obtained. This was removed from the furnace, hammered while hot to squeeze away the slag, then obtain a nearly carbon-free iron. This wrought iron was malleable and could be shaped into different forms. At the conquest of New France in 1760, the Forge passed to the British Government and was operated under military authorities until shut down in 1883.

In the mean time other iron works started operation using charcoal, for example, the Marmora Ironworks, near Peterborough, Ontario began production in 1823 (Figure 4). It consisted of two charcoal-fired blast furnaces and a forge with two sets of water-powered hammers. In 1860 at Radnor, not far from the St. Maurice Forge, another furnace was also built.

**Coke iron works**

All charcoal operated furnaces were shut down when more efficient furnaces were erected in Ontario and other place.
Nova Scotia employing coke-fired blast furnaces. For example, in 1871 the Canadian Titanic Company built two blast furnaces at Saint Urbain, Charlevoix County in Quebec for the utilization of titaniferous iron ore and using coke (Figure 5).

MODERN IRON ORE PRODUCTION

The largest source of iron in Canada is in Labrador discovered in 1892. Two major companies in this region exploit the ore (Figures 6 -11):

Iron Ore of Canada

Iron Ore of Canada was founded in 1949 in Montreal and operated Wabush mine in Schefferville. The hematite ore was first shipped without treatment in the 1950s then in the 1960s a concentrator and a pelletizing plant were built in Labrador City. The pellets were transported to Sept Iles and Pointe Noire where it was shipped to Contrecoeur for reduction in the Midrex process. In 1970 a concentrator was built in Sept Iles but closed in 1981. In 1992 Mitsubishi became shareholder and in 2000 Rio Tinto acquires the main shares. A 575 km railway links Schefferville to Sept Iles.

Quebec Cartier Mining

Québec Cartier Mining Company was founded in 1957 by US Steel. It owned Fire Lake and Jeannine Lake open pit mines for specular hematite or speculrite which is dark silvery metallic color. It produces more than 26 Mt of concentrates per year containing 66% Fe. The company built the town of Gagnon near Jeannine Lake, in 1963 to accommodate workers and families. Following the depletion of the Jeannine Lake mine in the late 1960s the company began to develop the Mont Wright mine which started in 1973.

The town of Fermont which is 24 km from Labrador City was created. The word is French contraction of Fer Mont, meaning Iron Mountain. The mine product is shipped to Port- Cartier where a pelletizing plant was constructed in 1977 by Sidbec-Normines a society formed from Sidbec, British Steel Corporation, and Quebec Cartier Mining. The falling market forced the company to shut down its Fire Lake and Janine Lake plants in the mid 1980’s. In 1989, US Steel sold the company to different investors and in 2005 Dofasco became the sole owner. The town of Gagnon was closed and its population moved to Fermont and Port-Cartier. In 2008 it became ArcelorMittal Mines Canada.

STEELMAKING

Dominion Iron and Steel Dominion Iron and Steel was founded in 1899 by the American businessman Henry M. Whitney (1839-1923) (Figure 12) at Sydney, NS. He had already formed the Dominion Coal Company in 1893 in Cape Breton and envisioned a local steel plant as the
ideal outlet for coal. Limestone was also available in Newfoundland. Sydney harbour also provided a shipping outlet to the world. Construction was finished in 1901 and it was the most modern steel plant in the world with a battery of 400 Coke Ovens capable not only of producing coke, but also of recovering saleable by-products such as tar, benzene, and industrial salt. It had four blast furnaces and ten open hearth furnaces. Sydney coal-field supplied more than 44% of Canada’s coal production and iron industry produced more than one-third of the country’s pig iron.

Two Bessemer converter furnaces were added in 1907 in an attempt to deal with the low grade iron ore and the high sulphur coal. The company had been a constant money loser but this situation improved when a domestic market developed for its rails. Whitney then sold out the steel and coal companies to a Canadian consortium in 1909. These two companies merged under the name Dominion Steel Company. The company expanded later by adding more blast furnaces and coke ovens. World War I was a major boom. In 1920, the British Empire Steel Corporation acquired all assets of the company.

By now the steel industry was in a recession. The plant was shut down and the massive layoffs triggered violent strikes. By 1927, the company collapsed into bankruptcy. The plant was operated for two years because of government subsidies which attracted new investors. In 1929, a British consortium took over and was called the Dominion Steel and Coal Company. The start of World War II in 1939 signaled a boom cycle. In 1942 a 10-ton electric arc furnace was introduced for the manufacture of specialty steel. Oxygen lancing was introduced into the open hearths, which reduced the time needed to produce a heat by half. Also, the Wabana Mines were closed...
in 1966 and a much higher grade of iron ore was imported from Quebec.

During the 1960’s there was massive layoffs and closure of operations. By 1967 the plant was losing money. In January of 1968, the plant became the property of the Provincial Government of Nova Scotia and became known as the Sydney Steel Corporation. A continuous caster was commissioned in 1975 as part of the modernization. By 1982 the plant was in financial difficulty. On May 22, 2000, the lack of a legitimate buyer closed the Sydney Steel Corporation.

Algoma Steel

Founded in 1901 in Sault Sainte Marie, Ontario on the St. Marys River by the American businessman Francis H. Clergue (1856 –1939) (Figure 13). Bessemer converter was put in operation using pig iron made from the Helen mine but it had to import coal and coke from the United States. Initially the company specialized in manufacture of rails for Canadian railways. Algoma currently is the second largest steel producer in Canada. In 2007, it was purchased by India’s Essar Group continuing operations as Essar Steel Algoma Incorporated.

Iron and Steel Company of Canada

Stelco (Figure 14) is a steel company based in Hamilton, Ontario founded in 1910 from the amalgamation of several smaller firms by the Canadian banker William McMaster (1811-1887) (Figure 15). Coke was produced in retorts, iron pellets were charged into blast furnace. By 1910 the Bessemer process was no longer in use. Hydrochloric acid was later used as pickle solution replacing sulfuric acid. Iron and steel production grew slowly until World War II and then rapidly as the post-war economic boom created a tremendous demand for steel. It filed for bankruptcy in 2007 and was bought by US Steel. The Hamilton plant has not produced steel since 2011, but its coke ovens and cold rolling finishing works remain in operation. Market conditions caused a shut down permanently on December 31, 2013.

In World War I Stelco produced shell steel and invested in mining operations. In World War II it supplied steel for land transport vehicles as well as thousands of navy ships and cargo vessels. Stelco became Canada’s largest producer of cold drawn steel during the 60s. In the 1990’s, Stelco faced competition from Japanese-owned auto assembly plants in southern Ontario. It continued on for almost 100 years, until it filed for bankruptcy in 2007 and was bought by US Steel and renamed US Steel Canada. Stelco was one of the first to use hydrochloric acid for pickling steel.

Dominion Foundries and Steel

Dominion Foundries and Steel now known as Dofasco was founded in 1912 by Clifton Sherman (1872-1955) (Figure 16) and his brother Frank Sherman (1887-1967) (Figure 17) sons of an American blast furnace and steel mill superintendent. It introduced the BOP to North America in 1954 and since then the open-hearth process steadily
declined, and none are in use today. Dofasco, the major shareholder of Québec Cartier, was bought by Arcelor Mittal the world’s largest steel producer. This made Québec Cartier one of the leading mining facilities of the world’s biggest steel producer. Dofasco, in 1999, was the most profitable steel producer in North America.

**Atlas Steel**

The Welland facility in Ontario was originally constructed in 1918 by Dillon Crucible Steel Alloy to produce high tensile tool steel. In 1920 the Atlas Crucible Steel purchased the company. The facility was acquired by Roy
H. Davis and Daniel W. Lanthrop in 1928 and operated under the name Atlas Steel. Subsequently it was expanded to include a rolling mill and other specialty steel production (Figure 18).

In 1939 the Canadian government invested heavily in the facility to produce steel for World War II and by 1948 it was regarded as the largest specialty steel company in the British Commonwealth. In 1963 Rio Algom purchased the company until 1985 when the facility was a stand alone company as Atlas Specialty Steels being the largest producer of stainless steel in Canada.

In 1989, it was acquired by SAMMI Corporation, a South Korean steel products manufacturer. In 2000 Atlas Steels including the Welland and Tracy facilities were sold to Slater Steel. In 2006 MMFX, acquired the Welland facility. In 2010 ASW Steel possessed all of the assets previously held by MMFX. Atlas Steel plant in Tracy was closed in 2004.

Atlas Steel in Welland, Ontario was the first in 1954 to adopt continuous casting in North America (Figure 19).

QIT Fer et Titan

Quebec Iron and Titanium later QIT Fer et Titane was founded in 1948 by KenncoExplorations, the Canadian subsidiary of the American Kennecott Copper to exploit the largest deposit of ilmenite in the world located at Lac Tio in the north of the Province of Quebec near Havre Saint Pierre. The deposit was massive ilmenite containing small amounts of pyrite contrary to the black sands usually found at the mouths of great rivers. Pilot tests were done by the New Jersey Zinc company of Palmerston, Pennsylvania. In 1950 the first electric furnace in Sorel was in operation and the scale of operations were increased later to nine furnaces to partially reduce ilmenite containing 36% TiO2 to iron and titanium slag known...
as Sorelslag containing 72% TiO2 (Figures 20 and 21). The slag was used to make TiO2 white pigment. It was recently purchased by Rio Tinto.

Further development took place as follows:

- In 1976 the company constructed electric furnaces to exploit the rich black sands deposits at Richards Bay in Natal, South Africa to produce slag containing 85% TiO2.
- In 1986 a steel plant was constructed to transform the iron produced into steel.
- In 1990 autoclaves were installed to upgrade the slag quality to 94.5% TiO2 by pressure leaching with hydrochloric acid to remove calcium and magnesium. The technology of manufacturing Sorelslag was adopted before the hydrometallurgical route for making "synthetic rutile".
- In 2005 QIT Madagascar Minerals owns and operates a mineral sands mining project near Fort Dauphin on the south-eastern tip of Madagascar.
- In 2014 SO2 removal plant was constructed by scrubbing the exit gases from the rotary kiln by hydrated lime.

Quebec Metallic Powders

Next door to QIT Fer et Titan is Quebec is Metallic Powders established in 1968 to produces iron powder by spraying water on a stream of molten iron obtained from QIT (Figure 22).

Midrex process

Sidbec-Dosco in Contrecœur near Montreal (Figure

Quebec Metallica 31 1 Julio-diciembre 2018 147
23) was established in 1968 by the Québec Government. It receives iron ore pellets from Sept Iles and reduce them in shaft furnaces where fuel was produced by reforming natural gas (Figures 24 and 25). Silica content is very critical: if high it sinters and blocks the descending flow of minerals. The electric furnaces convert this metallic charge together with scrap into liquid steel. Two continuous-casting machines solidify the liquid steel into steel slabs and billets. This is the only direct reduction plant in Canada.

OXYGEN FOR THE STEEL INDUSTRY

LD process

After World War II intensive research was underway to intensify melting of steel scrap generated during the war. Researchers at the Vereinigte Österreichische Eisen- und Stahlwerke abbreviated (VÖEST) in Linz in Austria came up in 1955 with the oxygen lance top blowing technology the so-called Linzer Düsenverfahren (Linz Lance Technology) or LD process, which had enormous advantages. The plant was built by the Germans before the war and originally named the Hermann Göring Works. After
the war, it was considered a German property and was confiscated by the Occupying Forces, later became an Austrian nationalized industry. The process developed there was adopted worldwide. As a result, the demand for oxygen increased and oxygen production plants were installed at the steelworks. The process, however, had the disadvantage of being noisy and generating much extremely fine dust.

In spite of all the advantages of top blowing technology, it was felt that the bottom oxygenblowing was superior for the following reasons:

- The reaction time is shorter because of the increased volume of oxygen that can be introduced into a batch.
- The slag formed does not hinder the flow of oxygen as in the case of top blowing.
- Less iron evaporates and consequently the amount of brown smoke is minimal, and the iron losses are reduced.
- Reduced iron losses by splashing from the converter because of the reduced volume of gases passing through it. This, together with the previous point are responsible for 1-2% increased production.

All attempts to use pure oxygen in bottom-blowing were unsuccessful because of the high temperature involved which resulted in the destruction of refractories.

Research in Canada

In 1939, Air Liquide Canada member of the Air Liquide Group, headquartered in Paris hired Guy Savard (Figure 26) a young graduate from the Royal Military College in Kingston, Ontario as a welding engineer in its Montreal branch. When the Nazi troops invaded France, directors of the Air Liquide left Paris and settled in Montreal. They expanded the Montreal Branch and gave it special attention after the war.

In 1947 the company hired a young graduate from McGill University, Robert Lee (Figure 27) as a research assistant in metallurgy. His assignment was to keep Air Liquide in contact with the Canadian iron and steel industry. In 1950, Savard became director of a new department at Air Liquide called Industrial Gas Applications to which Robert Lee was also attached. The knowledge that nitrogen not only plays no role in oxidation processes, but also it decreases the efficiency of combustion, Lee persuaded steel companies to use oxygen instead of air. For example, oxygen was introduced at the burners in the open hearth furnaces and into lances to accelerate the refining. This technology was adopted by steel com-
panies and also extended to other Canadian industries such as pulp and paper industry, in rotary kilns in cement manufacture, and in glass-making furnaces.

In 1963, Savard and Lee built experimental vessel using bottom oxygen blowing (Figure 28) where 150 kg of molten iron was used. Figure 29 shows the oxygen trailer used to handle oxygen. After months of reflection Lee decided to use a shrouded injector with natural gas as the protecting gas (Figure 30). It was argued that hydrocarbons crack readily at a temperature of about 800ºC and therefore the heat absorbed for cracking should result in cooling the tip of the nozzle. Contacts were made with many steel companies but nobody was interested.

Maximilianhütte

In the fall of 1967, Karl Brotzmann, Director of Research for Eisenwerk-Maximilianhütte in Sulzbach-Rosenberg near Nürnberg in Germany having learned of these activities in bottom blowing, requested a meeting. This company was facing difficulty in smelting its ores. A metal of high phosphorus and silicon contents refined by Thomas process had the disadvantages of high nitrogen...
content and a low scrap rate. It was impossible to process this iron by the LD process because lime injection was not possible through the oxygen lance. The meeting took place in Montreal in October, 1967. This led to a license agreement which enabled the company to develop the process to the full industrial scale. This process became the major steelmaking process and became known as Q-BOP, i.e., the Quiet Basic Oxygen Process because the consumption of oxygen takes place quietly during blowing.

FERROALLOYS

Due to the cheap electric power, Quebec became the center of ferroalloys by electric furnaces (Figure 31). Ferrosilicon, ferromanganese, and ferrochromium are produced by reducing the corresponding oxide with coke. In the case of the reduction of silica sand at SKW in Becancour, Quebec it was found that silicon monoxide, SiO, volatilized then oxidized to very fine SiO2 in the recovery system. Such fine silicon dioxide found application in the concrete industry. Ferroalloys produced in electric furnaces are expanding greatly while production in blast furnaces is decreasing. Ferroniobium is produced by reduction of pyrochlore concentrate with aluminum powder.

SUGGESTED READINGS
