高·等·学·校·教·材

金焱 主编

冶金工程专业英语

YEJIN GONGCHENG ZHUANYE YINGYU

化学工业出版社

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·北京·

本书是针对冶金工程学科发展和教学需要而编写的冶金工程专业英语教材。书中内容分三部分，共11单元，第一部分讲述钢铁冶金的基础知识，第二部分讲述炼铁部分的专业知识，第三部分讲述炼钢部分的专业知识。为方便学生自学，每单元配有词汇表，附录部分还有课文的参考译文及词汇索引。本书内容既注重对专业知识面的覆盖，又反映了冶金技术最新发展状况和若干重要科技领域。

本书可供高等学校冶金工程专业或相关专业三、四年级学生使用，也可供同等英语程度冶金行业工程师或相关领域的科技人员参考。

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前　　言

专业英语是大学英语教学的一个重要组成部分，它促进了学生从学习英语知识向专业应用英语知识的转变，也为三、四年级学生在专业课学习过程中使用英语教科书或参考书打下良好基础。专业英语的教学侧重培养学生的专业文献阅读能力、科技英语写作能力及专业语言交流能力，它是连接大学英语与双语教学的桥梁，三者互为补充。

近十几年来，冶金工业技术突飞猛进，革命性的技术不断出现，我国冶金工业也日益同国际接轨，技术交流日趋频繁。因此，想要掌握最新冶金工业技术，了解技术发展方向，必须具备较高的冶金工程专业英语水平。

本书的编写目的，首先是让学生掌握冶金工程专业英语的相关术语；其次是为了介绍冶金工业的最新发展。

本书遵循“重视基础、强调应用、突出实践”的编写原则，课文主要参考了最新出版的英文书籍或期刊杂志，力图选择内容新、实践性强的材料，以提高学生的学习兴趣，丰富他们专业领域的新知识。

全书分三部分，共 11 个单元。

第一部分讲述钢铁冶金的基础知识，包括世界钢铁行业发展概况、欧洲钢铁技术发展概况、炼铁理论基础、铁矿石还原理论、炼钢理论基础、钢包冶金的主要反应等方面。

第二部分讲述炼铁部分的专业知识，主要包括烧结设备、烧结矿的质量要求、高炉工艺、高炉煤气系统、高炉喷煤、高炉自动控制系统、COREX 熔融还原设备、HIsmelt 熔融还原设备等方面。

第三部分讲述炼钢部分的专业知识，包括铁水脱硫技术、铁水预处理工艺、氧气转炉工艺、转炉的过程控制、电弧炉工艺、直流电弧炉工艺、典型的炉外精炼工艺、连铸工艺等方面。

本书内容基本覆盖了冶金工程专业的各个主要方面，使学生能够掌握本专业最基本的英文词汇，为将来的学习及研究工作打下良好的基础。各单元由课文（包括词汇表）及阅读材料组成，附录部分还有课文的参考译文及词汇索引。较好地解决了学生在学习过程中，因专业知识欠缺、科技文体不熟、专业词汇量不够所带来的各种困难，为后续专业双语课的学习扫除障碍。

本书可满足多数高校教学计划内 32～48 学时的教学计划安排，考虑到各高校教学计划不尽相同，可根据不同学时数适当选取教学内容。

本书是冶金工程专业英语教学用书，适用对象为已经顺利完成基础阶段英语学习的大学本（专）科生。也可供冶金行业工程师或相关领域的科技人员参考。

本书由多年担任专业英语和专业双语课教学的教师执笔编写。第一、二、三部分由金焱编写，毕学工为第一、二部分各单元课后词汇及参考译文进行了补充，熊玮为第三部分各单元课后词汇及参考译文进行了补充。金焱担任全书的统稿工作。

本书在编写过程中得到武汉科技大学材料与冶金学院和冶金工程系的大力支持，在此表示衷心的感谢。限于作者水平，书中不妥之处在所难免，敬请广大师生批评指正。

编者

2007 年 11 月

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Part 1 Fundamentals of Iron and Steelmaking

Unit 1 Global Steel Industry

1. Overview

The global steel industry is highly cyclical, very competitive and still fragmented in terms of market share. Currently the industry is at the height of the business cycle and is going through a consolidation phase, which might result in the smaller players being acquired by the larger ones. The total output from the industry exceeds 1.24 billion tons in 2005, most of it augmented by the increase in output from China. This is expected to increase further, making steel output from China among the largest in the world.

The steel industry demonstrates a high degree of variability, both in terms of earnings and production. The factors attributable for driving this variability are global economic conditions with a particular sensitivity to the performance of the automotive, construction, capital goods and other industrial products industries. The commodity nature of steel, the producers and consumers limited control on price, and the demand and supply disparity have made steel prices volatile. Significant increases in prices for metals and energy over the past two years have also contributed to increased variability in the industry.

2. Brief Company Overviews

(1) Arcelor-Mittal: The five-month long duel between Netherlands-based Mittal and Luxembourg-based Arcelor has concluded. Mittal's unprecedented takeover victory in the battle for the global steel giant has brought the five-month battle to a halt, after the final shareholder approval. In the new Arcelor-Mittal combine the Mittal family collectively holds a 43.5 percent share. The new steel company will have about 334,000 employees' worldwide, and revenues close to $70 billion. Arcelor is well-positioned in Western Europe and catering the high-grade auto and construction industry. Mittal with mills spread out through the four continents in low-cost locations such as Czech Republic, Mexico, and Kazakhstan, producing mostly basic steel products. Still there are things to be settled between Arcelor and Mittal. For example, the fate of the Canadian steel maker Dofasco acquired in April 2006 by Arcelor is yet to be decided.

Mittal's aggressive business model has helped the company create a profitable enterprise in countries that were not regarded as obvious investment targets (such as Ukraine and Indonesia). It has track record of buying loss-making, bankrupt or under-producing steel companies, and turning them around by restructuring, cost cutting and layoffs, thereby creating leaner and more competitive operations. The company has production units in 17 countries. In contrast, Arcelor holds front running positions in its main markets: automotive, construction, household appliances and packaging as well as general industry. Arcelor is the number one steel producer in Europe and Latin America. Taking advantage of its now dominant position, Arcelor-Mittal has ambitions to further expand internationally in order to take advantage of the growth potential of developing economies and offer technologically advanced steel solutions to its global customers.

Arcelor-Mittal is more than three times larger in terms of production and revenue from steel, than its nearest rival Nippon Steel Corp. of Japan. The combined company will now have a significant advantage in setting prices and negotiating the terms of various contracts with key customers. The new steel industry titan will be better equipped to combat the volatile nature of the steel industry. This is due to the fact that it will have globally diversified operations and a diversified product line giving it the power to negotiate with large customer.

(2) Nippon Steel Corporation: Nippon Steel Corporation is Japan's No. 1 steelmaker and the world's third largest, in terms of crude steel production, with annual consolidated output of approximately 33 million tons. It is backed by a solid business franchise supported by diverse product lines with a focus on high value added products, outstanding product development capability, as well as a strong customer base. The Company has also secured a solid presence overseas, fueled by distinctive research and development capabilities and strategic alliances.

(3) Posco: The Pohang Iron and Steel Company based in Pohang, South Korea, it is one of the top steel producers. Posco operates two steel companies in South Korea, one in Pohang and the other in Gwangyang. In addition to this, Posco operates in a joint venture with US Steel with name of USS-Posco, located in Pittsburgh. In June 2005, Posco signed a memorandum of understanding with the State Government of Orissa, India and plans to invest $ 12 billion to construct a plant with four blast furnaces, an electricity plant, housing, and an annual production capacity of 12 million tons of steel and is expected to startin production in 2010.

(4) Severstal: Severstal is the largest Russian steel producer, with 2005 annual steel production of 17. 1 million tons. In addition, Severstal owns Severstal North America, the fifth largest integrated steel maker in the U. S. with 2005 production of 2. 7 million tons, and Lucchini, Italy's second largest steel group with 2005 production of 3. 5 million tons. Severstal is one of the world's lowest cost and most profitable steel producers, with 2005 EBITDA of approximately 150 euros per ton. Severstal-Resource, its own subsidiary owns 70 years of iron ore reserves and 84 years of coal reserves, 2005 revenue and EBITDA were approximately EUR 1. 12 billion and EUR 506 million, respectively. Severstal-Resource produces coking coal, thermal coal, iron ore pellets and iron ore concentrate.

(5) Corus: Corus is a customer focused, innovative solutions driven company, which manufactures, processes and distributes metal products as well as providing design, technology and consultancy services. The company's headquarters are in London, with four Divisions and operations worldwide. Corus ranks among the 10 largest steel producers in the world, with about 18 million tonnes of crude steel production in 2005. Activities include carbon steel production which are 90% of sales and aluminum smelting, rolling, and extrusion 10% of sales. The group's main production bases are the U. K. , the Netherlands, Swe-

den, Germany, France, Belgium, and the U. S.. It is often spoken about as a possible takeover candidate.

3. Global Steel Industry

The steel industry in the European Union is structured differently than the steel industry in the United States. The key difference is the consolidation of the industry. Arcelor-Mittal, Thyssen-Krupp, and Corus enjoy substantial market share in a largely consolidated market place.

The steel industry in the United States is completely different compared to other industries globally. US corporate bond issuers have a higher historical default rate than any other steel producer globally. This reflects highly leveraged capital structures of the US steel producers compared to the European counterparts who hold higher cash balances placing significant importance to a cautious approach to liquidity. The high default rate in the US steel industry can be attributed to an elevated level of shareholder pressure for high short-term returns, which then forces the management to deploy higher-risk strategies.

Oversupply in China, particularly in commodity based flat products and long products, and the inventory build-up in Asian countries are pressuring the region's profitability and cash flow and thus contributing to the variability in the global steel industry. A new record high was set for world trade in steel, which grew 8% in 2005 to about 1. 3 billion tons. The largest steel exporting countries in 2005 were EU 32. 4 million tons, Japan 32 million tons, Russia 30. 9 million tons, Ukraine 27. 3 million tons and, entering the top 5 for the first time, China 27. 4 million tons up a solid 37 percent. The largest importing countries were China 27. 5 million tons, the EU 25. 1 million tons and Japan 13. 2 million tons. The major exporters of iron ore in 2005 were Australia 239 million tons and Brazil 224 million tons. Imports into China increased by 32% in 2005, compared to 2004, imports into the EU and Japan actually fell by 2%. Imports into China from Australia in 2005 were 112 million tons, an increase of 34 million tons on 2004. Imports from India, at 68. 5 million tons, were up by 18 million tons on 2004, which means that imports from India have increased tenfold since 1998. Imports into China from Brazil reached 55 million tons, and increase of 8 million tons. The break-up of Chinese imports by country of origin shows that Australia supplied 41%, India 25% and Brazil 20%, other countries such as South Africa contributes to the remaining 14%.

(1) China: In 2005 steel production in China was 349 million tons up 25% from 2004. In comparison, production in 2004 was 280 million tons, 2003 was 222 million tons and 2002 was 182 million tons. Imports in 2005 fell 18% to 27. 3 million tons from 33. 2 million tons in 2004. Imports had previously risen significantly in 2003 to reach 43 million tons. Exports grew 36% in 2005 to reach 27 million tons compared with 20 million tons in 2004 and 8 million tons in 2003. Since September 2004 exports have exceeded imports to make China a net steel exporter although this was reversed from July 2005. However, in December 2005, exports again exceeded imports. Real GDP in China is expected to be around 10[❶] per-

❶ 2006 年中国 GDP 的实际增量为 11. 1%。

cent in 2006 and will most likely remain high in 2007 and in the run-up to the 2008 Beijing Olympics, hence feeding demand.

China, which is a major producer and consumer globally, is a net exporter of steel and its increased supply of products might find its way to the North America markets. The sudden increase in steel imports from China is not only fueled by the Beijing Olympics scheduled for 2008, but also because of the increase in domestic demand for infrastructure ignited by the rapid industrialization in China. Currently there are numerous small local steel companies in China, and in general view, the Chinese steel industry is ripe for a rapid consolidation state. After Beijing Olympics in 2008, there are prospects of a slow down in the industry.

(2) United States: The U. S., which is traditionally a steel importer, recorded imports of 30.2 million tons in 2005, a drop of 8% compared to 2004. The key imported products were semis 6.3 million tons, hot rolled coil 3.7 million tons, welded tubes 3.6 million tons and wire rod 2.8 million tons. Key supplying countries include the NAFTA members Canada 5.6 million tons and Mexico 3.8 million tons followed by Brazil 2.4 million tons and China 2.3 million tons. US steel mill exports in 2005 were 9.4 million tons compared with 7.8 miliion tons in 2004.

(3) European Union: EU imports, after reaching their highest level ever in 2005 at 8.7 million tons, fell back sharply in the second quarter to down to 7.7 million tons and also in quarter 3 down to 5.3 million tons. Hence in the first 9 months 2005 imports, at 21.7 million tons were 11% down on the same period 2004. Consequently, over the first 9 months the EU has resumed its position as a net steel exporter with a surplus of 2 million tons, imports 21.7 million tons and exports 23.7 million tons. Key products imported by the EU include semis, hot rolled coil, wire rod, galvanized sheet, hot rolled plates and cold rolled sheet. Key import sources include Russia 3.9 million tons, Turkey 2.1 million tons, Ukraine 2.2 million tons, China 1.5 million tons, India 0.9 million tons and Brazil 1.1 million tons.

Selected from "KWR Special Report Overview of Global Steel Industry, Salman Anwar, by KWR International Inc., 2006."

Words and Expressions

1. cyclical：周期的；轮转的，循环的。
2. fragment：（使）成碎片，（使）分裂。
3. market share：市场份额，市场占有率。
4. consolidation：统一，合并，调整（期）；巩固，加强；凝固；固结，压实。
5. acquire：取得，获得；招致；学得（知识等），养成（习惯等）；收购。
6. output：产量；生产，出产，产品；输出，输出量。
7. augment：（使）扩张，扩大；扩编；（使）增大，增加。
8. variability：易变，变化性；变异性。

9. earning：收入；工资；利润。
10. factor：要素，因素；原动力。
11. attributable：可归因于…的，由…引起的（to）。
12. sensitivity：敏感（性）；感受性。
13. capital：首位的，最重要的，主要的，基本的，根本的；资本的。
14. commodity：[常用 pl.] 日用品；商品；有用物品。
15. disparity：不同，不等，不一致，不相称；悬殊。
16. volatile：挥发（性）的，飞散（性）的；易变的，反复无常的，轻浮的。
17. duel：竞争，斗争，抗争，运动比赛。
18. conclude：结束，终止，使完毕；议定，缔结（条约等）；推断，断定。
19. unprecedented：没有前例的，空前的；无比的；新奇的；崭新的。
20. takeover：接收，接管（政权等）。
21. giant：巨人，大汉；庞大的，巨大的。
22. halt：暂停前进，止步；休息；立定。
23. shareholder：股东。
24. approval：批准；认可。
25. combine：集团；企业联合。
26. collective：集合的；聚合性的；共同的，集体的，集团的。
27. revenue：（国家的）岁入；税收；（土地、财产等的）收入，收益，所得；（个人的）固定收入；[pl.] 总收入；收入项目；财源。
28. well-positioned：较好的定位。
29. cater：为（宴会等）供应酒菜；供应；迎合，投合。
30. cost：费用；代价，价格；成本。
31. Kazakhstan：哈萨克斯坦 [亚洲国名]。
32. Ukraine：乌克兰 [欧洲国家名]。
33. Indonesia：印度尼西亚 [亚洲国名]。
34. profitable：有利可图的，可赚钱的，合算的。
35. track record：成绩纪录。
36. under-producing：生产不足；半停产。
37. layoffs：临时解雇；停工；停止活动。
38. lean：瘦的，瘠瘦的；精简的；精干的。
39. household appliance：家庭用具。
40. dominant：最有力的，占优势的；主要的；突出的，超群出众的。
41. rival：竞争者，对手，敌手；匹敌者，对等的人 [物]。
42. titan：力大无比的人；（学界、政界等的）巨头。
43. diversified：形形色色的，多样化的；（投资等）分散经营的。
44. consolidated：加固的；整理过的，统一的。
45. franchise：选举权；公民权，参政权；（某种）豁免权；某种特许权。
46. diverse：不同的，别的；形形色色的，多种多样的。
47. presence：在，存在，实在；存在的人 [物]。
48. fuel：（给…）加 [供给] 燃料，（给船等）上煤，（给…）加油。

49. distinctive：独特的，有特色的。
50. strategic：战略（上）的；（战略上）重要的。
51. alliance：同盟，联盟。
52. joint venture：合资（企业）。
53. memorandum：记录；备忘录；便笺［函］；通知书；寄售物品通知书。
54. blast furnace：高炉，鼓风炉。
55. housing：房屋；住宅。
56. EBITDA：未计利息、税项、折旧及摊销前的利润。
57. euro：欧元。
58. subsidiary：附属者，附属品；子公司。
59. reserve：贮藏，保存；保留；储备，预备；埋藏量，（石油）贮量。
60. respectively：各自地，分别地。
61. coking coal：炼焦煤。
62. thermal coal：动力煤。
63. iron ore：铁矿石。
64. pellet：球团矿。
65. iron ore concentrate：铁精矿。
66. innovative：创新的。
67. manufacture：制造业；产品；（大量）制造，加工。
68. consultancy：咨询，顾问服务；顾问服务公司；担任顾问的职位。
69. headquarters：司令部，指挥部，总部。
70. division：部门，政府或公司的一个部分，属一行政或功能单位。
71. crude steel：粗钢。
72. carbon steel：碳素钢。
73. smelt：精炼，冶炼。
74. roll：辗，轧；轧钢。
75. extrusion：挤出，推出；［地］喷出的；突出的，赶出；挤压成型。
76. takeover：接收；接管。
77. bond：契约；联盟；证券，债券；借据；证券纸；（付款）保证书。
78. issuer：发行者，出版者。
79. default：不履行；违约；拖欠；不履行债务；缺席。
80. leverage：为…提供杠杆装置；以“杠杆收购法”投资于（某个基金）。
81. liquidity：流动性，流畅。
82. oversupply：过度供给。
83. commodity：［常用 pl.］日用品；商品；农［矿］产品；有用物品。
84. flat product：扁平材产品。
85. long product：长材产品。
86. inventory：（财产等的）清单，报表；（商品的）目录；盘存，存货。
87. build-up：上升，升高，增长，增强。
88. break-up：明细表。
89. infrastructure：基础设施；永久性基地，永久性防御设施。

90. ignite：点火，点燃；使燃烧。
91. ripe：成熟的；时机成熟的，已准备妥当的。
92. be ripe for：…的时机成熟；渴想…。
93. appetite：欲望，（特指）胃口，食欲；嗜好，爱好。
94. semis：半成品。
95. hot rolled coil：热轧钢卷。
96. welded tube：焊管。
97. wire：钢丝。
98. rod：线材。
99. NAFTA：North American Free Trade Agreement 北美自由贸易协定。
100. steel mill：钢厂。
101. resume：拿回；恢复（自由等）；重占；再穿用；再开始用（烟管等）。
102. surplus：剩余；盈余；公职；（特指政府为了维持价格而贮存的）剩余农产品。
103. galvanized sheet：镀锌薄板。
104. hot rolled：热轧的。
105. plate：钢板，（中厚板）。
106. cold rolled：冷轧的。
107. sheet：薄板。

Reading Material 1：New Development in Europe

1. Steel Production in Europe

Steel is a global product, and due to the rapid information transfer worldwide, there are no fundamental differences regarding the production processes. Nevertheless, there are distinctions in the technologies applied, caused by the raw materials and energy situation, consumer orientation, and also caused by the speed of the introduction of innovations and new process developments in operational application.

The European Union (EU) is one of the most important economic blocks in the world. The treaty on the foundation of the European Coal and Steel Community (ECSC), established in 1952, was one of the origins of the European Union which today comprises 15 member states. This region has about 376 million inhabitants; in 1999 the production of crude steel amounted to 155 million tons. Geographically, Europe contains several other steel producing countries outside the EU. Without considering the share of the CIS member states, there is an additional crude steel production of about 50 million tons. An overview of the steel production locations in Europe having a capacity of more than 4 million t/year crude steel reveals that the city of Duisburg in Germany is the area with the highest production level.

The share of basic oxygen furnace steelmaking in integrated plants is heading towards 60%, and that of scrap based electric steelmaking towards 40%. Today, and in the future, only those production processes which achieve high productivity, cost efficiency, and also easy and sufficient environmental control will have a chance to survive. Therefore, the Basic Bessemer and Open-Hearth processes have been phased out.

2. Sinter Plants

Sinter is the main ferrous burden component for the blast furnaces in the European Union. The average burden composition in EU countries is 62.4% sinter, 26.1% pellets and 11.5% lump ores and others. Only Sweden has shut down all its sinter plants. In the other countries, the share of sinter ranges from about 45 to 85%. In 1999, 41% sinter plants were operated in the EU producing 100 million tons of sinter. Over 50% are medium to large plants with 200 to 500m^2 effective suction area——the largest being strand No. 3 at Sollac Dunkerque with 525m^2.

Sinter plants in the EU are focusing on reducing dioxin emissions to extremely low levels. Therefore, several activities to reduce dioxin emissions are carried out. Urea is added to the sinter plant in Lanwern, United Kingdom. This resulted in a decrease in dioxin emissions. One possible mechanism for the dioxin reduction using urea is the reduction of chlorine levels. The average dioxin emission levels could be decreased to 0.6ng TEQ/m^3 (s. t. p) in the waste gas.

At Corus in Ijmuiden, the Netherlands, half of the waste gas quantity is recycled via hoods to the sinter strand, whilst the residual gas is cleaned using the wet scrubbing Airfine system. This combination of EOS (Emission Optimised Sintering) and Airfine enabled the reduction of dioxin emissions to approx. 0.20 to 0.24ng TEQ/m^3 (s. t. p.). The authorities in the Netherlands prescribe a maximum allowable emission value of 0.5ng TEQ/m^3 (s. t. p.).

Wihin the framework of a European consortium, a dry gas cleaning system to reduce dioxin emissions was discussed with the German authorities. The system was to be tested at a Thyssen Krupp Stahl sinter plant, with the aim to reach a value of 0.1ng TEQ/m^3 (s. t. p.). Two methods have been tested up to now: The injection of lignite coke dust into the waste gas in front of the electrostatic precipitator and the use of catalysts in front of the stack. For the future of sinter plants in Germany, it is essential to clarify the health relevance of a dioxin emission value of 0.1ng TEQ/m^3 (s. t. p.).

3. Blast Furnaces

72 blast furnaces (BF) are operated in the EU, producing 91 million tons hot metal (HM) per year. Most of the furnaces are in the range of 9 to 13 m hearth diameter, 6 furnaces have a hearth diameter of over 13m. Average annual production per blast furnace, is approx. 1.26 million tons hot metal; the largest furnace, Schwelgern No. 2 of Thyssen Krupp Stahl, produces over 4 million t/a. Highest productivities achieved are in the range of 3.0t/m^3 working volume per 24h. Total reductant rate of the EU furnaces has on average remained at a low level during the last ten years (approx. 485kg/t HM). The relative distribution of reducing agents has changed remarkably. Average coke rates decreased by 60kg/t HM to 358kg/t HM, resulting in a saving of coke capacities of around 5.5 million t/a. These savings in coke were basically achieved by increasing the average coal injection rate. In 1999, the highest coal injection rates achieved by some blast furnaces were in the range of 190 to 200kg/t HM. As today certain blast furnaces are already constantly operated at a coke rate of 300kg/t HM and below, it can be expected that the average coke level can be

decreased from 358kg/t HM to approx. 320kg/t HM by the year 2005. This can be realized by further increasing the injection rates and by replacing oil injection by coal injection if the oil price remains at a high level. To improve coal gasification at the lance tip during injection at high rates, a demonstration project for the injection of preheated pulverized coal is being carried out within the ECSC.

At three blast furnaces, all located in Germany, processed waste plastics are injected as a replacement for oil. Plastic injection rates were up to 44kg/t HM, and the evaluated oil replacement ratio was 1 : 1. The blast furnaces using these plastics are paid an agreed premium by the plastics recycling industry. The plastics used have to fulfill extremely exacting requirements regarding chemical composition and grain size distribution. In 1999, 104000 tons of plastics were injected into these blast furnaces. A further increase of plastics injection in Europe is not likely at the moment.

In the field of blast furnace plant equipment, new developments in cooling technology should be highlighted. In addition to cast iron cooling staves, the newly developed copper staves are becoming increasingly established in the middle shaft area down to the hearth area. Compared with cast iron staves, copper staves enable significantly higher heat removal. They are considerably thinner, thus increasing the furnace volume without changing the shell size. It is advisable to install copper staves without refractory brickwork in the lower shaft and belly area, because due to the rapid heat removal deposits are formed on their surface and protect the staves against abrasive wear. Blast furnace No. 2 Stahlwerke Bremen (12.0m hearth diameter) was the first furnace in the world equipped with copper cooling staves in the hearth during its relining in 1999.

4. Basic Oxygen Furnace Steelmaking

The total EU basic oxygen furnace (BOF) production of about 100 million t/a has remained nearly constant during the last 10 years, although the share of this process line is slightly decreasing. The strong increase in vacuum treatment capacities in the EU reflects the demand for high quality steel grades. The last few years have been characterized by the trend of integrating ladle furnaces in BOF shops to enable lower tapping temperatures and independent temperature management.

High quality flat products are mainly produced by the BF-BOF steelmaking route in integrated steel plants. Scrap based flat steel production requires scrap preparation and selection, and high amounts of virgin materials like DRI and hot metal. The comparison of long and flat production and the scrap/hot metal situation in the world and in the EU, makes it obvious that the high share of flat products in the EU, and especially in Germany, is linked with a high hot metal input for steelmaking. "Extreme" situations can be identified in Japan and the United States, the former being characterized by very low scrap input and the latter by high scrap input (also for flat production). In some European countries the specific scrap input in BOF steelmaking has been decreased since 1980; these countries have still some potential for lowering CO_2 emissions by increasing scrap consumption.

A measure to increase scrap consumption in the converter is the achievement of a high degree of post-combustion. Pilot trials using a jet of hot air at 1200℃, bottom blowing of oxygen and fine coal, have led to post-combustion degrees of 60 to 65% and excellent heat transfer to the melt. Successful trials with a 10 tons converter have recently been performed at Neue Maxhfutte in Germany.

Developments in BOF steelmaking in Europe are mainly aimed at improving productivity. Dynamic BOF models and standardizing the blowing operation are under continuous development. Neural networks for process condition prediction offer a great potential, particularly where relationships are non-linear or input data are missing. With high scrap rates, strict demands concerning the residual elements are a necessity. The productivity of European BOF vessels is about 400 to 550t/h working time for 280 to 380 t vessels. Top productivity is mostly obtained in steel shops working with one vessel out of two.

Regarding the quality of the produced steel, slag-free tapping has a strong influence on the success of secondary metallurgy treatment. A new system with a taphole slide gate has been installed on the Salzgitter AG vessels. A system for slag detection (Amepa) is linked with the slide gate, stopping the tapping process within 1s. A special manipulator had to be developed for changing the slide gate system. Changing can be effected within 10 min.

The FeO content in the top slag has a significant influence on the macro-cleanness of slabs. Only low FeO contents lead to slabs free of macro-inclusions ($>50\mu m$). Such results are needed to produce strip used for the production of beverage cans with very low wall thicknesses.

Secondary metallurgy processes are increasingly automated by using more and more process models for calculating the current composition and temperature of the melt. In particular the control of vacuum degassing and decarburization based on a waste gas measurement is worth mentioning. Furthermore, at some AOD and VOD plants a model-based control of oxygen and inert gas injection for decarburization of high chromium steels is applied. For the calculation of alloy materials a "minimum cost" calculation has become standard. The resulting setpoints are normally directly passed to the bin system. Some plants also use the automatically transferred caster target values for delivery temperature and time of the heat for temperature control in the ladle furnace.

In general it can be stated that isolated applications for process automation with a non-homogeneous hardware structure are increasingly replaced by process computers which combine the different automation tasks for the corresponding treatment station. Furthermore, the process computer handles automatic data acquisition and archiving as well as the generation of heat reports. The computers in the different treatment stations within the steel plant are connected via networks to exchange process data and setpoints.

5. Continuous Casting

In the development of continuous casting, Japan and the EU have been playing leading roles. Slab, bloom and billet casting are now mature techniques. The quality of the produced strands is not only influenced by secondary metallurgy and tundish metallurgy, but also by changes in plant operation. Examples are the vacuum tundish technology, now being tested for commercial slab casting operations at Corus UK, Rotherham, or the revamping of curved-mould slab casters to vertical-bending casters. The inclusions rise in the liquid core and form an inclusion band on the strand top side. Operational results have clearly shown the great advantage of a vertical-bending type caster.

A further progress in slab casting is the introduction of dynamic soft reduction. This technique enables an adaptation of the soft reduction zone to the actual position of the crater end in the strand during casting. By this measure, the core segregation in slabs can be avoided. This is especially necessary for producing high quality plates from thick slabs. Consequently the new slab casters at Rautaruukki, Finland (up to 270mm casting thickness), and at Dillinger Hutte, Germany (up to 400mm casting thickness), are equipped with soft reduction devices. Producing plates of a maximum thickness of from 210mm to 400mm slabs, the casting machine in Dillingen is a real near-net-shape caster.

Following the introduction of thin slab casters in European minimills, a new aspect is now the integration of thin slab casters in existing integrated steel plants. The casting-rolling technology enables the production of thin hot strip down to a thickness of 0. 8mm which can compete with cold rolled strip. Other reasons are energy savings, lower man-power, shorter lead times, and the possibility of semi-endless or endless rolling of thin hot strips. There are different concepts for batch, semi-endless and endless rolling in CSP plants. The first two casting-rolling plants of this type started production in the EU in 1999 and 2000, namely at Thyssen-Krupp Stahl in Duisburg (2. 3 million t/a) and at Corus Netherlands in IJmuiden (1. 3 million t/a) respectively.

This development is not the end of the road. A further new near-net-shape casting process, Direct Strip Casting (DSC), applicable in integrated plants, is in the pilot stage. This process being tested at Mefos, Sweden, and Clausthal, Germany, is a moving-belt strip casting process combined with in-line hot rolling. The casting speed exceeds 50m/min for a casting thickness of 10 to 15 mm. High cost efficiency, high productivity, low investment costs and good quality of the rolled strip can be expected from this process. The results achieved show that this casting process constitutes a potential for hot and cold strip with enhanced properties.

6. Co-products of Iron and Steelmaking

Especially for integrated steel plants characterized by their long production chain from ore preparation to pickling and cold rolling, there is need for developing low and non-waste technologies establishing closed-loop production processes and producing co-products to be sold to other industries.

One example is the use of slag. For the use of blast furnace and steel works, slag in the EU for the year 1999, total slag utilization was approximately 44 million tons, 36% of which was used in the cement industry. This is a remarkable contribution by the steel industry to the reduction of CO_2 emissions, as the production of blast furnace cement (containing 50wt% granulated slag) requires only 59% of the energy needed to produce compared Portland cement. More than 40% of the slag is utilized for road construction. Only 7. 8% or 3. 4 million t/a are deposited or landfilled. However, also this amount must be further reduced. Today metallurgical slags have to be classified as co-products of iron and steelmaking. Through their use energy and resources are saved. This task used to be performed exclusive-