Introduction ..................................................4

Chapter One: History of steel ........................................7

Chapter Two: Ironmaking .............................................13

Chapter Three: Steelmaking ...........................................26

Chapter Four: Railroads and transportation .........................41

Chapter Five: Track planning .........................................55

Chapter Six: Putting it all together ..................................70

Chapter Seven: Modeling techniques .................................80

Glossary ......................................................................93

About the author .......................................................95
Introduction

Think of a steel mill and you picture smoke, sparks, molten metal, and grimy men working in cavernous, mysterious complexes laced with a bewildering array of pipes, wires, and rail lines radiating in every direction. Perhaps no other industry depends on railroads as much as the steel industry. Railroads transport trainloads of raw materials in and finished product out as well as providing intra-plant movement of intermediary products during nearly every manufacturing step.

This book presents a concise guide to the steel industry and offers track-planning ideas, modeling tips, and techniques for designing and building a rail-served integrated steel mill on a layout. There is enough railroad activity in a steel mill that a satisfying layout can be built just focusing on the mill, and I have included some plans with that approach.

Alternatively, a modeler can include a steel mill as a peripheral industry on a layout and model some of the traffic that flows in and out with perhaps an interchange yard acting as the connection point.

This is an introductory volume and as such cannot cover all the fascinating aspects of modeling the steel industry. The book focuses on the steelmaking process, mill structures, and railroads that support the steel mill. I hope it gives you a taste of the fun available to steel mill modelers. A highly weathered, detailed, and complex industry that hosts intense operations with specialized rail cars is hard to beat in a model railroad. If you are interested in finding out more, I’ve listed additional resources on page 6.

Basic steel chemistry

Steel is an alloy of iron, carbon, and other trace elements. An alloy is a metallic compound that combines two or more elements. Iron is an element, which means that a piece of pure iron contains iron—and only iron—atoms. Compounds are combinations of elements. A metal combined with oxygen is called an oxide.

Iron ore generally occurs as a form of iron oxide, usually as the mineral hematite, although other forms are possible. Most of the world’s iron ore deposits were formed under conditions that have not existed on Earth for about 1.8 billion years. While there is still a lot of ancient ore out there in Australia, Brazil, and even Minnesota, nobody’s making any more of it.

Iron oxides tend to be weak and flaky. Early metalsmiths learned that they could remove most of the oxygen by heating iron oxide in a pile of burning charcoal, which left elemental iron. To remove the iron from the oxygen, the oxygen must find an element that would have a stronger bond than it has with iron. The strength of a carbon-oxygen bond is greater than that of the iron-oxygen bond. At high temperatures, charcoal is mostly carbon. When iron oxides are heated in charcoal, chemical reactions between carbon and oxygen remove oxygen from the iron oxide to form carbon dioxide and elemental iron.

Iron has a very high melting temperature (2,800°F), so in a charcoal furnace, it never gets hot enough to liquify. Removing the oxygen leaves a porous metallic glob that is mostly iron. Early blacksmiths had to repeatedly manipulate the iron when heating and then pound the metal into a sword, shield, plow, or other item. The pounding not only created the desired shape, it drove out slag and other impurities in the iron and helped refine the ore.

Although these early metalsmiths did not know it, the charcoal does more than just remove oxygen from iron oxide. Some carbon atoms from the charcoal get absorbed into the iron to create an iron-carbon alloy. Over centuries of practice, they recognized that there was a connection between how much charcoal they used or how long they left the iron in contact with the charcoal and how strong the iron was.

Wrought iron, probably the first commonly used iron alloy, was named because it is wrought (worked by repeated hammering) from the porous iron produced by heating iron oxide with charcoal. Wrought iron is much stronger than pure iron even though it is less than 0.15 percent carbon by weight. Part of wrought iron’s strength comes from the inclusion of about 1-3 percent silica slag. The slag is also what gives wrought iron a “grain” resembling wood, which is visible when it is etched or bent to the point of failure. The Eiffel Tower is an example of a structure made primarily from wrought iron. Replaced by steel, not much wrought iron is produced anymore.

With an array of pipes, wires, beams, and structures, modeling a steel mill can appear to be a daunting task, but it is a fun and rewarding activity. Library of Congress
Open-hearth steelmaking is similar to the iron puddling process (described in Chapter 1) as it uses a reverberatory-type furnace, but the process takes place at a much higher temperature. Abram Hewitt of Cooper and Hewitt, a large iron and steel works at Trenton, N.J., introduced open-hearth technology to America in 1867. However, the use of open-hearth steel technology did not spread quickly. Problems, such as firebricks being unable to withstand the intense heat of the process, held the technology back.

In 1880, less than 10 percent of American steel was produced in open-hearth furnaces. However, Bessemer steel was unable to satisfy the growing demand for high-quality steel. The uneven quality of Bessemer steel did not suit the structural steel industry. Steel with a high-tensile strength was required in applications such as bridge building, and this need spurred steelmakers to further develop the open-hearth process.

The availability and superior strength of open-hearth steel led to its adoption as the specified material for the structural shapes and plates of U.S. Navy ships, and open-hearth steel became the preferred material for the production of ordnance, guns, armor plate, and propulsion machinery parts. Basic open-hearth steel overtook Bessemer production in 1908.

Open-hearth furnace

An open-hearth steel furnace was a roughly rectangular brick structure that contained a depressed, elongated, saucer-shaped floor or hearth. Hot gas created from burning coal, fuel oil, or natural gas passed through heat regenerators and ignited in the firebox to produce the flames needed to melt the charge. Workers charged the shallow refractory-lined hearth with a mixture of scrap steel and molten pig iron. The flames and hot gases from the firebox then passed across this charge until the temperature of the charge rose to 3,000°F, thereby melting the mixture and creating steel. As this was a reverberatory furnace, heat transferred via radiation and convection to the charge to avoid contamination with impurities in the fuel. Some open-hearth furnaces could tilt using huge hydraulic cylinders and rocker arms, but these were not as common as the stationary furnace.

Two large chambers containing a checkerwork arrangement of firebricks, through which air or gas could flow, preheated the incoming air. These...
The workers tapped the furnace when the heat was ready. They blew open the tapping hole with an explosive charge known as a torpedo. The molten steel flowed out of the open-hearth furnace into a hot-metal ladle. A second, smaller ladle sat alongside the hot-metal ladle to catch the slag that floated on the top of the metal. This was a sloppy process, and workers had to clean up the spilled slag and hot metal manually, a hazardous job since they had to work under the furnace. They closed the tap with a mixture of clay and dolomite in preparation for the next cast.

In most integrated mills, the open-hearth facility contained multiple furnaces usually arrayed in a line, 3-8. Pittsburgh Steel’s Monessen open hearth contained 12 separate furnaces arranged in a single structure, 3-9. Initially built as 95-ton furnaces, they were rebuilt twice to have an ultimate capacity of 250 tons each. At 1,055 feet long and 280 feet wide, this was a huge structure. In HO scale, this building would be more than 16 feet long and 4 feet deep. Numerous tracks support the open hearth, incorporating several crossovers for operational flexibility. In most layout designs, some selective compression will be necessary to model this building.

From the outside, the open hearth looked like any generic, gable-ended mill building, except for the prominent exhaust stacks for each furnace. You can exploit this attribute to make the modeling an open hearth much simpler by hiding interior details inside a metal-sided, gable-ended building built as big as the layout space can handle. A key visual element is that each furnace had its own stack. Any model of an open hearth should include one stack for each furnace. It is not necessary to model a hearth regenerator for preheating and reheating. Although interesting, most of this structure is not visible inside a model open-hearth furnace.

In the Monessen open hearth, there were two tracks under the charging floor, one to provide coal for the gas producers and another to remove ash. Gas producers were special ovens that partially combusted coal to form a rich gaseous mixture to supply oxygen, hydrogen, tar vapors, and other hydrocarbons that flowed through pipes into the gas main and then to the open-hearth regenerators for preheating and eventual burning. Not all open hearths used gas producers. Some relied on natural gas or fuel oil augmented with excess gas from coke ovens for fuel. In these cases, the tracks for the gas producers are not present. For example, Pittsburgh Steel removed the gas producers from Monessen in 1954 and installed fuel oil burners.

Basic oxygen furnace
In 1952, an Austrian company, Voestalpine AG, developed the first commercial basic oxygen steelmaking process. The process is called basic due to the nonoxidic pH of the refractory bricks (calcium oxide and magnesium oxide) that line the vessel. The bricks wear during the heat and become part of the slag. The slag reacts to remove phosphorus and sulfur from the molten charge, which allows the refining of high-phosphorous, high-sulfur pig iron. European companies rapidly replaced open-hearth furnaces with basic oxygen furnaces after World War II, but U.S. companies were reluctant to give up the old, tried-and-true open hearths or the last of the Bessemer. (The last U.S. Bessemer converter operated until 1968.) The first American company to use this type of furnace was McLouth Steel in Trenton, Mich., in 1954, and by 1991, all integrated mills converted to basic oxygen furnaces.
A unique saltwater mill

Sparrows Point has the distinction of being the only deep-water steel mill in the United States. The founders selected this tidewater site to minimize shipping costs on iron ore coming from Cuba and later from Chile. To economically move the ore, the company developed a small fleet of ore ships.

Coal for the furnaces came from West Virginia and Pennsylvania. While some of this coal was conveyed all the way by rail, most of it was carried part of the way by barge and by steamer, as this usually resulted in lower shipping costs. Nearly all the limestone used at Sparrows Point came from the company-owned quarries in Adams County, Pa., about 65 miles away.

The tidewater location caused some problems with water supply. The brackish water of the Chesapeake Bay was unsuitable for the mill's use. Fortunately, the mill was able to tap aquifers deep underground that provided ample freshwater to provide the 500,000 gallons needed per hour.

Along with the mill, the company established a residential community called Sparrows Point, where many workers settled. They enjoyed low rent and free home maintenance, company-subsidized churches and schools, easy access to credit, and a strong sense of community.

At first, the Sparrows Point plant just converted iron ore into pig iron for use in other Pennsylvania Steel plants. In 1891, the company installed Bessemer converters, and Sparrows Point began to produce steel. The mill became fully integrated with coke ovens, a by-product plant, and numerous rolling and blooming mills. Industries developed near the mill to take advantage of the steel production.

Purchased by Bethlehem Steel in 1916, the mill grew in size and capacity, six-3. The company expanded capacity seven times between 1916 and 1926. The mill’s steel ended up as girders in the Golden Gate Bridge and in cables for the George Washington Bridge.

During World War II, the steel industry underwent a production boom. In 1959, over 35,000 people worked at Sparrows Point, making it the largest employer in Maryland. By this time, facilities for steel production, sheet rolling, pipe fabrication, galvanizing, and shipbuilding and repair, along with ancillary steel-related industries, filled the coastal peninsula.

Modernization continued as a continuous caster went into production in 1974. Later, a massive blast furnace, labeled L, the 12th to be built at Sparrows Point, was built. All the others have been since torn down. The furnace is largely enclosed, and there is no skip hoist, as the furnace is fed by a conveyor and coal injector.

As the mill expanded, 12 blast furnaces were built. This is the largest blast furnace to be built at Sparrows Point. All the others have been since torn down. The furnace is largely enclosed, and there is no skip hoist, as the furnace is fed by a conveyor and coal injector.

Putting it all together

This chapter takes the concepts and ideas presented in the previous five chapters and applies them to designing a steel mill layout based on Bethlehem Steel’s Sparrows Point mill, six-1. It begins with a detailed look at the history of the mill and then presents three track plans, one N scale and two HO scale.

The sprawling Sparrows Point complex lies about 10 miles outside of Baltimore on the northern tip of Chesapeake Bay, six-2. At one time, it was the largest integrated steel mill in the world, and it still sets records for steel production. In 1889, Pennsylvania Steel Company erected the first blast furnaces at Sparrows Point on a low-lying, level piece of ground between Bear Creek and the Patapsco River, a tributary of Chesapeake Bay.

Even in the sprawling Sparrows Point complex, corners had to literally be cut to save space.

As the mill expanded, 12 blast furnaces were built. This is the largest blast furnace to be built at Sparrows Point. All the others have been since torn down. The furnace is largely enclosed, and there is no skip hoist, as the furnace is fed by a conveyor and coal injector.

In 1990, the last of the furnaces on blast furnace row, six-5, while two equally impressive basic oxygen furnaces replaced a large set of open-hearth furnaces, six-6. In 1990, the last of the furnaces on blast furnace row