STEEL IN AN AGE OF TECHNOLOGY

IN JAPAN, TRANSITION IS THE ANSWER

by K. TANAKA

Japan's steel industry, once the world's strongest, is in decline, the victim of shifts in the internal economy, drastic exchange rate changes and fierce competition. Japan's answer - new technology and diversification - has set off an industrial revolution.

The Japanese steel industry, which grew rapidly with the rise of the Japanese economy, has entered a phase of low growth following the industrial reorganisation which took place with the first and second oil shocks.

One of the factors involved here was that the Japanese economy, which had previously been based on heavy industry, shifted its emphasis to industrial sectors which were low consumers of steel. At the same time, major consumers such as the automobile industry are showing a clear preference for light, thin plate. The net result is that growth in steel consumption is declining with the overall growth of the economy.

Second, the Japanese currency doubled in value against the US dollar after the so-called Plaza Agreement of 1985, and its rapid appreciation is having a tremendous impact on the Japanese steel industry. A direct effect has been that we have lost a great deal of our export competitiveness. Also, as the exports of our major consumers such as machine and automobile manufacturers have seriously suffered, our sales to them have decreased. A further effect was that as imports of steel products became relatively cheap, the domestic market declined.

Fortunately, thanks to massive public spending under emergency economic measures brought in by the Government, domestic demand is becoming stronger and the steel industry is recovering beyond all expectations - but this is only temporary. It cannot be denied that the high yen value has had a great structural impact on industry. Many manufacturing industries have been relocating their production facilities abroad for that reason, and that is causing us much concern.

Third, we are facing increasingly fierce competition from newly developed steel-producing countries. Korean, Taiwanese and Brazilian steel manufacturers are improving their technological level year by year and, with their cheap labour, they have become formidable competitors which we can no longer ignore. Due to this and the enormous increase in the value of the yen, the international competitiveness of the Japanese steel industry, once the strongest in the world, is now in a state of decline.

The steel industry plans a number of counter-measures. The first of these is streamlining: the industry hopes to recover its international competitiveness by carrying out as much rationalisation as possible. Altogether, eight blast furnaces are being shut down, and together with the centralisation of rolling lines, about 40,000 persons (approximately 30 per cent of total employees) will have to be relocated to other jobs. I believe that within the next few years, this rationalisation will put the Japanese

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Steel industry back on top of world competition.

Second, we plan to strengthen the technical infrastructure of the industry by way of technical innovation. This will reaffirm our international competitiveness and at the same time establish a foundation for future growth.

Third, there is our plan to develop other fields apart from steel. In addition to engineering and chemicals, in which we have been involved for some time, we hope to participate actively in new materials, biotechnology, electronics, data communication, and social welfare and urban development projects. The steel companies hope that eventually these fields will become just as important to them as steel.

Our efforts to develop new technologies can be divided into three approaches. The first of these, which could be regarded as an extension of existing technologies, is an attempt to cut costs even further by converting existing technologies to continuous or on-line operations and, thereby also save personnel. Successful examples of these are:

- continuous casting which produces slab directly without making ingots;
- direct rolling, which rolls slab without heating it by making use of the heat obtained in the steelmaking step;
- the continuous annealing and processing line (CAPL), which connects the cold-rolling and annealing processes in a continuous line.

This level of technology has been brought in very rapidly over the past 10 years, and efforts will no doubt continue to be made in future to realise fully continuous operations.

The second approach is a drastic innovation or revolution of process technology. The diagram (Figure 1) gives an idea of how steelmaking processes are expected to change by around the year 2000. This shows the past, present and future in steelmaking. In the past, steel was made by combining many separate pieces of small-scale equipment. Now it is done by linking several continuous, large scale processes. Despite this, the basic flow — that is, the production of pig-iron by the blast furnace and its conversion to products after hot-rolling of the slab — has hardly changed at all.

In the next 10 years, however, we do foresee radical changes. Now that steel demand has entered a period of steady growth, the industry is trying to move away from its traditional structure of dependence on mammoth pieces of heavy equipment.

In this regard, I should like to mention two processes — the smelting-reduction process and the near-net shape casting process. Also, although it could not be called a revolutionary process, scrap bath melting or scrap bulk melting in an oxygen converter is worthy of mention.

Smelting reduction process

In the blast furnace process, iron ore is reduced in the solid state, but in the
smelting reduction process, it is reduced in a molten state at a temperature of more than 1,500 degrees C. Figure 2 is a simplified diagram of the “iron bath type smelting process.” This is regarded as the most common form of the process in Japan.

Fine iron ore is charged into a pre-reduction furnace. Then, using the CO gas recovered from the main smelting reduction furnace, the iron ore is reduced, to some extent, to a fluid state while pre-heating is carried out. Next, the iron ore is charged into a smelting reduction furnace of the converter type. Coal and slag-forming agents are added, oxygen is blown in and a final reduction takes place in the molten state. When reduction is complete, the furnace is tilted, the slag is removed and molten pig-iron is withdrawn.

What are the special features and advantages of smelting reduction?

First, as reduction is carried out in the molten state at high temperature, it proceeds more quickly than reduction in the solid state. Depending on the particular type of reduction used, the process is considered to be between 10 and 100 times faster than the blast furnace. Consequently, equipment can be scaled down and is far more compact.

As fine iron ore is used directly, there is no need for pre-treatment in pellet or sintered ore machines; and as no coke is used, there is no need either for a coke oven. The process is therefore far more economical, in terms of capital investment, than the blast furnace.

Second, without the restrictions imposed by pre-treatment stages (i.e., sintering and coke processing), there is much greater freedom in the choice of raw materials. Fine ore, which is difficult to use in a blast furnace, can be freely used, and iron sand, scrap or any mixture of these materials can also be used. There is also great flexibility in the choice of coal. Low grade thermal coal, anthracite, char or powdered coke may be used, even though they are difficult to use in the coking process.

Third, the smelting reduction process can be stopped and started with relative freedom, so it allows much more flexibility of operation than the blast furnace.

Fourth, the smelting reduction process can generate a large quantity of process gases which have high utility value as energy or chemical raw materials. In other words, the smelting reduction furnace can also be used as an energy generator. It can be run in a variety of modes determined by the rate of pre-reduction in the pre-reduction furnace and the rate of secondary combustion of gases produced in the smelting reduction furnace. The lowest mode generates the minimum energy required for the production of molten pig-iron. In the highest mode, the furnace is operated like a coal gas generator to produce more energy than is required by the steelmaking system, the remainder being supplied outside.

Japanese steel manufacturers and the Government are about to carry out experiments on the process under a joint research scheme and it is expected that it will gradually replace the blast furnace. After 1990, the coke ovens now operated by Japanese companies will have exhausted their useful life, so the time is right for the introduction of this new technology. It should be added that the productivity and efficiency of existing processes using the blast furnace are still very high, so it is unlikely that the blast furnace will be completely displaced by smelting reduction in the near future.

Near-net shape casting

At present, molten steel is solidified by a continuous caster into a slab 200mm or more thick, and this is hot-rolled into steel sheet. Near-net shape casting in its most advanced stage, on the other hand, forms the molten steel into thin plate in one operation. In this new process, many problems still have to be overcome with regard to metallurgy and equipment technology. If that can be done, the time from casting to cold-rolling, which now takes several days, will be shortened to less than an hour.

By combining near-net casting with smelter reduction, the whole steelmaking process will be made extremely compact and flexible. To control this continuous process, we intend to make full use of artificial intelligence so that plants can be operated with a minimum of personnel and so that we can cope flexibly with...
changes in demand.

What we refer to as near-net shape casting actually covers two concepts.

One of these is thin slab casting, in which molten steel is cast directly into very thin slabs of about 20-40mm thickness. There are various methods of doing this. One, the “twin-belt” method, in which molten steel is run between two caterpillar-type belts, has been developed by a Japanese steel manufacturer almost to the stage where it can be industrialised. If it can be applied commercially, it will make casting several times faster than with conventional continuous casters and permit the rough-rolling step in a hot-rolling mill to be omitted.

The other concept is strip casting, an extension of the above idea. Strip casting is a revolutionary process in which molten steel is cast in one step into a thin sheet several tenths of a millimetre to several millimetres thick. The form of this process now being studied is the “twin roll” method: molten steel is made to flow directly between two rollers without passing through a mould, and is then cooled while being rolled.

It appears that a great deal of research still needs to be done to commercialise this process. When that occurs, it will be possible to do away with continuous casters and hot-rolling equipment altogether. This will have an enormous effect on the time required for sheet production, reduction of personnel, improved yields and energy saving.

New products

Another new direction for the steel industry is the development of new products with more advanced, or newly added, functions.

More and more improvements are being made to steel products to increase their added value. At the same time market needs are rapidly diversifying. Some examples of new products:

Steel which, although it has about the same strength as ordinary steel, is lighter and has anti-corrosion properties. A typical application is steel of high tensile strength used in automobiles – a development which greatly contributed to the competitiveness of Japanese cars.

A vibration-damping steel plate which we developed to prevent noise from automobiles. We put resin between steel plates to suppress the vibration responsible for the noise.

A high image clarity steel sheet developed to meet the fashion-consciousness of consumers of household electrical appliances. The steel plate was given an ultra-smooth mirror surface finish.

Among the technologies behind these products are surface-improvement techniques such as multi-layer plating and vacuum plating, the development of advanced steel alloys and the compounding of steel with materials other than steel – for example, high performance resins. We also see the development of revolutionary material-processing techniques, an example being semi-solid processing (Figure 4).

In this process, molten steel is cast or forged while it is stirred and kept in a semi-solid state. As the process gives much better homogeneity in quality and facilitates complex shaping operations, it is expected to be useful for developing highly functional products.

The development of high-alloy steel will no doubt lead to increased demand for metals such as nickel, chromium and molybdenum.

New materials

Nippon Steel Corporation believes that steel has not only served us in the past but will continue to do so in the future. The industry is rationalising and bringing in technical innovations, so that steel will still be at the centre of our operations.

We realise, however, that the steel market has to some extent matured, while user needs are becoming increasingly complex, diversified and advanced. We therefore set up a system in which we could supply a variety of products, not limited to steel, to cope with changing user needs.

Continued Page 35
JAPAN’S STEEL REVOLUTION

Continued from Page 21

Nippon Steel is currently concerned with developing the following fields:
- carbon fibres, chemicals such as structural plastics and composites;
- fine ceramics;
- new functional metals such as titanium, metal foil, amorphous metals and metal hydride;
- magnetic materials such as high-performance magnets and magnetic recording media;
- electronics components such as silicon wafers.

Many materials are still in the development stage and we have not decided how to apply them in products. We do not yet know what effect their development will have on raw materials, but I should like to express a few personal opinions.

The new material which has been most commercialised is carbon fibre. This has been applied not only in leisure and sports products; it is also expected to find wide application as a construction material, structural component and aircraft and spacecraft component. Nippon Steel and other steel companies are now developing, producing and selling a pitch-type carbon fibre made of tar extracted from coal.

Several other new materials appear to have relatively good market prospects, including those used in electronics. Examples are silicon wafers and seal materials which are indispensable for electronic components.

Other new materials with market potential are engineering ceramics, expected to find applications in automobile engines and machine parts. The demand for high-purity alumina and zirconia, which are raw materials for these developments, will become much greater. There is also expected to be a high demand for magnetic materials, so interest in rare earths such as samarium and neodymium is bound to increase.

Business trends in new materials are still in a state of flux, so those of us in the material business will have to watch their impact very closely. By collaborating with suppliers, we hope in the long term to be able to cope with needs in a flexible and timely fashion.

JASSA INDEX 1988

SUBJECT INDEX

This index is a full list of articles which have appeared in JASSA in 1988. Each entry, under a general subject heading, contains the title of the article, a brief description of the content, and the issue in which it appeared (JASSA is published in March, June, September and December). Some entries appear more than once, where their content is appropriate to more than one subject category.

Following the subject index is an author index which lists the names of authors, the titles of their articles and the issue in which they appear.

ACCOUNTING STANDARDS

Deafness: is it too clever? (Tony Coleman): Companies which have been enjoying the benefits of debt defasance are waiting for the Tax Officer’s new rules to take effect. September

Accounting for goodwill (Michael Brown): Some areas of the ASRB’s new standard are not quite black-and-white. December

AUSTRALIAN STOCK EXCHANGE

Weathering the storm (Laurie Cox): ASX survives the test of 1987. March

BOOK REVIEWS

Guide to Management Buy-outs in Australia & New Zealand (Ross Grant and David Saunders). March

The Commercial Bill Market in Australia (Robert Peters). June

Modern Investment and Security Analysis (Russell J. Fuller and James L. Farrell Jr.). June

Two Centuries of Panic (Trevor Sykes). September

Australian Financiers – Biographical Essays (Eds R.T. Appleyard and C.B. Schedvin). September

The Bull, the Bear and the Kangaroo (Stephen Salsbury and Kay Sweeney). December

CRASH OF 1987

Finding a scapegoat (Leslie Hosking): The search for reasons and scapegoats in the aftermath of the crash turned the spotlight on techniques of futures trading March

Weathering the storm (Laurie Cox): The sharemarket collapse occurred in a year of historic development for Australian stock exchanges. March

Cause for optimism (Saul Eslake): By some measures, the effects of the crash may have been overestimated. Sustained corporate profits should keep recession at bay. March

Fine-tuning the risk (Pieter Franzen): The importance of differing techniques of analysis in making decisions on fund management. March

The index as a benchmark (Derek Condell): The crash highlights index funds as a low-cost, safe-performance investment strategy. March

Cleaning up the corporates (R.A. Ferguson): The dominant role of entrepreneurial managers has been criticised. Much of benefit has come from their shake-up of corporate structures. March

Unshaken to the foundations (N.H. Seek): The commercial property outlook is favourable despite the crash. June


Confessions of a chartist (Russell Lander): Should we have seen the crash coming? September

The virtues of discipline (Derek Condell): The golden rule of investment – maintaining a diversified mix of assets – saved many funds in the crash. September

ECONOMY

Cause for optimism (Saul Eslake): Sustained corporate profits should keep recession at bay. March

Budget sizes – maths or myths (David Rees): Measuring Budget deficits and surpluses can be a matter of chance or interpretation. June

Canberra – out of the closet (Russell Barmes): The efficiency of securities markets has benefited from the more “open” approach to information by the Reserve Bank and Treasury. September

EDITORIALS

Consequences and casualties March

Tax – and the forward push June

NCSC: let the debate begin September

Better offers are in the wind December

FINANCE COMPANIES

Capital: more than adequate (John Bills): Finance companies may be at an advantage as the new capital adequacy guidelines for banks come into effect. December

FINANCIAL FUTURES

Finding a scapegoat (Leslie Hosking): After the crash, the usual suspects – who is guilty? March

FINANCIAL REGULATION

Welcome back regulation (Gerry van Wyzgen): The Reserve Bank’s proposals on the capital adequacy of banks will have sweeping effects on the financial system. June

A bigger tin of shillings (Chris Disney): Credit analysis and its resultant impact on pricing corporate paper will be increasingly important. June

CGS: a market facing change (R.A. Johnston): Continuing deregulation could have sweeping effects on the tools of monetary policy as the