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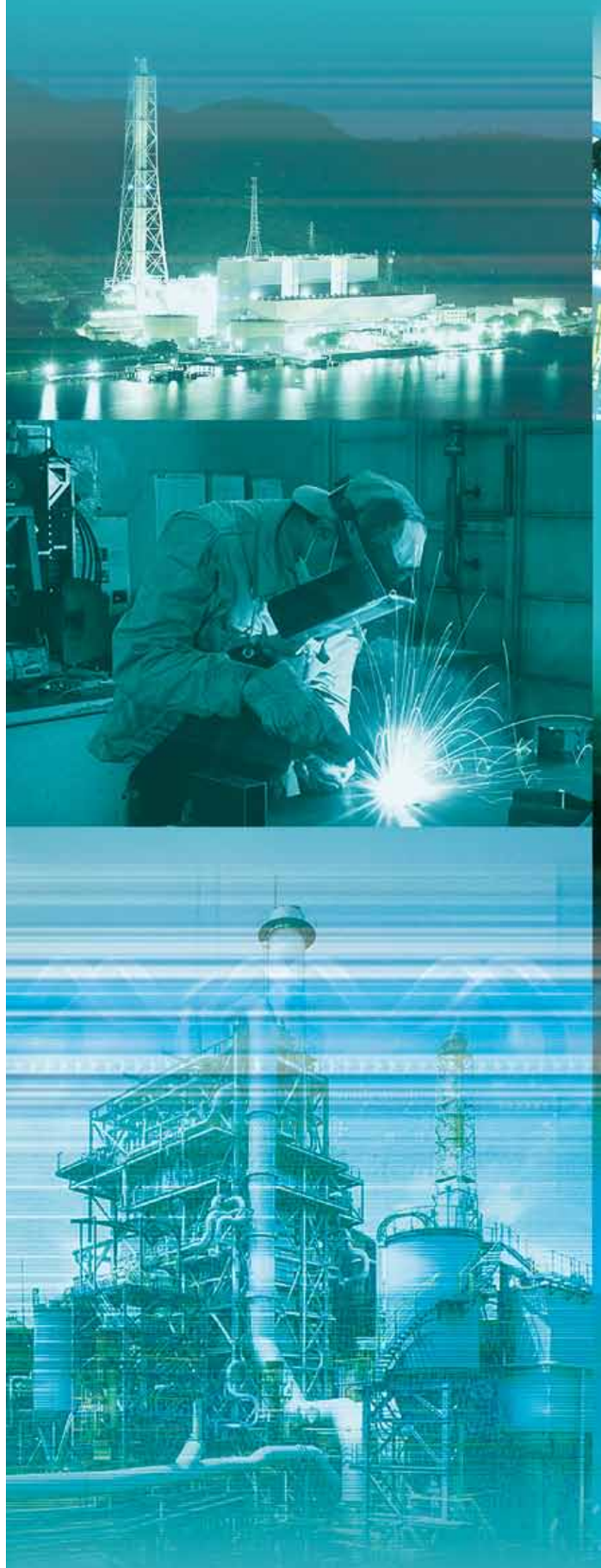

KOBELCO WELDING TODAY

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KOBELCO Puts the Customer First with All-in-One Product and Service

KOBELCO

SG-2Z-CE/Equipment for the SEGARC™ process in EU Highly efficient electro-gas arc welding process

SEGARC™ 2Z is an automatic electro-gas arc welding (EGW) process and equipment designed by Kobe Steel as a highly efficient and high deposition process that has been put into practical use mainly by Asian fabricators of ships, oil storage tanks and bridges for over 40 years. (See Table 1)

Table 1: Application of SEGARC™ process

Fields	Application
Shipyard	Side shells, bulkheads and hoppers of bulk carriers
Bridge	Box girder webs, I-plate girder webs
Machinery	Press frames
Storage tank	Grain silos, oil tanks
Steel structure	Water conduits, large diameter pipes, structural members of seawater desalination plants

Because the SEGARC™ 2Z had not received CE Marking for the EU region, it could not be marketed within the EU region. However, it has recently been certified by conforming to the Machinery Directive (2006/42/EC), the Low voltage Directive (2006/95/EC) and the Electromagnetic Compatibility (EMC) Directive (2004/108/EC). Accordingly, SG-2Z-CE with CE Marking was developed to be marketed within the EU region.

[Features of SG-2Z-CE]

Figure 1 shows schematic diagram of SEGARC™ process while an example of SG-2Z-CE equipment can be seen, in Figure 2.

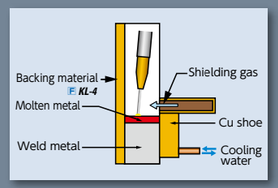

Figure 1: Schematic diagram of SEGARC™ process

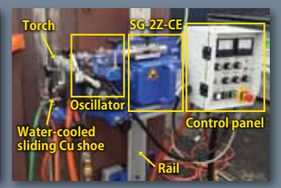

Figure 2: Overview of SG-2Z-CE

SG-2Z-CE performs basically the same functions as SEGARC™ 2Z, and offers the following features:

(1) Operation is easy with a control panel that can adjust welding current, arc voltage, oscillating width as well as dwelling time. Travelling speed during welding is automatically adjusted to keep wire extension constant even if there is a root gap.
(2) Vertical and single pass welding on heavy plates up-to 65 mm can be performed by installing an optional oscillator. (See Figure 2)
(3) High efficiency is achieved due to its high deposition rate.
(4)Its wide applicable range such as to vertical-up as well as inclined-vertical welding joints, enables adoption across diverse fields. (See Table 1)

In addition, welding is even possible if the thickness difference of joint plates is over 3 mm by adopting a tapered joint equal to or less than 1/5, as shown in Figure 3 (A tapered joint not required below 3 mm).

[Welding consumables for SG-2Z-CE]

The welding consumables for SG-2Z-CE are shown in Table 2.

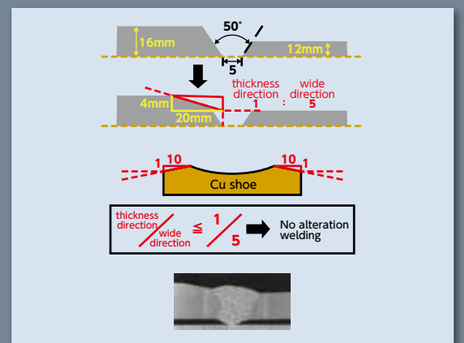

Figure 3: Application to a tapered joint & cross-sectional macrostructure of a tapered joint

Table 2: Welding consumables for SEGARC™ process

Trade designation	Type of steel	0.2% OS (MPa)	TS (MPa)	El (%)	Impact Value (J)	Approvals by ship classification society
F DW-S43G	Mild steel; HT490	490	600	29	60 (-20℃)	NK, ABS, LR, BV, DNV・GL, CCS, CR, KR
T DW-S60G	HT550-610	520	650	26	65 (-20℃)	NK, ABS, LR, BV, DNV・GL
F DW-S1LG	Mild steel; HT490 for low temperature service	500	615	26	100 (-60℃)	NK, ABS, LR, BV, DNV・GL

*FCWs in the list are designed for 100%CO_2 (C1) shielding gas.
*F KL-4 or a water-cooled sliding Cu shoe must be used as a backing material.
*F and T stand for FAMILIARC™ and TRUSTARC™ respectively.

The SG-2Z-CE equipment for live demonstration is available in KOBELCO WELDING OF EUROPE B.V. (KWE), the Netherlands or other branch and nearest Kobelco partners. Please feel free to ask for more detailed information about functions and live demonstrations.

New Year's greeting from the Head of the Welding Business

Dear KWT readers! I believe you have spent a marvelous New Year holiday. I would like to express my sincere gratitude for your patronage of KOBELCO products.

In Japan, the winter holiday is about a week long from the year end till the beginning of the year with New Year's Day in between. How to spend it depends on the individual; one may go on a domestic or overseas trip, simply stay home, or return to one's hometown. However, what just about everyone does during the first three days of the New Year is to visit a shrine (or a temple) and pray for the coming year. This is called HATSUMOUDE – or "the first visit to a shrine." On the grounds of most shrines, stalls, temporarily installed for the holiday, sell sweets, udon (wheat noodles), yakisoba (stir-fried soba noodles), oden (vegetables, fish dumplings and other ingredients served in a hot soy broth) or even sake (Japanese rice wine). With lottery stands and cork ball shooting galleries, both children as well as adults can enjoy the visit, buying the delicacies and eating outdoors on the shrine grounds. I also visited a shrine at my home town and enjoyed drinking together with my relatives.

In our Welding Business group, we spent the last year doing our jobs while focusing on the "three Ms" (Marketing, Monodzukuri (production system innovation) and Manpower) under the slogan, "aiming to be the most reliable welding solutions company in the world." While the environment surrounding our welding business has been stagnant due to the worldwide slump of shipbuilding and offshore structure industries, we will continue to enhance marketing capability through product strategies and business plans tailored for each market in cooperation with all group members. The ideal welding solution is one that solves a customer's welding problem and leads to our final goal of contributing to our clients' monodzukuri through the use of KOBELCO products. In this way, our welding solutions go beyond automation by robotic welding systems.

The KOBE STEEL group is one of the few company groups in the world that supplies welding consumables, robotic welding systems and power sources in addition to IoT and AI technology and products. By developing arc welding technology in response to customers' requests, from covered electrodes to state-of-the-art automation technology, we will contribute to development in respective enterprises, regions and countries. The environment surrounding the welding business changes day by day and so do customer needs. Capturing those changes with sensitivity, we'll make proposals that align with the needs of our customers. Thus, we differentiate our products from those of other companies and will strive to add more value to them in the future as well.

When KOBELCO representatives pay a visit to your country or area, please share your issues and let them know what's on your mind.

Lastly, I wish all of you and your families good health and a successful year in 2019.

Akira Yamamoto
Managing Executive Officer
Head of the Welding Business
KOBE STEEL, LTD.

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Flux cored wires for heat resistant steels that conform to AWS specifications

KOBELCO WELDING TODAY
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1 Preface

Heat resistant steels, typically Cr-Mo steels, have been widely utilized under such high temperature and high-pressure environments as thermal power plant boilers (hereinafter called boilers).

These steels are classified in Japan by the Japanese Industrial Standard (JIS) and overseas by the standards of both American Society for Testing and Materials (ASTM) and American Society of Mechanical Engineers (ASME).

The classification of welding consumables for heat resistant steels is also regulated by JIS in Japan and by both AWS and ASME standards abroad.

Table 1 shows Kobe Steel's line-up of heat resistant steel welding consumables (1.25Cr-0.5Mo and 2.25Cr-1Mo steels) for boilers.

SMAW, SAW, GMAW and GTAW are the welding processes commonly applied to fabricate boilers; however, flux cored wires (FCWs) provide higher efficiency than TIG filler rods (GTAW) and covered electrodes (SMAW) as shown in Figure 1. With their ability to create superb bead appearance even in such severe positions as on fixed pipes, FCWs have become mainstream in most shipyards. Hence, it is expected that FCWs will expand to industries requiring heat resistant steels such as boiler fabrication in the near future.

In this article, FCWs for 1.25Cr-0.5Mo and 2.25Cr-1Mo heat resistant steels that conform to AWS specifications will be discussed.

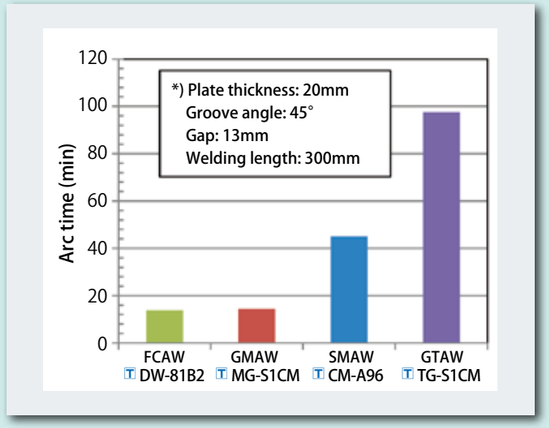

Figure 1: Comparison of arc time by welding processes

Table 1: Heat resistant steel welding consumables for boilers

Kind of steel	ASTM	SMAW	GMAW	GTAW	SAW Flux/Wire	FCAW
1.25Cr-0.5Mo	A387 Gr.11 Cl.1, 2 A213 Gr.T11,12 A335 Gr.P11,12	T CM-A96 T CM-B98	T MG-S1CM T MG-S80B2F	T TG-S1CM T TG-S80B2	F G-80/ T US-511 F G-80/ T US-B2	T DW-81B2C[CO_2] T DW-81B2[Ar-CO_2]
2.25Cr-1Mo	A387 Gr.22 Cl. 1, 2 A213 Gr.T22 A335 Gr.P22	T CM-A106 T CM-B108	T MG-S2CM	T TG-S2CM T TG-S90B3	F G-80/ T US-521 F G-80/ T US-B3	T DW-91B3C[CO_2] T DW-91B3[Ar-CO_2]

2 Line-up of FCWs for heat resistant steels

Kobe Steel's selection of FCWs for heat resistant steels is shown in Table 2. They are classified according to the steels and shielding gases as specified by the AWS while also conforming to ASME's F-No. and A-No.

AWS also specifies Post Weld Heat Treatment (PWHT) at 690°C for 1 hour (690°Cx1h). Because PWHT is usually carried out in practice, it is necessary to design welding consumables that provide excellent mechanical properties after PWHT by taking the following points into consideration:

(1) minimizing impurities such as P & S in raw materials;

(2) designing for low C and high Mn in order to provide moderate hardenability and to stabilize notch toughness;

Tables 3 and 4 show typical chemical compositions and mechanical properties after PWHT of the deposited metals, respectively. Both chemical compositions and tensile properties satisfy the AWS requirements, and the impact properties at room temperature (+20°C) are sufficient.

Table 2: FCWs for heat resistant steels

	100%CO_2	Ar-20%CO_2	ASME F-No.	ASME A-No.
1.25Cr-0.5Mo	T DW-81B2C [AWS A5.29 E81T1-B2C]	T DW-81B2 [AWS A5.29 E81T1-B2M]	6	3
2.25Cr-1Mo	T DW-91B3C [AWS A5.29 E91T1-B3C]	T DW-91B3 [AWS A5.29 E91T1-B3M]	6	4

Table 3: Typical chemical compositions of deposited metals (mass%)

Kind of steel	Trade designation	Shielding gas	C	Si	Mn	P	S	Cr	Mo
1.25Cr-0.5Mo	T DW-81B2C	100%CO_2	0.05	0.21	0.96	0.009	0.004	1.22	0.50
	T DW-81B2	Ar-20%CO_2	0.06	0.29	0.97	0.010	0.005	1.30	0.50
	AWS A5.29 B2	Min Max	0.05 0.12	– 0.80	– 1.25	– 0.030	– 0.030	1.00 1.50	0.40 0.65
2.25Cr-1Mo	T DW-91B3C	100%CO_2	0.06	0.18	0.99	0.007	0.004	2.26	1.00
	T DW-91B3	Ar-20%CO_2	0.06	0.29	1.12	0.008	0.004	2.38	1.01
	AWS A5.29 B3	Min Max	0.05 0.12	– 0.80	– 1.25	– 0.030	– 0.030	2.00 2.50	0.90 1.20

Table 4: Typical mechanical properties of deposited metals after PWHT (mass%)

Kind of steel	Trade designation	Shielding gas	PWHT condition	0.2%YS (MPa)	TS (MPa)	El (%)	vE+20°C (J)
1.25Cr-0.5Mo	T DW-81B2C	100%CO_2	690°Cx1h	539	619	23	54
	T DW-81B2	Ar-20%CO_2		570	654	22	31
	AWS A5.29 B2		677-704°C x1-1.25h	Min.470	552 -689	Min.19	–
2.25Cr-1Mo	T DW-91B3C	100%CO_2	690°Cx1h	571	659	22	82
	T DW-91B3	Ar-20%CO_2		621	696	22	111
	AWS A5.29 B3		677-704°C x1-1.25h	Min.540	621 -758	Min.17	–

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3 Usability of FCWs for heat resistant steels

In Kobe Steel's FCWs for heat resistant steels, slag forming agents like a rutile (TiO_2) are added in order to improve usability in all position welding. Figure 2 shows applicable ranges of welding current and arc voltage in horizontal fillet and vertical upward welding. Accordingly, welding current can be as high as about 300A in horizontal fillet welding and 240A in vertical upward welding. Also, a wide range of arc voltage can be used.

Figure 3 shows bead appearances and cross-sectional macrostructures in horizontal fillet and vertical upward welding, respectively. In addition to obtaining sufficient penetration and a sound weld toe, no large particle spatter adhesion appears, the bead shape shows little unevenness, and bead appearance is glossy.

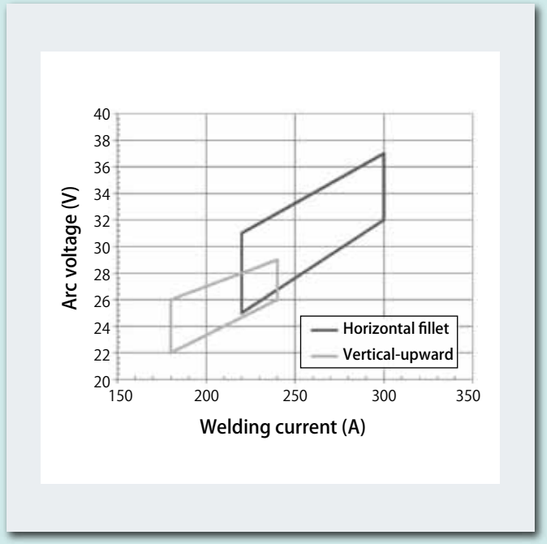

Figure 2: Applicable ranges of welding current and arc voltage by welding positions
Note: T DW-81B2C 1.2mm dia.

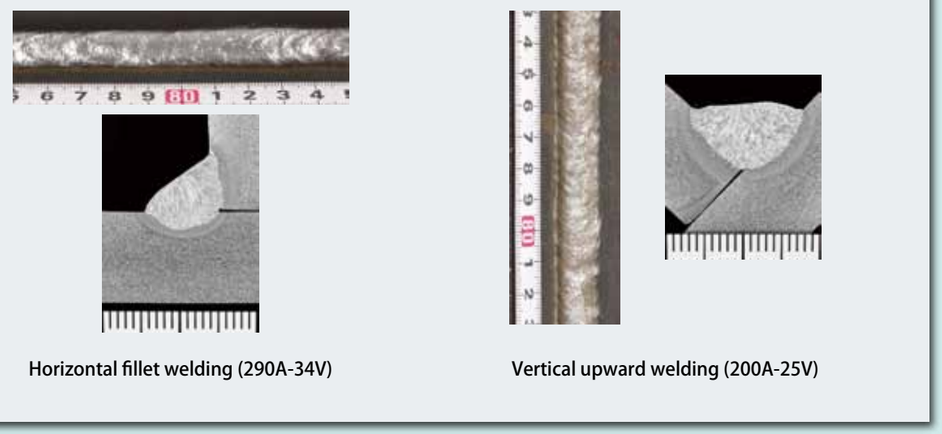

Figure 3: Bead appearances and cross-sectional macrostructures by welding positions
Note: T DW-81B2C 1.2mm dia.

4 Mechanical properties of FCWs for heat resistant steels under various PWHT conditions

Figures 4 and 5 indicate the mechanical properties under various PWHT conditions including the as-welded condition for reference.

With regard to 0.2% offset yield strength (0.2%YS) and tensile strength (TS), the FCWs fully satisfy the lower limits of those of the base metal even under such high temperature and long time PWHT conditions as 690°C x 4h. On the other hand, it is more effective to perform PWHT under higher temperature (650°C→690°C) and longer time (1h→4h) in order to get better impact properties.

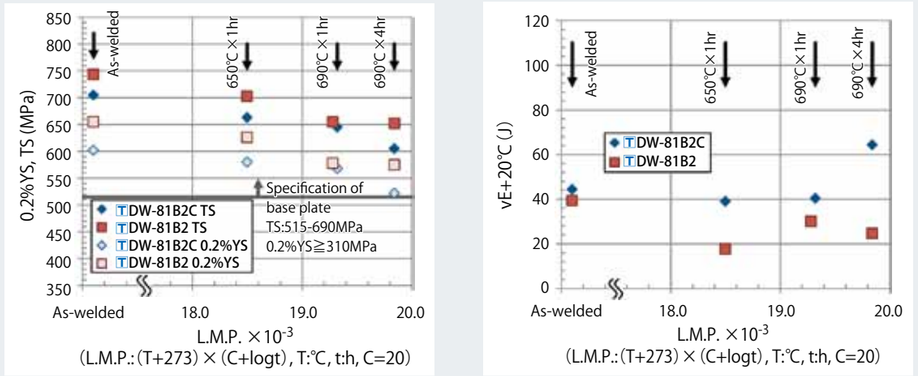

Figure 4: Tensile and impact properties of FCWs for 1.25Cr-0.5Mo heat resistant steels after PWHT

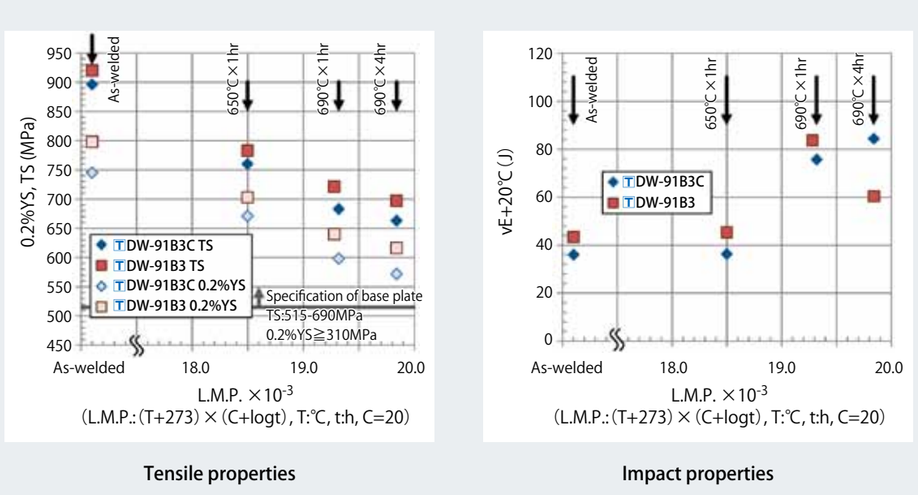

Figure 5: Tensile and impact properties of FCWs for 2.25Cr-1Mo heat resistant steels after PWHT

5 Diffusible hydrogen contents of weld metals with FCWs for heat resistant steels

Figure 6 compares the diffusible hydrogen content of the weld metals with FCWs for heat resistant steels with that of a solid wire (GMAW) and a covered electrode (SMAW).

The FCWs' diffusible hydrogen content is from 2 to 4ml/100g which is inferior to that of T MG-S1CM (GMAW) but, almost equivalent to that of T CM-A96 (SMAW).

Each of the above tests was conducted right after the package of welding consumables was opened. However, because of moisture absorption by or adherence to the welding consumables, diffusible hydrogen content may increase if the welding consumables are left in the packages for long periods after unsealing. It is, therefore, recommended for the consumables to be used promptly once their packages are opened.

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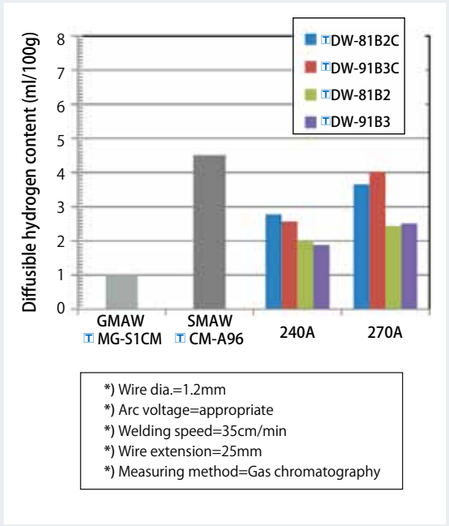

Figure 6: Diffusible hydrogen content of weld metal

6 Stress relief crack resistance of weld metals with FCWs for heat resistant steels

In actual welding of heat resistant steels, PWHT is performed to improve weld metal impact properties and also to remove residual stresses. However, stress relief (SR) cracking or reheat cracking may occur during the PWHT process. Two reasons are widely recognized as the cause of SR cracks.

(1) Impurity elements that cause the grain boundary strength to deteriorate.

(2) Precipitation hardening elements that cause the grain boundary strength to increase.

The formula of SR crack susceptibility for precipitation hardening is as follows:

$\Delta G=Cr(\%)+3.3Mo(\%)+8.1V(\%)-2$
[In case of $\Delta G>0$, the crack occurs.]

$P_{SR}=Cr(\%)+Cu(\%)+2Mo(\%)+7Nb(\%)+5Ti(\%)-2$
[In case of $P_{SR}\geq 0$, the crack occurs.]

Note: Applicable range of each element: Cr≤1.5%; 0.1%≤C≤0.25%; Cu≤1.0%; Mo≤2.0%

The above formulae show that Cr, Mo, Ti, V and Nb are the elements that lead to the formation of precipitate and weakening of SR crack resistance. However, it is important to note that these concerns are more relevant to heat resistant steels than carbon steels, because Cr and Mo are principal and unavoidable elements in heat resistant steels.

In this regard, the rutile (TiO_2) is another important aspect in the design of FCWs for heat resistant steels. Although it is commonly utilized in all-position-type FCWs as a slag forming agent, the Ti element decomposed from TiO_2 inevitably mixes into the weld metal, resulting in reduced SR crack resistance. There is also a possibility that V and Nb may mix into the weld metal as they are unavoidable impurities in the raw materials for welding consumables.

FCWs for heat resistant steels must be carefully designed from the SR crack point of view. In Kobe Steel's FCWs for heat resistant steels, impurities in the raw materials are strictly controlled, resulting in the achievement of excellent SR crack resistance.

Two evaluation methods of SR crack resistance are available: the high temperature/-slow strain rate-tensile test and the C-shaped ring cracking test. Figure 7 compares the reduction of area after fracture in the high temperature/-slow strain rate-tensile test.

When the reduction of area after fracture is low, SR crack resistance is poor. The FCW with no control of impurities resulted in a low reduction of area after fracture. By contrast, T DW-81B2 FCW, in which impurities are controlled, had nearly the equivalent reduction of area after fracture as T CM-A96MBD, a covered electrode that is utilized in the welding of pressure vessels.

The results of the C-shaped-ring cracking test are shown in Figure 8. It can be observed that the crack occurred with the FCW with no control of impurities, which was the same FCW as the one shown in Figure 7. On the other hand, no crack occurred with T DW-81B2 FCW, in which impurities are controlled. These results demonstrate that T DW-81B2 has excellent SR crack resistance.

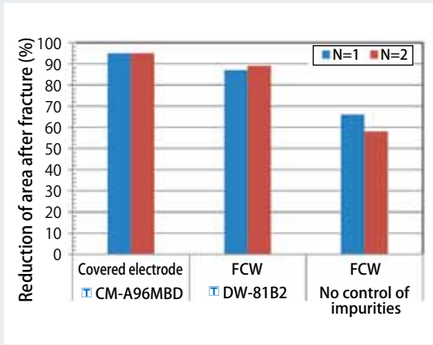

Figure 7: Comparison of reduction of area after fracture in high temperature-slow strain rate-tensile test

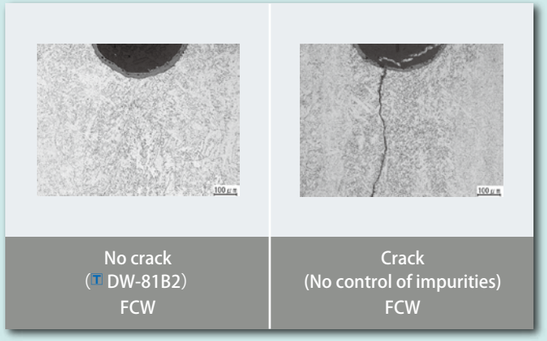

Figure 8: Observation of crack or no crack at U notch portion in C-shaped-ring cracking test

7 Notes on usage

In welding, the PWHT condition should be determined by considering the required mechanical properties, even though FCWs for heat resistant steels show good mechanical properties within the range of 650-690°Cx1-4h as shown in point 4, above (Mechanical properties of FCWs for heat resistant steels under various PWHT conditions).

For example, under the high temperature and long time PWHT condition like 690°Cx4h, FCWs' 0.2%YS and TS can fully satisfy the lower limit of those of the base metal, and it is advantageous to improve impact properties. On the other hand, if excessive high temperature and long time PWHT is performed, it will cause the formation of a soft structure called the ferrite band and may result in extreme decreases in TS and notch toughness.

It is, therefore, recommended to conduct a confirmation test in advance to determine whether the mechanical properties will satisfy the requirements when excessive high temperature and long time PWHT exceeding 690°Cx4h is applied.

Finally, it is not recommended that the FCWs discussed above be applied in the welding of pressure vessels or parts requiring pressure resistance that specify low temperature toughness. The application of these FCWs should be utilized on parts with no strict toughness requirements, or, in other word, with no pressure resistance requirement.

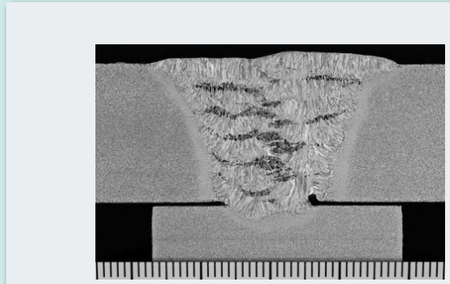

Figure 9: Cross-sectional macrostructure showing ferrite band generation (PWHT: 710°Cx24h)

8 Postscript

In this article, the FCWs for 1.25Cr-0.5Mo and 2.25Cr-1Mo heat resistant steels that conform to AWS standard were discussed. They are designed to fulfill requirements not only for chemical compositions and tensile properties but also for impact properties. Furthermore, as they are aimed to decrease the SR crack susceptibility that is peculiar to heat resistant steels, it is hoped that these FCWs will contribute to the improvement of welding efficiency.

Upon reflecting on feedback from customers who apply these welding consumables onsite, Kobe Steel will make utmost efforts to further improve the properties of these FCWs.

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2. API RP 934-A, 2012, Addendum 2, Annex B
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Note: F, T and P are the abbreviations of FAMILIARC™, TRUSTARC™ and PREMIARC™, respectively.

10th year anniversary of KOBE WELDING OF QINGDAO, China

Overview of KWQ

Established in 2008, KOBE WELDING OF QINGDAO CO., LTD. (KWQ) celebrated its 10-year anniversary at Wyndham Grand Qingdao Hotel in Huangdao District, Qingdao City on October 12, 2018. Among the subsidiaries managed by the Welding Business in overseas, KWQ is the youngest production company.

It was an honor to participate at this 10-year turning point in KWQ's history and report on the anniversary ceremony and get-together party.

National staff members in charge of preparing the ceremony inspired themselves from the start. It seemed part of Chinese culture that they were fond of anniversary and celebration. As a result, almost all employees, except for a few mothers who had to take care of their small children at home, took part in the anniversary celebration.

An enormous display board for the ceremony, much larger than anything I'd seen in Japan, was signed by the employees and set in front of the ceremony. This got them even more excited ahead of the ceremony. Mr. Yamamoto, the Head of the Welding Business (Chairman of the KWQ Board), and the outside directors of KWQ also participated in the ceremony with congratulatory speeches and by extending encouraging words.

In a presentation, the 10-year path of KWQ was introduced, many of the employees became emotional while remembering their history.

The award for 10 years of service at KWQ was presented to many employees. Because the number of such long-term employees will increase further over the next one or two years, they must be the ones who have continuously supported KWQ.

At Chinese get-together parties, special programs are always promised, and this party did not disappoint. It started with *karaoke* singing of KWQ's 10-year anniversary song, whose lyrics were written by KWQ's group leader of equipment and electric power, and continued with Chinese acrobatics, games, dance performances and a magic show performed by professionals in cooperation with the All-China Federation of Trade Unions (ACFTU) in Qingdao. It was exciting. The final performance was a mixed chorus by KWQ employees who had practiced during their short lunch breaks and managed to perform with great success.

Such a get-together party provided me, a representative of the Welding Business in China, with a good opportunity to drink and talk with many Chinese national staff members and plant operators and build personal connections. Moving from one table to another in order to toast all the participants was a hard but enjoyable task.

Because competition among producers of flux cored wire (FCW) for carbon steel, KWQ's main product, is severe in China as well as globally, it means that there is extensive need for FCWs in our societies. (The basis of our business shall be that on a timely basis, we keep supplying welding consumables of stable quality that enables our clients to utilize them with ease) We might not maintain the status quo; however, we will keep developing our presence by taking on new challenges that lead to further reinforcing the company's foundation and employees' happiness.

We do hope you may extend your support to us toward the next 20th or 30th year anniversary.

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The huge display board with all employees' signatures


The mixed chorus by employees


All participants are posing on the stage

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KWAI at FABTECH 2018: KOBELCO-Your Best Partner on display

FABTECH, Exhibition hall

KOBELCO booth

Attendants including KWAI staff members

FABTECH is one of the largest annual exhibitions held in the USA – or occasionally in Canada or Mexico. In the USA, the location alternates between Chicago and either Atlanta or Las Vegas).

In 2018, it was held in Atlanta from November 6 (Tuesday) to 8 (Thursday) and attracted over 33,000 visitors and about 1,500 exhibitors. Reflecting the recent active market situation, the show was extremely active for all three days, and the number of visitors did not drop until the last day.

FABTECH targets general fabricators in metal manufacturing and draws participants in such related industries as metal forming, processing, fabricating, welding and finishing industries. It also features spot sales, and quite a few companies aim to sell their displayed products on the spot at special, discounted prices.

30th exhibition at FABTECH of KOBELCO WELDING OF AMERICA INC. (KWAI) focused on the following points under the slogan "KOBELCO – Your Best Partner:"

(1) establishing KOBELCO's brand-image as the welding solution company. The combination of the ARCMAN™ MP welding robot and F MX-50R metal type flux cored wire was on display, and a video showed the equipment in use at Beck Steel (USA) as well as an interview with the president of that company.
(2) emphasizing technological capabilities for high-end products. T DW-A62LSR, a new flux cored wire (FCW) for the energy industry and F DW-S1LG, an FCW for electro-gas arc welding, shipbuilding and tank fabrication were exhibited.
(3) introducing the extensive line-up of products and features. Stainless steel FCWs such as P TG-X series, P DW-G series for thin-gauge sheet, and P DW-XR series that reduce Cr(VI) emissions were introduced on video. Additionally, F DW-50 (conforming to AWS D1.8Structural Welding Code-Seismic Supplement), F MX-50 for steel structures and a 15 lbs (6.8 kg) spool of F DW-50 for ship building was also displayed.

The display of ARCMAN™ MP together with F MX-50R attracted much attention from visitors, and many of them asked about the robot and the welding wire as well. We believe it successfully conveyed the KOBELCO brand-image as the welding solution company that can provide both welding and robot.

As an exhibition, FABTECH offers value because we can catch new market trends in the ideas, products and concepts emphasized by participating companies. In the case of KWAI, the sales people who work hard in their own territories around the USA join FABTECH as a team and talk business with customers. I felt as if the exhibition helped them become strongly united.

I'd like to take the opportunity and encourage myself to further cultivate the North American market as a member of the KOBELCO group. The next FABTECH will be held in Chicago from November 11 to 14 in 2019. Dear KWT readers, please join us there, and I'm looking forward to seeing you again.

Reported by
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