SPOTLIGHT
on Stainless Steel in Japan

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The Stainless Steels '91 Conference, which was held in Chiba, Japan in June 1991, was the fourth in a series of related international conferences on this theme. These conferences have a high profile and currently constitute a premier forum for exchange between researchers and industrialists active in stainless-steel technology.

About 70 per cent of the more than 440 delegates were from Japan, and a further 10 per cent were from the other Pacific Rim countries. While geographical factors can largely account for this apparently disproportionate representation, the figures can be said to fairly reflect the large degree of investment in research and development (R & D) in Japan. There were 47 delegates from Europe, 10 from the USA, 10 from South Africa, and 8 from South America.

A comprehensive review of the approximately 160 papers presented at the Conference is beyond the scope of this spotlight. However, several fields of development deserve mention: the development of high-nitrogen stainless steels, advances in the application of ferritic and duplex steels, and the application of stainless steels in the motor industry. Other applications worthy of mention are: the use of boron as an alloying element (mainly in the nuclear industry), the development of Fe–Cr–Ni–Co stainless shape-memory alloys, and the decoration of stainless steel by chemical colouring, prepainting, selective etching, ceramic coating, and mirror-finishing.

Among the highlights of the event were the associated plant visits and discussions with Japanese metallurgists.

Production of stainless steel in Japan

Despite, or because of, the growth in the Japanese economy, new constraints are being placed on industrial expansion. The shortage of land and raw materials remain the most important, but problems with environmental pollution, and a labour shortage stemming from the low birth rate, have introduced a growing amenability to investment offshore, where labour, cheap energy, less-stringent pollution control, and greater proximity to raw materials are available.

Expansion of the Japanese stainless-steel industry is fuelled primarily by the growth in the domestic demand. The Japanese currently produce about 30 per cent of the world's stainless steel, of which the domestic market absorbs as much as 80 per cent.

Secondly, every effort is made to fill all possible niche markets, even though the limited tonnages of these products represent only a small fraction of the total production, implying relatively low productivity. For example, Nisshin Steel produces about 40 000 tonnes of stainless steel per month at its Shunan Works, but somehow finds it possible to also schedule 50 tonnes per month of a special ferrite–martensite alloy for use in 'stiffy' diskettes for computers.

The increasing demand for vehicles, and the ongoing drive towards stricter emission control, has caused manufacturers to focus their attention on stainless steels for, *inter alia*, exhaust systems, and this represented the fastest growing field of application in 1990. Stainless-steel mufflers have become the norm for improved corrosion resistance, and have largely displaced aluminized mild steel in this application. Similarly, cold-rolled stainless steel has replaced asbestos as a gasket material in higher-performance engines. Also of interest is the potential replacement of ceramic catalyst supports with honeycombed metal foil about 50 μm thick. The benefits include higher thermal conductivity and the quicker attainment of operating temperatures, while thinner walls reduce the resistance to gas flow. Furthermore, in the final stage of converter manufacture, the carriers are canned in a stainless-steel shell. Further examples can be cited, but the essential concept is the replacement of an ever-widening range of components with stainless-steel equivalents.

According to Tsuyoshi Kai, President of Nisshin Steel Company, the Japanese stainless industry currently produces over 3 million tonnes of crude stainless steel, which is more than the USA does. While the total production has continued to grow, exports have been declining since 1985. The largest areas of demand have been, in diminishing order, home and office appliances, industrial machines and equipment, construction materials, and transportation. Some 60 stainless-steel grades are recognized industrially. While the chromium–nickel austenitic grades are predominant in construction and industrial-equipment applications, the ferritic grades enjoy equal status on a tonnage basis in electrical machinery and home appliances, and are more widely used in transport applications.

New steelmaking technologies have been developed to meet the demands for stainless steel and the increasingly higher-quality standards. Among these are:

- generation of part of the chromium units required by the addition of chromite ore directly into the steelmaking process
- the use of vacuum–oxygen decarburization (VOD) to produce ultra-low carbon and nitrogen levels; charge capacities of 75 tonnes at 0,2 torr are achievable
- the pre-heating of scrap, using waste heat for energy savings
- the development of electric furnaces with a charge capacity of 90 tonnes
- the ongoing development of twin-roll strip casters and thin-strip casting.

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Facilities for the processing of stainless steel in Japan include:

- the ability to handle hot-coil units up to 19 tonnes
- the edge-heating of coils prior to roll deformation for improved surface quality
- no less than twenty Sendzimir mills (although few have automatic shape-feedback control)
- mills with the ability to roll increasingly thinner sections, with greater reductions per pass. In hot rolling, the minimum attainable hot-strip thickness is 2,0 to 2,5 mm, while ultrathin gauge mills (UTM) can cold-roll down to 0,05 mm cold strip. The world's biggest planetary mill at Nippon Yakin Kogyo can roll hot slab from 150 mm to 2,5 mm in one pass!

Curiously, not all manufacturers employ the usual route using an electric-arc furnace (EAF) and argon–oxygen decarburization (AOD) for the manufacture of stainless steel. Some, such as Nisshin Steel at their Shunan Works, use LD converters followed by vacuum degassing. It is not clear whether this practice reflects some perceived advantage in the use of LD converters, or whether it is the result of capital expansion undertaken before the EAF–AOD route was well established worldwide.

It is noteworthy that, while Japanese steelmakers co-operate on a national level on large capital projects of mutual interest, intense competition exists between plants in the drive to capture segments of the local market. This results in honing of the final products to exceptionally high quality (on one plant, quality control extends to ultra-violet lights to screen any insects from the plant), but an additional offshoot is the dedication to the establishment and holding of niche markets. The following are examples.

- Coloured stainless-steel strip is produced by the INCO method. Although one plant runs only one week of the month for a total output of 60 tonnes, coloured stainless steel has found application in everything from roofing to bathtubs.
- NKK, which is the second-largest steel producer in Japan, penetrated the stainless-steel market a few years ago, producing only 2500 tonnes per month. Their advantage is the ability to roll plate up to 3,6 m in width.
- The Nisshin Steel Shunan Works runs the world's only tandem Sendzimir (four Sendzimirs in series), in which the contact rolls are replaced every 10 minutes. The product has exceptional surface quality.

Another notable technological development is the increasing degree of automation of Japanese steelmaking plants. Not only has the shrinking labour force given rise to the (apparently unprecedented) poaching of workers from competing companies; it is reflected in the soulless environments of the steel plants, e.g. remotely computer-controlled automatic cranes and shuttle vehicles, which store and fetch coils from the stacking houses. Other refinements include

- enclosure of the electric-arc furnace in a box to seal off noise and dust—a typical example of the rigorously clean environment necessitated by quality demands
- modelling of the conditions within a blast furnace in real time, with graphic profiles on overhead monitors in the control room
- touch-activated computer quality control at the quality centres.

The 'take-home' message

As a world player in the production of chromium ore and ferrochromium, the local stainless-steel industry has opportunities to penetrate new areas at home and abroad. In view of developments overseas, several areas of stainless-steel technology are ripe for exploitation.

(1) Expanding acceptance of the cheaper ferritic grades has seen these alloys in everyday uses that are limited only by the imagination. In South Africa, these grades continue to form only a relatively small proportion of the total stainless steel used.

(2) The growing importance of surface properties and quality is reflected in the attention paid to the surface finish, the mechanical properties of sheet metal, and surface-treatment techniques such as chemical colouring. Concomitant emphasis has been placed on the understanding of crystallographic texture, deep-drawing qualities, and corrosion resistance.

(3) The motor industry, in particular, has run with stainless steel as a design material. In the context of the local industry, opportunities exist particularly for the export of stainless components. This is already a feature in the automotive-exhaust-manufacturing sector. Further potential exists in sectors such as the burgeoning auto-catalyst market, in which South Africa is establishing its role as a key player.

However, the potential of stainless-steel development is not confined to export markets. A salient point is that the enormous Japanese stainless-steel machine operates primarily for the benefit of the user at home. The producers have succeeded in taking stainless steel into every town and home; it has become the work-horse of modern society. The current annual *per capita* consumption of stainless steel in South Africa is less than 2 kg per person. Compare this with Japan where a figure closer to 20 kg per person is the norm. This suggests that a tenfold increase in local demand is possible. The looming housing demand presents one such opportunity, while the increasing demand for consumer goods such as holloware provides another.

Conclusions

Japanese dominance in the production of stainless steels is not invincible, and organizations in South Africa can, with effort, attention to detail, and persistence, carve out as big a share of the market as they desire. Research and development of stainless steels in South Africa is on a par with the best overseas. The challenge lies in the use of this know-how to

(a) disseminate on as wide a scale as possible the necessary technology to keep South Africa competitive,

(b) define niche markets and areas of excellence in which this country can compete on an international level, and

(c) market stainless steel on the home front as a user-friendly, cost-effective material for the general populace.