Coffee Break

Review of Research on Stainless Steel by Nippon Steel Corp. for 30 Years

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In publishing the Special Issue on Stainless Steel, I would like to look back on the thirty years of research on stainless steel sheet on which I have spent most of my career, first at Nippon Steel Corporation and then at Nippon Steel & Sumikin Stainless Steel Corporation.

I joined Nippon Steel Corporation in the late 1970s when the company started research on ferritic stainless steel in earnest. Until that time, the major emphasis had been on research into austenitic stainless steel. I remember that the company was actively studying age cracking of austenitic stainless steel. In those days, Nippon Steel and other steelmakers were developing high-manganese stainless steels of a nickel-saving type. It was also austenitic stainless steel that I was put in charge of soon after I joined the company. We developed a new stainless steel sheet for railway carriages. Based on SUS 301, the stainless steel has less carbon and more nitrogen added to achieve superior strength and corrosion resistance. Today it is used in almost all stainless steel cars in Japan.

At that time, Nippon Steel also developed three types of high-purity ferritic stainless steels, which were eventually handed down to Nippon Steel & Sumikin Stainless Steel Corporation. Even today, they comprise the company's main products.

One of them is NSSC®180 (19Cr-Nb-Cu). Originally developed for automotive moldings, this stainless steel eventually took an overwhelming share of the market for automotive moldings in Japan. I think that NSSC 180 was the first ferritic stainless steel to be adopted as an exterior material in earnest. Around that time, the slogan "from interior to exterior" was prevalent at Nippon Steel. I think that slogan initiated an expansion in the scope of stainless steel applications as an exterior material. Because of its good formability and excellent corrosion resistance comparable to that of SUS 304, NSSC 180 began to be widely used in home appliances, buildings, kitchen utensils, etc. In recent years, in view of the hikes in nickel prices, NSSC 180 has been used in large quantities as a substitute for SUS 304.

As another reason why NSSC 180 became so popular, the progress of manufacturing technology can be cited. Namely, there was a dramatic advance in hot coil manufacturing technology made at Yawata Works. Formerly, the steel was subject to surface defects during hot rolling and those defects had to be eliminated using a special line called CG in the cold rolling process. Under that condition, the company introduced various improvements in the hot rolling process, including those on the heating method, rolling method and rollers. As a result, it became possible to manufacture cold-rolled products directly from hot-rolled steel and improve productivity of the steel significantly. That was a remarkable result from the concerted efforts of the works and the laboratory.

In the field of moldings, an improved version of NSSC 180—NSSC 220 (22Cr-0.8Mo-Nb, Cu)—was developed for use in more severe environments (specifically, as a measure against exposure to volcanic ash in Kagoshima). NSSC 220 was applied to the roof of the Makuhari Messe building in 1989. That was the first large structure in which ferritic stainless steel was used. This stainless steel was followed by NSSC 220M (22Cr-1.5Mo-Nb, Ti), which afforded better corrosion resistance. NSSC 220M was adopted for the roofing of the second Makuhari Messe building, Osaka Dome (present Kyocera Dome) and Sapporo Dome in quick succession.

Another major ferritic stainless steel is NSSC 190 (19Cr-2Mo-Nb, Ti). Developed for electric water heater boilers, this steel secured an overwhelming share (more than 90%) in this particular field in Japan. NSSC 190 is also used for the tanks of heat pump-type hot water supply systems, which have rapidly become more widespread in recent years. In addition, this steel has been adopted for the hot water storage tanks of fuel cell systems for home use, which are expected to become popular in the future.

The concept of adding Nb and Ti to this steel was also applied to NSSC 220M mentioned above. In addition, NSSC 190 incorporates many of the techniques to improve the hot rolling process that are applied to NSSC 180.

The third major ferritic stainless steel is NSSC 430D (17Cr-Ti). When this steel was developed, the company was considering using it for kitchen sinks. In the beginning, NSSC 430D was used for professional kitchen utensils, etc. Around 1990, it began to be used for the drums of washing machines, paving the way for consumption of large quantities of stainless steel in home appliances. The subsequent progress of refining technology made it possible to develop NSSC PDX (extra-low C, N-17Cr-Ti), which is soft and has superior formability. Thanks to the combination of this steel and clear coating technology, stainless steel came to be used for the first time for the doors of refrigerators for home use. That helped consolidate the position of stainless steel in domestic kitchens.

Concerning the development of new processes in those days, the company was studying processes for efficient production of SUS 430—a general-purpose stainless steel. Unlike austenitic stainless steels, ferritic stainless steels have poor formability. Besides, they are subject to ridging (i.e., the phenomenon whereby creases occur

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in the rolling direction) in the forming process. The critical issue was how to develop an efficient process which would improve the above characteristics. By that time, the company had completed, with difficulty, the continuous casting & one-time cold rolling technology. However, the hot coils still were annealed in a box furnace for many hours. In the 1980s, with the addition of Al to the steel and the improvements in the hot rolling process, the company could make the annealing process continuous without impairing the r-value and ridging characteristic. The subsequent progress of this technology made it possible to omit the annealing of hot coils. Similar technology was developed for austenitic stainless steels too, although the metallurgy involved was different. This technology is still applied to certain grades of austenitic stainless steels even today.

The above technology was evolved further to permit manufacturing stainless steel using equipment for manufacturing ordinary steel (PL-TCM-CAPL). Thanks to the newly developed, high-productivity process, stainless steel began to be used in large quantities for automobile exhaust systems. The process that was initially employed to produce NSSC 409L (11Cr-Ti) was eventually also applied to NSC 436S (17Cr-1.2Mo-Ti) and NSSC 432 (17Cr-0.5Mo-Ti), which were developed later.

So far, I have described one remarkable research result that has evolved with the times and been handed down from generation to generation.

I believe that the above R&D efforts have contributed much to the progress of the stainless steel business of Nippon Steel Corporation and Nippon Steel & Sumikin Stainless Steel Corporation.

The Special Issue on Stainless Steel focuses on the most recent R&D activities. I think that the results of these R&D activities will continue to evolve with the times and will be handed down to future generations.

I sincerely hope that younger researchers will tackle R&D for leading-edge technologies that benefit not only the present generation, but also future generations.

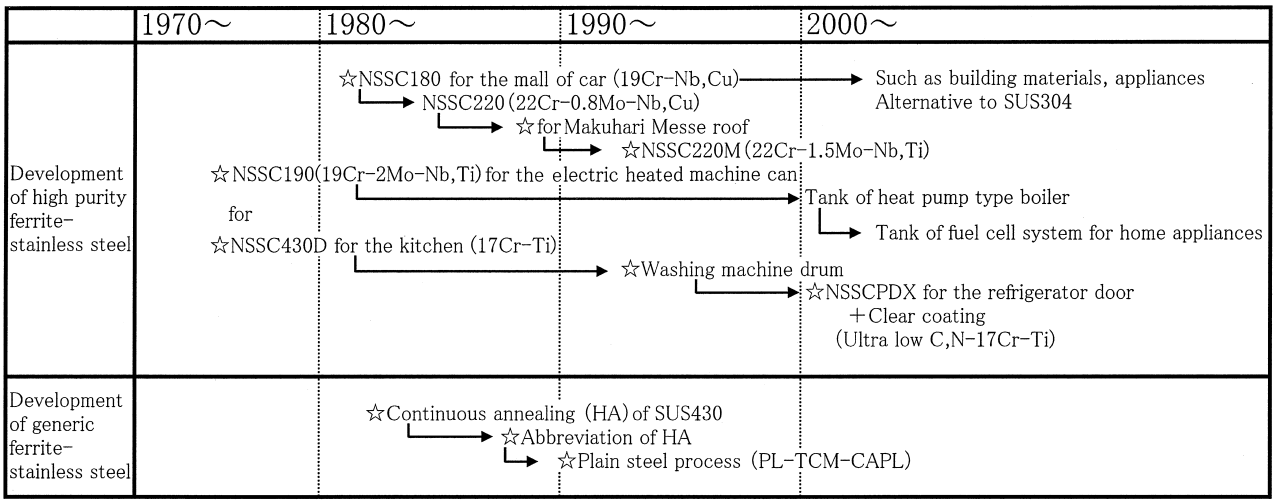

Fig. 1 Nippon Steel Corporation stainless steel lamina research 30 years of walking