Sunrise in Steel Town: A Renaissance in Steel

Alan W. Cramb

Whoever said that the steel industry is dead? It is alive and flourishing, this time with an efficiency and environmental cleanliness that will make the semiconductor industry proud! The renaissance is not local, limited to a few developed economies, but global, based on innovations in iron and steel technology and on technology spillover from other areas. The appetite for steel has not decreased: Developing economies such as China and India need millions of tons to build their inadequate and overstretched infrastructure, and the developed countries demand new steels with superior properties for applications in areas previously reserved for other materials. Today the global production of steel is assessed not by mere tonnages but by their quality.

A major attraction of the iron and steel industry is its compatibility with the materials cycle: Iron and steel scrap has become the new raw material, curtailing the global hunger for newly mined iron ores. In a sense, this recycling is an atonement of the excesses of the earlier decades when mining and metallurgical industries paid little attention to energy efficiency and environmental protection. Experts now agree that these and increasing competition from other materials drove the industry to its near extinction. How real then is this renaissance and what are the technology drivers for the growth? Will steel regain its pride of place among materials used by society? In the following article, Alan Cramb reviews the spectacular growth of this industry and predicts an exciting future for it. Silicon, it seems, is not eliminating steel from our materials consciousness!

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The North American steel industry, once written off as a "sun-downer industry" and an "aging dinosaur" by prognosticators, has had a remarkable renaissance in the last 10 years and has again become competitive in a global market.[1] This rebirth has been difficult and has led to a complete restructuring of traditional companies and the growth of new, aggressive companies. In the early 1980s it did not seem feasible that within 10 years the industry would not only be restructured but would become a fertile opportunity for investors and entrepreneurs through which new companies would be formed, plants built, and products sold to a growing domestic market.

Growth in the North American steel industry has been due to new aggressive investment and management philosophies and to the development of new technologies that have allowed long- and flat-rolled products to be produced in new scrap-

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based, in-line processing facilities. Productivity has increased dramatically—from three to seven man hours per ton in the 1980s to less than one man hour per ton at these new facilities. Quality of steel products has improved to the point that there is no disparity between the quality of steel products produced in North America and those produced in Europe or Japan.

The steel market in North America is currently very strong where even with the addition of 20 million new tons of capacity in the last 10 years, imported steel has increased to over 30 million tons per year in a total market of over 130 million tons. Therefore, the North American steel industry has potential for future growth by displacement of imported steel or for stability of existing companies if the total market decreases. This position is a remarkable change in only 10 years.

Figure 1. Modern control pulpit in a steelmaking facility.

Recycling of steel is growing and almost all new facilities built in the last 10 years are based upon the melting of steel scrap. This had led to a large burden upon the scrap recyclers to sell "quality scrap" that is low in the residual elements copper and tin and, in time, will lead to advanced scrap treatment facilities. Steel recycling rates in North America have reached 65% (68 million tons) and in 1996, 19 billion steel cans and 12 million tons of steel from automobiles were recycled.

In addition to economic changes, significant technological developments have occurred within the steel industry. Purity levels in bulk steels have been continually increased and solute contents of carbon, sulfur, phosphorus, nitrogen, and hydrogen can now be controlled on the industrial scale to parts per million levels if necessary. New ironmaking technologies are under development to supplement the scrap used in the electric arc furnaces that are used to recycle steels. New near-net shape-casting technologies have been implemented and are currently under further development. The industry has also been aggressive in the development of new applications and in implementing new steel grades that are stronger and more formable so that the amount of steel used in an automobile, for example, can be reduced.

The future for steel is very interesting and complex. This is a time of rapidly changing technology and the influence of advanced control systems and automation has changed the structure of the industry from one which was characterized by smokestacks to an industry where high level technicians remotely control complex robotic machinery (Figure 1). Future developments will be toward increased automation and a simplified flow sheet where new technologies will replace multiple steps of older technologies.

Global pollution and environmental issues will be a potent force in the development of the steel industry of the future. Developments underway aim at reducing carbon dioxide, waste water emissions, and energy consumption. The majority of efforts in this regard must be centered upon the basic iron and steelmaking process itself. New techniques for iron production, which have the ability to produce a liquid steel from coal, iron ore, and oxygen in an energy-efficient and environmentally friendly manner, are under development worldwide. These developments have also led to a large effort aimed at the optimization of conventional processes and have resulted in significant reductions in energy consumption and increased productivity in the blast furnace.

Developments in combined casting and rolling operations led to the new minimills for flat-rolled products that have revolutionized steel production in North America. Current developments in this area combine the casting machine with a hot rolling machine to produce steel sheet at thicknesses as low as 0.6 mm in a distance of only 170 m (Figure 2). This would allow a further process simplification as products from these machines would be targeted at a market previously only served by production facilities with a hot- and cold-rolling mill.

A major technological development is currently underway in Europe, Japan, and Australia: strip-casting for steels. Steel strip 1-mm thick will be produced from liquid steel directly using a twin-roll-strip-casting machine. This technology, if successful, will lead to a further downsizing of the equipment necessary to process liquid steel and subsequent decreases in the entry cost for new companies to become steel production companies. At the moment the majority of the interest in this technology lies in the production of stainless steels but the technology, once developed, may be appropriate for other carbon and alloy steels.

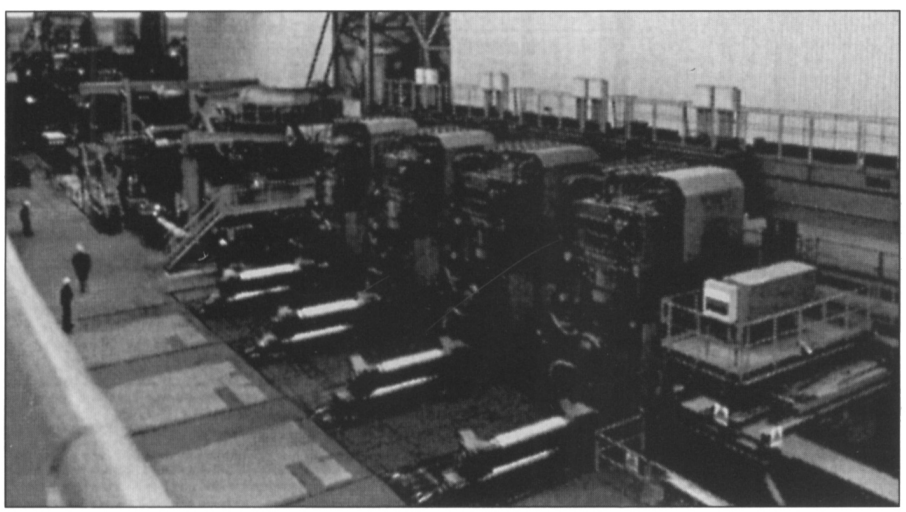

Figure 2. In-line strip production: liquid steel to flat-rolled strip (<1-mm thick).

Research on steels continues and most recently the American Iron and Steel Institute (AISI) developed a technology roadmap to guide research and development in the steel industry.[2] This roadmap outlines the developments necessary for a sustainable steel industry and outlines necessary research in production efficiency, recycling, environmental engineering, and product development. Significant

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funding for research that falls within the roadmap is available through the AISI and the U.S. Department of Energy.

Two National-Science-Foundation-initiated Industry-University Cooperative Research Centers focused upon steel have become self-sustaining: The Center for Iron and Steelmaking Research (CISR) at Carnegie Mellon University[3] and the Center for Advanced Materials processing at Colorado School of Mines. Canada has major centers of steel research at the University of British Columbia and at McMaster University. In addition, many prominent North Amercian universities have significant individual investigator activity.

A restructuring of the steel industry continues to grow worldwide. While Japan has slightly decreased its steelmaking capability, it has developed its industry to be highly automated and able to service the high-quality end of the steel market. In addition, Japan has sponsored a number of high-profile nationally funded projects to develop new steel processing technologies and attempt to solve environmental problems related to steel. Europe has been the source of new casting developments and a number of European engineering companies have become the major steel technology suppliers to the world. The Asian market has been growing and last year, China became the world's largest steel-producing nation. Significant technological developments are underway in South Africa, Australia, Korea, Japan, the United States, France, Germany, and Italy. Steel is shipped from Argentina to Europe, from Japan and Korea to North America and Europe, from North America to Europe, and from Europe to North America. The market and challenges in steel are truly global and technological developments are quickly distributed throughout the world.

The steel industry has gone and continues to go under immense changes; however, the North American steel industry (a 50-billion-dollar industry) will apparently not become an offshore service industry, as once predicted, but will continue to be a primary production industry in North America for the foreseeable future. The problems of the 1980s were indicative of the birth of a new world competitive North American industry rather than the death throws of an anachronism. Rather than a dinosaur, it turns out that the steel industry is a phoenix, reinventing itself from its own ashes.

References

1. Details of this rebirth are outlined in R.S. Ahlbrandt, R.J. Fruehan, and F. Giarratani *The Renaissance of American Steel* (Oxford University Press, New York, 1996).
2. For details of the roadmap, see the AISI website at http://www.steel.org/.
3. For details of the CISR, see website http://neon.mems.cmu.edu/cramb/cisr.html/.

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