# CHAPTER 1

# INTRODUCTION

## 1.1 SCOPE AND PURPOSE

The U.S. Environmental Protection Agency (EPA) proposes and promulgates water effluent discharge limits (effluent limitations guidelines and standards) for industrial sectors. This Economic Analysis (EA) summarizes the costs and economic impacts of technologies that form the bases for setting limits and standards for the iron and steel industry.[1]

The Federal Water Pollution Control Act (commonly known as the Clean Water Act [CWA, 33 U.S.C. §1251 et seq.]) establishes a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (section 101(a)). EPA is authorized under sections 301, 304, 306, and 307 of the CWA to establish effluent limitations guidelines and standards of performance for industrial dischargers. The standards EPA establishes include:

- Best Practicable Control Technology Currently Available (BPT). Required under section 304(b)(1), these rules apply to existing industrial direct dischargers. BPT limitations are generally based on the average of the best existing performances by plants of various sizes, ages, and unit processes within a point source category or subcategory.

- Best Available Technology Economically Achievable (BAT). Required under section 304(b)(2), these rules control the discharge of toxic and nonconventional pollutants and apply to existing industrial direct dischargers.

- Best Conventional Pollutant Control Technology (BCT). Required under section 304(b)(4), these rules control the discharge of conventional pollutants from existing industrial direct dischargers.[2] BCT limitations must be established in light of a two-part cost-reasonableness test. BCT replaces BAT for control of conventional pollutants.

- Pretreatment Standards for Existing Sources (PSES). Required under section 307. Analogous to BAT controls, these rules apply to existing indirect dischargers (whose discharges flow to publicly owned treatment works [POTWs]).

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[1] The industry, however, is free to use whatever technology it chooses in order to meet the limit.

[2] Conventional pollutants include biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, pH, and oil and grease.

- # New Source Performance Standards (NSPS). Required under section 306(b), these rules control the discharge of toxic and nonconventional pollutants and apply to new source industrial direct dischargers.

- # Pretreatment Standards for New Sources (PSNS). Required under section 307. Analogous to NSPS controls, these rules apply to new source indirect dischargers (whose discharges flow to POTWs).

The current iron and steel rule, 40 CFR Part 420, was promulgated in May 1982 (EPA, 1982), and was amended in May 1984 as part of a Settlement Agreement among EPA, the iron and steel industry, and the Natural Resources Defense Council (EPA, 1984). In promulgating Part 420 in 1982, aside from the temporary central treatment exclusion for 21 specified steel facilities at 40 CFR 420.01(b), EPA provided no exclusions for facilities on the basis of age, size, complexity, or geographic location as a result of the remand issues. EPA also revised the subcategorization from that specified in the 1974 and 1976 regulations to more accurately reflect major types of production operations and to attempt to simplify implementation of the regulation by permit writers and the industry. The factors EPA considered in establishing the 1982 subcategories were: manufacturing processes and equipment; raw materials; final products; wastewater characteristics; wastewater treatment methods; size and age of facilities; geographic location; process water usage and discharge rates; and costs and economic impacts. Of these, EPA found that the type of manufacturing process was the most significant factor and employed this factor as the basis for dividing the industry into the twelve process subcategories currently in Part 420.

## 1.2 DATA SOURCES

The economic analysis rests heavily on the site- and company-specific data collected under authority of the CWA Section 308 (EPA, 1998). Other data sources used in the economic analysis include:

- # Census data.

- # Trade data and information from the International Trade Commission and the U.S. International Trade Administration (Commerce Department).

- # Industry data, such as the American Iron and Steel Institute statistics.

- Industry journals.
- General economic and financial references (these are cited throughout the report).

## 1.3 REPORT ORGANIZATION

This EA Report is organized as follows:

- Chapter 2—Industry Profile
  Provides background information on the facilities, companies, and the industry from publicly available sources. Also presents the proposed resubcategorization of the iron and steel industry.

- Chapter 3—Survey Data
  Summarizes information collected in the EPA survey. The data cover the period 1995 though 1997 and reflect the sites to which the proposed rule is applicable.

- Chapter 4—Economic Impact Methodology
  Presents the economic methodology by which EPA examines incremental pollution control costs and their associated impacts on the industry.

- Chapter 5—Regulatory Options: Descriptions, Costs, and Conventional Pollutant Removals

  Presents short descriptions of and cost estimates for the regulatory options considered by EPA. More detail is given in the Technical Development Document (U.S. EPA, 2000).

- Chapter 6—Economic Impact Results
  Using the methodology presented in Chapter 4, EPA examined projected impacts for all options considered on a subcategory basis. The chapter presents the projected impacts from the co-proposed options on site, company, and industry basis.

- Chapter 7—Small Business Analysis
  EPA is certifying that the proposed rule will not have a significant impact on a substantial number of small businesses. However, EPA did prepare a small business analysis.

- Chapter 8—Benefits Analysis
  Summarizes the methodology and findings by which EPA identifies, qualifies, quantifies, and—where possible—monetizes the benefits associated with reduced pollution.

- Chapter 9—Benefit Comparison and Unfunded Mandates Reform Act Analysis
  Compares the benefits and costs of the proposed regulation and shows how the analysis meets the requirements of the Unfunded Mandates Reform Act.

## 1.4 REFERENCES

U.S. EPA. 2000. Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category. EPA-821-B-011. Washington, DC: U.S. Environmental Protection Agency, Office of Water. October.

U.S. EPA. 1998. Collection of 1997 iron and steel industry data: Part A: Technical data. Part B: Financial and economic data. Washington, DC OMB 2040-0193. Expires August 2001.

U.S. EPA. 1984. Part II: Environmental Protection Agency; Iron and Steel Manufacturing Point Source Category Effluent Limitations and Standards. *Federal Register 49:21036*ff. May 17.

U.S. EPA. 1982. Part II: Environmental Protection Agency; Iron and Steel Manufacturing Point Source Category Effluent Limitations and Standards. *Federal Register 47:23258*ff. May 27.

# CHAPTER 2

# INDUSTRY PROFILE

The industry profile provides background information for those unfamiliar with the iron and steel industry. As such, it sets the baseline against which to evaluate the economic impacts of increased pollution controls. The rulemaking effort covers sites with manufacturing operations in Standard Industrial Classification (SIC) codes:[1]

- 3312: Steel works, blast furnaces (including coke ovens), and rolling mills
- 3315: Steel wiredrawing and steel nails and spikes
- 3316: Cold-rolled steel sheet, strip, and bars,
- 3317: Steel pipes and tubes
- 3479: Electroplating, plating, polishing, anodizing, and coloring; Coat/engrave/allied services not elsewhere classified.

Today, steel spans rivers, forms the bodies of our automobiles and appliances, serves as structural skeletons for buildings, protects food, and supplies a host of different objects in everyday life. But iron and steel have a technological history of over 5,000 years. Based on beads found at Jirzah, Egypt, meteoric iron was worked as early as 3,500 B.C. Smelted iron, dated 2,700 B.C., in the form of a dagger was found at Tall el-Asmar, Mesopotamia (ancient Iraq). Iron served as a flux for copper in earlier objects. Historical texts indicate that archaeological finds are not common because metals were regularly recycled (Moorey, 1988). Different regions (Europe, the Mediterranean, Asia, and Africa) developed ironmaking of different types but with relatively similar technologies. Furnaces were holes in the ground where the draft was introduced through a pipe and bellows. Shaft furnaces, however, relied on natural drafts. Both furnace types involved creating a bed of red-hot charcoal to which a mixture of iron ore and charcoal was added. Chemical reduction of the ore occurred and a "bloom" of iron was produced. The iron was heated and hammered into shape (wrought iron). Wrought iron was more common except in China where cast iron implements dominated (Taylor and Shell, 1988). Carburization may have occurred by allowing the artifact to remain in

[1]The United States is changing from the SIC system to the North American Industrial Classification System (NAICS). Appendix B cross-references these two systems for the iron and industry.

the forge long enough to render the edges steel (Stech and Maddin, 1988). Steel was known in the Classical Greek and later periods.

Iron-making technology changed very little until medieval times. The blast furnace appeared in Europe in the 15th century when it was realized that cast iron could make one-piece guns with good pressure-retaining properties. Increased iron production led to a scarcity of wood for charcoal. Abraham Darby in 1709 is credited with the realization that coal in the form of coke could be substituted for charcoal. Because of coke's greater strength, it could support larger amounts of ore for processing. The fundamental technology for converting iron ore into iron has been essentially unchanged for the last two centuries. However, the performance of the technology has been remarkably improved. The principal reasons are the mechanization of materials handling and charging, the improvement of furnace design and the increase of furnace size, the improvement of tapping and removal of hot metal, and the recovery and recycle of waste products. Since World War II, dramatic increases in productivity have been achieved using high top pressure, burden beneficiation, wind beneficiation, and supplemental fuel injection. Burden beneficiation techniques have included the firing of iron ore fines, coal dust and lime in a grate-kiln to form uniform pellets, the firing of iron ore fines and other recovered iron units with coke breeze and a flux to form sinter, and the screening of coke to yield uniform size. Wind beneficiation techniques have included the injection of steam and oxygen enrichment of the blast. The last new blast furnace constructed in the U.S. was blown-in (started production) in 1980.

Unlike ironmaking, steelmaking technology has been marked by continual change. The introduction of the pneumatic Bessemer process, which first allowed mass production of steel occurred simultaneously in the 1850s in the United States by William Kelly and Britain by Henry Bessemer. The acid Bessemer process and the related basic Bessemer (or Thomas) process, introduced some years later, replaced two very low productivity production processes (the crucible process and the cementation process). The Siemens regenerative open hearth process was developed in the 1860s and introduced in the U.S. as early as 1868. An open hearth furnace with a basic bottom, rather than the previous acid bottom, went into commercial production in 1888 in Homestead, Pennsylvania. The open hearth process superseded the Bessemer process as the predominant means of steel production in the U.S. in 1908, due to the flexibility of the process and the improved quality of the steel. The electric arc steelmaking furnace was placed in operation in France in 1899 and introduced to the U.S. in 1906.

Until the early 1950s, the open hearth furnace remained the unchallenged premier steel production unit in the U.S. and the world, with the electric arc furnace playing a role in the production of alloy and special steels. The Bessemer converter slowly declined in importance, being surpassed in output by the electric arc furnace in 1948, and with the last new converter shop being built in 1949 (in Lorain, OH) and the last converter being shutdown in 1969 (in Ambridge, PA). In 1952, and 1953, the pneumatic basic oxygen process (BOP) started commercial production in Linz and Donawitz, Austria. The basic oxygen process was introduced in the U.S. in 1954 by McLouth Steel in Detroit. The last new open hearth shop was constructed in 1958. The output of the basic oxygen process surpassed the output of the open hearth process in the U.S. in 1970, after surpassing the electric arc furnace output in 1964. The basic oxygen process provided substantially shorter production times, lower capital and operating costs, and at least equivalent quality. Meanwhile, the electric arc furnace had experienced substantial technological improvements in the 1960s and early 1970s leading to increased output of both carbon and specialty steels, while the open hearth process sharply declined, despite marked technical improvements. The output of electric arc furnaces exceeded the output of open hearth furnaces in 1975 and the final open hearth furnace shop closed in 1991. The basic oxygen process remains the largest producer of steel in the U.S. today with approximately 60 percent of output, even though the number of BOF shops has declined since 1980 and the last new BOF shop was completed in 1991 (the shop actually incorporated used furnaces from another shuttered mill). The electric arc furnace accounts for the remainder of steel production, with a growing output share and new furnaces being added regularly.

Pollution concerns about coke-making are leading to new approaches, one of which involves no coke in the iron-making process. Section 2.1 provides a brief overview of current industry practices; the Development Document accompanying the proposed rule contains more detailed information (EPA, 2000).

Given the long history of the manufacture and use of iron and steel, the industry profile presents only a snapshot of the domestic industry against which to evaluate the potential impacts of increased pollution control costs. The industry profile includes:

- Overview of industry processes (Section 2.1)
- Site classification (Section 2.2)
- Products (Section 2.3)

- Subcategories (Section 2.4)
- Environmental protection issues (Section 2.5)
- Production (Section 2.6)
- Specialization and coverage ratios (Section 2.7)
- Major markets (Section 2.8)
- Patterns for the industry 1986-1999 (Section 2.9)
- International competitiveness of the industry (Section 2.10)

## 2.1 OVERVIEW OF INDUSTRY PROCESSES

A more detailed description of industry processes and technologies may be found in the Development Document accompanying this proposal (EPA, 2000) and AISE, 1985. The text in this section draws heavily on AISE, 1985, and EPA's Preliminary Study and Sector Notebook for the iron and steel industry (U.S. EPA, 1995a and b). Figure 2-1 is a schematic of iron and steelmaking operations from the iron ore to the casting of blooms, billets, and slabs.[2]

### 2.1.1 Cokemaking

Coke serves as a fuel and carbon source to heat and reduce iron ore to iron in a blast furnace. The burning of the coke generates carbon monoxide which is a reducing agent. Two batch processes are used to produce coke from coal, one in which the by-products are recovered and a second in which they are not.

A coke oven is a tall and narrow oven with a charging port on the top side and doors on each of the narrow sides. A coke battery is a series of 10 to 100 individual ovens arranged side by side with a heating flue between each oven pair. The cokemaking process begins with charging the oven with

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[2]Blooms and billets both may be square in cross-section or be less than twice as wide as thick. Blooms are usually more than 36 square inches in cross-section; billets are usually less than 36 square inches. A slab has a width as least twice its thickness.

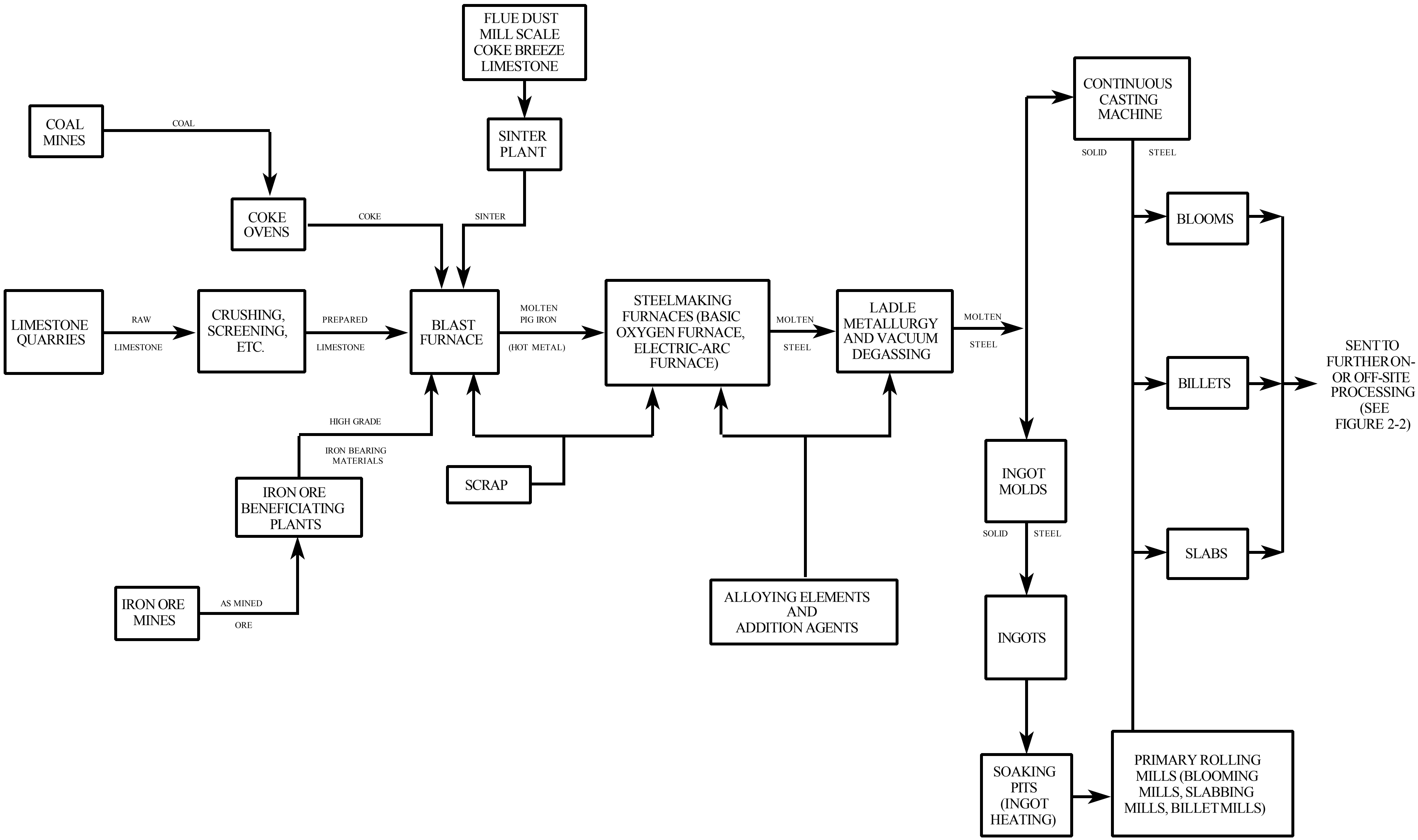


**Figure 2-1: Iron and Steelmaking Operations**

pulverized coal through ports at the top of the oven. After charging, the ports and doors are sealed and the coal is heated to 1600E- 2300E F in the absence of oxygen. The heating cycle typically lasts from 16 to 18 hours (Hogan and Koelble, 1996). The heat drives off the volatile components, leaving a relatively pure carbon-rich fuel that burns with high temperature and a relatively small amount of emissions. When the heating cycle is complete, the doors are opened and the coke is pushed from the oven into a rail quench car. The quench car takes the coke to a tower where the coke is cooled with a water spray. Finally, the coke is screened. Coke pieces too small to use in the blast furnace generated during quenching, handling, and screening are called coke fines or coke breeze and are generally used in other manufacturing processes (see Section 2.1.2). The finished coke may be sold or used in the company's own blast furnace. A facility that exists to process coke solely for the purpose of selling the product is called a "merchant coke" facility.

Foundry coke is the other important subgroup of metallurgical coke accounting for approximately 5 to 7 percent of annual U.S. coke production. Foundry coke is primarily used in cupolas as a heat and carbon source for melting scrap, iron and other additives to produce gray iron or ductile iron. The molten iron is then used in the production of castings. Metal castings are used extensively in automotive parts, pipe fittings, and various types of machinery.

Foundry coke is produced by the byproduct recovery process in the United States. The coking process involves heating the coking coal to 900 to 1100 C, for periods of 26 to 32 hours. Foundry coke is relatively large, 4 inches or larger in diameter. Foundry coke must also have good strength and low ash content (ITC, 2000a).

#### *2.1.1.1 By-Product Recovery Cokemaking*

Moisture and volatile components of the coal are about 20 to 35 percent by weight. In by-product recovery cokemaking, these components are collected and processed to recover coal tars, crude light oil, anhydrous ammonia or ammonium sulfate, naphthalene, and sodium phenolate. Coke oven gas is used as a fuel for the coke oven. Until 1998, nearly all U.S. coke was produced with by-product recovery. Air emissions and water effluents from by-product cokemaking processes are of environmental concern, see Section 2.5. With the promulgation of National Emission Standards for Hazardous Air Pollutants (NESHAP), coke oven batteries are coming under increasingly stringent standards. In response, some aging batteries have shut down, while plants using non-byproduct recovery cokemaking methods have opened (see Section 2.1.1.2). Furthermore, other non-coke methods of making iron are being developed (see Section 2.1.3.2).

#### *2.1.1.2 Non-By-Product Recovery Cokemaking*

In non-by-product recovery cokemaking, all volatile gases are incinerated; sulfur is the only remaining pollutant. As such, it is considered a more environmentally-friendly process. The first non-by-product coke plant was Jewell Coal & Coke which opened in the late 1970s. Not until mid-1998, in light of rising environmental costs, was a second facility built. The Sun Coal and Coke Company (Jewell's parent company) opened a new non-recovery coke manufacturing plant at Inland Steel's complex in East Chicago, Indiana. Inland ISPAT Steel shut its coke ovens in 1993 largely because of the Clean Air Act regulations. Inland ISPAT Steel's obligation is to purchase 1.2 million tons of coke per year for a period of 15 years. The plant has a capacity of about 1.3 million tons per year. The new coke plant is combined with a waste heat recovery and cogeneration facility (i.e., the excess coke oven gas will generate electricity from steam; Hogan and Koelble, 1996; New Steel 1997a; and ENR, 1998).

#### *2.1.1.3 Direct Injection of Pulverized Coal and/or Natural Gas*

The injection of pulverized coal and/or natural gas at the tuyeres (openings into the bottom of the blast furnace) reduces coke consumption. Some sites inject oil, tar, or other fuels. Some high-quality coke is still needed in the blast to provide a permeable, high mechanical strength support for hot-metal production. Injection techniques have reduced coke consumption from about 1,000 pounds/ton of hot metal (thm) in 1990 to about 800 pounds/thm in 1995 (Agarwal, et al., 1996). U.S. Steel and National Steel have sites that co-inject both coal and natural gas. Not only is coke usage reduced, but natural gas injection—when combined with proper oxygen enrichment—can boost hot-metal output (Woker, 1998).

### 2.1.2 Sintering

Sintering is a process that recovers iron and agglomerates fine-sized particles ("fines") from iron ores, coke breeze, mill scale, processed slag, wastewater treatment sludges, and pollution control dust into a porous mass for charging to the blast furnace. The materials are mixed together, placed on a slow-moving grate (also called a sinter strand), and ignited. Windboxes under the grate draw air through the materials to enhance combustion. In the process, the fine materials are fused into the clinkers (sinter agglomerates) which can be charged to the blast furnace (U.S. EPA, 1995a and b).

### 2.1.3 Ironmaking

#### *2.1.3.1 Blast Furnace*

Coke, iron ore, limestone and sinter are fed into the top of the blast furnace. Heated air (the blast) is blown into the bottom of the furnace through a pipe and openings (tuyeres) around the circumference of the furnace. The iron-bearing material is supported by the coke and reduced to molten iron and slag as it descends through the furnace. The carbon monoxide from the burning coke reduces the iron ore to iron while the acid part of the ore reacts with the limestone to form slag. The slag floats on top of the molten iron. Slag and iron are tapped periodically through different sets of runners. The term "pig iron" originated in the 15th Century. The iron was tapped down a long channel to which short, straight molds joined at right angles. The layout reminded the ironworkers of a sow suckling piglets, hence the name. Today the 2,800 to 3,000E F iron is tapped into refractory-lined cars for transport to the steel making furnaces while the slag may be used as railroad ballast, as cement aggregate, or for other construction uses (Britannica, 1998; U.S. EPA, 1995a, and U.S. 1995b).

#### *2.1.3.2 Alternative Processes*

Industry has been developing iron-making alternatives to the blast furnace partly in response to the emissions associated with cokemaking and partly to respond to high scrap steel prices. A steel scrap substitute is a high-iron material in which the iron has been extracted from the ore with natural gas or steam coal as the reductant, i.e., without the use of coke (WSD, 1996a). Table 2-1 is a summary of alternative processes, taken from WSD, 1997a. The most common iron substitutes are directly reduced iron (DRI, where the iron is reduced at temperatures below the melting point of the iron produced ), hot-briquetted iron (HBI), and iron carbide (Barnett, 1998). With the industry downturn in 1998-1999, the prices for alternative iron dropped, making the viability of some of the projects questionable (Woker, 1999).

Alternative iron sources have been used in the United States for more than a quarter century. GS Industries, Georgetown, SC has used DRI since the 1970s. GS Industries teamed with Birmingham Steel to build a new DRI plant in Convent, LA (American Iron Reduction) that started in the beginning of 1998. Nucor Corporation began operations at an iron-carbide plant in Trinidad in 1994 but shut the plant five years later because of technical difficulties and low pig iron prices (New Steel, 1999a). Corus' DRI shop in Mobile, AL began operations in December 1997 and barges DRI to the Tuscaloosa steelmaking plant. Iron Dynamics, Inc. (IDI)—a subsidiary of Steel Dynamics, Inc. (SDI)—opened a DRI facility in November 1998 that transports the liquid metal across the street to SDI. IDI's start-up has been plagued with breakouts through the refractory wall and the technical difficulties are limiting the metal shipped to SDI in 1999 (Bagsarian, 1998; Woker, 1999; WSD 1996b). Qualitech opened an iron carbide facility in Texas in 1997 and declared bankruptcy less than a year later. A joint venture of LTV and Cleveland Cliffs Inc. in Trinidad uses Lurgi's Circored process to produce HBI.

Although DRI projects are becoming more frequent, DRI needs more careful handling, transport, and storage than HBI or iron carbide. Exposure to moisture may lead to violent reoxidation; in 1996, Russian DRI caught fire during shipping to the U.S. when it improperly came into contact with moisture (WSD, 1997a).

### 2.1.4 Steelmaking

All steel in the United States is made either in basic oxygen furnaces (BOFs) or electric arc furnaces (EAFs). Both are batch processes with tap-to-tap (batch cycle) times ranging from 45 minutes to 3 hours. Open hearth furnaces stopped operating in 1991.

**Table 2-1**

**Scrap Steel Substitutes**

**Summary of Characteristics of Direct Reduction Processes**

| Process | Feedstock | Reductant | Reducer | Temperature | Pressure |
|---|---|---|---|---|---|
| AREX | Pellet/lump | Gas | Shaft | Medium | Low |
| Circofer | Fines | Carbon | Fluid bed | High | Medium |
| Circored | Fines | Gas | Fluid bed | Low | Medium |
| Davy DRC | Pellet/lump | Carbon | Kiln | High | Atmosphere |
| FASTMET | Fines | Carbon | Hearth | Very high | Atmosphere |
| FINMET | Fines | Gas | Fluid bed | Medium | High |
| HYL III | Pellet/lump | Gas | Shaft | Medium | Medium |
| Iron Carbide | Fines | Gas | Fluid bed | Low | Medium |
| Inmetco | Fines | Carbon | Hearth | Very high | Atmosphere |
| MIDREX | Pellet/lump | Gas | Shaft | Medium | Low |
| SL/RN | Pellet/lump | Carbon | Kiln | High | Atmosphere |

Source: WSD, 1997a

#### *2.1.4.1 Basic Oxygen Furnace*

Molten iron from the blast furnace, flux, alloy materials, and scrap are placed in the basic oxygen furnace, melted, and refined by injecting high-purity oxygen. The charge to the BOF is typically about two-thirds molten iron and one-third scrap. Oxygen is injected either through the top of the furnace (top blown), bottom of the furnace (bottom blown), or both (combination blown). Slag is produced from impurities removed by the combination of fluxes with the injected oxygen. Various alloys may be added to produce different grades of steel. Residual sulfur is controlled by managing furnace slag properties. BOF slag can be processed to recover high metallic portions for use in sintering or blast furnaces, but its applications as saleable construction material are more limited than blast furnace slag.

#### *2.1.4.2 Electric Arc Furnace*

Scrap steel is the charge to an electric arc furnace. It is melted and refined using electric energy. During melting, oxidation of phosphorus, silicon, manganese, and other materials occurs and a slag forms on the top of the molten metal. Oxygen is used to de-carburize the molten steel and to provide thermal energy.

Because of the absence of cokemaking and blast furnace operations coupled with the ability to be economically scaled for smaller batches, these sites were termed “minimills.” The first use of the term “minimill” seems to be in a 1969 Wall Street Journal article on wiremakers (Depres, 1998). Traditionally, the term “integrated mill” referred to sites with all processes from cokemaking through finishing. Because of recent closures in coke oven batteries, there are integrated mills both with and without cokemaking. The term “minimill” is relative only to a fully integrated mill; minimill EAFs may melt up to 200 to 300 tons per heat. At one point, it might have been common to contrast integrated and mini-mills in a straight forward manner, e.g., integrated mills had iron-making operations (blast furnaces and BOFs), minimills did not. BOFs are typically used for high tonnage production of carbon steels while EAFs are used to produce carbon steels and low tonnage alloy and specialty steels. When EAF technology first came into operation, it produced typical “long” products where quality was less important than for other products such as, reinforcing bars (rebar), beams, and other structural materials.

The distinction is blurring, however. Beginning in 1989, Nucor opened its first EAF-based sheet mill in Crawfordsville, Indiana. Mini-mills therefore began making the higher-quality sheet products. Nucor is now joined by Gallatin Steel, Steel Dynamics, Trico, North Star, and possibly IPSCO (WSD, 1997b). With Trico, a joint venture of LTV, British Steel, and Sumitomo Metals, traditionally integrated producers have begun EAF operations. With the start up of Iron Dynamics and iron carbide operations in Trinidad, Steel Dynamics and Nucor are "integrating" by controlling these sources of steel scrap substitutes. Iron Dynamics, Inc. is located adjacent to a Steel Dynamics site, emphasizing the integrated nature of the relationship.

### 2.1.5 Ladle Metallurgy/Vacuum Degassing

Molten steel is tapped from the BOF or EAF into ladles large enough to hold an entire heat. At this stage, the metal is subjected to temperature control, composition control, deoxidation ($O_2$ removal), degassing ($H_2$ removal), decarburizaton to remove other impurities from the steel.

### 2.1.6 Casting

#### *2.1.6.1 Ingots*

After the ladle metallurgy stage, the molten iron is poured (teemed) into ingot molds. The cooled and solidified steel is stripped from the mold, transported to forming operations, reheated, and roughly shaped. Although this was the traditional method of steelmaking, it is being replaced by continuous casting (see below) due to the latter's economic efficiencies.

#### *2.1.6.2 Continuous Casting*

Continuous casting methods bypass several of the conventional forming steps by casting steel directly into semifinished shapes. Molten steel is poured into a reservoir (tundish) from which it is released to a water-cooled mold at controlled rates. The steel solidifies as it descends through the casting machine mold, emerging from the mold with a hardened shell. The steel feeds onto a runout table where the center solidifies sufficiently to allow the cast to be cut into lengths. Blooms, billets, round, and slab-shaped pieces may be continuously cast.

### 2.1.7 Hot Forming

With hot-forming operations, the flow diagram changes from Figure 2-1 to Figure 2-2. The semi-finished steel shapes are re-heated to about 1,800E F and passed between two rolls revolving in opposite directions where the mechanical pressure reduces the steel's thickness. While a single rolling stand feeds the steel through in one direction, the hot rolling mill may be a reversing mill that adjusts the space between the rolls and feeds the steel back in the opposite direction. Or, a site may have a series of rolling stands where each stand in the series progressively reduces the thickness of the steel. A 40-foot slab entering a hot rolling mill may exit as a 5,000 foot strip. The final shape, thickness, and characteristics of the steel depends on the rolling temperature, rolling profile, and the cooling processes after rolling.

### 2.1.8 Acid Pickling/Salt Descaling

In this step, steel is immersed to remove oxide scale from the surface of the semi-finished product prior to further processing. The process may be batch or continuous. In the latter cases, coils may be welded end-to-end at the start of the line and cut by torch at the end of the line. Sulfuric acid, hydrochloric acid, or a combination of the two are common pickling solutions. In salt descaling, the aggressive physical and chemical properties of molten salts are used to remove heavy scale from selected specialty and high-alloy steels. Two proprietary baths are available, one oxidizing (Kolene) and one reducing (Hydride).

### 2.1.9 Cold Forming

Cold forming involves the rolling of hot rolled and pickled steel at ambient temperature. The reduction in thickness is small compared to that in hot rolling. Cold rolling is used to obtain improved mechanical properties, better machinability, special size accuracy, and thinner gages than can be

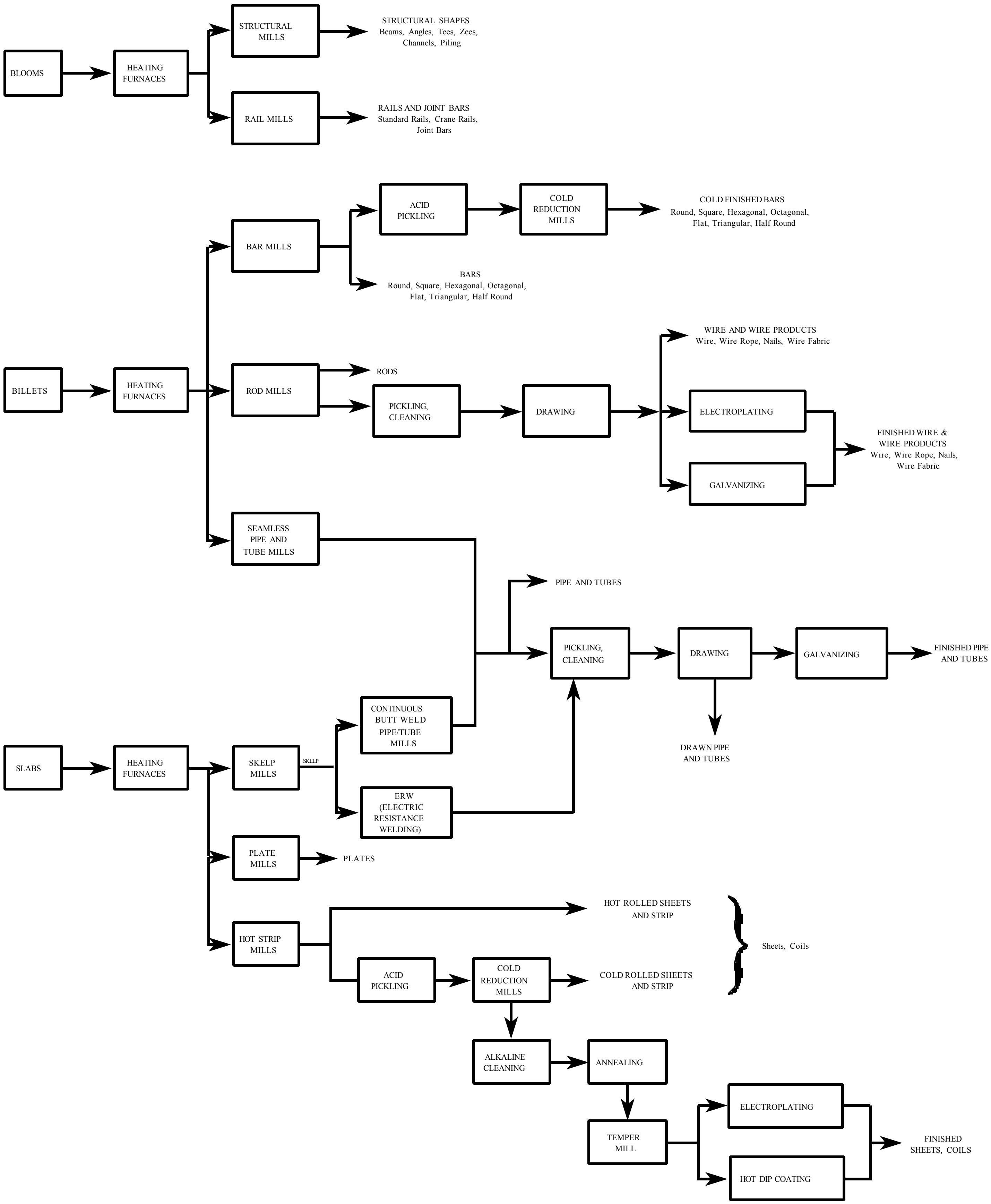


**Figure 2-2: Forming and Finishing Operations**

economically produced with hot rolling. Cold rolling is generally used to produce wire, tubes, sheet, and strip steel products. During cold rolling, steel becomes hard and brittle. The steel is heated in an annealing furnace to make it more ductile.

### 2.1.10 Finishing

One of the most important aspects of a finished product is the surface quality. Several finishing processes are in current use: alkaline cleaning, hot dip coating, galvanizing, and electroplating. Qualities desired in the final product will determine which process or combination of processes is used.

#### *2.1.10.1 Alkaline Cleaning*

Alkaline cleaning typically occurs after cold forming and prior to hot coating or electroplating. The purpose is to remove mineral oils and animal fats and oils from the steel surface, i.e., preparing a surface that will accept a later coating. Alkaline cleaning involves baths that are less aggressive than pickling operations.

#### *2.1.10.2 Hot Dip Coating*

Hot dip coating operations involve immersing cleaned steel into molten baths of:

- Tin
- Zinc (galvanizing)
- Zinc and aluminum (galvalume coating)
- Lead and tin (terne)

Sometimes coating operations have a final step such as chromium passivation. Hot coating is usually performed to improve corrosion resistance and/or appearance (EPA 1995a and 1995b).

#### *2.1.10.3 Electroplating*

Electroplating involves covering the steel product with a thin layer of metal through chemical changes induced by passing an electric current through an ionic solution. The food and beverage market uses tin and chromium electroplated projects. Zinc electroplated (electro-galvanized) steel is used in the automotive market. The latter market has been increasing in recent years due to automobile manufacturers demand. New coatings, such as combinations of iron, nickel, and other metals, are under development and refined in response to market specifications.

## 2.2 SITE CLASSIFICATION (INTEGRATED/NON-INTEGRATED/STAND-ALONE)

Not all sites have all the operations described in Section 2.1. For the purpose of designing the survey performed under the authority of the Clean Water Act, Section 308, EPA uses three terms to generally classify iron- and steelmaking sites:

- Integrated. Traditionally, integrated steel mills performed all basic steelmaking operations from cokemaking through finishing. Today, the term refers to a site that has a blast furnace or BOF, many of the integrated sites having closed their cokemaking and sintering operations.

- Non-integrated. Also known as “minimills,” these sites have EAFs and do not have blast furnaces or BOFs.

- Stand-alone. A stand-alone site has no melting capability. Stand-alone facilities cover a wide range in operations. There are stand-alone coke plants ranging in capacity from 615 tons/day (Tonawanda Coke) to 12,280 tons/day (U.S. Steel Clairton Works; Hogan and Koelble, 1996). Stand-alone sites with finishing operations typically process hot rolled steel into finished steel products by pickling, cold-rolling, cleaning, hot coating, or electroplating. Other stand-alone facilities manufacture tube and pipe or wire from semi-finished steel.

The general categories may be broken down further by facilities that manufacture or finish carbon, alloy, and/or stainless steels (see Section 2.3). Stand-alone facilities may be located near or adjacent to other steelmaking operations but typically have separate wastewater treatment systems and discharge permits.

## 2.3 PRODUCTS

The three principal steel types produced in the United States are carbon, alloy, and stainless (EPA, 1998). They are defined as:

- Carbon. Carbon steel owes its properties chiefly to various percentages of carbon without substantial amounts of other alloying elements. Steel is classified as carbon steel if it meets the following conditions: (1) no minimum content of elements other than carbon is specified or required to obtain a desired alloying effect, and (2) the maximum content for any of the following do not exceed the percentages noted: manganese (1.65%), silicon (0.60%), or copper (0.60%).

- Alloy. Steel is classified as alloy when the maximum range for the content of alloying elements exceeds one or more of the following: manganese (1.65%), silicon (0.60%), or copper (0.60%), or in which a definite range or definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, boron, chromium (less than 10%), cobalt, lead, molybdenum, nickel, niobium (columbium), titanium, tungsten, vanadium, zirconium, or any other alloying element added to obtain a desired alloying effect.[1]

- Stainless. Stainless steel is a trade name given to alloy steel that is corrosion and heat resistant. The chief alloying elements are chromium, nickel, and silicon in various combinations with possible small percentages of titanium, vanadium, and other elements. By American Iron and Steel Institute (AISI) definition, a steel is called "stainless" when it contains 10% or more chromium.

Carbon steels have diverse uses and are produced in much greater quantities than alloy and stainless steels. Alloy steels are used where enhanced strength, formability, hardness, weldability, corrosion resistance, or notch toughness is needed for specific applications. Stainless steels are designed for corrosion-resistant applications or where surface staining is not desired.

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[1]Specialty steel is a steel containing alloying elements added to enhance the properties of the steel when individual alloying elements (e.g. aluminum, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium) are more than 3%, or the total of all alloying elements exceeds 5 percent.

## 2.4 PROPOSED SUBCATEGORIZATION

Table 2-2 summarizes the subcategorization proposed in this rulemaking. More detailed information may be found in the Development Document accompanying the rulemaking (EPA, 2000). The number of subcategories reduces from twelve to seven. While cokemaking and ironmaking remain separate subcategories, they are revised to remove references to obsolete technologies and include new technologies. For example, references to beehive coke plants and ferromanganese are deleted from cokemaking and ironmaking, respectively. Non-byproduct cokemaking processes are now included in cokemaking while the ironmaking subcategory now subsumes sintering and ironmaking.

The remaining subcategories, based on plant classification, are new (see Section 2.2). There are two integrated subcategories—one through ingot casting (Subcategory C) and the other through hot forming operations (Subcategory E). There is one non-integrated (mini-mill) subcategory, Subcategory D. Subcategory F is for steel finishing operations. Note that electroplating, formerly under 40 CFR 433, is now part of the steel finishing-carbon subcategory. The final subcategory (G) is for other operations, such as alternative ironmaking processes (DRI and briquetting) and forging.

## 2.5 ENVIRONMENTAL PROTECTION ISSUES

EPA promulgated NESHAP for coke oven charging in 1993. Cokemaking sites are faced with three choices:

- Meet the Maximum Achievable Control Technology (MACT) limits in 1995 and more stringent limits in 2003. The 2003 limits are either MACT limits more stringent than the 1995 values or residual risk standards (RRS) that limit the risk to public health in the surrounding communities, depending upon whichever is more stringent (known as the "MACT track").

- Meet a series of three increasingly stringent emissions limits consistent with the Lowest Achievable Emissions Rate (LAER). The first deadline was November 1993, the second deadline was January 1998, and the third deadline is January 2010. Full compliance with RRS must occur in 2020. (known as the "Extension track").

- Cokemakers may choose to "straddle" the tracks until 2003. If this option is chosen, the site must meet the interim standards under both the MACT and Extension tracks until 2003. At that time, a cokemaker could decide to forgo RRS compliance for a battery. If

**Table 2-2**

**Proposed Iron and Steel Manufacturing Subcategories and Segments**

| Subcategory | | Segment |
|---|---|---|
| A. | Coke Making | By-product |
| | | Other—Nonrecovery |
| B. | Ironmaking | Blast furnace |
| | | Sintering |
| C. | Integrated Steelmaking Operations | |
| D. | Non-Integrated Steelmaking and Hot Forming Operations | Carbon & Alloy Steel |
| | | Stainless Steel |
| E. | Integrated Hot Forming Operations, Stand-Alone Hot Forming Mills | Carbon & Alloy Steel |
| | | Stainless Steel |
| F. | Steel Finishing Operations | Carbon & Alloy Steel |
| | | Specialty Steel |
| G. | Other Operations | Direct Iron Reduction |
| | | Briquetting (HBI) |
| | | Forging |

so, the battery may operate until 2010 because it already had to meet the Extension track's 1998 LAER standards. (known as the "Straddle track").

If a coke battery could not meet the January 1998 LAER limits, it must either close or rebuild (Hogan and Koelble, 1996). In other words, the number of sites with cokemaking operations may change substantially as a result of not being able to meet the January 1998 LAER limits. This deadline occurs just as the survey period ends, so the cokemaking profile may need to be adjusted to address these changes. The second deadline for the MACT and Straddle track sites is 2003, and another shift in the profile may occur. In addition, two MACT standards for the industry (coke pushing and quenching, and integrated iron and steel) are scheduled for proposal in 2000.

## 2.6 PRODUCTION

There are potential difficulties with both the Current Industrial Reports (Census) data and American Iron and Steel Institute (AISI)data for the EPA analysis. First, the sites in the Census and AISI data span two EPA effluent guideline subcategories—iron and steel and metal products and machinery. Because the regulated community examined in this analysis is a subset of that presented in secondary data, EPA relies on the survey data when evaluating impacts. Second, EPA surveyed the iron and steel industry in the Fall of 1998, requesting data for fiscal years 1995, 1996 and 1997. During this period, the government was changing from the Standard Industrial Classification (SIC) to the North American Industry Classification System (NAICS). The 1997 Current Industrial Report (MA33B(97)) presents data by product code related to SIC codes (DOC, 1998). The 1997 Census, however, presents data by NAICS code. The Small Business Administration noted that it intends to convert business size standards to NAICS effective 1 October 2000 (FR, 1999). This industry profile, then, reports some information via SIC code (see beginning of Chapter 2) and some by NAICS code (see Section 2.7) depending on the form in which the data are available.[2] For the two reasons listed above, production data for the regulated community is based on EPA survey data, presented in Chapter 3.

[2]Appendix B cross-references the NAICS and SIC codes for the iron and steel industry.

## 2.7 SPECIALIZATION AND COVERAGE RATIOS

A specialization ratio represents a comparison between primary products shipped and total products shipped by establishments classified within the industry. A coverage ratio represents the ratio of primary products shipped by establishments classified in the industry to total shipments of such products by all manufacturing establishments, wherever classified (DOC, 1999a).

The ratios retrieved from the Census for the purpose of our analysis include the following product categories: NAICS 331111 iron and steel mills, NAICS 331210 steel pipes and tubes, NAICS 331221 cold finishing of steel shapes, and NAICS 331222 steel wire and related products. Table 2-3 displays the specialization and coverage ratios for the above product categories from the 1997 Census data. Each product category, with the exception of cold finishing of steel shapes, has a specialization ratio of 96 percent or higher. The high specialization ratios indicate that the establishments within the industry have total production that consists mostly of their primary products. The coverage ratios range from 90 percent to 98 percent. These coverage ratios indicate that the total production of these particular categories are generated by establishments within the industry and not other manufacturing establishments outside of the industry.

## 2.8 MAJOR MARKETS

### 2.8.1 Service Centers

Service centers and distributors are the largest domestic market for steel shipments. A service center is an "operation that buys finished steel, often processes it in some way and then sells it in a slightly different form" (SSCI, 1999). Service center staff alter the steel (e.g., slit, cut to length, pickled, annealed, etc.) and sell the product at a higher value. Products, processes, and markets may vary by service center. In general, service centers sell the refined product to either fabricators, manufacturers, or the construction industry. In 1998, steel mills shipped about 27.8 million tons of steel to service centers and distributors which amounts to about 27% of the market (AISI, 1998). The more than 5,000 service centers are located mainly in the northeastern United States with a smaller concentration in the southeast. Service centers are less capital-intensive than steel mills and compete with steel mills for providing finished products to the end market.

**Table 2-3**

**Specialization and Coverage Ratios**

| NAICS | Description | Specialization Ratio | Coverage Ratio |
|---|---|---|---|
| 331111 | Iron and Steel Mills | 97% | 98% |
| 331210 | Pipes and Tubes Manufactured From Purchased Steel | 96% | 93% |
| 331221 | Cold Rolled Steel Shape Manufacturing | 83% | 90% |
| 331222 | Steel Wire Drawing | 96% | 91% |

Sources: DOC, 1999b-d.

### 2.8.2 Automotive

Motor vehicles are the second largest market for steel in the United States. In 1998, the automotive industry had more than 15.9 million tons of steel shipments (about 16% of the market). The sales increase of the heavier sport utility vehicles helped fuel an overall increase in steel shipments of 5.8 million metric tons from 1991 to 1998 (AISI, 1998). Recently, however, other materials compete for an increasing share of motor vehicles. Plastic and aluminum have become more popular with the demand for lower-weight and more gas-efficient automobiles. Steel is heavier than these materials, but it is more durable, safer, and easier to recycle. Steel producers and the automobile industry are working together to improve the steel efficiency in today's cars. The leading world steel producers have joined together to form the UltraLite Steel Autobody-Advanced Vehicle Concepts (ULSAB-AVC) program (Ulsab, 2000). This is an auto design and engineering program intended to exhibit that steel can reduce weight, increase safety, and lower cost. Using these ideas, Porsche vehicle weight has decreased 25% with the continued use of steel. The use of more advanced steels such as corrosion-resistant and stainless steel increased in the 90's as well.

### 2.8.3 Construction

Construction is the third largest market for steel industry with 1998 steel shipments amounting to about 15.3 million tons (15% of the market). Between 1991 and 1998, shipments for construction increased by 3.8 million tons (AISI, 1998). This results from an increase in commercial and residential building with steel. From 1992 to 1994, the number of homes built with steel increased from 500 to 75,000 (Cyert and Fruehan, 1996). Steel offers advantages in strength and stability during adverse weather conditions (e.g., rot resistance without chemicals) and natural disasters. With "aggressive marketing, changes to building codes, and instruction to home builders," the steel industry has a goal of reaching one-quarter of the market by 2000 (Cyert and Fruehan, 1996).

### 2.8.4 Remaining Markets

Service centers, automotive, and construction markets account for about 58 percent of steel shipments. The remaining 42 percent is dispersed over a wide range of products and activities, such as agricultural, industrial, and electrical machinery, cans and barrels, and appliances. The building of other transportation means such as ships, aircraft, and railways are included in this group as well.

## 2.9 PATTERNS FOR THE INDUSTRY 1986-1999

### 2.9.1 Raw Steel Production

Figure 2-3 traces the domestic production of raw steel from 1986 through 1998. The time series begins in 1986 with 81.6 million tons and climbs to nearly 100 million tons in 1988. After stabilizing for a few years, production drops to 88 million tons in the 1991 recession. From 1991, steel production has increased annually to nearly 109 million tons.

### 2.9.2 Steelmaking Capacity and Capacity Utilization

Figure 2-4 shows both steelmaking capacity (left axis, black squares) and capacity utilization (right axis, shaded diamonds). Because steelmaking is a capital intensive industry with high fixed costs, capacity utilization is a measure of the industry's ability to run profitably. There is an ebb and flow in capacity utilization over time as industry tries to balance supply and demand. In 1986, the United States had its highest steelmaking capacity and lowest production in the thirteen-year period, resulting in a dismal capacity utilization rate of 64 percent. The industry reduced its capacity sharply in 1987 by about 15 million tons. This, coupled with an increase in steel production, increased capacity utilization to nearly 80 percent. Further growth in production in 1988 pushed capacity utilization to 89 percent.

With the improving market, individual companies added capacity in 1989. Steel production leveled off and capacity utilization slipped to 85 percent, where it stayed for the next year. (1990 capacity increases were offset by increased production.) 1991 brought small continuing capacity additions but a sharp drop in raw steel production, resulting in a capacity utilization rate of 75 percent.

From 1991 through 1998, domestic steel production increased (see Figure 2-3). Perhaps in response to the conditions in 1991, the industry closed capacity over the next three years. This resulted in a climb in the utilization rate that peaked in 1994 at 93 percent. There was a slight increase in utilization in 1995 (93.3 percent) but the industry began adding capacity again. From 1995 through 1998, the industry added nearly 13 million tons of capacity. The robust economy—with its increasing steel use—absorbed much of this increase, but capacity utilization began a slow, consistent decline, reaching 87 percent in 1998.

The fluctuations in capacity utilization imply that steel is a cyclical industry, in terms of profits, even when steel consumption shows a monotonic increase (see Figures 2-3 and 2-4, 1991-1998). The fluctuating possibility for profits has implications for the revenue forecasting model used in the site financial analysis (see Chapter 4).

### 2.9.3 Raw Steel Production by Furnace Type

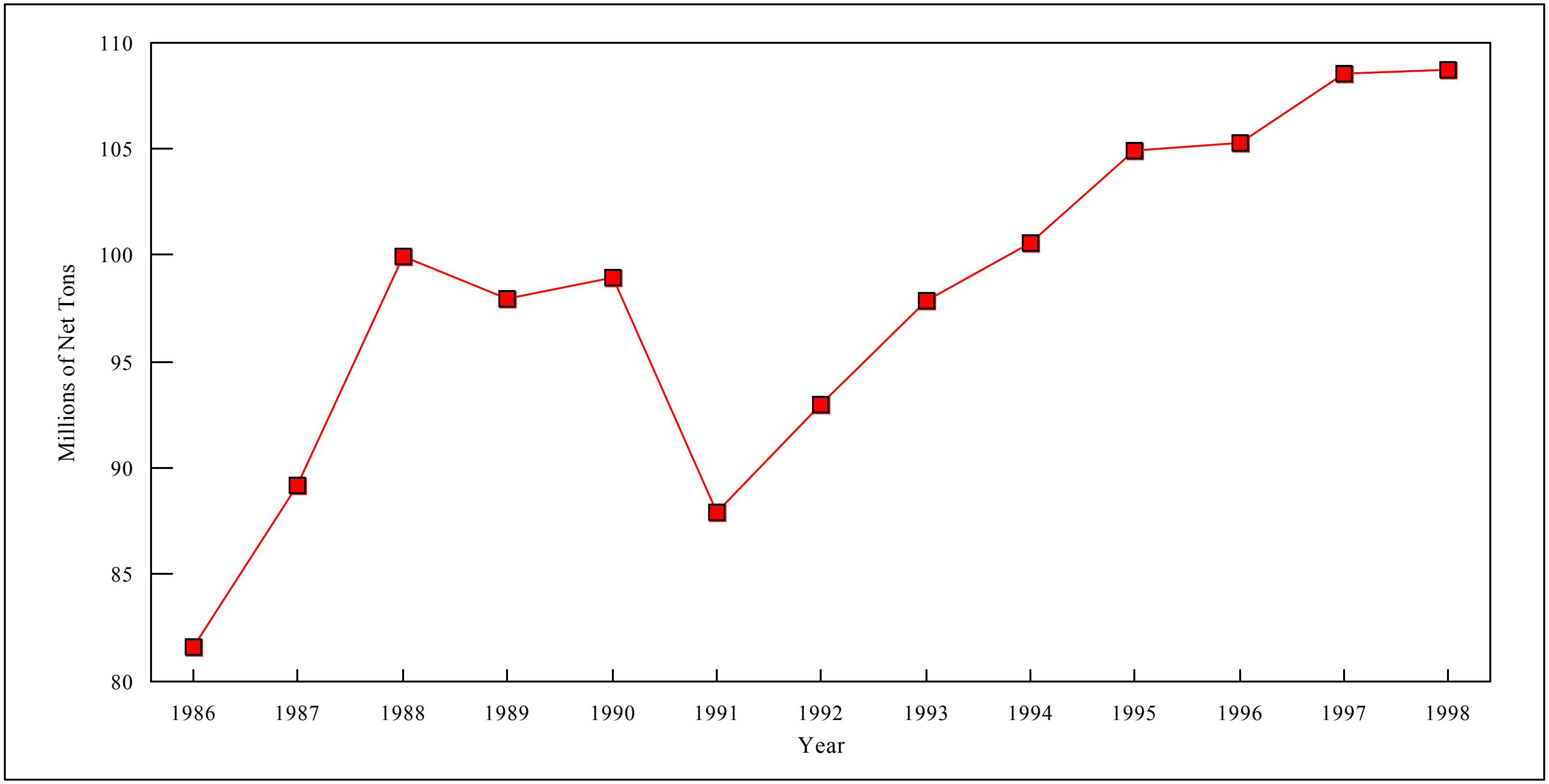
Figure 2-5 shows the relative production of steel by open hearth, basic oxygen process (BOP), and electric arc furnaces (EAF). Open hearth production ceased in 1991. From 1992 through 1998, the percentage of steel made with BOP furnaces declined while that for EAF production rose. In effect, Figure 2-5 illustrates the growing strength of the mini-mills versus integrated producers.

### 2.9.4 Continuous Casting

As described in Section 2.1.6, once the metallurgy of the steel is finalized, the ladle pours the liquid metal either into ingots or to a continuous caster. Ingots may be used on-site or sold as a commodity. In the first case, the ingot must be "soaked" in a temperature-controlled pit to equalize the temperature throughout the cross-section. (When cast, the exterior of the ingot cools faster than the interior.) In the second case, the ingot must be heated until it reaches a temperature at which it can be rolled into a semifinished shape (e.g., slabs, billets, or blooms). In continuous casting, the metal is cast directly to a semifinished shape, thus condensing three steps into one (ingot casting, heating, and rolling) with concomitant energy and time savings. Continuous casting began in the United States in the 1960s (AISE, 1985). By 1986, more than half of the steel produced in the United States was continuously cast.

**Figure 2-3**

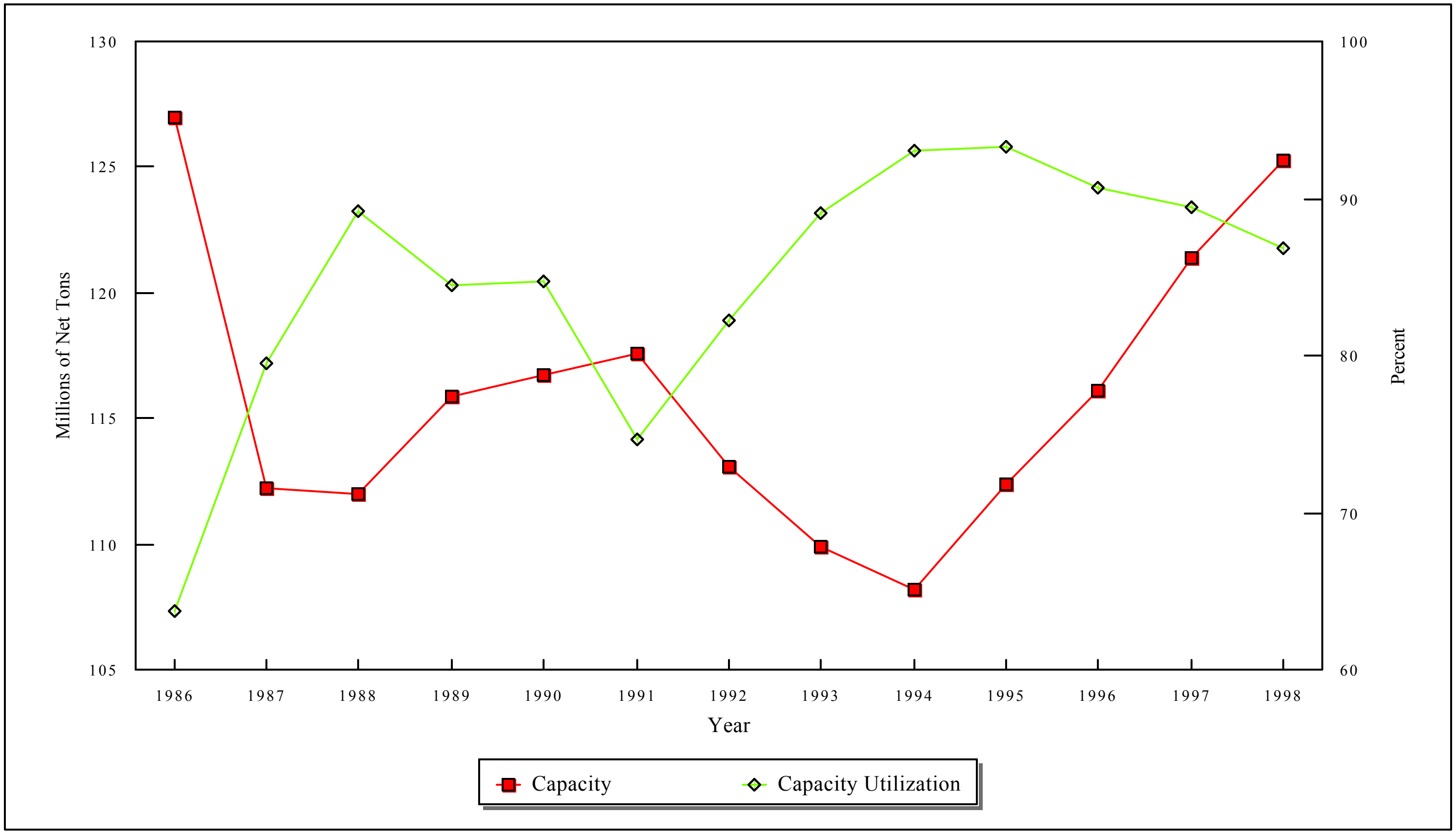
**Raw Steel Production in the United States: 1986-1998**




Source: AISI, 1998, 1995

**Figure 2-4**

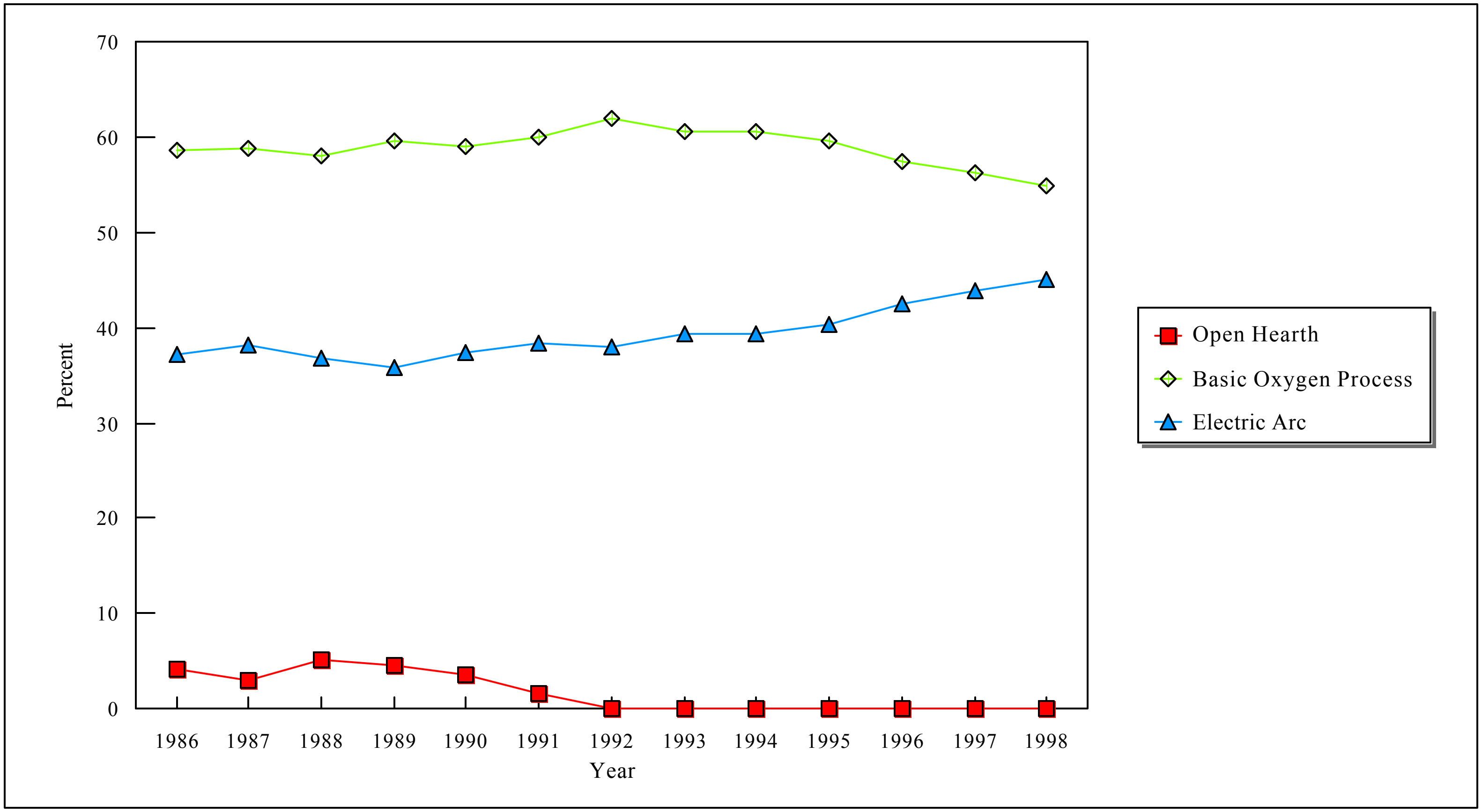
**Steelmaking Capacity and Capacity Utilization in the United States: 1986-1998**




Source: AISI, 1998, 1995

**Figure 2-5**

**Percent Raw Steel Production by Furnace Type in the United States: 1986-1998**




Source: AISI, 1998, 1995

The percentage continued to climb over the years, with slightly more than 95 percent of the steel being continuously cast in 1998 (see Figure 2-6). The importance of continuous casting as a technological impact on the steel industry is reflected in the market model, see Chapter 4.

### 2.9.5 Imports/Exports

The United States is one of the three largest raw steel producers in the world, accounting for 11 to 13 percent of total world production during 1986 to 1998. (Japan and the People's Republic of China are the other two countries, OECD, 1999 and AISI, 1999.) This is a notable drop from the market share held by the U.S. industry in the early 1970s. The period from 1973 to 1982 saw U.S. market share drop in half from nearly 20 percent to 10 percent. The turmoil in the industry during this period explains the industry's sensitivity to imports and its willingness to fight what it considers unfair practices through international trade cases (see Section 2.10 for a more detailed discussion of recent trade cases). Figure 2-7 illustrates the percentage of imports in the United States steel industry. From 1986 to 1998 the percentage of imports has varied from 17 percent to 26 percent. 1998 saw the largest percentage of imports with just over 26 percent.

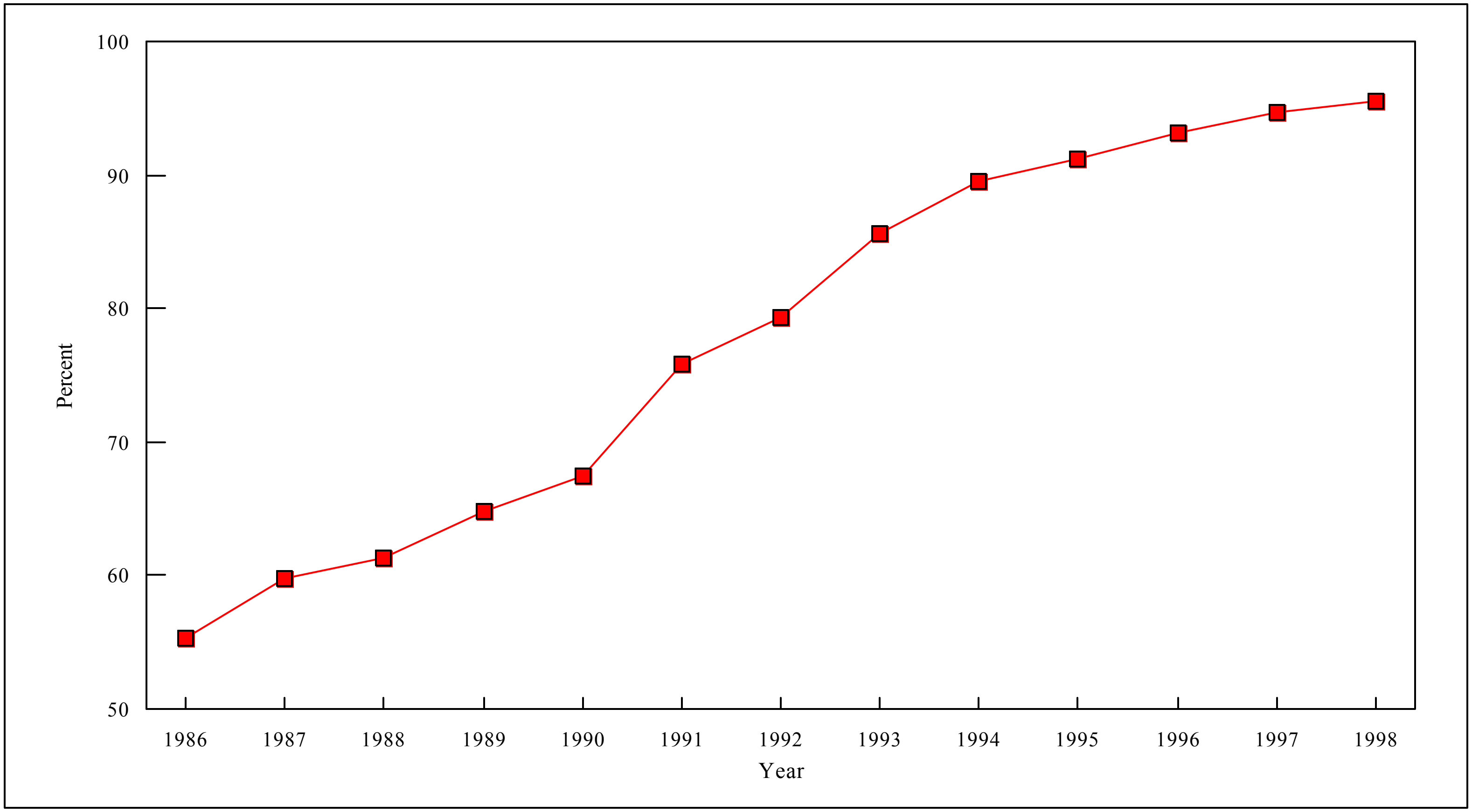
Import and export tonnage for 1986-1998 is illustrated in Figure 2-8. The U.S. has been a consistent net importer during this period. Import tonnage ranged from 20 to 26 million net tons from 1986 through 1993. Although U.S. raw steel production increased by about eight percent from 100.6 million tons in 1994 to 108.8 million tons in 1998 (Figure 2-3), domestic production could not keep pace with increased demand. Imports jumped to 38 million tons in 1994 and jumped again to 54 million tons in 1998, a 43 percent increase.

### 2.9.6 Employment

Employment peaked about 1974 when the industry had slightly over half a million jobs (both wage and salaried). As mentioned in the previous section, the industry contracted severely during the late 1970s and early 1980s. In 1986, total employment was approximately 175,000 with 128,000 employees receiving wages (Figure 2-9). Both wage-based and salary-based employment dropped to 60 to 65 percent of the 1986 levels by 1998.

**Figure 2-6**

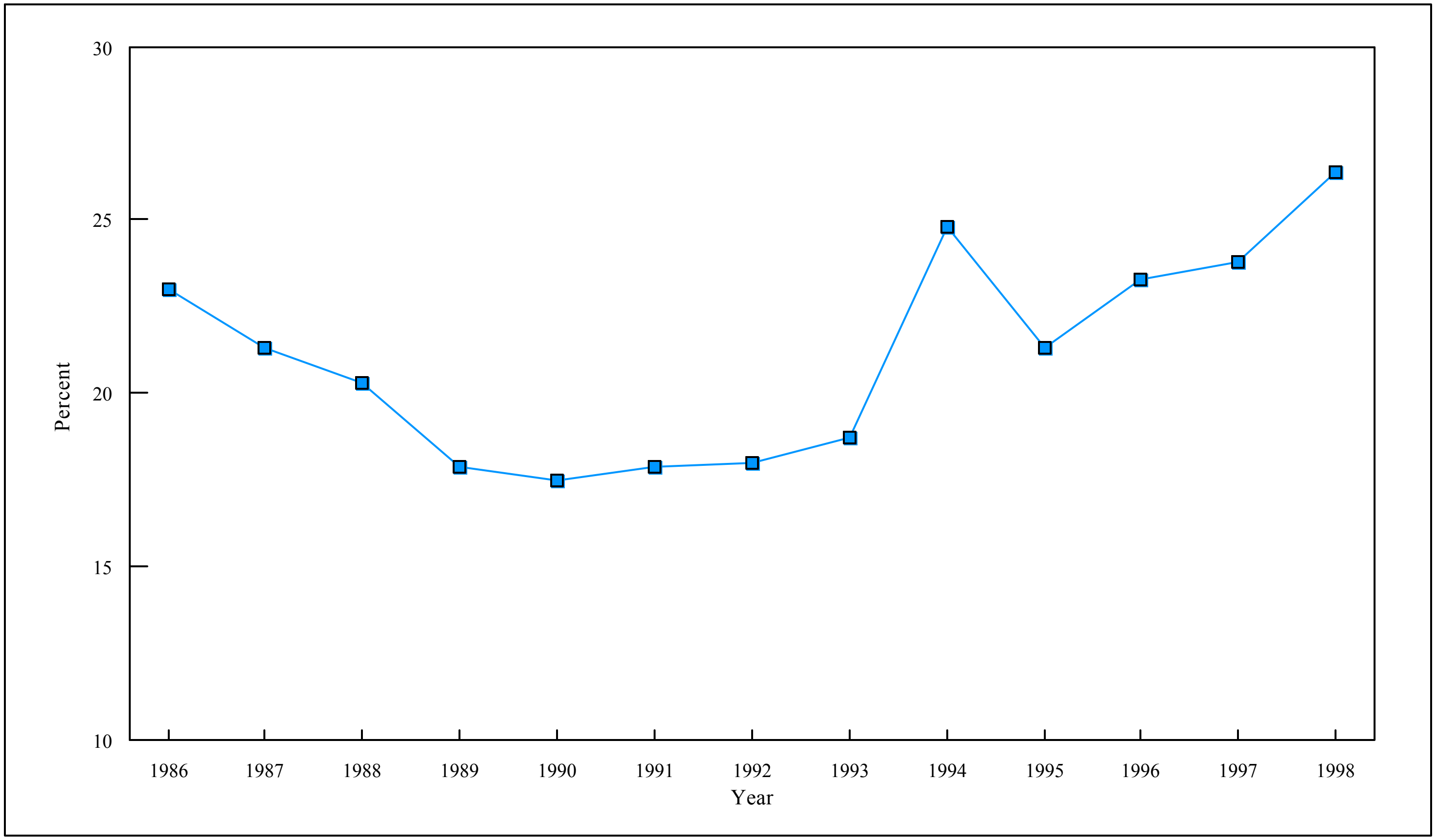
**Percent Continuously Cast Steel in the United States: 1986-1998**




Source: AISI, 1998, 1995

**Figure 2-7**

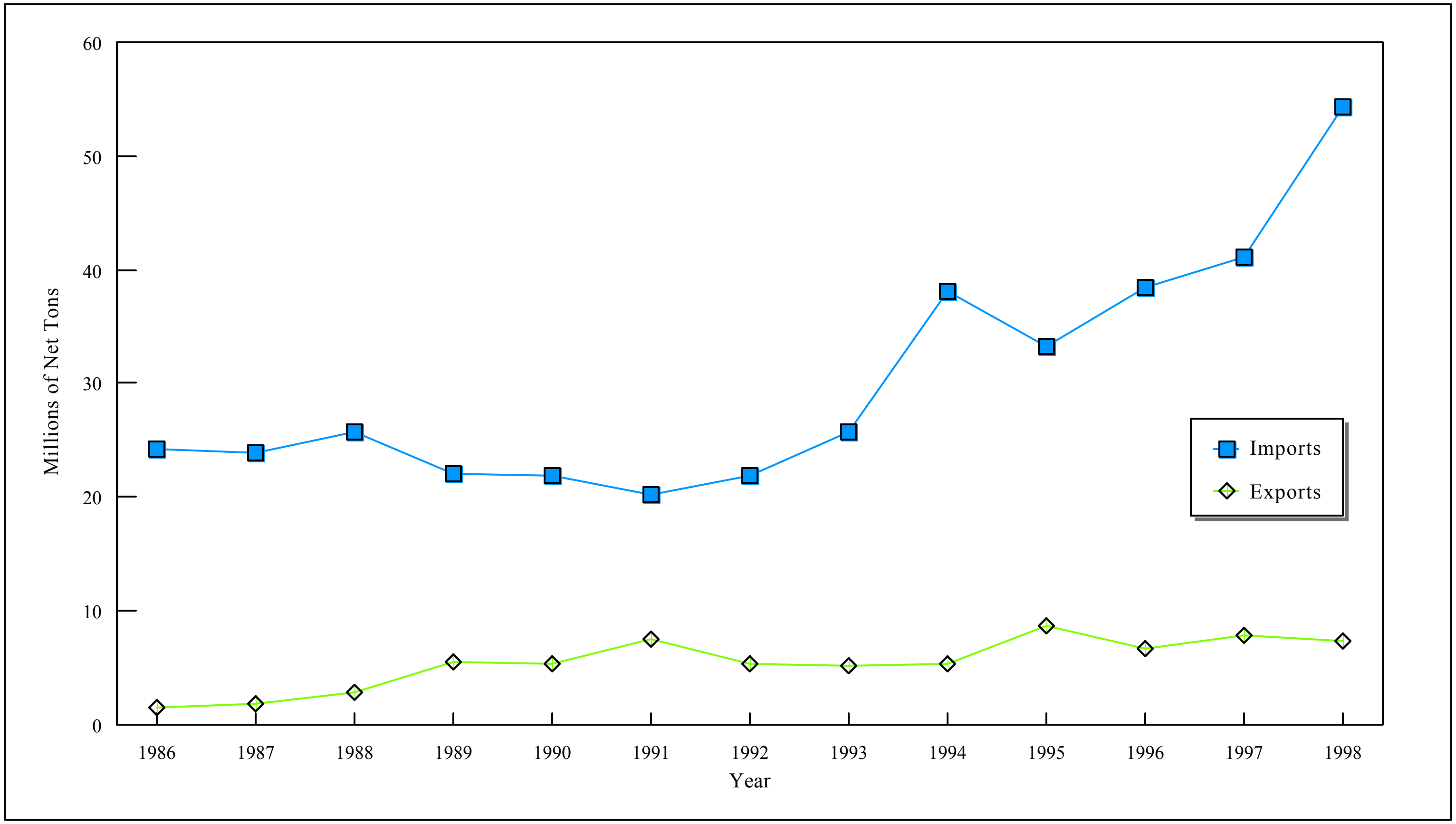
**Percent Imports of Steel Industry in the United States: 1986-1998**




Note: Data for 1998 excludes semi-finished imports.
Source: AISI, 1998, 1995

**Figure 2-8**

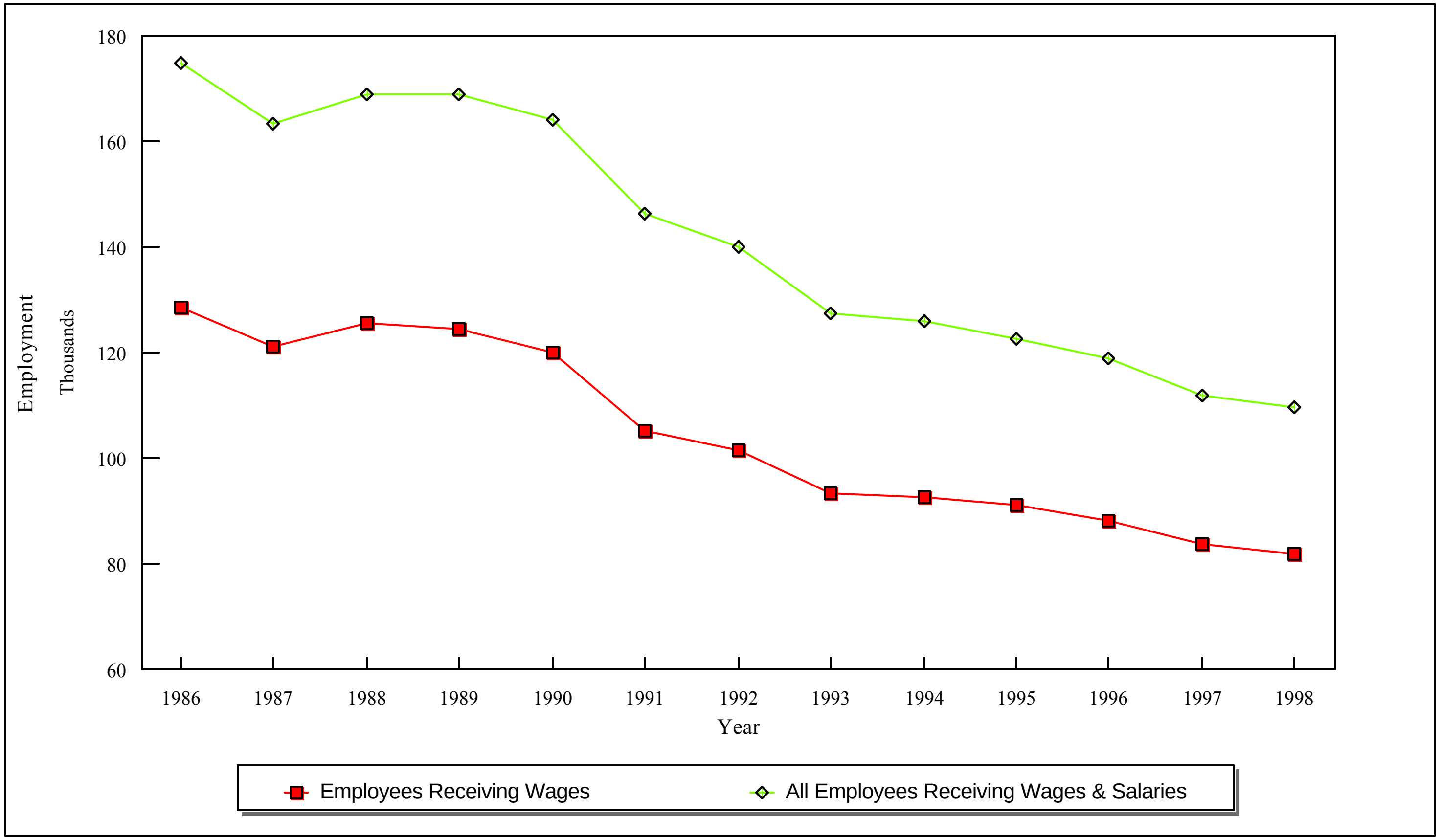
**Iron and Steel Import/Export Tonnage in the United States: 1986-1998**




Source: AISI, 1998, 1995

**Figure 2-9**

**Average Number of Employees Engaged in the Production and Sale of Iron and Steel Products in the United States: 1986-1998**




Source: AISI, 1998, 1995

A reduced number of jobs does not coincide completely with a constriction in the industry. Part of the loss in employment reflects technological advances, such as continuous casting, that allows steel to be made faster and with fewer people. Raw steel production increased (Figure 2-3) while employment decreased (Figure 2-9). In 1986, it took 174,783 employees to make 81,606 thousand tons of raw steel or about 467 tons per employee per year or 4.5 hours per ton. In 1998, it took 81,572 employees to make 108,752 thousand tons of raw steel or about 1,333 tons per employee per year or 1.6 hours per ton. That is, the labor required to produce a ton of steel in 1998 is slightly more than one-third of the labor required thirteen years earlier. Technological change, then, is a driving factor in this industry. (See Chapter 4 for a further discussion of the role of technological change in the market model.)

#### 2.9.7 Industry Downturn: 1998-1999

The EPA survey collected financial data for the 1995-1997 time period (the most recent data available at the time of the survey). This three-year time frame marks a period of high exports (six to eight million tons per year, see Section 2.10.1). This high point in the business cycle allowed companies to replenish retained earnings, retire debt, and take other steps to reflect this prosperity in their financial statements.

The financial situation changed dramatically between 1997 and 1998 due to the Asian financial crisis and slow economic growth in Eastern Europe.[3] When these countries' currencies fell in value, their steel products fell in price relative to U.S. producers. While the U.S. is and has been the world's largest steel importer (and a net importer for the last two decades), the U.S. was nearly the only viable steel market to which other countries could export during 1998. U.S. imports jumped by 13.3 million tons from 41 million to 54.3 million tons—a 32 percent increase—from 1997 to 1998 (see Section 2.10.1). About one out of every four tons of steel consumed in 1998 was imported. At least partly due to increased competition from foreign steel mills, the financial health of the domestic iron and steel industry also experienced a steep decline after 1997. This decline is not reflected in the survey responses to the questionnaire, which covered the years 1995 through 1997 and which were the most recent data available at the time the questionnaire was administered in 1998. Based upon publicly available sources, EPA learned that, after 1997, at least five

[3]Although the industry downturn is discussed here in general terms, details on imports, exports, and trade cases are discussed in more detail in Section 2.10.

companies went into Chapter 11 bankruptcy[4] while at least four additional companies merged with healthier ones[5]. Other companies filed trade cases with the International Trade Commission and the International Trade Administration of the Commerce Department (see Section 2.10.2).

The flood of imports affected the industry disproportionately. Integrated steelmakers manufacture semi-finished and intermediate products, such as slabs and hot rolled sheet, as well as finished products, such as cold rolled sheet and plate. Integrated steelmakers were hurt most severely during 1998, as imports increased dramatically across most of their product line (for example, slabs, hot rolled sheet and strip, plate, and cold rolled sheet and strip). Mini-mills suffered as well, albeit to a lesser extent financially. The low-priced imports, however, benefitted some companies that purchase semi-finished and intermediate products for further processing.

The Clinton Administration launched an initiative to address the economic concerns of the steel industry in 1999. The Steel Action Plan includes initiatives focused on eliminating unfair trade practices that support excess capacity, enhanced trade monitoring and assessment, and maintenance of strong trade laws (DOC, 2000a).

Further, in a separate action on August 17, 1999, President Clinton signed into law an act providing authority for guarantees of loans to qualified steel companies. The Emergency Steel Loan Guarantee Act of 1999 (Pub L 106-51) established the Emergency Steel Guarantee Loan Program (13 CFR Part 400) for guaranteeing loans made by private sector lending institutions to qualified steel companies. The Program will provide guarantees for up to $1 billion in loans to qualified steel companies. These loans will be made by private sector lenders, with the Federal Government providing a guarantee for up to 85 percent of the amount of the principal of the loan. A qualified steel company is defined in the Act to mean: any company that is incorporated under the laws of any state, is engaged in the production and manufacture of a product defined by the American Iron and Steel Institute as a basic steel mill product, and has experienced layoffs, production losses, or financial losses since January 1998 or that operates substantial assets of a company that meets

[4]Acme Metals, Inc. Geneva Steel, Gulf States Steel, Laclede Steel Company, and Qualitech Steel Corporation (Adams, 1999, New Steel, 1999b and 1999d).

[5]Bar Technologies merged with Republic Engineered Steel which, in turn, merged with a portion of USX/Kobe; Handy & Harman became a subsidiary of WHX Corporation; Steel of West Virginia was acquired by Roanoke Electric Steel (10-K forms filed with the SEC by the acquiring companies).

these qualifications. Certain determinations must be made in order to guarantee a loan, including that credit is not otherwise available to a qualified steel company under reasonable terms or conditions sufficient to meet its financing needs, that the prospective earning power of the qualified company together with the character and value of the security pledged must furnish reasonable assurance of repayment of the loan to be guaranteed, and that the loan must bear interest at a reasonable rate. All loans guaranteed under this Program must be paid in full not later than December 31, 2005 and the aggregate amount of loans guaranteed with respect to a single qualified steel company may not exceed $250 million.

According to a March 1, 2000 press release from U.S. Department of Commerce, thirteen companies have applied for loan guarantees totaling $901 million (DOC, 2000b). Of these, the Emergency Steel Loan Guarantee Board approved loans to seven companies:

- Geneva Steel Company, $110 million (DOC, 2000c).
- GS Technologies Operating Company, $50 million (DOC, 2000c).
- Northwestern Steel and Wire Company, $170 million (DOC, 2000c).
- Wheeling-Pittsburgh Steel Corporation, $35 million (DOC, 2000c).
- Acme Steel, $100 million (DOC, 2000d).
- Weirton Steel Corporation, $25.5 million (DOC, 2000d).
- CSC, Ltd., $60 million (DOC, 2000e.)

On October 18, 2000, the Emergency Steel Loan Guarantee Board announced a second window opening for applications. This window runs from November 1, 2000 until March 31, 2001 (DOC, 2000f). In light of the resurgence of imports in 2000 from countries other than those named in the trade cases (MetalSite, 2000), the future financial health of some members of the iron and steel industry is far from certain.

## 2.10 INTERNATIONAL COMPETITIVENESS OF THE INDUSTRY

### 2.10.1 Exports/Imports

Table 2-4 lists U.S. steel industry's imports and exports from 1986 through 1998. Even though the U.S. exported anywhere from 1.5 million to 8.6 million tons of steel in any given year, its imports far outweighed its exports. In 1998, the year after the data represented in the EPA survey, net imports skyrocketed by nearly one-third from 33 million tons to 47 million tons. Not only did imports surge, the price of the imported steel was so low due to currency fluctuations and the Asian fiscal crisis that U.S. companies could not sell at a profit. Five companies declared bankruptcy and layoffs occurred at other sites. Steel is clearly a global commodity where the U.S. is severely affected by financial conditions half a world away. Table 2-5 provides greater detail on changes between 1997 and 1998. Japan and Russia show a tremendous increase in imports. The one recourse for the industry was to file legal action against unfair trade practices. These are discussed in Section 2.10.2.

### 2.10.2 Trade Cases

In response to the flood in imports, the domestic steel producers filed several lawsuits involving unfair trade practices by foreign producers. These cases have arisen as a consequence of supposed dumping of iron and steel products or alleged unfair subsidization of foreign firms by their governments. Section 2.10.2.1 provides background material to trade cases, how they are filed, the parties involved, and the sequence of decisions that may or may not lead to penalties on the exporting countries. Section 2.10.2.2 focuses on recent steel trade cases.

#### *2.10.2.1 Background*

Two circumstances considered to be dumping may lead an American industry to pursue a lawsuit against foreign producers. Dumping occurs when a foreign producer sells a product in the United States at a price that is below that producer's sales price in the country of origin. Dumping may also occur if the producer sells the product at a price below the cost of production. Price discrimination is a result of dumping because the firm is charging different prices for the same product in different markets.

**Table 2-4**

**Imports and Exports of Iron and Steel (in Tons)**

| Year | Imports | Exports | Trade Deficit |
|---|---|---|---|
| 1986 | 24,237,800 | 1,451,254 | 22,786,546 |
| 1987 | 23,836,367 | 1,707,717 | 22,128,650 |
| 1988 | 25,659,253 | 2,757,389 | 22,901,864 |
| 1989 | 22,056,070 | 5,374,332 | 16,681,738 |
| 1990 | 21,882,058 | 5,308,667 | 16,573,391 |
| 1991 | 20,237,275 | 7,376,114 | 12,861,161 |
| 1992 | 21,872,600 | 5,340,066 | 16,532,534 |
| 1993 | 25,644,394 | 5,048,552 | 20,595,842 |
| 1994 | 38,135,623 | 5,210,419 | 32,925,204 |
| 1995 | 33,243,871 | 8,568,271 | 24,675,600 |
| 1996 | 38,327,538 | 6,576,860 | 31,750,678 |
| 1997 | 41,048,045 | 7,826,559 | 33,221,486 |
| 1998 | 54,303,217 | 7,335,029 | 46,968,188 |

Source: AISI, 1998, 1995

**Table 2-5**

**Imports by Countries of Origination and Exports by Countries of Destination for Iron and Steel Products (in Tons)**

| | 1997 | | 1998 | |
|---|---|---|---|---|
| **Country/World Region** | **Imports** | **Exports** | **Imports** | **Exports** |
| Canada | 6,041,758 | 4,550,711 | 6,281,259 | 4,282,476 |
| Mexico | 3,778,389 | 1,467,806 | 3,757,878 | 1,517,152 |
| Other Western Hemisphere | 7,246,876 | 646,635 | 7,783,021 | 526,952 |
| European Union | 7,943,483 | 349,026 | 7,754,368 | 356,368 |
| Other Europe | 7,371,736 | 38,162 | 10,704,821 | 37,295 |
| Oceania | 683,337 | 34,760 | 1,170,088 | 22,755 |
| Africa | 971,807 | 154,646 | 1,528,498 | 157,510 |
| Asia | 7,010,659 | 584,804 | 15,323,284 | 434,515 |
| **Total:** | 41,048,045 | 7,826,550 | 54,303,217 | 7,335,023 |

Source: AISI, 1998

Ultimately, if a foreign producer is dumping, the home market will not experience perfectly competitive conditions. Likewise, if the threat of sanctions results in a country voluntarily reducing exports to the U.S. (before a determination is reached) or if sanctions are levied, the market will not be operating under competitive conditions.

Another action that may lead to unfair market conditions for home producers is subsidization of foreign producers by foreign governments. Foreign governments subsidize industries by providing financial assistance to benefit the production, manufacture, or exportation of goods. Subsidies may take many forms, including cash payments, credits against taxes, and loans at terms that do not reflect the market condition. United States statutes and regulations provide standards to establish if a subsidy is unfair to producers in the U.S.

Industries in the United States may request that antidumping or countervailing duties be issued by filing a petition with both Commerce Department and International Trade Commission (ITC). The Import Administration of the Commerce Department determines if dumping or unfair subsidization has occurred. ITC decides whether the industry producers in the United States are suffering material injury as a result of the dumped or subsidized products. Generally, the final steps of the investigation is completed within twelve to eighteen months of the date the petition was initiated. Both Import Administration and ITC must confirm findings of dumping or unfair subsidization and injury in order to proceed with the issuance of duties against imports of a product into the United States.

Import Administration calculates dumping margins by comparing the difference between the price of the product in the U.S. to the price of the product in the firm's home market or the cost of production. Import Administration adjusts the value to account for differences in price resulting from physical characteristics, levels of trade, quantities sold, circumstances of sale, applicable taxes and duties, and packing and delivery costs. The dumping margin is the result of the difference between the two prices. Subsidy rates are determined by the value of the benefit provided by subsidies on a company-specific basis. The amount of subsidies that a foreign producer receives from its government provides a basis by which the subsidy is offset or countervailed through higher import duties.

### *2.10.2.2 Recent Steel Trade Cases*

The industry filed numerous countervailing duty and antidumping cases with the U.S. DOC and the U.S. ITC charging various countries with unfair trade practices concerning carbon and stainless steel products. The countries commonly named in the trade cases are in the Pacific Rim (Japan, S. Korea, and Taiwan ), and Europe (France, Germany, Italy, Czech Republic, and Russia). ITC decisions may determine that imports from some, none, or all of the countries listed in the petition caused injury.

Due to the surging imports of hot-rolled steel and other products, the Department of Commerce shifted resources to expedite investigations thus shortening the time required for decisions. Commerce also determined that it could make an early critical circumstances determination, thereby putting importers on notice that they might be liable retroactively for up to 90 days of duties prior to the preliminary dumping determination. Russia decided to negotiate with the United States to restrict exports of hot-rolled steel and 15 other steel products by 64 percent rather than incur trade remedies. Imports of hot-rolled steel (sheet, strip, and plate) surged to nearly 1.5 million metric tons in November 1998, the same month many of the early critical circumstances determinations were made. December 1998 imports of hot-rolled steel fell 65 percent compared to the previous month (DOC, 2000g and New Steel, 1999c).

Table 2-6 summarizes the findings of recent trade cases. The ITC found for the U.S. industry in most, but not all, cases meaning that it determined that the domestic industry was materially injured or threatened with material injury by the imports. The aggressive pricing by the foreign steel exporters resulting in substantial dumping margins, see 185 percent for hot-rolled flat carbon products (Russia), 164 percent for cold-rolled flat carbon products (Slovakia), and 106 to 108 percent for carbon seamless pipe (Japan).

### *2.10.2.3 Recent Coke Trade Case*

On October 17, 2000, the ITC initiated an antidumping duty for foundry coke products from the People's Republic of China with a preliminary determination whether there is reasonable indication that imports are causing or threatening to cause material harm to the domestic industry scheduled for November 6, 2000 (ITC, 2000d). In August 1999, the House Committee on Ways and Means requested

**Table 2-6**

**Recent Steel Products Trade Cases**

| Product | Countries | Range of Margins (percent) | AD or CVD Orders | Negative DOC or ITC Decisions |
|---|---|---|---|---|
| Stainless steel plate in coils | 6 AD, 4 CVD | 2-45 | 9 | 0* |
| Stainless steel round wire | 6 AD | 3-36 | 0 | 6 |
| Stainless steel sheet and strip in coils | 8 AD, 3 CVD | 0-59 | 11 | 0 |
| Carbon hot-rolled steel flat products | 3 AD, 1 CVD | 6-185 | 4 | 0 |
| Carbon-quality cut-to-length plate | 8 AD, 6 CVD | 0-72 | 11 | 3 |
| Carbon quality cold-rolled flat products | 12 AD, 4 CVD | 7-164 | 0 | 16 |
| Carbon/alloy seamless pipe (over 4.5") | 2 AD | 11-106 | 2 | 0 |
| Carbon alloy seamless pipe (4.5" or less) | 4 AD | 20-108 | 4 | 0 |
| Structural steel beams | 4 AD, 1 CVD | 26-65 | 1 | 2 |
| Tin mill products | 1 AD | 32-95 | 1 | 0 |
| Circular stainless steel hollow products | 1 AD | 0 | 0 | 1 |

AD = antidumping. CVD - countervailing duty.

*The ITC split the case into two like products and went affirmative with respect to stainless hot-rolled plate in coils.

Source: DOC, 2000e; ITC, 2000a; and ITC, 2000b.

ITC to review the foundry coke industries in the U.S. and the People's Republic of China and to provide various market information for 1995-1999. That report appeared in July 2000 (ITC, 2000a). Among other observations, the report notes that China is now the world's largest exporter of foundry coke while it imports none and the U.S. is the largest importer of Chinese foundry coke.

## 2.11 REFERENCES


Adams, Chris. 1999. Geneva steel co. files for protection under Chapter 11. *Wall Street Journal.* 2 February. p. B5.

Agarwal, Jay, Francis Brown, David Chin, Gregory Stevens, and David Smith. 1996. Injecting coal and natural gas: which one? How much? New Steel. December. <http://www.newsteel.com/features/NS9612f2.htm> November 2.

AISE. 1985. The making, shaping, and treating of steel. Association of Iron and Steel Engineers. Pittsburgh, PA.

AISI. 1998. Annual statistical report. American Iron and Steel Institute. Washington, DC.

AISI. 1995. Annual statistical report. American Iron and Steel Institute. Washington, DC.

Bagsarian, Thomas. 1998. New DRI in the U.S. and Trinidad. New Steel. July. pp. 62-66.

Barnett, Donald F. 1998. Is the blast furnace dead? In: Steel survival strategies XIII. New York, NY. Peter F. Marcus and Karlis M. Krisis, editors. World Steel Dynamics, Core Report SSS. Paine Webber Inc., New York, NY. p. 271.

Britannica Online. 1998. Extraction and processing industries: industrial metals: iron: history. <http://www.eb.com:180/cgi-bin/g?DocF=macro/5003/11/64.html. October 15; Decorative arts and furnishings: metalwork: Western metalwork: iron: early history. <http://www.eb.com:180/cgi-bin/g?DocF=macro/5001/70/224.html. October 15.

Cyert, R.M. and R.J. Fruehan. 1996. Meeting the challenges: U.S. industry faces the 21st century: the basic steel industry. A Sloan steel industry competitiveness study prepared for U.S. Department of Commerce, Office of Technology Policy by Carnegie Mellon University, Pittsburgh, PA (December). p. 31.

Depres, Joanne. 1998. Personal communication from Joanne Depres, Merriam-Webster Editorial Department to Maureen F. Kaplan, Eastern Research Group, Inc., citing Wall Street Journal, June 12, 1969 as first documented use of the term "minimill." November 4.

DOC. 2000a. Department of Commerce. Steel action program. <osecnt13.osec.doc.gov/public.nsf/docs/ F1175665BD253B43852567C4005D1C37> downloaded 16 October.

DOC. 2000b. Department of Commerce. Emergency steel loan guarantee board receives applications for $901 million. News Release. <osecnt13.osec.doc.gov/public.nsf/docs/AD7E673ED391FD2B852 56896000A5427> downloaded 16 October.

DOC. 2000c. Department of Commerce. Emergency steel loan guarantee board approves $365 million in loan guarantees. News Release. <http://osecnt13.osec.doc.gov/public/nsf/docs/13F87D292F49032F825690E0069902B> downloaded 19 October.

DOC. 2000d. Department of Commerce. Emergency steel loan guarantee board approves $125.5 million in loan guarantees. News Release. <osecnt13.osec.doc.gov/public.nsf/docs/ 51B5017859D2E7568525696D0061DA13> downloaded 5 October.

DOC. 2000e. Department of Commerce. Emergency steel loan guarantee board approves $60 million in loan guarantees. News Release. <http://osecnt13.osec.doc.gov/public.nsf/docs/ D62F95E7D5D393C18525696D006439DB> downloaded 5 October.

DOC. 2000f. Department of Commerce. Emergency steel loan guarantee board opens second window for loan guarantee applications. News Release. <http://osecnt13.osec.doc.gov/public.nsf/docs/4D834789FCD598028525697C006922871> downloaded 19 October.

DOC. 2000g. Department of Commerce. International Trade Administration. *Report to the President: Global Steel Trade: Structural Problems and Future Solutions.* Washington, DC. July. Chapter 4.

DOC. 1999a. Department of Commerce. 1997 Economic Census. Manufacturing. Industry Series. Iron and Steel Mills. Document No. EC97M-3311A. October.

DOC. 1999b. Department of Commerce. 1997 Economic Census. Manufacturing. Industry Series. Iron and Steel Pipes and Tubes Manufacturing from Purchased Steel. Document No. EC97M-3312A. September.

DOC. 1999c. Department of Commerce. 1997 Economic Census. Manufacturing. Industry Series. Cold-Rolled Steel Sape Manufacturing. Document No. EC97M-3312B. September.

DOC. 1999d. Department of Commerce. 1997 Economic Census. Manufacturing. Industry Series. Steel Wire Drawing. Document No. EC97M-3312C. September.

DOC. 1998. Department of Commerce. 1997 Current Industrial Reports. Steel mill products - 1997. Document No. MA33B(97)-1. Washington, DC: U.S. DOC, Bureau of the Census. Issued 8 September.

ENR. 1998. Things go better with this coke. Engineering News Record. May. p.30.

FR. 1999. Small Business Administration. 13 CFR 121. Small business size regulations; size standards and the North American Industry Classification System. Proposed rule. *Federal Register* 64:57188-57286.

Hogan, William T. and Frank T. Koelble. 1996. Steel's coke deficit: 5.6 million tons and growing. New Steel. December. pp.50-60.

ITC. 2000a. *Foundry Coke: A Review of the Industries in the United States and China.* U.S. International Trade Commission. Investigation No. 332-407. Publication 3323. Washington, DC. July.

ITC. 2000b. Certain tin mill products from Japan: notice of antidumping order. International Trade Commission. *Federal Register* 65(167):52067-52068. August 28.

ITC. 2000c. Circular seamless stainless steel hollow products from Japan; determination. International Trade Commission. *Federal Register* 65(169):52784. August 30.

ITC. 2000d. Initiation of antidumping duty investigation: foundry coke products from the People's Republic of China. *Federal Register* 65(201):61303-61305. October 17.

MetalSite. 2000. MetalSite News Services. *Big Steel's Surprise Price Collapse.* Special Report. September.

Moorey, P.R.S. 1988. Early metallurgy in Mesopotamia. In: The beginning of the use of metals and alloys. Papers from the Second International Conference on the beginning and use of metals and alloys, Zhengzhou, China. Robert Maddin, Editor. Cambridge, MA: The MIT Press. pp. 28-33.

New Steel. 1999a. Sun sets on Nucor Iron Carbide. *New Steel*. March. p. 9.

New Steel. 1999b. Qualitech seeks bankruptcy protection. *New Steel*. April. p. 9.

New Steel. 1999c. U.S. signs steel agreements with Russia, Brazil. *New Steel.* August. p. 8.

New Steel. 1999d. Gulf States Steel shuts down. New Steel. September. Also. <http://www.newsteel.com/2000/nw000901.htm> October 19, 2000.

New Steel. 1997a. Coke plant for Inland is 50-percent complete. New Steel. October. Also. <http://www.newsteel.com/news/nw971011.htm> October 28, 1998.

OECD. 1999. Iron and steel industry in 1997. Organisation for Economic Co-operation and Development. Paris:France.

SSCI. 1999. FAQ - Service centers and the industry. Steel Service Center Institute. Chicago. IL. <http://www.ssci.org/faq_service_centers.adp> December 27,1999.

Stech, Tamara and Robert Maddin. 1988. Reflections on early metallurgy in Southeast Asia. In: The beginning of the use of metals and alloys. Papers from the Second International Conference on the beginning and use of metals and alloys, Zhengzhou, China. Robert Maddin, Editor. Cambridge, MA: The MIT Press. pp. 163-174.

Taylor, S.J. and C.A. Shell. 1988. Social and historical implications of early Chinese iron technology. In: The beginning of the use of metals and alloys. Papers from the Second International Conference on the beginning and use of metals and alloys, Zhengzhou, China. Robert Maddin, Editor. Cambridge, MA: The MIT Press. pp. 205-221.

Ulsab. 2000. UltraLite steel autobody—advanced vehicle concepts. <http://www.ulsab.org> January.

U.S. EPA. 1995a. Preliminary study of the iron and steel category: 40 CFR 420 effluent limitations guidelines and standards. EPA 821-R-95-037. September.

U.S. EPA. 1995b. Profile of the iron and steel industry. EPA Office of Compliance sector notebook project. EPA/310-R-95-005. Washington, DC. September.

U.S. EPA. 1998. Collection of 1997 iron and steel industry data: Part A: Technical data. Part B: Financial and economic data. Washington, DC OMB 2040-0193. Expires August 2001.

U.S. EPA. 2000. U.S. Environmental Protection Agency. Development document for the proposed effluent limitations guidelines and standards for the iron and steel manufacturing point source category. Washington, DC. EPA 821-B-00-011.

Woker, Craig. 1998. Coal vs. natural gas at blast furnaces. New Steel. October. pp. 50-56.

Woker, Craig. 1999. Tough times for alternative iron. New Steel. July. pp. 32-34.

World Steel Dynamics. 1996a. North American iron ore industry: opportunities & threats. Core report YY. Paine Webber, 1285 Avenue of the Americas, New York, NY. p. 2-25.

World Steel Dynamics. 1996b. Steel Dynamics, Inc., progress report. Monitor Report. Paine Webber, 1285 Avenue of the Americas, New York, NY. May . pp. 12-14.

World Steel Dynamics. 1997a. The piggy bank: a study of the world pig iron industry. Core report EEE. Paine Webber, 1285 Avenue of the Americas, New York, NY. October. pp. 3-55 through 3-57.

World Steel Dynamics. 1997b. Trico Steel: Raising the ante in steel's flat-rolling revolution. Monitor report. Paine Webber, 1285 Avenue of the Americas, New York, NY. June.