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In this issue

NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

NSSC FW series
New Standard! Ferritic!!

Innovation
Knowledge
NSSC Experience

New Standard for Stainless Steel

NSSC FW Series

—World's First Successful Addition of Tin Provides Superb Corrosion Resistance and Reduced Rare Metal Consumption—

Nippon Steel & Sumikin Stainless Steel Corporation (NSSC) has developed the "NSSC FW Series" that offers greatly improved corrosion resistance and resources conservation by utilizing an innovative technology that for the first time in the world adds trace amounts of tin. Now that almost a century has passed since the invention of stainless steel, the FW Series holds great promise as a third type of commodity-grade steel capable of standing abreast with the two major types of commodity-grade steel—SUS304 and SUS430—that together account for more than half of all stainless steel demand.

NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

Eco-products: Opening a New Chapter in the History of Stainless Steel

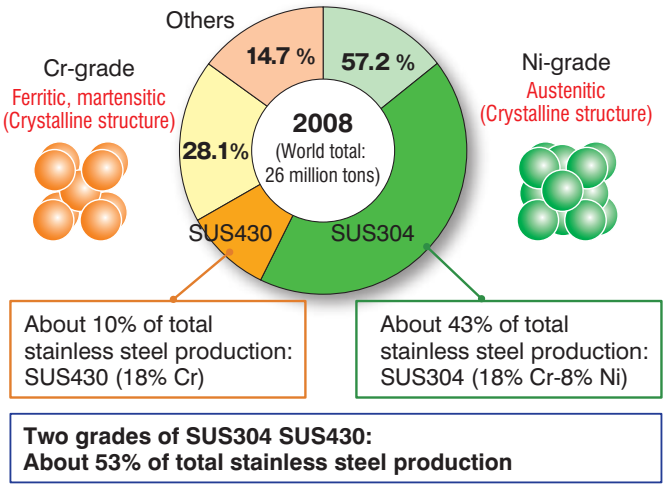
Even with Great Reductions in Rare Metal Content, These Products Encompass All the Applications of the Two Major Commodity Grades

Stainless steel is an alloyed steel that contains chromium in amounts of 10.5% or more and has the outstanding characteristic of being more resistant to rust than mild steel. Its range of applications is very broad, extending from construction and civil engineering to home electric appliances, kitchen utensils, and transport machinery, and even to precision instruments and industrial machinery. The key to stainless steel's excellent corrosion resistance is chromium, a rare metal. When mild steel is scratched, rust occurs in the damaged area. In the case of stainless steel, chromium combines with oxygen to form a thin protective film (passivation film) on the surface that protects against further rusting. The ultra-thin passivation film, measuring one to three nanometers thick, is very tough. When damaged, it shows the capability of automatically repairing itself if oxygen is present.

A look at global stainless steel production shows that, while SUS430, typical Cr-grade (ferritic type) stainless steel accounts for about 10%, SUS304, a typical Cr-Ni grade (austenitic type) stainless steel accounts for about 43% (Fig. 1) and provides much improved corrosion resistance and workability due to the addition of nickel. Among the various grades of stainless steel, these two have remained the best selling products throughout the nearly one hundred years since stainless steel was invented.

It was against this backdrop that NSSC developed the FW Series, putting "NSSC® FW1" on the market in July 2010 and bringing out "NSSC® FW2" in December 2010. The FW Series consists of extra low-interstitial ferritic stainless steels. Although the addition of tin leads to reductions not only of nickel

Fig. 1 Stainless Crude Steel Production in the World



NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

but also chromium, an essential element of stainless steel, the FW Series still offers excellent corrosion resistance. Compared with SUS430, FW1 has a 20% reduction in chromium content and shows improved corrosion resistance and workability. FW2 made its appearance as an extension of the technology adopted for FW1. The corrosion resistance of FW2 is equivalent to that of SUS304, but its chromium and nickel content has been successfully reduced by 40% (Fig. 2).

Operating Officer Hiroyuki Hiramatsu of NSSC comments on the underlying aim for developing the FW Series: “It is true that SUS304 is for all-purpose use, but the designed quality is excessive for some applications. This shows that there is still room for another grade of low-interstitial ferritic stainless steel between the two major commodity-grade steel types SUS304 and SUS430 (Fig. 3). If we succeed in introducing a new grade for general-purpose applications, there is a strong chance of becoming a third commodity-grade steel. The newly developed FW Series can be used for virtually all the steel sheet applications covered by the two major commodity-grade steel types. The new series is also innovative in that its intensive alloying operation goes a long way towards conserving rare metals, while also minimizing possible fluctuations in raw materials prices. The two major stainless steel types together have long held their position as the kings. In the future, however, by focusing on the FW Series, we intend to create a new direction in stainless steel history.”

Hiroyuki Hiramatsu
Operating Officer
General Manager of Product Development Div.
NSSC

Fig. 2 Effect of Reduced Use of Rare Metals in NSSC FW2

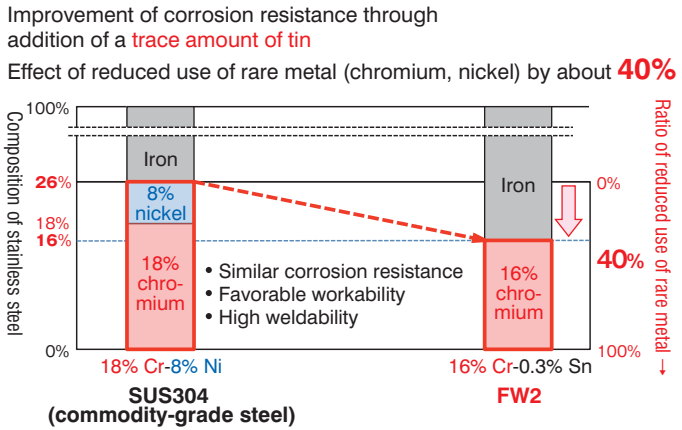
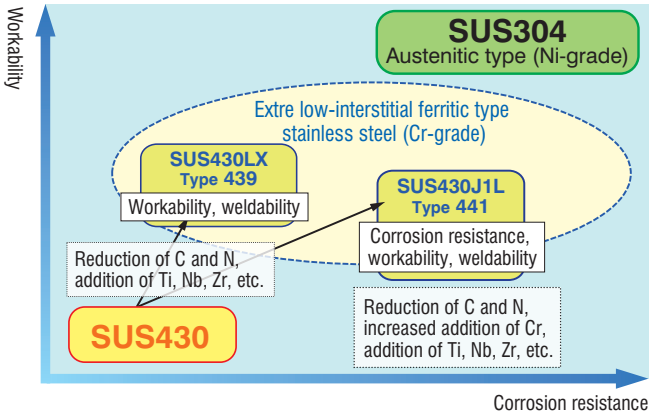


Fig. 3 Positioning of Main Grades of Stainless Steel



NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

A Strategically Important Ferritic Product in the World Market

In January 2011, NSSC won the Grand Prize of the Nikkei Excellent Products and Services Awards and the Nikkei Sangyo Shinbun Award (Photo 1). This was the twenty-ninth of such annual presentations. Nikkei Inc., the sponsor of the Nikkei Excellent Products and Services Awards and one of Japan's largest media enterprises, conducts a comprehensive evaluation of many emerging products and services based on criteria such as the level of technological development, cost performance, track record, growth potential, originality, and impact on industry and society. FW1 was especially hailed by the judges for paying close attention to the global instability in the supply of rare resources and for developing the world's first technology to effectively reduce the use of such resources.

Photo 1
Award-winning ceremony for the Nikkei Excellent Products and Services Awards

Since the FW Series was first announced, more than 3,000 inquiries have been received from both domestic and overseas customers, with transactions expanding at a steady pace. In order to quickly respond to customer needs, NSSC established its "Project FW Promotion Team" in February 2011. This team aims to promote collaboration between Nippon Steel's Yawata Works and NSSC's individual divisions of research, production, and marketing, thereby accelerating further evolution of the FW Series.

Department Manager Jun Kamimura of the Coil & Sheet Products Marketing & Sales Div. of NSSC devised the name of the FW Series and has expressed these hopes: "This brand name includes two meanings—"Forward" and "Ferritic for the World." In order to enhance the FW Series' name recognition not merely in Japan but also abroad, we are strongly committed to market development through such steps as introducing the material to the product design divisions of our customers and actively sponsoring study meetings with distribution companies."

Jun Kamimura
Department Manager
Coil & Sheet Products Dept-1
Coil & Sheet Products Marketing & Sales Div.
NSSC

NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

Synergistic Effects Yielded by Nippon Steel and Sumitomo Metals

—New Challenges by NSSC Disprove Common Conceptions in Materials Development—

Nippon Steel & Sumikin Stainless Steel Corporation (NSSC) was established in October 2003 by spinning-off and integrating the stainless steel operations of Nippon Steel Corporation and Sumitomo Metal Industries, Ltd. and is now ranked as the largest stainless steel company in Japan. The FW Series of low-interstitial ferritic stainless steel was developed by the fusion of two factors: tin additive technology derived from Sumitomo Metals and low-interstitial ferritic stainless steel production technology amassed by Nippon Steel. The path from materials development to new product development of the FW Series is introduced below.

World's First Tin Additive Technology Capitalizing on Reversal Idea and Obsession

The FW Series was developed with innovative world-leading technology for adding trace amounts of tin that not only produces outstanding improvements in the corrosion resistance and workability of stainless steel but also provides for resources savings (Figs. 4~7). On the other hand, in conventional materials development for steel products, because the addition of tin has impeded production efficiency, it has commonly been accepted that tin should not be added in steelmaking. However, the idea to disprove this common conception arose at NSSC—the addition of tin is taboo in the production of mild steel and Ni-grade stainless steel, but this is not the case when producing Cr-grade stainless steel. The FW Series was developed by capitalizing on this contrary idea.

Senior Researcher Masaharu Hatano, Research & Development Center of NSSC, speaks about the origin of the idea to add tin: "In 2000 at Sumitomo Metals, I was involved in research on steel scrap recycling that was spurred by growing concerns about CO_2 emissions reductions and waste treatment. Copper and tin are difficult-to-separate im-

Masaharu Hatano
Senior Researcher
Coil & Sheet Products, Automotive Products R&D Div.
Research & Development Center
NSSC

NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

Fig. 4 Basic Technology for FW Series (Effect of Tin Addition)

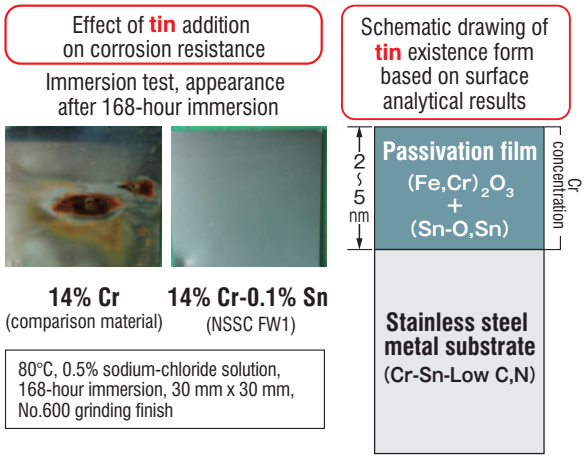


Fig. 5 High Corrosion Resistance of FW Series

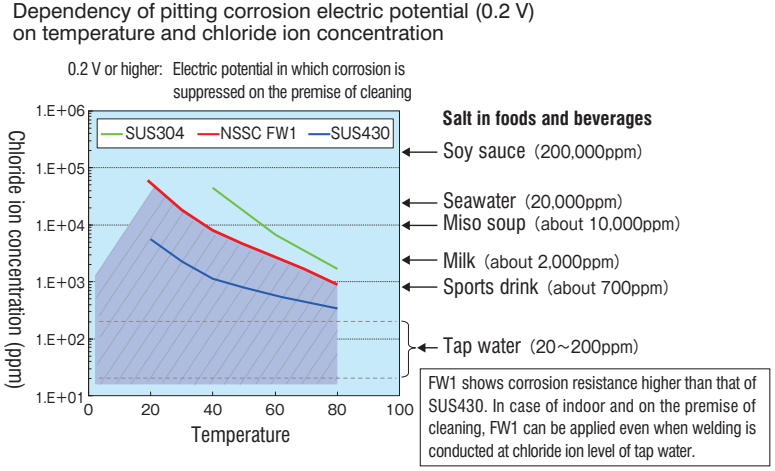
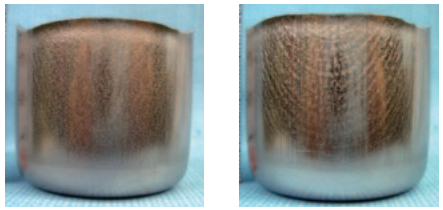


Fig. 6 Surface Property of FW1 after Fabrication



*Test conditions: Plate thickness 0.6 mm (1-pass cold rolling); Drawing ratio: 2.0

Formation of tree ring-shaped patterns is suppressed for FW1, compared to that for SUS430LX, and surface roughness is less and surface condition is good.

Fig. 7 Multi-step Deep Drawability of FW2 (Appearance after Multi-step Drawing)

Multi-step drawing can be applied to NSSC FW2 with no cracking, but causes season cracking in SUS304.

purities that are contained in steel scrap, and the recycling of such scrap without any treatment presented an ever-present concern: namely, deterioration of steel product production efficiency. In the course of researching how to eliminate the harmful effects of copper and tin, it was found that, contrary to mild steel, the impeding effect of tin is much less pronounced in the production of Cr-grade stainless steel. In this way, we got the idea to apply tin in stainless steel production by making the most of a new idea that was unobtainable from research on mild steel and by taking note of the corrosion resistance of tin observed in the application of tinplate.

It was in 2007 that the seed planted and nursed by Hatano began to grow. Operating Officer Hiroshi Hiramatsu, who served as the director of the Research & Development Center of NSSC at that time,

NIPPON STEEL NEWS
No. 386 October 2011

Feature Story

was inviting in-company applications for voluntary research projects with an eye focused on future technological development. Among these themes was Hatano's suggestion to use tin as an additive. This proved to be Hatano's golden opportunity.

Hiramatsu, who examined the data on tin as an additive, recalls: "We had suspected that if the surface film of stainless steel could be controlled or if trace amounts of certain kinds of elements were added, corrosion resistance might show outstanding improvement. We started to search for such dream technologies, among which we found a research on the use of tin as an additive. From our trial addition of tin to low-interstitial Cr-grade stainless steel, we obtained unbelievable data showing an amazing improvement in corrosion resistance. And because there was no known precedent in stainless steelmaking of adding even minute amounts of tin (up to a few tenths of a percent), we found the data to be very interesting."

Research on the slight addition of tin was conducted throughout 2008, after which full-scale research to clarify the mechanism was initiated. There was skepticism in certain sections of NSSC arguing that although corrosion resistance might be improved, commercialization would be difficult. In spite of this, Hatano repeated a number of additional surveys and verifications in order to prove its practicality and to establish the world's first technology for tin additions. In 2009, the use of tin as a steel additive was authorized as a product development theme, thereby opening the door for developing the FW Series.

Development Target: Post SUS 304 Product

Around that time, a number of epoch-making events occurred in the stainless steel industry. In 2007, the price of nickel used as a material soared, and the demand for Cr-grade SUS430 as a substitute for Ni-grade SUS304 stainless steel increased. However, following the Lehman Shock of September 2008, the price of nickel fell sharply. Then, the price of chromium soared, and the relative competitiveness of Cr-grade products declined. As a result, the demand for Ni-grade SUS304 products rose once again.

In view of the increasing demand for rare metals and the growing concern about their supply, NSSC accelerated the development of tin-added steel as a candidate for a new stainless steel grade to supplant SUS304—a new steel grade that could produce price stabilization and realize resources savings. As soon as the decision was made at a strategic head office meeting on new product development to commercialize commodity-grade types (FW1) applicable to a wider range of applications, as well as SUS304 grade equivalent types (FW2), the Research & Development Center began working on alloy design conforming to the target products.

"With the idea of product development aimed at resources savings, we directed our research efforts towards bringing together two separate requirements: reducing the use of chromium, a major alloying element needed for stainless steel, and providing high corrosion resistance and workability." (Hatano)

NIPPON STEEL NEWS
No. 386 October 2011

Back to Top Back Next

Feature Story

Pursuing the Potential of Stainless Steel by Maximizing Our Technological Edge and Pushing a Higher Tempo

After completion of the alloy design, trial manufacture started at a production line of the Yawata Works of Nippon Steel. Prior to the establishment of NSSC, heavy steel plate mill operations started at the Yawata Works in 1957 and the production of stainless steel plates started in 1963.

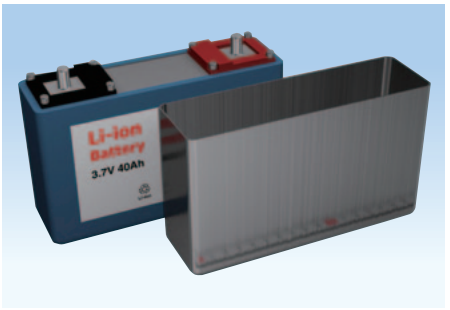
Along with the spinoff of the stainless steel operations of Nippon Steel and Sumitomo Metals and the subsequent establishment of NSSC in 2003, the stainless steel plate mill operations at the Yawata Works were transferred to NSSC. Nevertheless, at this time, the Yawata Works continues not only to prpoduce Cr-grade stainless steel but also to undertake the hot rolling of stainless steel sheets for NSSC. Low-interstitial ferritic stainless steel production technology, nurtured over many years by Nippon Steel in its role as a pioneering steelmaker, has played a significant role in the current development of the FW Series.

The stainless steel hot coils produced at the Yawata Works are finished into diverse types of FW2 stainless steel sheets at the Kashima Works of NSSC. Since the establishment as Kashima Nippon Stainless Steel Corporation, the Kashima Works has concentrated on the production of stainless steel sheets. Following the establishment of NSSC in 2003, the Kashima Works, jointly with the Hikari Works, conducts stainless steel sheet operations and serves as the base for Cr-grade stainless steel sheet production.

The Kashima Works has surmounted the issues peculiar to stainless steel products by capitalizing on advanced production technologies and strict quality control to supply products that accurately meet diversifying user needs. In realizing the FW Series, the production system was established merely one month after tapping by effectively using basic data obtained from the research sections and by conducting advance adjustments of production-related data and test specimens within the works.

NSSC succeeded in developing the FW Series in the short period between the start of research on tin as an additive in 2007 to marketing in 2010.

Application examples for FW Series



Lithium ion battery case (Image)

Large-size pan

Gutter-supporting metal fitting

NIPPON STEEL NEWS
No. 386 October 2011

Back to Top Back

Feature Story

Operating Officer Hiroshi Hiramatsu concludes: "It was the end of April 2010 that a sample of the FW Series was completed. Because the FW1 Series is the first of its kind in the world, we at first asked the knowledgeable users to evaluate FW1, and then we announced its marketing in July 2010. As for FW2, we asked for similar users to evaluate FW2, and then announced the start of marketing in December 2010. Under the guiding principle of joining forces among the production, marketing and technology sections in order to maintain a technological edge and a higher tempo, we are working to expand overall stainless steel demand by enriching the FW Series while at the same time promoting the superior performance of Cr-grade stainless steel."

Stainless steel holds great potential. By making the most of its excellent properties such as corrosion resistance, durability and hydrogen resistance, stainless steel offers promising applications in social infrastructure—fuel cells, solar power generation and other new energy fields; stack gas desulfurization equipment and other environmental equipment; and seawater desalination plants. NSSC continues to pursue further evolution of stainless steel, based on technological developments related to such new materials as the FW Series and duplex stainless steel.

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