Feature Article

Breakthrough of the Chinese and Asian Market in Steel Industry and the Development of the Gas Analyzer in Solid Sample
鉄鋼業界における中国・アジアの躍進と 固体中ガス分析装置の開発

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In recent years, as breakthrough of Chinese and Asian market in steel industry, this opinion can't be ignored for product development. The gas analyzer in solid sample is important device in quality control and the research development of steel. Especially the improvement of the maintenance and performance are desired. In this time, we developed gas analyzer in solid samples for important element as determine the performance of steel. This paper is discussed several features for carbon and sulfur analyzer (EMIA series), oxygen, nitrogen, hydrogen analyzer (EMGA series) and automation unit.

近年, 鉄鋼業界における中国・アジアの躍進により, 本市場をターゲットにした製品開発の重要性は増してきている。固体中ガス分析装置は, 鉄鋼の品質管理・研究開発において鉄鋼の性質を決める重要な元素を計測する装置である。これらの装置において, 保守性や精度向上が望まれており, 中国の顧客の意見を取り込むことは必要不可欠である。 本稿では炭素・硫黄分析装置（EMIAシリーズ）と酸素・窒素・水素分析装置（EMGAシリーズ）ならびに自動化装置についてその特長を述べる。

Introduction

In recent years, breakthrough of China indicates notable improvement in steel industry. Official announcement at World Steel Association in January22nd 2010 say the world crude steel production is 1219.71.milion tons in 2009. The feature is shown as the below,

1) In 2007, the world crude steel production was the biggest as 1245.82 million tons. In 2008, it decreased 1.4% year-on-year as 1336.45 million tons. In 2009, it continuously decreased 8.0% year-on-year.

2) In 2009, main country's crude steel production decreased under the influence of worsening of the world economic situation. How ever the crude steel production in China of 1st ranking and India of 5th ranking has increased. The increase of China's crude steel production was 13.5% up year-on-year, and its amount was 47% in the world.

3) In 2009, the crude steel production in Japan and main countries of the EU decreased 20% over compared to the previous year, and that of USA was significantly down 36.4%. In contrast, that of Russia and Korea stayed the decrease of 12.5% and 9.4% compared to the previous year.

In 2008, Chinese crude steel production was down temporally, however Chinese government injected the public funds into that market as an economic stimulus measure. Chinese steel market indicated big breakthrough due to the strong automotive market and the increase of demand for infrastructure building of the Shanghai Expo. Especially automotive production keeps beating record high. In 2009, automotive production increased 48% as

Table 1   The World Crude Steel Production (2009)

	Rank	2009	2008	2007	2006	2005	2004	%2009/2008
1	China	567.8	500.3	489.3	419.1	353.2	282.9	13.5
2	Japan	87.5	118.7	120.2	116.2	112.5	112.7	-26.3
3	Russia	59.9	68.5	72.4	70.8	66.1	65.6	-12.5
4	United States	58.1	91.4	98.1	98.6	94.9	99.7	-36.4
5	India	56.6	55.1	53.1	49.5	45.8	32.6	2.7
6	South Korea	48.6	53.6	51.5	48.5	47.8	47.5	-9.4
7	Germany	32.7	45.8	48.6	47.2	44.5	46.4	-28.7
8	Ukraine	29.8	37.3	42.8	40.9	38.6	38.7	-20.2
9	Brazil	26.5	33.7	33.8	30.9	31.6	32.9	-21.4
10	Turkey	25.3	26.8	25.8	23.3	21.0	20.5	-5.6
11	Italy	19.7	30.6	31.6	31.6	29.3	28.6	-35.5
12	Taiwan China	15.7	19.9	20.9	20.0	18.9	19.6	-20.8
13	Spain	14.3	18.6	19.0	18.4	17.8	17.6	-23.3
14	Mexico	14.2	17.2	17.6	16.4	16.2	16.7	-17.7
15	France	12.8	17.9	19.2	19.9	19.5	20.8	-28.2
16	Iran	10.9	10.0	10.1	9.8	9.4	8.7	9.1
17	United Kingdom	10.1	13.5	14.3	13.9	13.2	13.8	-25.4
18	Canada	9.0	14.8	15.6	15.5	15.3	16.3	-39.6
19	South Africa	7.5	8.3	9.1	9.7	9.5	9.5	-9.5
20	Poland	7.2	9.7	10.6	10.0	8.3	10.6	-25.9
21	Malaysia (e)	6.0	6.4	6.9	5.8	5.3	5.7	-6.6
22	Austria	5.7	7.6	7.6	7.1	7.0	6.5	-25.4
23	Belgium	5.6	10.7	10.7	11.6	10.4	11.7	-47.2
24	Egypt	5.5	6.2	6.2	6.0	5.6	4.8	-11.1
25	Australia	5.2	7.6	7.9	7.9	7.8	7.4	-31.2
26	Netherlands	5.2	6.9	7.4	6.4	6.9	6.8	-24.2
27	Thailand (e)	5.0	5.2	5.6	4.9	5.2	4.5	-4.1
28	Saudi Arabia	4.7	4.7	4.6	4.0	4.2	3.9	0.5
29	Czech Republic	4.6	6.4	7.1	6.9	6.2	7.0	-28.1
30	Kazakhstan	4.1	4.3	4.8	4.3	4.5	5.4	-2.4
31	Argentina	4.0	5.5	5.4	5.5	5.4	5.1	-27.6
32	Venezuela	3.8	4.2	5.0	4.9	4.9	4.6	-9.5
33	Slovakia	3.7	4.5	5.1	5.1	4.5	4.5	-16.5
34	Indonesia (e)	3.5	3.9	4.2	3.8	3.7	3.7	-10.6
35	Finland	3.1	4.4	4.4	5.1	4.7	4.8	-30.3
36	Sweden	2.8	5.2	5.7	5.5	5.7	6.0	-46.0
37	Romania	2.7	5.0	6.3	6.3	6.3	6.0	-46.4
38	Byelorussia	2.4	2.6	2.4	2.3	2.0	1.8	-6.6
39	Luxembourg	2.2	2.6	2.9	2.8	2.2	2.7	-14.2
40	Greece	2.1	2.5	2.6	2.4	2.3	2.0	-15.9
	Others	23.3	28.3	29.8	28.6	25.8	24.8	-17.5
	World	1219.7	1326.5	1345.8	1247.3	1144.1	1071.5	-8.0

WSA: World Steel Association

13.79 million units compared to the previous year, and China became world's biggest automotive production country.[1] After 2006, the investment cost and its cost rate of the sales volume in China were larger than them of Japan.[2] As mentioned above, Chinese steel production is growing rapidly in steel industry. The gas analyzer in solid sample is important device in quality control and research development of steel field.

Feature Article (vertical sidebar)

The Gas Analyzer in Solid Sample

In steel production, rapid and high accuracy analysis is becoming increasingly necessary in concept material feature and quality control. Especially elements such as carbon, sulfur, oxygen, nitrogen and hydrogen are important to decide the steel fund a mental property. Also, these elements are extremely important factors for process and quality control. Elemental content varies from low concentration to high concentration with the type of the steel.[3]

Currently, HORIBA sells the different gas analyzers in solid sample. EMIA series is a carbon and sulfur gas analyzers in solid sample. It uses the high-frequency induction heating and infrared absorption method. EMGA series is an oxygen, nitrogen and hydrogen gas analyzer. It uses the inert gas fusion and infrared absorption/ thermal conductivity method.

This paper describes the contents of the developed analyzer based on Chinese's market requirements and also describes the unit automation.

Improvement of Work Efficiency by Software

We improved the software of EMIA and EMGA together developing EMIA/EMGA unit. In this section, we introduce the feature of the new software. The main feature of the new software is the support of the maintenance procedure. In existing system, the explanation on maintenance procedure only opened the instruction manual file. It was difficult to perform maintenance. Then we developed the maintenance navigation function. This function shows the maintenance parts and explains the different steps using video images. With this new function, the risk of error by the operator during maintenance is reduced as well as the total downtime of the system.

EMIA-920V2 (Carbon/Sulfur Analyzer)

This section shows the feature of the carbon/ sulfur analyzer EMIA-920V2.

Principle

This analyzer uses high-frequency induction heating and infrared absorption methods. By high-frequency induction eddy current, the steel sample is heated in a crucible and

Figure 1   EMIA-920V2

then burns and melts in the oxygen stream. An accelerator is used for improving this combustion. Commonly used accelerators are Metal tungsten, tin, copper or iron. During the combustion process, gaseous carbon and sulfur turn to carbon dioxide and sulfur dioxide. These gases are introduced to the infrared detector and then the concentration of carbon and sulfur is calculated.3). An example of such a measurement is shown below.

Table 2   EMIA Data of Japanese Iron and Steel Certified Reference Materials

	Carbon		Sulfur	
Sample Cord	JSS1201-1	JSS111-12	JSS606-8	JSS150-14
Standard Value % (m/m)	0.0005	4.25	0.0008	0.030
1	0.000495	4.241	0.000803	0.0301
2	0.000506	4.269	0.000839	0.0301
3	0.00050	4.236	0.000815	0.0299
4	0.000479	4.258	0.000823	0.0301
5	0.00047	4.251	0.000796	0.0298
Average Value	0.00049	4.251	0.000815	0.0301
σ n-1	0.000015	0.013	0.000017	0.0002
CV (%)	3.1	0.31	2.08	0.49

Auto Cleaner Unit

During the sample combustion, dust is also produced. It accumulates in the combustion furnace and prevents the sample's combustion. Also it catches the produced SO_2

gas. As a result, measured sulfur value is lower than expected. To prevent dust, EMIA uses an auto cleaner unit and a heated dust filter unit. Still these units need to be cleaned regularly due to the accretive dust on units. In existing units, this maintenance work requires tools and time. With EMIA-920V2 series the auto cleaner unit can be removed without tool. As a result, mistakes during maintenance work are reduced and the maintenance speed is increased.

Dust Box

EMIA-920V2 features a new method for cleaning the combustion furnace. In the existing system, the carrier gas is sprayed to furnace after measurement for removing the dust. To improve the cleaning capacity, we added a suction system to EMIA-920V2. The combination of suction and spray gas systems increases the cleaning efficiency of EMIA-920V2. As a result, the interval periods of regular maintenance extended.

For adding the suction system, the installation position of the dust box which collects the dust was modified to front side of device. With previous units, it was difficult for operator to access the dust box on the left side of the device. EMIA-920V2 has a dust box on the front side so operators can clean the dust box easily.

EMGA-900 Series
(Oxygen / Nitrogen / Hydrogen Analyzer)

Next we introduce the EMGA-900 series which is oxygen, nitrogen and hydrogen gas analyzer in steel sample.

Figure 2   EMGA-900

Principle

EMGA-900 series uses the inert gas fusion and infrared absorption/thermal conductivity method.

First, the graphite crucible is heated over 3000 °C by applying an electric current (~1000 A). During this heating process, the gas components which are inside the crucible or adhering to it are removed. The crucible temperature is decreased by stopping the current. The steel sample is then inserted into the crucible. The crucible is heated again. During this heating step, the sample is melting and reacts with graphite crucible. Oxygen, nitrogen and hydrogen are extracted as carbon monoxide, nitrogen gas and hydrogen gas. The extracted gases are introduced to detector by inert gas (carrier gas). EMGA series units are equipped with a non-dispersive infrared detector (NDIR) and a thermal conductivity detector (TCD). For gas detection, NDIR has gas selectivity but TCD don't. In the previous system, the oxygen analysis from low to high oxygen concentration was measured by one NDIR detector. However new EMGA-900 series have two detectors: O_2 detector for low concentration and CO detector for high concentration. High accuracy analysis in each concentration is now possible using two detectors.

After measurement of oxygen and hydrogen, these gases pass through the CO_2 absorbent reagent and the water absorbent reagent. By this process, only nitrogen gas component remain. After that, nitrogen gas is detected by TCD.[4]

At three component (oxygen, nitrogen, hydrogen) gas analyzer, hydrogen gas which is converted to water (H_2O) by oxidizing agent is detected by the non dispersive infrared detector. And we sell the special hydrogen analyzer. This analyzer has the gas column which separates hydrogen, and the TCD for detecting the hydrogen.

The measurement example is shown below.

Table 3   EMGA Data of Japanese Iron and Steel Certified Reference Materials

	Carbon	Sulfur	Hydrogen
Sample Cord	JSS GS-6b	JSS 366-8	JSS GS-1d
Standard Value % (m/m)	0.00034	0.00075	0.00016
1	0.000362	0.000722	0.000160
2	0.000357	0.000774	0.000160
3	0.000366	0.000751	0.000162
4	0.000367	0.000769	0.000156
5	0.000361	0.000725	0.000163
Average Value	0.000362	0.000758	0.00016
σ n-1	0.000043	0.0000206	0.000003

Auto Cleaner Unit

In gas extract, the graphite dust is generated with sample gas. This dust affects the analytical performance. Therefore the operator needs to clean the furnace. In existing system, the operator has to do it manually. Therefore, the difference of condition in the furnace is caused easily by the operator. This difference is one of the factors that cause changes in the measurement results. To prevent this problem, EMGA-900 series has an auto cleaning unit as standard equipment. As a result, the changing of the result and the burden to operators were reduced.

Crucible Loader Unit

In existing EMGA system, the operator has to set the crucible on the electrode at every measurement. However, EMGA-900 series have a crucible loader unit. This unit supplies the crucible to electrode automatically.
Adding the auto cleaner unit and crucible loader unit reduced the total measurement time and improved the measurement stability.

The Automation of Gas Analyzer

With growing Chinese market, the movement to reduce cost and the decreasing of individual difference by operators becomes strong. Therefore the requirement to the automation of gas analyzer is increased. The automation unit needs to include all the process steps: receiving the sample, measuring the weigh, analyzing the element, and wasting a crucible. Existing automation unit's large size is due to functional restriction. Therefore there are many maintenance parts in it. To satisfy the miniaturization and easy maintenance, we developed a new automation unit.
The following points are features of the new automation unit.

Handling Unit

To satisfy the miniaturization, we developed a sample transportation unit. The sample transport unit uses a 4 axis arm. In existing system, there are lots of moving parts: crucible transfer, opening and closing of weighing machine cover, and the infundibulum jig for sample and accelerator. In Y and Z direction, the position is fixed by using for driving cylinder. Therefore each function part has to set to X direction.(Refer to Figure 3(a))
Developed new automation unit is using electric motor for arm moving system. The feature of this system is the thing that the arm movement zone can be set arbitrarily. By this function, the constraint of Z and Y direction is removed and then the possibility of alignment for transportation is expanded. As a result, the footprint of the automation unit is reduced.
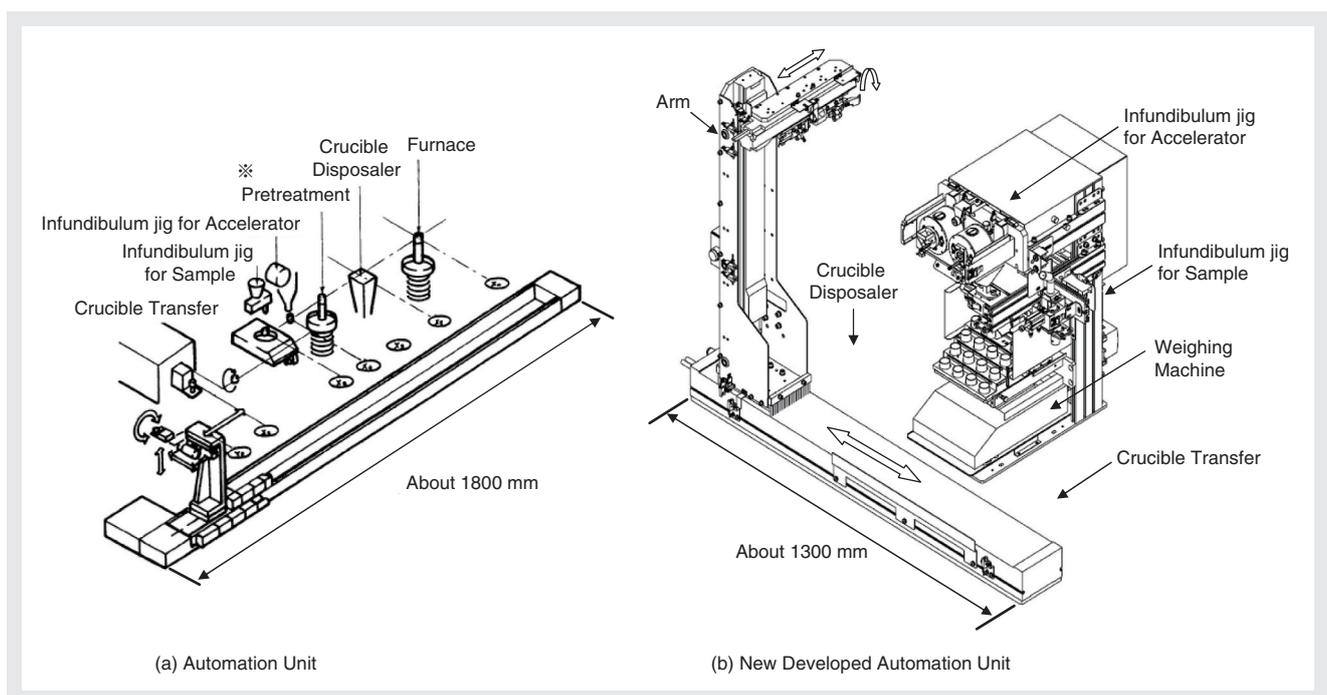As mentioned above, new automation unit substitute the

Figure 3   Automation Unit

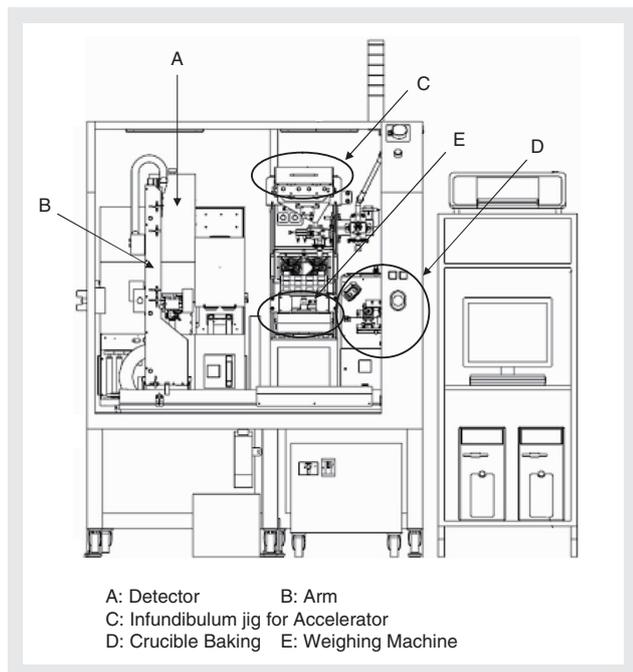electric driving arm for air cylinder. Maintenance part can be reduced in automation unit.

A: Detector   B: Arm
C: Infundibulum jig for Accelerator
D: Crucible Baking   E: Weighing Machine

Figure 4   EMIA-9200V

Interface

As automation unit, the other important point is the interface of the sample preparation unit. Recently, Local Area Network (LAN) which has the advantage of two-way and high-capacity communication is frequently used. By the use of the LAN as communication interface, automation unit can work with various sample preparation unit. The automation unit can flexibly respond to various requirements by LAN communication.

Conclusion

Chinese and Asian market in steel industry has grown very much to become top of the automotive production. Therefore, we need to develop anew analyzer which responds to the requirement of steel industry.
The steel plate for automotive industry is mainly high-quality steel. In the future, the production of high quality steel in China is expected to increase. Therefore the requirements such as the serviceability and the high accuracy are increasing in Chinese market.
We expect the developed analyzers in this time to reach Chinese market, and we would like to develop new analyzers which responded Chinese requirement.

References

[1] Technical Division of Instrumentation Control and System Engineering, Production and technology of Iron and Steel in Japan during 2009, Ferrum, 2010, Vol.15, No.3, p.22-41

[2] N. Kawabata, Competition for Building of Production System of High Grade Steel among the Integrated Steel Companies in East Asia, Ferrum, 2010, Vol.15, No.3, p.16-25.

[3] K. Tsuji, A. Hirano, Toward Greater Automation in Carbon/Sulfur Analyzer, Readout, 1991, No.2, p.73-74.

[4] A. Hirano, Toward Graeter Automation in Oxygen, Nitrogen, Hydrogen analyzer, Readout, 1992, No.5, p.64-73.

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