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KOBELCO WELDING TODAY

Vol.17
2014 No.3

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

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Study to further improve creep rupture and temper embrittlement properties of weld metal for 2.25Cr-1Mo-V steel

2.25Cr-1Mo-V steel, typically represented by ASTM A542/A542M Type D, which has remarkable anti-hydrogen embrittlement and creep rupture properties, is widely used for main components of pressure vessels in oil refinery plants and is welded by submerged arc welding (SAW), shielded metal arc welding (SMAW) and gas-shielded tungsten arc welding (GTAW) consumables, equivalent to the base metal.

As referred to in ASME Sec.VIII, properties such as tensile strength and impact toughness as well as creep rupture are required in 2.25Cr-1Mo-V steel weld metal. Particularly in regard to creep rupture properties for main components of pressure vessels in oil refinery plants, the revision of the ASME code in 2009 required reducing the lower limit of the design temperature from 470˚C to 440˚C. Additionally, temper embrittlement, which occurs when high temperatures are held over long periods of time, should also be considered when dealing with this weld metal. It is of interest, then, to examine the validity of carbonitride in order to improve both the creep rupture and temper embrittlement properties of the weld metal.

As shown in Figures 1 and 2, the creep rupture and temper embrittlement properties of the weld metal were greatly improved by means of decreasing Cr content. Thermo-dynamical simulation shows that the reduction of Cr content increases the amount of vanadium carbide (VC) and niobium carbide (NbC) which enhance the creep strength of the weld metal. In addition, it shows that lower Cr content decreases the amount of solute V and Nb in the matrix, which inhibits the coarsening of VC and NbC by the Ostwald growth under high temperature over a long period of time. The design of VC-rich welding consumables is also effective to improve the temper embrittlement property of the weld metal. While temper embrittlement is caused by the segregation of impurities such as P in the prior γ (austenitic) grain boundary, VC cancels out the influence of P by dissolving it in its crystal structure.

Figure 1: Young's modulus and creep rupture time

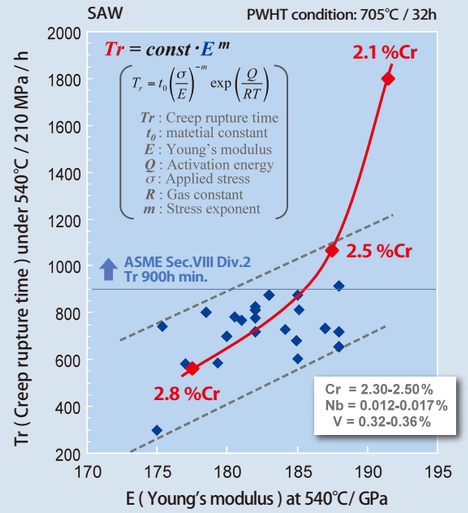


Figure 2: ⊿vTr54 and vTr54+3⊿vTr54

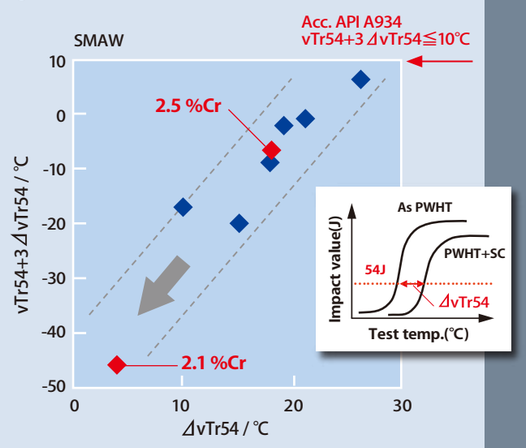


Table 1: Chemical composition and mechanical property of welding consumables for 2.25Cr-1Mo-V steel

Process	Product name	Welding position & polarity	Chemical composition of deposited metal (mass%)							Mechanical properties			
										vE-30℃ (J)	⊿vTr54(℃)	vTr54+3⊿vTr54(℃)	Tr(h)
			C	Si	Mn	Cr	Mo	Nb	V	PWHT: A	PWHT: B		PWHT: C
SAW	PF-500/ US-521H	Flat AC-AC Tandem	0.12	0.15	1.14	2.04	0.99	0.015	0.33	Avg. 67	1	– 48	1387
	ASME Sec. VIII Div.2 (2009 Addenda)		0.05-0.15	0.05-0.35	0.50-1.30	2.00-2.60	0.90-1.20	0.010-0.040	0.20-0.40	54min.(Avg.) 48min.(Each)	——	——	900min.
SMAW	CM-A106H	Flat AC	0.09	0.28	0.87	2.13	1.01	0.018	0.39	Avg. 112	0	– 50	1524
	ASME Sec. VIII Div.2 (2009 Addenda)		0.05-0.15	0.20-0.50	0.50-1.30	2.00-2.60	0.90-1.20	0.010-0.040	0.20-0.40	54min.(Avg.) 48min.(Each)	——	10max. (API A934)	900min.

* PWHT A: 705℃×8h, PWHT B: 705℃×8h + Step Cooling, PWHT C: 705℃×32h

In 2014, our marketing aimed at Kobelco becoming the most reliable welding company in the world

Greetings KWT readers! We thank you for your continuous patronage of the Kobelco group's welding products. Time flies and this year will end in about two months. The Kobelco group's programs to become "the most reliable welding solution company in the world" have proceeded steadily this year as well.

Regarding marketing, we have opened new offices in Jakarta, Indonesia and Dubai, the United Arab Emirates; because of anticipated economic growth, we are ready to offer quick and effective support to end users and local agents. In fact, as the Dubai office is our first marketing base in the Middle East, we expect it to expand quickly. In China, we have recently revamped our marketing organization in order to respond better to the needs of such fields as shipbuilding and offshore structures, energy, automobiles and construction machinery.

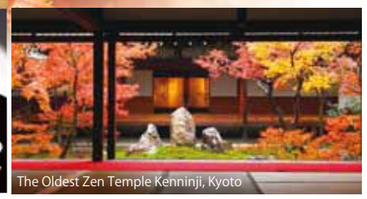
The key to this marketing program is close cooperation with local agents so that they may provide end users with the products and services they need in a timely manner.

Over the course of this year, the word "trinity" is one that often came to mind. For it was team work by three of Kobelco's departments - production, research and development, and sales and marketing – that allowed us to supply the necessary welding consumables for special projects. I am proud that we could provide the products that met our clients' special requirements. With our partners (agents) communicating effectively between the end users and the Kobelco group, I believe all three parties were able to see fair profits.

As for exhibitions, we took part in them in Japan, China as well as India, and will participate in the FABTECH & AWS Show in the USA in November. Because this show is important not only for displaying the latest technologies and products but also for maintaining close communication with KWT readers, we ask you to join us there and we look forward to seeing all of you then.

In the meantime, how has the weather been where you live and work? We are now enjoying autumn and expect winter to come soon. At this time in Japan, we enjoy an "autumn appetite" because it is the season that almost all foods taste delicious. Fish, vegetables, fruits as well as the world-famous Kobe beef are abundant. Autumn is also the time when Japanese sake best matches the food. It is never too late to plan a visit to Japan. We hope you can visit us here and enjoy the seasonal tastes together with us.

Koichi (Jay) Sugiyama
General Manager
International Sales & Marketing Section
Welding Business
Kobe Steel, Ltd.


The Oldest Zen Temple Kenninji, Kyoto

KOBELCO WELDING TODAY No.3 2014

CONTENTS Vol.17

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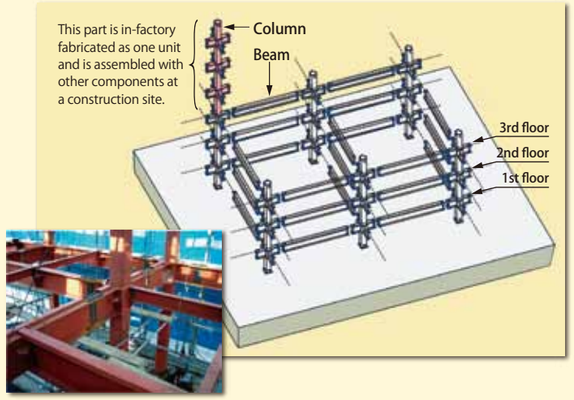
A robotic welding system equipped with the REGARC™ process for architectural steel frames

KOBELCO WELDING TODAY
Vol.17 No.3 2014

1 Preface

Improving earthquake resistance in buildings is essential in countries prone to strong earthquakes. In Japan, earthquake-resistant design for construction out of wood, steel or reinforced concrete has evolved after many serious earthquakes and is a required feature of architectural design and building fabrication. Steel frame technology for buildings has been a particularly important development in earthquake-resistant design. More than one third of all buildings (including small shops and factories as well as high rise buildings) are made of steel frames, which can account for as much as 60% of a total building. Wood construction is now used primarily for detached houses.

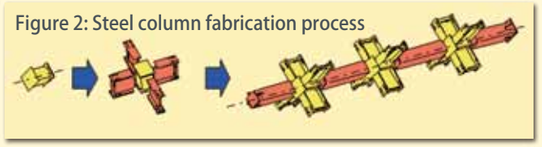
Figure 1: Architectural steel frames using steel pipes for columns



Due to the desire for large spaces in offices or factories, cold-rolled square or circular steel pipes, which do not require diagonal braces, have increasingly been replacing H-section steel columns. Indeed, square steel pipes or circular tubes are now applied in 95% of low and medium-rise structures. These columns and beams are constructed at the steel frame fabricator and transported to and assembled at the construction sites.

The standard fabrication process of columns used for architectural steel frames at the fabricator is shown in Figure 2.

Figure 2: Steel column fabrication process



A section of a large column is fabricated by first welding the core part (left), then by welding the beams to the column joint (center) and finally by welding the column assembly (right).

Because the welding of the diaphragm to the structural hollow section joint requires much welding and rotational work, it is a job for robotic welding. By welding in the flat position, robotic welding provides better efficiency, fewer defects, and smooth and stable beads than semi-automatic welding. Kobe Steel developed a robotic welding system for architectural steel frames in the late 1980s that enjoys a high degree of market share as a result of its high quality and efficiency.

Since the Japanese Building Standard Law was amended after the Great Hanshin Earthquake of 1995, the requirements for the welding of steel structural joints of buildings have become stricter. However, Kobe Steel has developed new systems and functions that increase productivity by means of a synchronized two-joint robotic welding system for column assembly that maintains the heat input limit on each welding joint.

As for the welding process, a standard CO_2 gas shielded arc welding process has long been favored for high efficiency as well as lower cost than Ar gas even though high spatter generation has been a well-known drawback. Therefore, Kobe Steel has developed "REGARC™ process" to be used in combination with the new SENSARC™ AB500 power source and FAMILIARC™ MG-50R(N) and FAMILIARC™ MG-56R(N) solid wires.

This process achieves high deposition while minimizing spatter and fumes even with standard CO_2 gas shielded arc welding. This article introduces the REGARC™ process and a robotic welding system for architectural steel frames equipped with REGARC™ process.

Figure 3: Typical robotic welding systems for architectural steel frames

Figure 3-1:
Robotic welding system for core parts/ beam to column joint

Figure 3-2: Two-joints synchronized robotic welding system for column assembly

2 Features of the REGARC™ process

This process utilizes the specially-designed SENSARC™ AB500 power source (see Figure 4), as well as MG-50R(N) or MG-56R(N) solid wire for the robotic welding of architectural steel frames. Table 1 shows the typical deposited metal chemistries of MG-50R(N) and MG-56R(N).

Figure 4:
New power source:
SENSARC™ AB500

Table 1:
Typical deposited metal chemistries of MG-50R(N) and MG-56R(N)

Product name	JIS classification *1	Typical chemistry of deposited metal (mass%)					
		C	Si	Mn	P	S	Ti+Zr
MG-50R(N)	Z3312 YGM11	0.09	0.57	1.00	0.010	0.013	0.03
MG-56R(N)	Z3312 YGM18	0.06	0.48	1.33	0.009	0.007	0.03

Note:*1 JIS: Japanese Industrial Standard

2-1. Low spatter

In conventional CO_2 gas shielded arc welding, the metal transfer mode is generally globular transfer, in which large droplets transfer irregularly as the welding current increases. After working on droplet transfer control through pulsed current waveform, Kobe Steel developed the REGARC™ process, which reduces spatter by producing and detaching droplets in regular fashion.

What is the difference in droplet transfer between the conventional process and the REGARC™ process? In the conventional process, a droplet is formed (Figure 5-1) and then short-circuited by the molten pool just before detaching, after which the droplet as well as some of the molten metal explodes right after the arc is re-ignited (Figure 5-2), or when a droplet grows, it is detached while being pushed upward by arc force, and scattered while rotating (Figure 5-3).

Figure 5: Globular droplet transfer by conventional process

Figure 5-1: Droplet forms

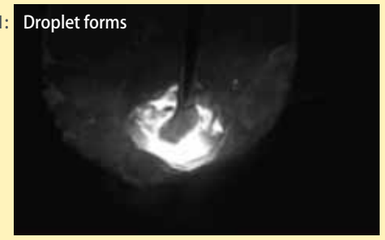
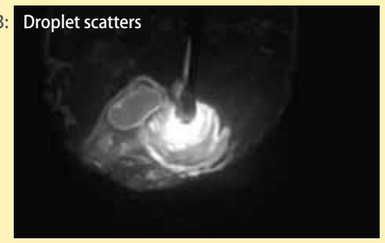


Figure 5-2: Droplet and some molten metal explodes

Figure 5-3: Droplet scatters



KOBELCO WELDING TODAY
Vol.17 No.3 2014

By contrast, in the REGARC™ process, the droplet is squeezed by the pulsed peak current as soon as it forms (Figure 6-1), and then it is detached by the low current during a base duration (Figure 6-2).

The detached droplet is absorbed into the molten pool smoothly. With the timely control of optimum pulsed peak current at the time a droplet forms or detaches, the droplet size remains small and uniform and transfer is smooth.

Figure 6: Droplet transfer by REGARC™ process

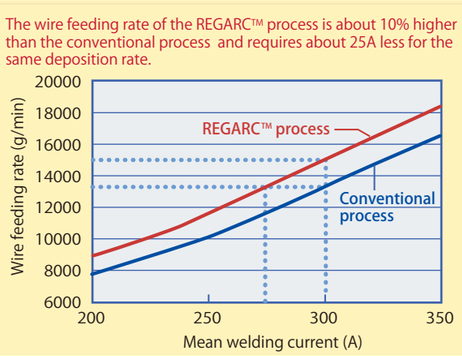
Figure 6-1: Droplet is small and squeezed

Figure 6-2: Droplet is detached smoothly

2-2. High deposition rate and low heat input

Figure 7 shows the relationship between welding current and wire feeding rate (wire melting rate) in the conventional CO_2 gas shielded arc welding process and the REGARC™ process.

Figure 7: Relationship between mean welding current and wire feeding rate



The wire feeding rate of the REGARC™ process is more than 10% higher than that of the conventional process. Because the pulsing welding current of the REGARC™ process is higher than that of the conventional process, resulting in higher Joule heat, the deposition rate (and overall efficiency) of the REGARC™ process is higher for any amount of welding current (mean value) used.

This means that the REGARC™ process can achieve the same deposition rate with 10% less of the mean welding current required of the conventional process. The deposition rate at 300A in the conventional process is equivalent to that at 275A in the REGARC™ process. This allows for a reduction in heat input, increasing weld metal properties as well as minimizing welding distortion or deforming.

2.3 Good and deep penetration

Figure 8 shows the difference in penetration shape between the conventional and REGARC™ processes while obtaining the same deposition rate.

Figure 8: Difference in penetration shape between conventional and REGARC™ processes

Figure 8-1: Penetration shape by conventional process

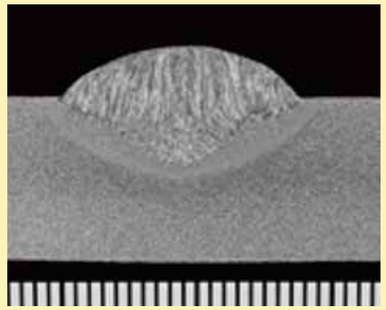


Figure 8-2: Penetration shape by REGARC™ process

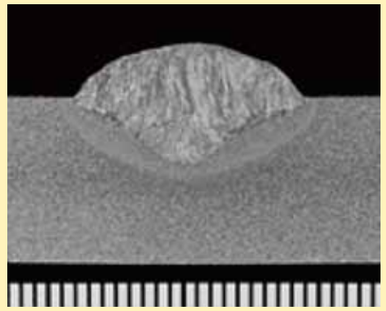
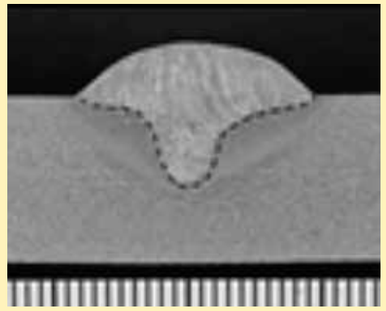


Figure 8-3: Penetration shape by Ar-CO_2 mixed gas (Reference)



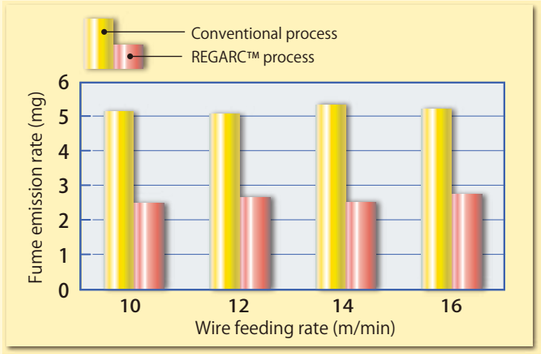
Even though the mean welding current of the REGARC™ process is lower than that of the conventional process, similar penetration is obtained (Figures 8-1 & 8-2) because of the higher peak current of the REGARCTM process. Hence, it can be seen that sound welding can be performed despite lower heat input.

For reference, Figure 8-3 shows the penetration shape derived from MAG welding using Ar-CO_2 mixed gas, which is known as a low spatter welding method. Penetration is finger-shaped, which would be poor in porosity resistance; by contrast, penetration by the REGARC™ process is wide, deep and bowl-shaped, which is porosity- and hot crack-resistant.

2.4 Low fume

The difference in fume emission rate per unit weight of welding wire by the conventional and REGARC™ processes is shown in Figure 9.

Figure 9: Difference in fume emission rate between the conventional and REGARC™ processes



It is clear that the REGARC™ process generates nearly half the amount of fumes compared with the conventional process.

3 Robotic welding system for architectural steel frames equipped with REGARC™ process

A robotic welding system for architectural steel frames equipped with the REGARC™ process has the following advantages over the conventional process:

1- Increased productivity by shortening cycle time

2- Improved weld quality

3- Less post-welding work, such as scraping or grinding

4- Better energy savings

Figure 10 clearly shows much less spattering during the welding of a diaphragm to a structural hollow section joint under the REGARC™ process than the conventional process.

Figure 10: Difference of spattering during column welding between the conventional and REGARC™ processes

Figure 10-1: Conventional process

Figure 10-2: REGARC™ process

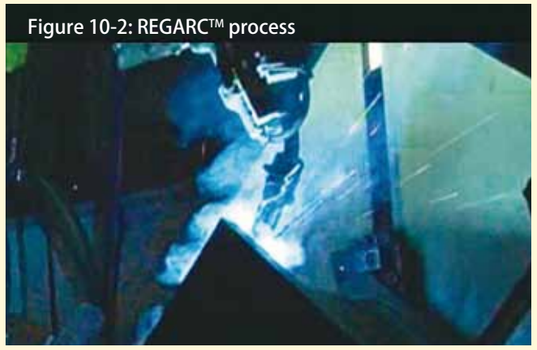
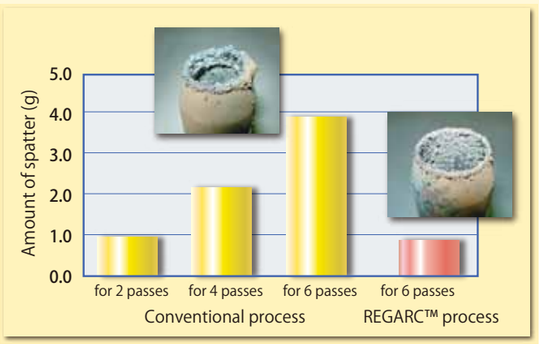


Figure 11 compares the two processes in relation to the amount of spatter sticking to a nozzle during the welding of a diaphragm to a structural hollow section joint with single bevel groove. The REGARC™ process can reduce the amount of spatter to one fourth that of the conventional process, even on welding a groove inside.

Figure 11: The amount of spatter sticking to a nozzle during column welding (with a single bevel groove) in the conventional and REGARC™ processes



When spatter sticks to the inside of a nozzle, shielding may be reduced, resulting in poor mechanical properties as well as welding defects such as weld metal porosity. For this reason, robotic welding incorporates automatic nozzle cleaning and nozzle exchanging in order to maximize operation time.

The robotic welding equipped with REGARC™ process reduces the frequency of nozzle cleaning or exchanging to one half so that idle time is minimized. This leads to increased arcing time and shorter cycles.

Figure 12 compares the results obtained from welding a square tubular steel column with a side length of 400 mm and a plate thickness of 22 mm by the conventional and REGAEC™ processes. The REGARC™ process reduced the cycle time by 10%, and because of less spatter, post-welding scraping and grinding work was also lessened.

Figure 12: Comparison of cycle time between conventional and REGARC™ processes

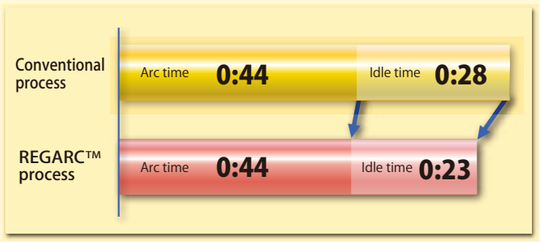


Figure 13 compares the welded bead appearance in both the conventional and REGARC™ processes.

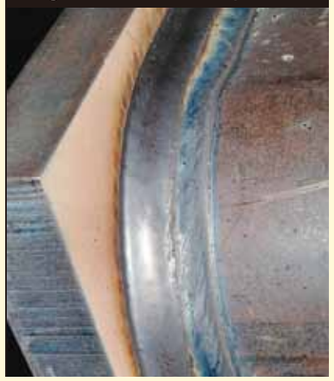
Much spatter is visible on the plate surface of the diaphragm as well as the column sides on the piece welded by the conventional process, while very little spatter can be seen on the bead surface of that welded by the REGARC™ process.

As mentioned earlier, the REGARC™ process can save energy because it achieves a higher deposition rate with a lower mean welding current as compared with the conventional process. As much as 5% less electric power may be consumed.

Figure 13: Comparison of spatter amount on plates between conventional and REGARC™ processes

Figure 13-1: Conventional process

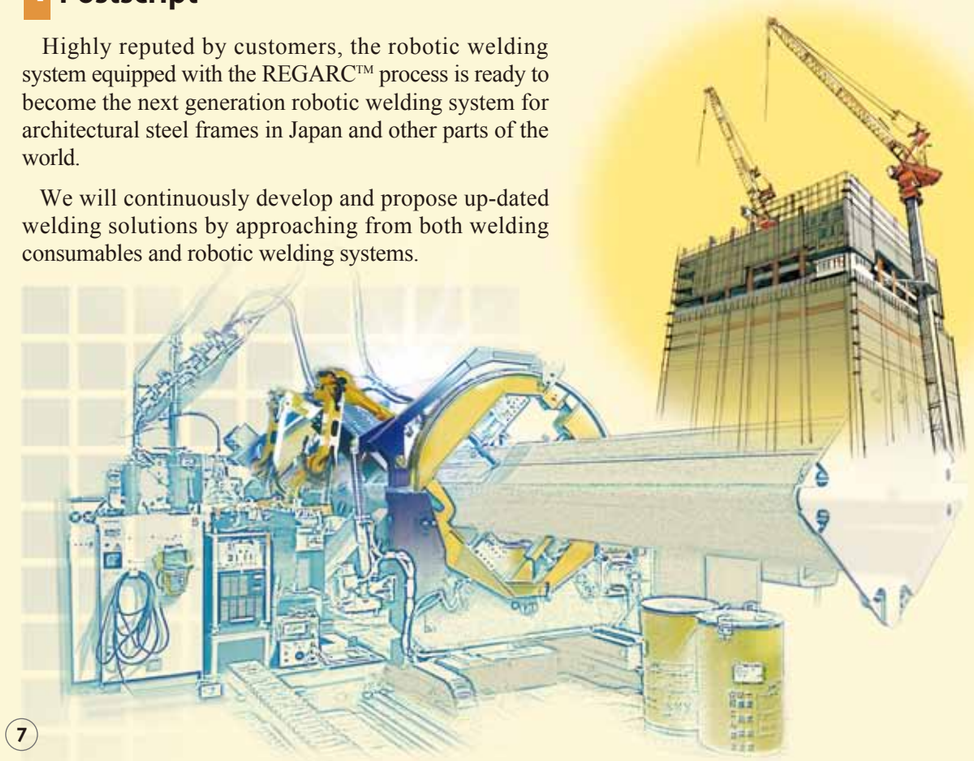
Figure 13-2: REGARC™ process



4 Postscript

Highly reputed by customers, the robotic welding system equipped with the REGARC™ process is ready to become the next generation robotic welding system for architectural steel frames in Japan and other parts of the world.

We will continuously develop and propose up-dated welding solutions by approaching from both welding consumables and robotic welding systems.

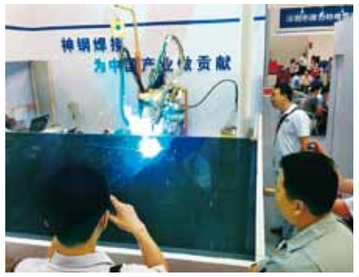


KOBELCO WELDING TODAY
Vol.17 No.3 2014

Beijing Essen: an opportunity to grasp the China market

Dear KWT readers! I am Hajime Kamata, and it is my pleasure to report on the 19th Beijing Essen Welding & Cutting Fair that was held from June 10 to 13. On joining Kobe Steel, Ltd., in 2012, I was assigned to the Fujisawa Plant to work in production planning of flux cored wires (FCWs) for mild steels as well as stainless steels. Since 2014, I've been working in the Sales and Marketing Section with responsibilities for China and Taiwan. It was my first time attending the Beijing Essen Fair.

Outside the huge exhibition hall



Live welding demonstration of the REGARC™ robotic system

Fruitful meetings in the business talk corner

Party for representatives of Kobelco's distributors

The cavernous exhibition hall filled with elaborate booths was overwhelming. At 38,000m², the floor was almost three times bigger than in Japan, and there were 900 exhibitors, about four times more than we get in Japan. The exhibition was too big to experience in just one day. I was impressed by the booth designs as well as the well-made promotional videos displayed on the big screen. Some of the exhibitors displayed things I'd never seen in Japan such as welding masks in a range of colors or a full range of welding torches.

Three Kobelco group companies located in China (KWSH in Shanghai, KWT in Tangshan and KWQ in Qingdao) participated in the exhibition together with Kobe Steel, Ltd. The booth featured welding consumables as well as welding processes for auto manufacturing and shipbuilding with displays of bead samples and panels. We also offered live welding demonstrations of the REGARC™ process, DW-55E/DW-100EV FCW for carbon steel: and DW-T308/DW-T309L FCW for stainless steel. All of them attracted many visitors.

In a corner reserved for business discussions, Kobelco staff members as well as the representatives of our distributors and trading firms engaged in "omotenashi (selfless customer service)" with clients. The scene reminded me of how Kobelco's technology and products never fail to attract our customers' attention and expectations.

We also had a get-together party with our distributors during the fair. Meeting these representatives was particularly enjoyable as we sipped the famous Chinese "Baijiu," a white spirit with an alcohol content of 52%.

At the fair I was able to see the booths of exhibitors from Europe, America, Korea as well as Japan. I was impressed with the many robotic welding displays but also with simply realizing that people around the world know that China is an important market that requires both quantity and high quality. I also relearned the importance of seeing such an exhibition site with one's own eyes. I will never forget it and will make my utmost effort to gain the trust of our distributors and end users.

Cheerful and friendly Kobelco employees in Thailand

At Narita Airport with TKW Technical Department staff members after the International QC Circle Meeting (Mr Kawamoto, third from the right)

At the 2013 year-end party with Technical Department staff members (Mr Kawamoto, center)

Kanchanaburi

Together with Technical Department staff members at the 2014 New Year Party (Mr Kawamoto, second from the right)

Dear KWT readers! My name is Hiroaki Kawamoto, Manager of the Technical Department, Thai-Kobe Welding Co., Ltd. (TKW). Almost one and half years have passed since I was transferred to TKW, and though working in English has been difficult to get used to, my daily life at work and at home has been exciting and fun.

TKW and Kobe MIG Wire (Thailand) Co., Ltd. (KMWT) manufacture covered electrodes and solid wires respectively and sell them mainly in Thailand but also in other ASEAN countries as well. In the Technical Department, we work on improving our products or developing new ones and provide technical services like welding seminars and troubleshooting in order to expand the sales of Kobelco products. By enhancing our product lines and technical services to satisfy the needs of clients, we believe we are contributing to development in Thailand as well as in the ASEAN countries.

Though Thailand's political instability continues due to the military coup d'etat, it has interfered little with our daily lives and work.

I often feel that Thai people are much more friendly and cheerful than Japanese. I've seen this particularly in the various events we' ve held as a company. One example is the athletic meet, which is not only an athletic competition but a competition for cheering on the four teams that the employees are divided into. Many participants wear costumes and cheer loudly and spiritedly from start to finish. Afterwards it seemed they were worn out more from cheering than from the exercise!

I saw more cheerful employees during a company trip. In 2013, we traveled in five large buses for a two-day/one night trip to Kanchanaburi in the west of Thailand, which offers beautiful views of mountains and valleys (and was also the setting for the novel and movie The Bridge Over the River Kwai). I was astonished at how everyone made music and danced throughout the entire eight-hour bus journey! In fact, they remained in high spirits from morning till night.

Allow me to welcome you anytime to the land of smiles: Thailand, where cheerful and friendly people are ready to meet you!

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Shanghai, a cosmopolitan city where global celebrities come to perform

Mr Agatsuma, dressed like a fan at the Rolling Stones concert

Mr Agatsuma, posing at the entrance to the Shanghai Rolex Masters Tennis Tournament

Dear KWT readers! My name is Yu Agatsuma. I was assigned to Kobe Welding of Shanghai Co., Ltd. (KWSH) as the Manager of Welding Consumable Department in May last year.

The company used to import and sell welding consumables that were manufactured at Kobe Steel's plants in Japan, mainly to the energy-related clients in China. In 2014, however, all sales and marketing functions related to Kobe Welding of Tangshan Co., Ltd. (KWT) and Kobe Welding of Qingdao Co., Ltd. (KWQ) were transferred to KWSH. Thus, a new sales and marketing organization in China has been launched at KWSH and is expanding sales of welding consumables to many fields, such as car manufacturing and shipbuilding as well as energy.

We aim to help the Kobelco group become a supplier of total welding solutions and gain the trust of customers from all over China. We hope they will accept us as business partners, working together to serve our mutual interests.

Shanghai, the center of the Chinese economy and financial world, is China's largest cosmopolitan city. With so many high rise buildings standing close together, the scenery is fantastic. A great variety of international events related to sports, music, and the arts occur throughout the year, and Chinese as well as foreign residents look forward to attending these popular attractions if possible.

I am the one of them and love watching the superstar athletes play live: Rafael Nadal, Novak Djokobic or Kei Nishikori in tennis; or Rory McIlroy, Phil Mickelson or Ryo Ishikawa in such golf tournaments as the Shanghai Rolex Masters, BMW Masters or HSBC Champions.

Regarding music, I was thrilled to see The Rolling Stones, living legends of rock and roll, in concert in Shanghai last March. As you can see, by living in Shanghai I've been fortunate to experience enjoyment and stimulation through such great performances by some of the greatest stars in the world.

Now I am looking forward to watching more sports at events that are going to be held in the early autumn of this year.