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Conference Proceedings

# Production of IRON/STEEL & High-Quality Product Mix:

## LATEST TECHNOLOGICAL INNOVATIONS AND PROCESSES

Edited by B.R. Nijhawan

# Production of Iron, Steel, and High-Quality Product Mix: Latest Technological Innovations and Processes

*Proceedings of the*
Applications of the Latest Technological Innovations and Processes for the Production of Iron and Steel and High Quality Product-Mix Conference
ASM/TMS Materials Week
2-5 November 1992
Chicago, Illinois, USA

*Edited by*
B.R. Nijhawan



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Technical Divisions Board
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**The Materials Information Society**

First printing, November 1992

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Library of Congress Cataloging Card Number: 92-82923
ISBN: 0-87170-457-9
SAN: 204-7586

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**ASM International®**
Materials Park, OH 44073-0002

Printed in the United States of America

# Preface

Near the end of the 19th century, world steel production was minute compared with today's standard. For example, annual steel production worldwide in 1880 was only 4-million tons, increasing to 12-million tons in 1890, and reaching 28-million tons at the turn of the century. During the 20th century, production has increased steadily overall while going through peaks and dips, reaching 705-million tons in 1974, 747-million tons in 1979, 783-million tons in 1990 and 735-million tons in 1991.

The continual emergence of advanced materials, such as composites and other hybrid materials, makes it difficult to predict what global steel output will be as we near the 21st century, what steel technologies will be dominant, and what the product mix will be. The intense competition from alternative materials not only should provide formidable challenges, but also should put a high premium on technological ingenuity and initiative.

Some of these issues were addressed at a two-day technical program, "Emerging Technologies of New Materials and Product Mix of the Steel Industry," at ASM Internationals's Materials Week '91, and also will be addressed at Materials Week '92 at a two-day technical program, "Applications of the Latest Technological Innovations and Processes for the Production of Iron, Steel, and High-Quality Product Mix." This proceedings contains papers from both programs.

Steels and superalloys continue to "hold their own" despite the challenges of substitute materials/products, which result from the courtship of metals and nonmetallics that leads to promising hybrid composites.

The restructuring of the steel industry in the path of restructured global boundaries, while driving annual global steel output down, will eventually lead to a reorientation of the industry based on application of the latest technological innovations, elimination of obsolete capacity, and a market-oriented balance of the global steel industry.

In a global economy where the only certainty is uncertainty, gathering and disseminating information to increase knowledge is a key factor in maintaining a competitive edge. This philosophy is promoted at Materials Week, which provides a forum for the exchange and transfer of technical information.

This proceedings is not the last word on the status and progress of the steel industry, since some of the highlighted current developmental work in the world of iron and steel will become reality.

B.R. Nijhawan

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## Additional Paper*



* This paper was submitted too late to be inclued in its proper location in the proceedings.

# 1992 Conference

# The Applications of the Latest Technological Innovations and Processes for the Production of Iron, Steel, and High-Quality Product Mix

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# Changing Patterns of Industrial Development and the Steel Industry

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## CHANGING PATTERNS OF INDUSTRIAL DEVELOPMENT AND THE STEEL INDUSTRY

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## INTRODUCTION [1]

The changes in the pattern of industrial development which have occurred over the last twenty years are the symptoms of an evolutionary process towards higher levels of economic maturity manifesting themselves as rising incomes and more balanced income distribution. The changes in the pattern of industrial development are also brought about by technological progress which is both, cause and consequence of economic progress. The role of external influences, like energy price surges or profound political and policy changes, including the recent developments in Eastern Europe and the USSR, is also of importance.

While the changes in industrial development patterns have first occurred mainly in the advanced countries, their impact was very quickly also transmitted to the newly-industrializing nations NICs); this is a result of the growing interdependence of the world economy, the increasingly tightly-knit network of international trade and the rapid spread of most modern technologies.

The impact on the structure and functioning of the industrial system in general and on the steel industry in particular has varied from one region to the other, from country to country, depending on the stage of development reached, on the type of economy (share of manufacturing, services, agriculture, mining), and on the degree of export or import dependence, particularly in the field of energy; it also is a function of the prevailing economic and social system (market-oriented, State-influenced or -controlled economy) or, more generally, on government policies and government participation in the economic process.

In the following an attempt is made to highlight some of the main changes which have occurred or which are still underway, with a view to assessing their impact on the steel industry in countries at different stages of development: this should be helpful to corporate planners who have the difficult task to develop strategies for the steel industry.

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[1] This paper is based on a study which has been prepared under the auspices of the IISI Committee on Economic Studies, entitled "Changing Patterns of Industrial Development and the Steel Industry", Brussels 1990.

## CHANGES IN THE ECONOMIC AND INDUSTRIAL STRUCTURE

(**Table 1**) After rapid growth in the post World War Two era, industrial development of the advanced economies has assumed a somewhat slower pace, as it was entering a phase of maturity, with the services sector (transport, communication, finance, distribution, medical care, education, etc.) expanding rapidly, accounting for an ever-rising share of the Gross Domestic Product (GDP). Taking Germany, Japan and the United States as representative of this group of countries, services in the United States produced at the end of the 1980s almost 70 per cent of GDP, and in Germany and Japan their share is rising towards 60 per cent. As agriculture is in the advanced industrial economies of relatively small significance, the size of industry is inversely proportional to services, and its share in the creation of national wealth is on the decrease.

(**Table 2**) A few of the newly industrializing countries have been selected to illustrate the structural changes which are also manifesting themselves in these economies. The selection was, however, mainly determined by the availability of statistical information. It should also be pointed out that "1990" refers to a year at the end of the 1980s, as close as possible to 1990.

When looking at the data for the newly industrializing countries it should also be borne in mind that in these economies structural changes are often overlaid by the all-dominating forces of the ongoing industrialization process; furthermore, the lines of economic evolution are often blurred by financial difficulties which have, particularly in Latin America, interrupted or at least delayed the development process.

As is to be expected, agriculture still holds a larger share of GDP than in the advanced economies, but this share is on the decrease, with both industry and services rising in importance. It is noteworthy that in a number of the countries shown the proportion of services is closing in on the 50 per cent mark.

(**Table 3**) Within the industry sector, manufacturing holds the largest share in the industrialized countries, and the share has been on the rise over the last twenty years. Industry, it should be noted, also covers mining, construction and electricity, gas and water production, all of which hold their ground to manufacturing.

(**Table 4**) Among the NICs, Brazil and India have lower or falling shares of manufacturing in total industrial output; both countries are less export-oriented than Mexico or the Rep. of Korea where the part of manufacturing has risen to levels comparable to those obtaining in the advanced economies.

(**Table 5**) One group within manufacturing, namely the metal-using industries, is of particular importance for steel planners; it comprises the production of electrical and non-electrical machinery, motor vehicles and ships, and also the production of scientific and professional equipment.

(**Table 6**) Metal-using is an important sub-sector indeed, and it accounts for a rising share within total manufacturing in terms of value added, reaching now over 50 per cent in Japan and the United States, and closing in on that level in Germany. In other industrialized countries this part has tended to remain at around 40 per cent. The consumption of steel is concentrated in the metal-using sector, and together with construction -the other main outlet for steel products- metal-using industries account for about 15 per cent of GDP (in the USA), for 21 per cent in Germany and 23 per cent of GDP (in Japan). Thus, steel consumption is dependent on two relatively small segments of total economic activity.

(**Table 7**) In the metal-using industries of the industrialized countries, the production of electrical and non-electrical machinery accounts for the largest part, for between 55 and 60 per cent. This is followed by transport equipment, predominantly motor vehicles

(between 60 and 90 per cent of transport equipment, depending on the country); other metal products such as structural parts, containers, tools and furniture give a further 8 to 14 per cent, and the remaining 4 to 6 per cent consist of professional and scientific equipment.

(**Table 8**) Although expanding in all countries, the metal-using sector is in most of the NICs less important than in the advanced economies. This is because other manufacturing activities like food production, textiles, wood, non-metallic minerals and even basic chemicals still hold a higher share in manufacturing than machinery, transport equipment and fabricated metal products taken together.

The traditional sub-division of machinery into electrical and non-electrical is rather misleading since for example Office, Computing and Accounting Machinery is classified as non-electrical; furthermore, much of the industrial machinery classified as non-electrical is powered by electricity and contains an ever-increasing portion of electronics for control and steering.

(**Table 9**) If electrical machinery and scientific equipment are singled out from among the metal-using industries, it will be seen that between 30 and 37 per cent of the total is accounted for by these items; and the share of these high-value, little steel-containing products is increasing, not only in the industrialized countries, but also (**Table 10**) in the emerging industrial economies. For the steel planner it is interesting to note that their share in total metal-using industries is also in the new countries already approaching the 30 per cent mark; the high figure for the Rep. of Korea shows an early specialization in the area of electrical and electronic equipment, as is also the case for other Asian countries.

(**Table 11**) Statistical data for a few countries permit to measure the value of output of the electronics sub-sectors, i.e. Office, Computing, Accounting Machinery; Radio, TV and Communication Equipment and Professional, Scientific, etc. Implements. Together they account in Japan for close on 29 per cent of the total production of metal-using industries, up from 22 per cent in 1980; in the United States this share is now at over 26 per cent, having been at just under 19 per cent in 1970. In Germany the percentage is still relatively low, due to the overwhelming importance of the general engineering industries. The total value of these "high-tech" products which are of course rather low in steel content have in recent years exceeded the value of road vehicles produced in both, Japan and the United States.

Clearly, electronics has been the growth area of the 1970s and 1980s: automation, robotisation and computerisation have spread through industry and services; in the household sector there has been equally rapid diffusion of such products as video recorders, microwave oven and the home computer.

The adjustment process to which both, the advanced and the emerging economies have been subject since the mid-1970s has led to the modification of production methods in manufacturing industries and other steel-consuming sectors as well as in the terms of inter-material and international competitiveness. It has brought about the emergence of entirely new sectors, particularly in the area of information and communication technologies; and it has also modified existing industries where the introduction of "mechatronics" has changed processes in mechanical and electrical engineering, or in the production of precision and scientific instruments, but also in other industries and sectors. Finally, it has given rise to the development of new materials, like carbon fibres, ceramics, advanced engineering plastics and composite materials.

To summarise, manufacturing's product mix has changed over the past two decades to become much less material-intensive, and also less steel-intensive. Along with these changes in the manufacturing sector, there has been its own decline for the creation of national wealth, as services have become the

mainstay of economic life. And services are not regular consumers of steel or other engineering materials: only when hotels, office buildings and transport infrastructure are being erected do they consume materials, as a once-off stimulus to consumption; later they only require it for replacement or possible expansion.

## IMPACT ON THE STEEL INDUSTRY

(**Table 12**) As a consequence of the various changes in the economic and industrial structure and also, of course, of the slower pace of economic development related to the maturation process, steel production in the **industrial countries** has never regained the 1974 peak level of 463 million metric tons. It rose back to 490 million metric tons in the boom year of 1979, but it has been on the decline ever since and stood at 390 million tons in 1990. The fall was less pronounced in terms of finished steel output, amounting to about 6 per cent compared with 16 per cent for crude steel.

The adjustment process in the steel industry had started with some delay: the first "oil shock" of 1973/74 had brought a sharp drop in steel demand, but the all-out export efforts to balance current accounts, together with increased investments in energy sources as well as a revival of consumer demand, had resulted in an upturn of steel consumption which lasted until 1979. This had re-inspired confidence in the steel industry, and already existing investment projects were resumed or completed. (**Table 13**) They included investments not only for rationalization and energy economy but also for capacity expansion: nominal crude steel capacity in the OECD countries taken together continued to grow until 1981 and was then 15 per cent higher than it had been in 1974. It was only after the second oil price increase in 1979 and the ensuing recession of the early 1980s that steel industry capacity adjustment started in earnest: by 1990 the industrialized countries' crude steel capacity had been reduced by 19 per cent under the 1980 level.

Capacity closures and modernization have involved considerable reduction in employment which stood in 1990 at less than half the peak figures of 1974 in the EC and the United States, and had dropped by one third in Japan. Altogether, a total of one million jobs had been shed between 1974 and 1990 in the industrialized countries, which amounts to approximately one third of the employment in 1974. The steel industry had pursued the adjustment process over a period when it suffered considerable financial losses, particularly in the early 1980s, amounting to many billions of US dollars. More recently, however, the improved outlook and the revival of the investment process in the economy at large during the second half of the 1980s which might announce the end of the adjustment phase, have brought a halt to capacity reductions also in the industrialized countries.

A positive feature of the adjustment process was the replacement of obsolete by modern equipment, the improvement of the remaining facilities, the streamlining of the product pattern and a remarkable increase in the quality of steel. The rising share of continuous casting in the industrialised countries, from 15 per cent in 1974 to nearly 85 per cent in 1990, illustrates the improvement of steelmaking technologies. The share of flat products in the total output of industrialised countries has risen from roughly 40 per cent in the early 1970s to more than two thirds at present. Within flat products the share of extremely thin sheets and coated products has increased significantly. Finally, the share of alloy steels has grown considerably, and so has the proportion of micro-alloyed high-strength steels and other steels improved by secondary metallurgy, heat-treatment and other processes. Precise statistical information on the quantity of "fine" or "improved" steels is unfortunately not available; it can, however, be estimated that they account at present for about 30 per cent of total steel output, having doubled their share since 1970.

In line with the growing internationalisation of

the economies, international trade in steel has also been rising while production was falling. The export share of steel output in the industrialised countries has risen from 23 per cent in 1970 to near 40 per cent in 1989; at the same time the import share of steel consumption grew from 19 per cent in 1970 to 30 per cent in 1989. This was not necessarily always a sign of growing division of labour, but rather also a consequence of increasing competition in international trade, as steel demand in certain domestic markets grew at a slower than expected pace.

The adjustment process has also left its mark on long-term planning in the steel industry. The manifold pressures of the moment, the daily struggles for survival had, particularly in the industrialised countries, blurred the view of the future. It was only over the last years that in a number of countries corporate planning changed from survival strategies towards a positive view of the future. Apart from further efforts to raise the value-added content of steel products and the improvement of production processes, there is a distinct tendency in most countries for diversification into new materials, but also into electronics, computer and communication systems, and even into areas remote from the traditional steel industry like bio-technical and service-related activities.

A further feature of the adjustment process was that there is a trend towards concentration through mergers, resulting in streamlining the product pattern of output, improving economies of scale and rationalising investment activities. Furthermore, the number of transnational joint ventures and co-operation agreements has risen considerably.

(**Table 14**) The rapid growth of steel consumption in the 1960s and early 1970s had encouraged the **developing countries** to expand their steel industries: crude steel output rose from 23 million tons in 1970 to 56 million tons in 1980, and by the end of the decade it had passed the 100 million ton mark, accounting for over 20 per cent of Western World output, compared with only 5 per cent in 1970. As steel requirements continued to rise during the 1970s (to 2.6 times the initial level), there was further growth of capacities, from 28 million tons in 1970 to 60 million tons in 1980.

(**Table 15**) Most of the growth was in Asia and Latin America where new integrated plants using modern technologies were erected. Following the positive experience of countries like Japan which had used the steel industry as the principal vehicle for export-oriented industrialisation, steel exports from the more advanced developing countries were also rising, from 2.6 million tons in 1970 to 9.5 million tons in 1980. This trend continued in the 1980s: capacity reached 118 million tons for the developing countries taken together and their exports stood at 35 million tons (crude steel equivalent). At the same time, indirect exports of steel-containing manufactured goods produced in the newly industrializing countries made their appearance on the world market, comprising not only passenger cars and ships, but also certain types of electrical and non-electrical machinery and equipment.

There is, however, a distinct difference in patterns between the developing regions: in Latin America, domestic steel consumption was stagnating or even falling during the 1980s, while exports from the region continued to rise; in Asia home usage of steel was increasing and exports had grown only by a relatively small margin. The reasons for the Latin American situation are well known: capacity growth was because of financial and often also political constraints not met by an equally strong expansion of the domestic economy and its capacity to consume steel; furthermore, exports had to be increased to help easing the financial situation of the steel companies and balance of payments difficulties.

For these and other reasons it is difficult to discern the impact which advancing industrialization has had on the structure of the steel industries in the newly industrializing

countries: the rapid growth of steel requirements for creating infrastructure and industrial capacities is the dominating factor, and it often masks any changes in the structure of the steel industry. The more advanced among the developing countries follow the traditional patterns of steel industry growth: the share of flat products is rising; in Brazil and in South Korea it has reached about 60 per cent, which is very close to the situation in the industrialized countries. The share of welded and seamless tubes gains in importance, and the proportion of alloy steels begins to grow. While the bulk of steel is produced in (often State-owned) integrated plants, electric furnace producers gain in importance. In corporate planning, the guidance provided initially by the drive for import substitution is replaced by orientation towards the demands arising from emerging, increasingly sophisticated manufacturing industries; import dependence on bulk steel products is diminished, and the product pattern of exports develops from simple off-loading of marginal quantities towards the sale of products where there is either a genuine comparative advantage or an otherwise acquired competitive edge.

## IMPLICATIONS FOR STEEL PRODUCERS

Given the changes in the pattern of industrial development of the **mature economies**, corporate strategies of the steel industry are likely to place less emphasis than in other regions on quantitative expansion and rather concentrate on the following main areas:

1. Improvement of the value-added content of output by raising the quality, variety and cost-efficiency of products; this will require increased research and development efforts for creating new products of higher quality to meet increasingly diversified and sophisticated customer demands;

2. Improvement of the efficiency of production processes by introducing most modern or entirely new technologies, including automation (CAM - computer assisted manufacturing), artificial intelligence, flexible manufacturing systems, permitting among others to produce economically relatively small lots of different product qualities, etc., with a view to raise competitiveness over low-cost, low-wage producers as well as over alternative materials; this involves also the further improvement of energy economy and of the environmental compatibility of iron and steelmaking processes;

3. Improvement of marketing (market management) and customer relations, including the provision of technical guidance and assistance for solving manufacturing problems; general strengthening of co-operation with steel distributors and consumers;

4. Improvement of the image of steel as a modern industry producing a modern, easily recyclable material by employing most advanced technologies;

5. Increasing diversification into downstream activities, but also into industries producing new materials (e.g. carbon fibres, amorphous and shape-memory alloys, ceramics) and so-called high-tech industries (e.g. electronics, bio-technology) with a view to taking advantage of available corporate resources, like technical and management know-how, employee skills, knowledge of markets and material-using industries, etc., and to provide a stabilising element against the cyclical swings of steel demand which will continue to occur also in the future.

6. As a result of the continuing internationalisation of the economies in general and the steel-using industries in particular, both direct and indirect steel trade flows will change in volume, direction and product composition. Therefore, steel planners will wish to increase the flexibility of investment strategies, concerning the size and location of plants, the product range and international co-operation agreements, joint ventures and mergers and increased efficiency of distribution systems.