ADVANCE OF FERROUS METALLURGY AND WELDING CONSUMABLES PRODUCTION IN PRC (Review)

I.K. POKHODNYA and **A.S. KOTELCHUK**
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine

The paper presents the data on development of ferrous metallurgy and welding consumables production in China during the last decade. Components of successful growth of steel and welding consumable production in this country have been analyzed.

Keywords: *ferrous metallurgy, steel, welding consumables, production dynamics, organizational structure*

In 2009 PWI conducted Ukrainian-Chinese seminar, in which presentations were made by PWI staff members, as well as Prof. Tian Zhiling, Vice General Manager for Research of the «China Iron and Steel Research Institute» Group, on development of ferrous metallurgy and welding consumables production in PRC. This paper was prepared by the materials of this presentation [1], as well as the data of [2].

Ferrous metallurgy. After creation of PRC steel production in this country was growing at a relatively slow pace, starting from 158 thou t in 1949 and up to 100 mln t in 1996. The next 12 years were a period of rapid development of ferrous metallurgy. In 2008 PRC enterprises produced about 500 mln t of steel, which amounted to approximately 39 % of world production (Figure 1). Such a growth of cast iron and steel production is due to rapid economic development and increased demand, primarily, in the local market. Steel consumption by PRC enterprises in 2006 was equal to 442.5 mln t, with the fraction of metallurgy reaching 8 % of the gross national product.

Progress was due, primarily, to large-scale upgrading of capital assets and creation of modern metallurgical production. The Table gives the data on the scope of upgrading the equipment for production of cast iron and steel. A lot of attention was given to introduction of power-saving technologies. By 2006 44 units for dry quenching of coke were put into operation. Recycling of coke oven gas annually yields 2.6 bln kW·h of power, and recycling of blast-furnace gas — 3.6 bln kW·h.

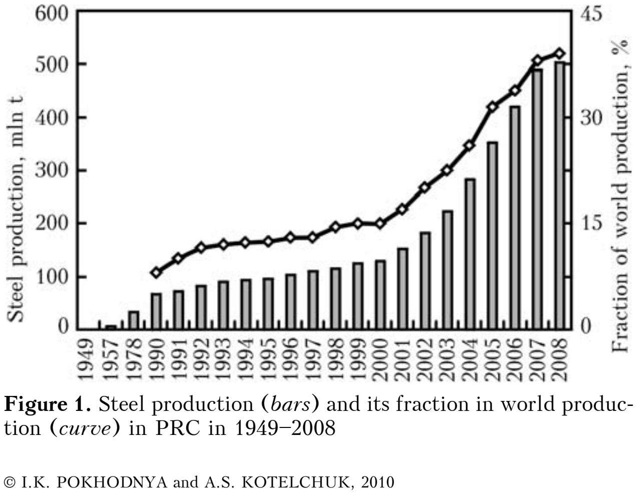

Figure 1. Steel production (*bars*) and its fraction in world production (*curve*) in PRC in 1949–2008

By 2006, 10 steam-gas power plants were in operation, allowing annual processing of 300 bln m^3 of gas and producing about 10 bln kW·h of power.

Advanced metallurgical technologies are widely used, namely injection of coal dust into blast furnaces, slag splashing on the converter refractory lining, continuous steel casting, hot loading of ingots and continuous rolling. During the period from 1990 to 2006 the fraction of billets produced in continuous casting machines increased from 25 to 99.7 %, and coal dust injection increased on average from 50 to 135 kg per tonne of produced cast iron. Slag splashing on the refractory lining allowed extension of converter operating life from 700–800 to 10 thou melts on average. Average power consumption decreased approximately 2 times — from 1611 to 734 kg of coal equivalent.

Compared to 2000 marked progress was has been made in recycling the wastes and introduction of recirculating water supply. Exhaust emissions were reduced from 18.7 in 2000 to 16.1 m^3/t of produced metal in 2004, SO_2 emissions were reduced almost two times from 6.1 to 3.2 kg/t, and water recirculation reached 92 %.

Starting from 2006, compared to 2000, the fraction of rolled plates and cold rolled sheets, electroplated metal, silicon steels, seamless pipes has increased greatly. Range of rolled products produced in PRC in 2000 and 2006 (thou t) is equal to: rails — 1580 and 3340 (increase of 111.4 %); large sections — 3600 and 9170 (154.7); rolled plates — 17440 and 85420 (389.8); cold-rolled sheets — 4950 and 26050 (426.3); electroplated metal — 3280 and 16250 (395.4); silicon steel — 640 and 3300 (415.6); seamless pipes — 4150 and 14840 (257.6). Technologies, ensuring an increase of metal purity, are currently introduced. The fraction of processed metal in 2006 reached 65 %. In the same year, 83 mln t of reinforcing-bar steel were produced, the fraction of reinforcing steel of strength class III being equal to 12.5 %. Technology of producing steel

Indices of upgrading of capital assets for cast iron and steel production

Metallurgical plants (volume, tonnage)		2002		2006	
		Quantity	Power, thou t	Quantity	Power, thou t
Blast furnaces	≥ 3000 m^3 2000–2999 m^3	3 17	9300 31490	12 37	35760 700090
Total		20	40790	49	105850
Oxygen converters	≥ 300 t 100–299 t	3 32	8190 48190	3 91	8190 124640
Total		35	56380	94	132830
Electric-arc furnaces	≥ 100 t	7	6730	14	11860

of this class envisages comprehensive alloying with vanadium, nitrogen and niobium. Ultrafine-grained steel is produced by a technology, using deformation-induced ferrite transformation.

New generation steels with up to 400 MPa yield point, high-strength steels with up to 800 and up to 1500 MPa ultimate strength are developed. Required mechanical properties of such steels are achieved through provision of their high purity and uniformity, as well as ultra fine-grained structure (about 2 μm grain size).

In connection with development of automotive industry in China, deep-drawn cold-rolled steels, high-strength steels of several types, namely low-carbon and improved high-strength steels have been developed. Fraction of shipments of Chinese hot-rolled sheet steel for automotive industry in 2005 was equal to 87, and that of cold-rolled steel was equal to 62 %.

Steels for the main pipelines of X80, X100 and X120 grades have been developed. The world's longest pipeline from steel of X80 grade — «West–East» II pipeline is under construction, its length reaching 7000 km. Chinese spirally-welded pipes of up to 1219 mm diameter with 18.4 mm wall thickness are used for its construction. Developed steel of X80 grade has impact energy on the level of 368 J at −40 °C; fraction of the tough component in the fracture SA (DWTT) is not less than 90 % at −15 °C. Such steels are characterized by a low content of carbon (approximately 0.03 wt.%); niobium alloying (about 0.10 wt.%) and rolling, initiating ferrite formation at deformation, are applied.

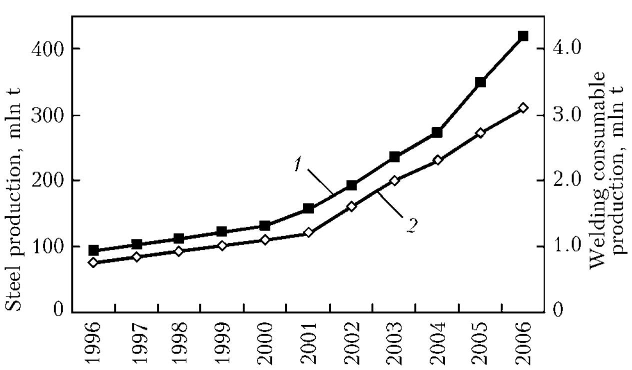

Figure 2. Production (*1*) of steel and welding consumables (*2*) in PRC in 1996–2006

Production of stainless steels is developing. In 2006 their production volume reached 5.3 mln t [1], in 2008, despite the production drop compared to 2007 by 3.6 % , it was 6.9 mln t, which amounted to 27 % of world production of stainless steels [3]. Steels alloyed with nitrogen on the level of up to 0.7 wt.% are being developed, they having not less than 600 MPa yield point and 1000 MPa ultimate strength.

The given data are indicative of an unprecedented progress of ferrous metallurgy in PRC. Most of the produced steel rolled stock is sold in the domestic market. In 2006 China produced 467 mln t of steel, exporting 43 mln t, and imported only 18.5 mln t. Domestic consumption was 442.5 mln t. That is why the world crisis phenomena had little effect on PRC metallurgical production.

Welding consumable production. Welding consumable manufacture in PRC has intensively developed over the last decade and in 2006, compared to 1999, it increased more than 4 times (Figure 2). Structure of the manufactured products has also changed. Fraction of solid wire for gas-shielded mechanized welding increased several times, production of coated electrodes for manual welding decreased, and fraction of materials for submerged-arc welding stayed on the same level and remains to be 10–12 % (Figure 3).

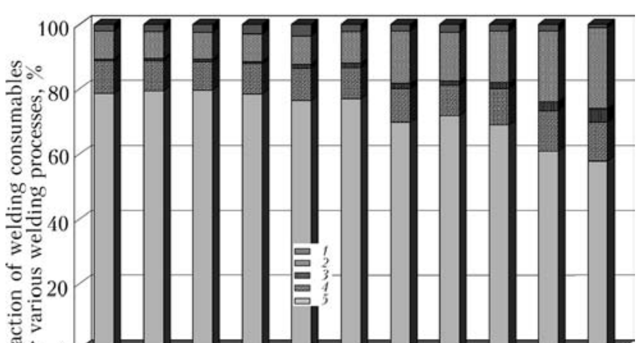

Figure 3. Structure of welding consumable production in RPC in 1996–2006: *1* — consumables for nonconsumable electrode arc welding; *2* — solid wire for gas-shielded welding; *3* — flux-cored wire; *4* — submerged-arc welding consumables; *5* — coated electrodes for manual arc welding

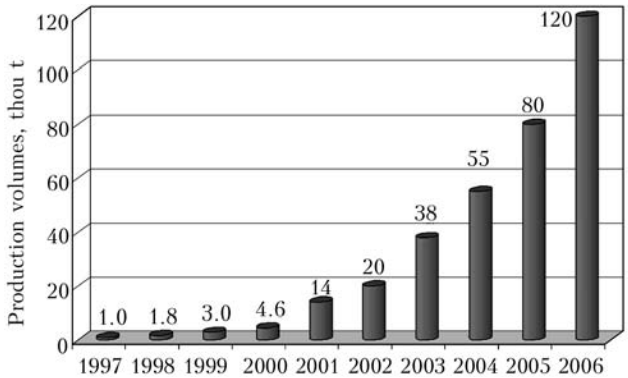

Figure 4. Dynamics of flux-cored wire production in 1997–2006

Figure 4 shows the dynamics of flux-cored wire production. Initially, flux-cored wire production in PRC was organized in 1995 by a license from PWI. Annual efficiency of the line was 1000 t. During this decade the volume of flux-cored wire production increased several times, and in 2006 it was equal to about 120 thou t. PRC specialists have properly appreciated the advantages of welding consumables of this kind. By their predictions by the end of 2015 the overall production of welding consumables in China will reach 3.5–4.0 mln t, here the fraction of coated electrodes for manual arc welding will drop to 22 %, fraction of solid wire for CO_2 welding will rise to 50 %, and that of flux-cored wires will increase up to 15 %. Fraction of consumables for submerged-arc welding will remain on the level of 12 %, and that of consumables for nonconsumable electrode welding will be about 1 %.

China Iron and Steel Research Institute Group. China Iron and Steel Research Institute Group (CISRI) was established in December, 2006 and approved by the Assets Supervision and Administration Commission (SASAC). CISRI was formed as a result of merging of the earlier Central Iron and Steel Research Institute, and Automation Research and Design Institute of Metallurgical Industry, the assets of which were evaluated to be 6.6 bln yuan (about 900 mln USD) [2].

As one of the first 103 test innovation enterprises CISRI is the research base for development of metallic materials, innovation base for key technologies of metallurgical industry, as well as the authorised agency for analysis and tests for metallurgy.

CISRI has 10 national engineering research centers, including National Engineering Research Center of Advanced Steel Technology, National Engineering Research Center of Continuous Casting Technology, National Amorphous and Nanocrystalline Alloy Engi-

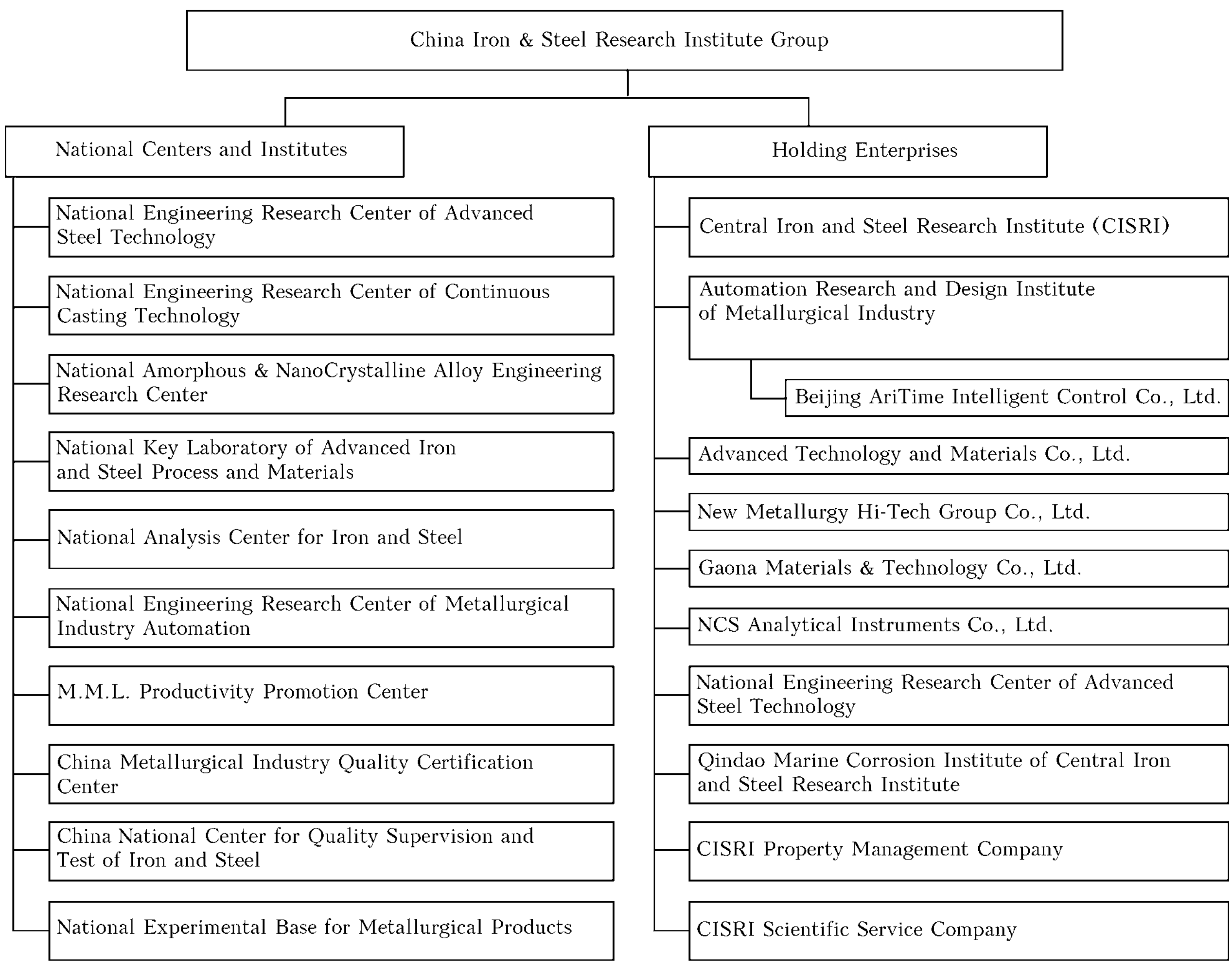

Figure 5. Institutes, engineering centers and enterprises of CISRI Group

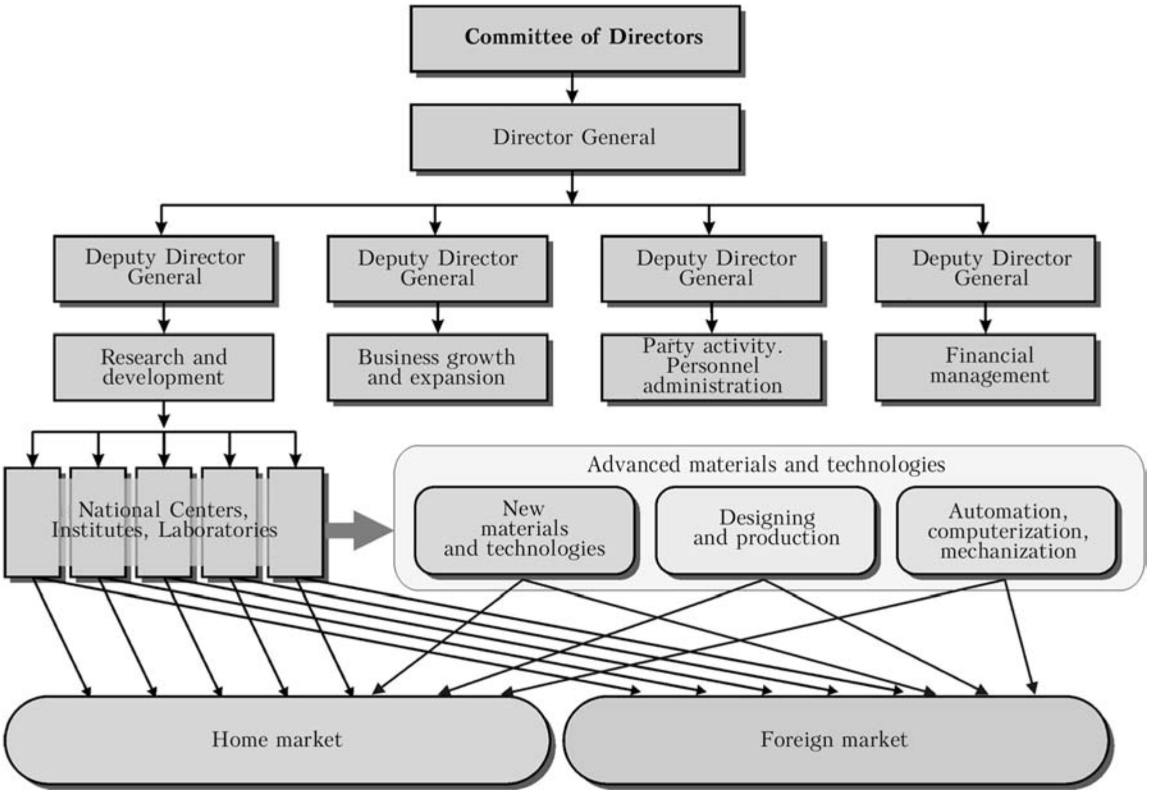

Figure 6. CISRI organizational chart

neering Research Center, National Research Center of Metallurgical Industry Automation, etc.

For promotion of large-scale and international projects and products into industry, CISRI is quickly developing advanced materials, automation technologies, applied technologies, conducts development in the instrument-making and analytical field. Figure 5 gives the structure of enterprises and organizations, included into CISRI group. In order to facilitate the realisation of R&D results, CISRI founded several limited liability joint stock companies. Two companies were initially established: Advanced Technology and Materials Co., Ltd and Beijing AriTime Intelligent Control Co., Ltd, and then several more high-technology enterprises, such as New Metallurgy Hi-Tech Group Co., Ltd and Gaona Materials & Technology Co., Ltd [2].

CISRI has approximately 5800 employees, of which 2800 are staff members, and about 3000 are temporarily employed under contracts. These temporary employees are a constant source for adding new staff to the Institute. In 2007 CISRI annual budget was equal to 500 mln USD. The main sources of funding are state budget (about 10 %), orders from state industrial enterprises (approximately 30 %) and funds from sale of proprietary developments (approximately 60 %).

Figure 6 gives the organizational chart of CISRI. Restructuring conducted in 2006 promoted an increase of research efficiency, and acceleration of introduction of the results of investigations and developments into industry.

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3. (2009) World stainless steel output falls by 6.9 % — China Mining. http://www.chinamining.org/News/2009-03-13/123690966d22451.html