EAF Steelmaking in North America – An Overview

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INTRODUCTION

In 2003, AIM Market Research conducted a survey of electric arc furnace (EAF) steel producers in North America to characterize currently operating production facilities, (i.e., the types of EAF’s, heat sizes, tapping methods, heats per day, the use of various auxiliary technologies, utilities consumption, steel making practices employed, the types of steels produced), and much more. The basis of this research was a telephone survey of 100 electric arc furnace (EAF) shops in the U.S., Canada, and Mexico. This survey was conducted from November 4, 2002 to January 29, 2003. These EAF shops accounted for 97% of the EAF steel production in North America. This is a brief summary of a portion the results of that research.

We all agree that the last few years have been difficult times for EAF steel producers and their suppliers. Many firms that supply products and services to the steel industry were forced to cut back their resources and most had insufficient resources to effectively keep their finger on the pulse of where opportunities could emerge once the depressed situation would begin to improve and steel plants would start to invest in upgrading their facilities. This was an important reason for conducting this study. The melt shop characterizations derived from this study will provide steel producers with a benchmark for evaluating their performance against other comparable steel plants. The complete results of this study which was the basis of this paper will provide EAF Melt shop suppliers with a better understanding of the problems facing steel producers, their fundamental priorities and upgrade opportunities and enable suppliers to more strategically positioning themselves in the market.

Individuals Interviewed

Overall, 258 individuals were interviewed in the survey. Individuals from “Operations” accounted for 50% of all individuals interviewed and “Process Automation” represented another 17%.

Segment Analysis

For the purpose of a more in-depth analysis, the EAF melt shops surveyed were each assigned to one of five “types of plant” segments based on the steel products that account for the most significant portion of their production. First of all, these plants typically either produce “long” or “flat roll” products. Secondly, the long products producing plants are characterized as producing either “Construction” long products (Const LP), such as rebar and structural or the higher “Quality” long products (Qual LP), such as, SBQ, merchant bar, seamless tube, and wire rod. The “flat roll” product producers were further divided into “Plate” and “Strip”. All other plants that typical produce semi-finished steel shapes, (such as ingots, billet, and blooms); rolls; and powder were placed in the “Semis / Powder” group of EAF shops.
Products Produced by EAF Melt Shops Surveyed

SBQ (28) was the most frequently identified steel product produced by the plants surveyed, followed closely by rebar (27) and merchant bar (27). Surprisingly, Strip is the fourth most frequently produced steel product identified by the plants surveyed. Table 1 provides a summary of the number of plants surveyed in each segment and the products produced by the plants surveyed.

### Table 1

**Segments for Analysis & Products**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Number of Plants Surveyed</th>
<th>Types of Products Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const LP</td>
<td>36</td>
<td>Rebar (27), Structural (14)</td>
</tr>
<tr>
<td>Qual LP</td>
<td>30</td>
<td>SBQ (28), Merchant Bar (27), Seamless Tube (7), Wire Rod (14)</td>
</tr>
<tr>
<td>Plate</td>
<td>8</td>
<td>Plate (10)</td>
</tr>
<tr>
<td>Strip</td>
<td>16</td>
<td>Strip (18)</td>
</tr>
<tr>
<td>Semis / Powder</td>
<td>11</td>
<td>Ingots (3), Powder (3), Rolls (1), Billets/Blooms (2)</td>
</tr>
<tr>
<td>Total</td>
<td>101</td>
<td></td>
</tr>
</tbody>
</table>

**CHARACTERIZING THE EAF MELT SHOPS SURVEYED**

Grades of Steel

Overall, 48% of the steel that is produced by the EAF melt shops surveyed is LC (low carbon) grades of steel. The highest share of LC grade steel production by segment is produced by the Strip Producers. In the Strip segment, 77% of production is LC steel. Table 2 provides a summary of the steel production by segment that is either Low Carbon or Medium/High Carbon steel.

### Table 2

**Steel Production By Segment**

**By Carbon Grades (Low vs Medium/High)**

<table>
<thead>
<tr>
<th>Type of Plant</th>
<th>Low Carbon</th>
<th>Medium/High Carbon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(000 Tons)</td>
<td>(000 Tons)</td>
<td>(000 Tons)</td>
</tr>
<tr>
<td></td>
<td>Share of Total (%)</td>
<td>Share of Total (%)</td>
<td>Share of Total (%)</td>
</tr>
<tr>
<td>Const LP (35)</td>
<td>7,250</td>
<td>13,701</td>
<td>20,951</td>
</tr>
<tr>
<td>Qual LP (29)</td>
<td>4,971</td>
<td>10,947</td>
<td>15,918</td>
</tr>
<tr>
<td>Plate (7)</td>
<td>3,290</td>
<td>3,301</td>
<td>6,590</td>
</tr>
<tr>
<td>Strip (15)</td>
<td>16,080</td>
<td>4,770</td>
<td>20,850</td>
</tr>
<tr>
<td>Semis / Powder (10)</td>
<td>103</td>
<td>1,337</td>
<td>1,440</td>
</tr>
<tr>
<td>Total</td>
<td>31,692</td>
<td>34,056</td>
<td>65,748</td>
</tr>
</tbody>
</table>

Fundamental Priorities of EAF Melt Shops Surveyed

Overall, the leading “fundamental priority” mentioned by the EAF melt shops surveyed was Reduced Operating Costs. Reduced Operating Costs earned 40% the total points assigned by the respondents to this issue.10 This issue earned more than twice the number of points of the next most important priority – Improving Quality (18%). Reduced Operating Costs was the most important priority in all five of the EAF melt shop segments. Improving Quality earned the second highest share of points in four of the five

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1 ( ) indicates number of plants surveyed.
segments. The *Qual LP* producers were the most ardent (20%) of the producer segments regarding *Increasing Production*. The *Semis / Powder* segment producers were the most fervent (22%) of the producer segments regarding *Increasing Productivity*. The overall results regarding the leading “fundamental priorities” of the EAF melt shops surveyed is presented in Figure 1.

![Figure 1 - Fundamental Priority of Plants Surveyed - Overall](image)

**Operational Bottlenecks**

Overall, the major process related “bottleneck” in the EAF melt shops surveyed that was most frequently indicated was the continuous caster. Overall, 68% of the plants that responded said there is no “bottleneck”. Of the 32 plants that indicated a particular “bottleneck”, 18 (64%) said it was the caster. The “Caster” was identified as the bottleneck 2.5 times more often than the next most frequently mentioned “bottleneck” - the EAF. The “caster” was most often mentioned as the major process related “bottleneck” in the EAF melt shops surveyed in four of the five segments. The overall results regarding the major process bottleneck in the EAF melt shops surveyed is displayed in Figure 2.

![Figure 2 - Process Bottleneck Specified in the 28 Melt Shops with a Bottleneck](image)

**Steel Production of EAF Melt Shops Surveyed**

Overall, the EAF melt shops surveyed produced about 68 million tons of steel in 2002. The *Const LP* and *Strip* producer segments each accounted for about one-third of this total production. Annual steel production by the plants surveyed is projected to increase by 9% over the period 2003-2005. This will most significantly be impacted by an 18% increase in production projected by EAF Melt shops in the *Strip* producing segment. Overall, The EAF melt shops surveyed are operating EAFs producing steel at a rate ranging...
from 4 to 37 Heats per Day. Figure 3 shows the steel production of the EAF melt shops in each segment and the percentage increase that they as a whole project for the period 2003-2005.²

CHARACTERIZING ELECTRIC ARC FURNACES

In this section, we summarize the data obtained regarding the electric arc furnaces operated in the plants surveyed. These EAF’s are characterized, as to how they are powered (AC or DC), heat sizes, tapping methods, EAF transformer ratings, heats per day, manufacturers, and start-up year. In addition, we examine the use of various EAF auxiliary technologies, such as scrap preheating, fixed wall injectors, manipulated lances, tuyeres, water cooled panels and ducts. With regard to the water cooled panels, we summarize where they are installed, and the current suppliers. Finally, we briefly consider the economics of flux versus refractory.

Number of EAFs

Overall, the 101 EAF shops surveyed operate 144 EAFs. Overall, 65 shops have a single furnace operation, while the other plants have multiple furnace operations. Thirty-three plants have two furnaces and five have three furnaces. Table 3 provides a summary of the number of EAFs in the plants surveyed.

Table 3

<table>
<thead>
<tr>
<th>Segment</th>
<th>Total EAFs</th>
<th>Number of EAF’s per Melt Shop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 EAF</td>
</tr>
<tr>
<td>Constant LP (36)</td>
<td>45</td>
<td>28</td>
</tr>
<tr>
<td>Qual LP (30)</td>
<td>42</td>
<td>21</td>
</tr>
<tr>
<td>Plate (8)</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Strip (16)</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>Semis / Powder (11)</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>144</td>
<td>65</td>
</tr>
</tbody>
</table>

Type of Power (AC vs. DC)

Of the 144 total EAFs, 21 are DC furnaces and the balance are the AC powered furnaces. The Strip producing plants are the most likely to have DC furnaces. Five of these plants each have two DC furnaces. All other cases of DC furnaces are single furnace operations except one Plate producer. Table 4 provides a summary of the types of furnace (AC vs DC) in the plants surveyed.

² ( ) indicates number of plants that responded.
EAF Transformer Rating - Overall, the EAF transformer ratings in the EAF melt shops surveyed ranged from 6000 MVA to 208,000 MVA. The EAF melt shops in the Strip steel producing segment operate furnaces with EAF transformers with power ratings ranging from 17.5 to 208 MVA. About one-half of the shops have an EAF with a rating of 120 MVA or below.

Tapping Methods

Overall, 62% (61) of the EAF Melt shops have an EAF with bottom tapping. All but four are EBT (eccentric bottom tapping). The Strip producing plants are the most likely (69%) to have EBT, while about 60% of the EAF Melt shops have an EBT in three of the four other segments. The least likely to have bottom tapping are EAF melt shops in the Semis / Powder segment. Overall, 69% (25) of the plants surveyed that do not have bottom tapping use an oxygen lance to open up their tap hole. All three of the Plate producing plants and all but one of the 12 Const LP EAF melt shops use oxygen to lance open the tap hole. Overall, 17% (6) of these shops have an “Exposed” tap hole. The share of plants with either EBT or OBT (oval bottom tapping) is revealed overall and by segment in Figure 4.
EAF Start-up Year

Overall, 46% of the 141 EAFs specified in the survey were started up since 1990. Figure 5 shows a definite trend over the last four completed decades. The above overall trend is similarly reflected in the *Const LP* and *Strip* segments. The start-up of EAFs in the *Qual LP* segment appears to be stable over the last three decades, but we see downward trends in the *Plate* and *Semis / Powder* segments.

![Figure 5 - Year of Start-up of EAFs in Plants Surveyed](image)

Scrap Preheating

Overall, 14% (12) of the plants surveyed have a scrap preheating system. EAF melt shops in the *Const LP* segment are the most likely (17%) to have scrap preheating. The share of EAF melt shops in each segment that have scrap preheating is shown in Figure 6.

![Figure 6 - Plants with Scrap Preheating Facilities by Type of Plant](image)

Fixed Wall Injectors

Overall, 56% (56) of the EAF melt shops surveyed have fixed wall injectors mounted on an EAF. EAF melt shops in the *Const LP* segment are the most likely (64%) to have fixed wall injectors. The share of EAF melt shops in each segment that have scrap preheating is presented in Figure 7.

![Figure 7 - Plants with Fixed Wall Injectors of EAFs by Type of Plant](image)
Water Cooled Panels

Overall, 83% (84) of the EAF melt shops surveyed have water cooled panels on the side walls of their EAF and 8% have a water cooled roof. All of the EAF melt shops in the Plate segment and nearly all in the Qual LP segment shops have water cooled sidewall panels and roof. Only one-half of the EAF melt shops in the Strip producing segment have a water cooled roof. EAF melt shops in both LP segments were the most likely (22-23%) to have water cooled off-gas ducts.

Manipulated Lances

Overall, 70% (71) of the EAF melt shops surveyed operate lance manipulators. EAF melt shops in the Plate segment all have lance manipulators. In almost all cases, these lance manipulator are used to introduce oxygen to the EAF and used to introduce carbon in 53% of the EAF melt shops surveyed. Nearly all of the shops that use it for carbon, use it for both oxygen and carbon. The share of EAF melt shops in each segment that have a lance manipulator and what these lances are used for is summarized in Figure 8.

UTILITIES USAGE & CONSUMPTION

In this section, we summarize the data obtained in the survey regarding the use and consumption of certain utilities including: electricity, natural gas, and oxygen. In addition, we summarize electricity costs indicated by the plants surveyed.

Electricity Usage

Overall, The electric arc furnaces (EAFs) in the melt shops surveyed are consuming electricity from 325 to 640 kWh per ton. The EAF melt shops surveyed are spending from 2 to 5.5 cents per kWh. In the two Flat Roll steel producing segments surveyed electricity costs (minimum) range from 3 to 5.5 cents for electricity. About one-half of these melt shops are paying 4 cents per kWh or less. The cost of electricity in EAF melt shops in the Flat Roll steel producing segments are shown in Figure 9.
**Natural Gas Usage**

Overall, 58% (58) EAF melt shops are using natural gas. The Plate producing plants are the most likely (75%) to be using natural gas. The share of plants that are using natural gas is about the same in three of the other four segments ranging from 58% to 63%. The steel Strip producing plants each use 100 to 480 SCF per ton of natural gas. About one-half of the EAF melt shops surveyed in this segment that responded consume 150 SCF per ton or less of natural gas. Figure 10 provides a comparison of the use of natural gas among the EAF melt shops surveyed by segment and overall.

**SECONDARY STEELMAKING**

This section summarizes the data obtained in the survey regarding the secondary steelmaking facilities in the EAF melt shops surveyed, the share of plants that employ specific refining technologies, such as ladle furnace and vacuum degassing. In addition, we assess the future adequacy of the existing vacuum degassing facilities and plans regarding vacuum degassing.

**Secondary Steelmaking Overview**

The most common type of secondary steelmaking process technology employed by the EAF melt shops surveyed is an LMF (ladle metallurgy furnace). Overall, 66% (67) plants operate a ladle furnace. The next most common secondary steelmaking process is vacuum degassing which is used by 25% (25) of the plants surveyed. Overall, 14% (14) of these plants have both an LMF and a Degasser. The share of EAF melt shops that have specified that they are using certain secondary steelmaking process technologies is summarized in Figure 11.
Ladle Metallurgy Furnaces

The Plate producing plants surveyed are most likely (88%) to have a ladle metallurgy furnace and the Semis / Powder plants are the least likely (36%). The share of EAF melt shops in each segment that have ladle metallurgy furnaces is shown in Figure 12.

![Figure 12 - Plants with Ladle Metallurgy Furnace By Type of Plant](image)

Other Secondary Steelmaking Processes

Vacuum degassing units are the next most common type of secondary steelmaking process in all segments. Vacuum degassing units were most common (64%) in the Semis / Powder plants. VAD units are most common in plants in the Qual LP segment. The Plate producers are most likely to have both a ladle furnace and vacuum degassing, but by the numbers, the Qual LP segment has the largest number of plants both a ladle furnace and a vacuum degassing unit.

IRON BEARING METALLICS CONSUMED AND THE DISPOSITION OF IRON BEARING BI-PRODUCT WASTES

This section provides information about the use of steel scrap and the iron bearing charge materials employed by the plants surveyed. First of all, we assess the importance of low residuals to the plants surveyed, the share of production for which low residuals are important. Finally, we examine the types of iron bearing materials used by plants surveyed.

Steel Scrap and Iron Bearing Charge Materials

Overall, 51% of the EAF melt shops surveyed indicated that having “low residuals” in their EAF iron bearing charge materials is “important”, and 27% (27) indicated that this is “very important”. This result is presented in Figure 13.

![Figure 13 - The Importance of Low Residual Charge Materials to the Plant Surveyed - Overall](image)
“Low residuals” in iron bearing charge materials were most likely (53%) to be “most important” in the Strip producing segment. The importance of “low residuals” was also evident in the Qual LP segment. “Low residuals” were of least importance in the Semis / Powders and Const LP segments. Overall “low residuals” are important regarding 35% (23.8 million tons) of the steel produced by the EAF melt shops surveyed. Overall, 54 of the plants use low residual charge materials. The share of production for which “low residuals” are most important were highest (72%) in the Strip segment and second highest (34%) in the Qual LP segment. The share of steel production for which “low residuals” are most important were lowest (6%) in the Const LP segment. The results regarding the share of steel production for which low residuals are important by segment is shown in Figure 14.

The Use of Iron Bearing Charge Materials

The type of iron bearing charge material most frequently used by the EAF melt shops surveyed is “Shredded Scrap”. Overall, 24% of these plants are using “Shredded Scrap” as a feed source to their EAF’s. This material was mentioned twice as often as the next most frequently employed iron bearing charge materials - “Scrap Substitutes” and “Bushlings”. The type of iron bearing charge material most frequently used by the EAF melt shops surveyed is “Shredded Scrap”. Overall, 24% of these plants are using “Shredded Scrap” as a feed source to their EAF’s. This material was mentioned twice as often as the next most frequently employed iron bearing charge materials - “Scrap Substitutes” and “Bushlings”. The share of the overall consumption of iron bearing charge materials by the EAF melt shops surveyed is presented in Figure 15.
PLANS TO UPGRADE, REPLACE, OR ADD MAJOR PROCESS EQUIPMENT

Overall, 15% (14) of the EAF melt shops surveyed said they are planning to upgrade, replace or add major melt shop process equipment in the next five years. However, although plans are not yet committed, 60% of these plants indicated that projects are being considered. The Qual LP producing EAF melt shops surveyed were the most likely (22%) to have firm plans and 90% either plan or at least are considering such improvements. EAF melt shops in the Const LP segment were nearly as likely (19%) to have firm plans, but the Strip producing plants were the second most likely segment to either have plans or considering such investments.

SUMMARY

In 2003, AIM Market Research conducted a survey of electric arc furnace (EAF) steel producers in North America to characterize currently operating production facilities, including: the number, types, and heat sizes of EAF’s, tapping methods, heats per day, operational bottlenecks, steel production, utilities consumption, steel making practices and technologies employed, the types of steels produced, and much more. The basis of this research was a telephone survey of 100 electric arc furnace (EAF) shops in the U.S., Canada, and Mexico. This survey was conducted from November 4, 2002 to January 29, 2003. These EAF shops accounted for 97% of the EAF steel production in North America.

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