

THE INTEGRATED AUTOMATION SYSTEM OF IRON & STEEL ENTERPRISE

Chai Tianyou Li Huiying Yu Zhangxiong

Research Center of Automation, Northeastern University, Shenyang, P.R.China, 110004

Li Huafu

Handan Iron & Steel Group, Heibei, P.R.China, 056015

Abstract: In order to improve product quality, reduce cost, increase enterprise competitive power, Integrated Automation System (IAS) should be applied. On the basis of the architecture of process industry IAS, according to the production procedure of Handan Iron & Steel Corporation, combining the famous Handan Iron & Steel Group experiences with the 3-layer structure, the Integrated Automation System with financial management system at its center and cost control as the main line is designed. Since it has been applied in Handan Iron & Steel Corporation. Remarkable practice benefits were achieved.
Copyright © 2002 IFAC

Keywords: Integrated Automation System; Manufacturing Execution System; Cost control

1. INTRODUCTION

Based on advanced manufacturing technique, modern management technology and information technology, the Integrated Automation System (IAS) of manufacturing process brings about optimized operation, control and management, improves enterprise competitive power through considering the enterprise management, manufacturing process control, operation and management as a whole entity to control and manage (Li Bohu, *et al.*, 1998a; Li Bohu, *et al.*, 1998b). International advanced metallurgical enterprises have established IAS in varying degree (O.araif, 1995). IAS that was founded in developed country (Including USA, Japan, Korea etc) had achieved comprehensive economic results.

IAS realizes the integration in the process of manufacturing management and control of enterprise. It relates to management pattern closely. Since management pattern of past enterprise is pyramid-style. Purdue model (CIM Reference model committee, 1989), which divides manufacturing

process into process control, process optimization, production schedule, enterprise management and management decision, was used in IAS. It separates the control from management of manufacturing process obviously, and ignores the material consumption, energy consumption in the process and the real-time control and management of equipment. The layer is many; the structure is complicated, the cost of realizing CIPS is high. It is difficult to form software platform and to extend. At present with the development of information technology and computer net technology, the management pattern has become flat model. And research on 3-layer IAS structure of flat management, is the hot point.

In this paper, ERP/MES/PCS (shown in figure 1) have been first used in Iron & Steel plant to improve competitive power. Based on ERP/MES/PCS process industry IAS in which MES is regard as key point has been practically applied in Handan Iron & Steel Co. successfully. It also brings about great economic & social profits for enterprise. (M.Nakamura and K.Masada, 2000; M.Nakamura, 2000).

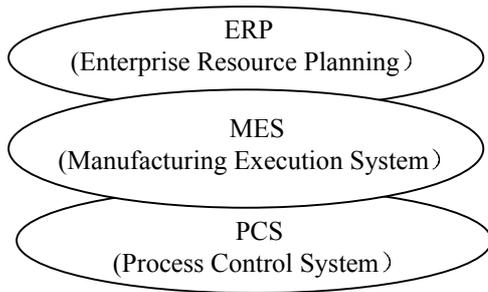


Fig. 1. 3-layer structure

2. TECHNOLOGICAL FLOW AND MANAGEMENT MODE IN HANDAN IRON & STEEL CORPORATION

The production process in Handan Iron & Steel Corporation is composed of coking, sintering, iron making, steel making and rolling. Raw material office and sale office are starting point and terminal point separately. The main production flow diagram begins with the washed coal and concentrated ore. Coke oven turns washed coal into coke. Sintering furnace turns concentrated ore into sintered ore. Blast furnace turns coke and sintered ore into melted iron; steel-making furnace turns melted iron into ingot. At last rolling turns ingot into steel. Shown in figure 2.

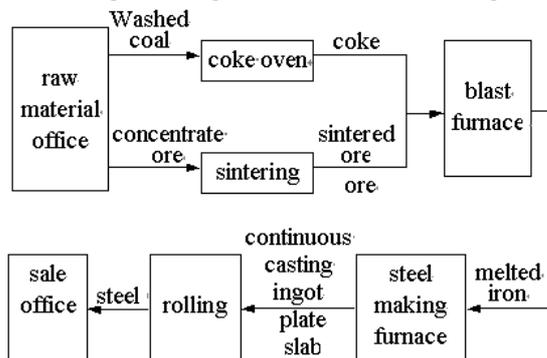


Fig. 2. Technological flow diagram in Handan Iron & Steel Corporation

“Simulating market accounting, exercising cost veto” is the advanced management experience, which suit for China actual situation. Its management model is “market — inverting — veto — entire staff”. Market, simulating market mechanism was practiced in internal enterprise. Inverting, the method to account cost from the start to the end procedure by procedure is turns into from the end to the start. Veto, income distribution and staff achievement checking are based on cost and profit. Entire staff, every staff shares responsibility for cost index or expense index, carries out whole staff — whole process management.

3. INTEGRATED AUTOMATION SYSTEM ON HANDAN IRON & STEEL CORPORATION

3.1 System Structure

There are four sub-systems in Integrated Automation

System in Handan Iron & Steel Corporation (IASHC): Enterprise Resource Planning (ERP), Manufacturing Execution System, Process Control System and Computer Network & Database System. Shown in figure 3. Based on ERP/MES/PCS three-layer structure combined with practical conditions, the following structure of IASHC is introduced on the basis of advanced information technology, modern management technology and advanced metallurgical production technology.

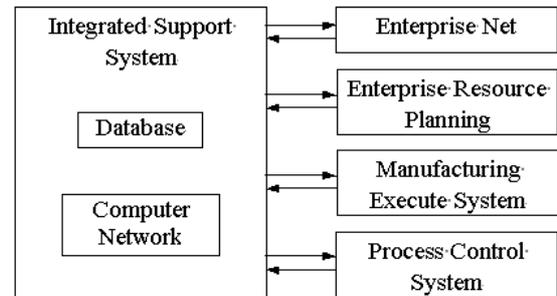


Fig. 3. the structure of IAS in Handan Iron & Steel Corporation

3.2 Functional Description

The Function of PCS; Shown in figure 4, PCS includes sintering, coking, iron-making, steel-making and continuous casting & continuous rolling. In order to meet the demands of product quality and technique, advanced control technology is used in those control systems. PCS is a base for enterprise to accomplish processing automation and information integration. By the aids of advanced automation appearance, its main task is to accomplish stable control for manufacturing process by logistic control, sequential control and loop control. It also provides friendly human-machine mutual interface for human to interference the process.

Oriented by finance management of ERP; ERP consists of raw material management, supply management, spare parts management, human resource management, item invest management, sales management, finance management, fixed assets management, plan management (energy plan, production plan, material plan, production cost). Overall optimized technique whose key point is finance analysis & decision is employed to distribute these resources under the circumstance of anticipated profit. ERP is a base of control and decision for upper management and administration in enterprise. It is also an effective way to improve enterprise management and administration. According to market and the level producing & administration in metallurgical enterprise, it adjusts its strategy decision, producing plan and investment. Thus rational disposition of human resources, funds and material resources can be achieved. It also sharpens the ability of promptness and accuracy in information collecting, data

transferring, data statistics and report forms submitting. At last it decreases the dependence on human in enterprise management, taps the potentialities of resource in an enterprise, and realizes the integration of fund flow and information flow. So high competitive power of enterprise can be brought about through effective organization of production.

Cost control as main line of MES; MES contains energy schedule & management, production statistics & analysis, production schedule, material control & management, production cost control & management, equipment management, quality management, safety management and process optimization. MES in which economical index is applied as a target to run optimized operation optimized control and optimized management makes it possible to real-time control energy consuming, material consuming and equipment. It

also decreases dynamic cost occurring in the process of manufacturing and utilization of equipment. MES is the core technique system in optimization and management of manufacturing process. Close-loop control in logistics and fund flow can be achieved by the way of effective controlling of information flow (Chen Zhenyu, 1994). In one hand MES and PCS are linked closely in order to establish mathematics model of process object by intelligent control technique. Once effective optimized method and suitable working parameter utilized, optimized control & operation are developed in the manufacturing process of metallurgical enterprise. Then the target to decrease the production cost is attained by stable technological index and effective production capability. On the other hand MES and ERP are interrelated. Following the production plan of ERP, MES arranges production with the hand of production schedule management.

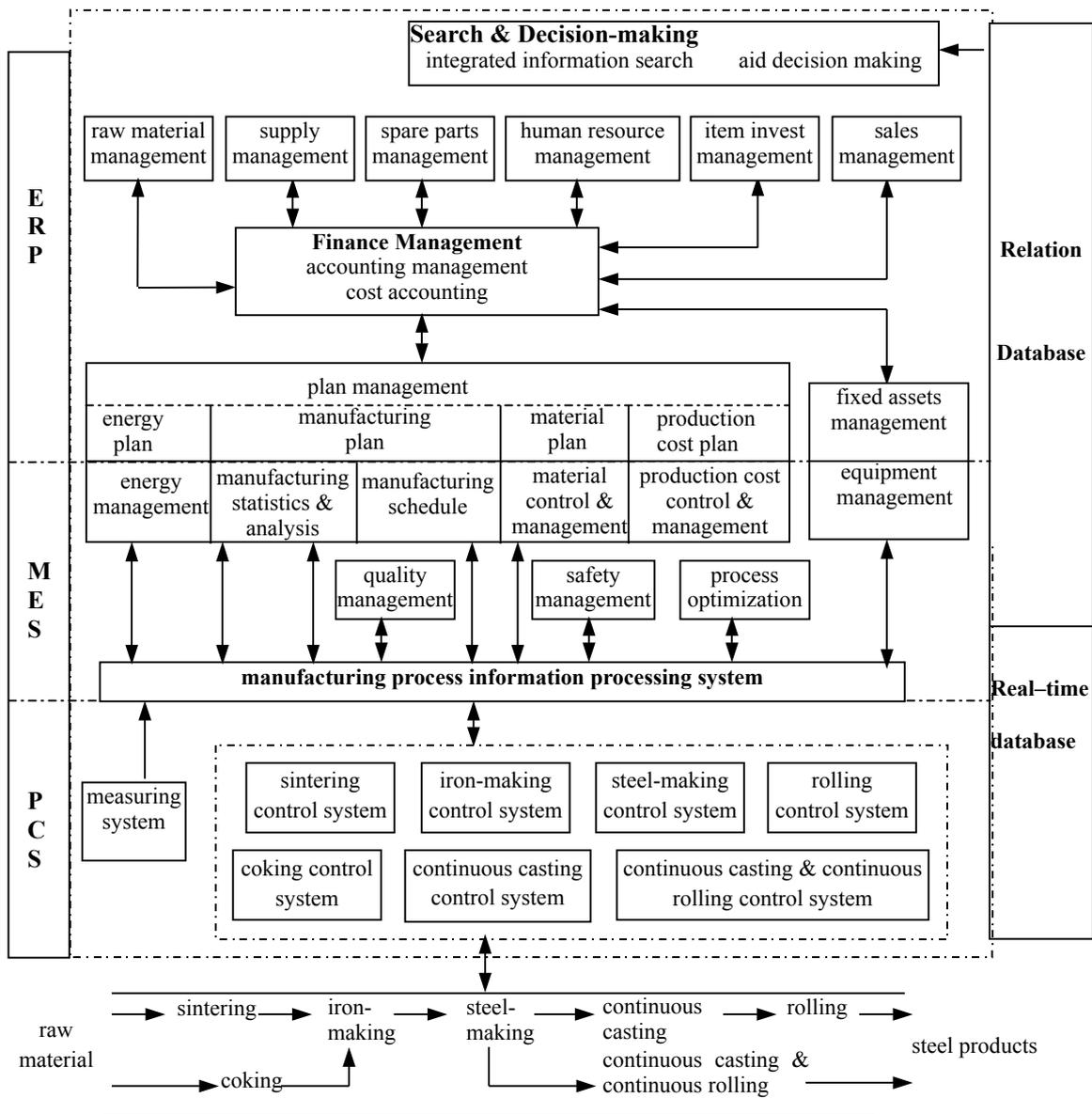


Fig.4 the function figure of IAS in Handan Iron & Steel Corporation

It collects, filters and transfers the process information at the manufacturing process of metallurgical enterprise, and then submits it to upper strata ERP as a base to work out production plan. MES carries out effective and reasonable plan, arrangement, control and adjustment by connecting resources (human, funds and materials) and circles (production, purchasing and sale). MES makes best use of those factors for continuous harmonious production, low stock and little occupation of funds.

3.3 Function of Integration

The function of MES is to connect upper and lower layer. Administration decision to market must be handled and transferred by production management system accurately and promptly, and then transformed to reaction of production systems. ERP can be integrated with PCS through information control and management of production in MES. Plan management, finance management, Raw material purchase and sale management in ERP are integrated with production process data-collecting system of PCS through energy management, production statistics & analyses, production schedule, production material control and production cost control in MES which handle and manage energy and production data. The production instruction transmit time from top to bottom is shortened. The production

information feedback speed from bottom to top is accelerated. Thus it is possible to provide response for production promptly. It also decreases the stock and provides reasonable, accurate purchase information for raw materials, the best precise benefit sale information based on production cost and production amount, exact strong data base for finance cost accounting. Fixed resources management of ERP is integrated with equipment supervising systems of PCS through equipment management of MES. Thus it makes possible for full utilization rate of production equipment. Computer network and database system accomplish the rational arrangement of computer system, realize the integration of net, information, function and appliance, and provide a transparent net circumstance and friendly custom interface. High reliability and security meet the demand for opening and standardizing. The integration of metallurgical enterprise IAS is also the integration of fund flow, material flow, information flow in this system.

4. APPLICATION

It is necessary to employ IAS in Handan Iron & Steel Corporation to improve product quality and win the competition. Now IAS in metallurgical enterprise is developing rapidly in our country (Chen Zhenyu, 1994) and makes it as the nation key model project in Handan Iron & Steel Corporation on Nov. 1999.

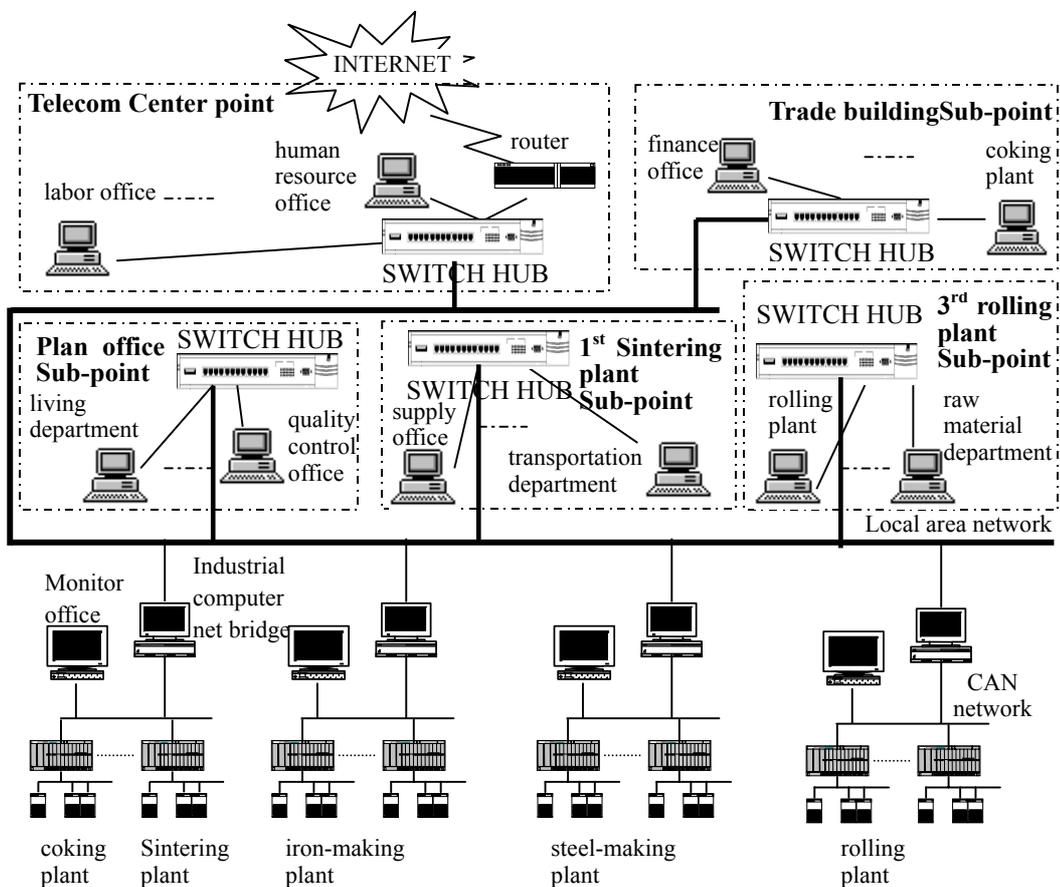


Fig.5 network structure of Handan iron & steel corporation IAS

Because of the resources of time, funds, human and materials, IAS in Handan iron & steel Corporation is applied and implemented following the principle of step-by-step. The first step of IAS in Handan iron & steel Corporation has finished researching and developing ERP (including finance management, cost management, human resources management, manufacturing plan management, item investment management, spare parts management, fixed assets management, raw material management, sales management) and MES (including production data measuring management, manufacturing process cost control management, manufacturing data statistics management, material control management, raw material quality testing management), and has realized their integration through computer network & database system. The computer network structure of Handan IAS is shown in figure 5.

Handan iron & steel corp. The enterprise main net consists of 1 net center point, 4 sub-points and local area network (LAN). The center point in center net uses CoreBuilder9000 of 3Com. Sub points use CoreBulider3500 or Super Stack II 3900. Database server is SUN Enterprise 250 list server. Document server and region server are HP-LH4. Database is ORACLE 8 and SQL 7.0.

4.1 Cost control on-line management system

The practical cost-control management system connects closely with model project and work site environment. Since control theory and method are used in cost-control management (CCM), it makes the experience of Handan iron & steel Corporation (simulating market accounting, exercising cost veto) more scientific and systematic.

Considering the organization and unit dispatching in

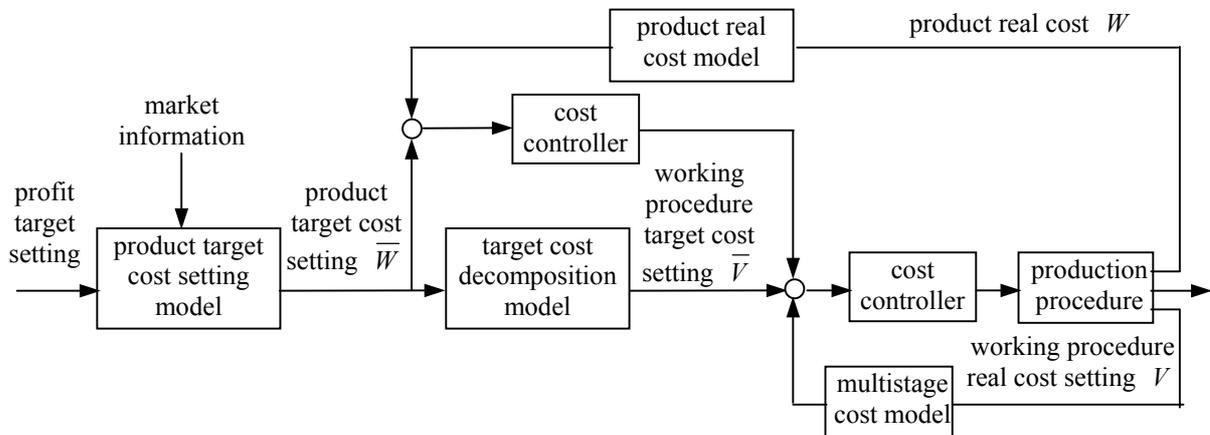


Fig.6 dynamic cost control system

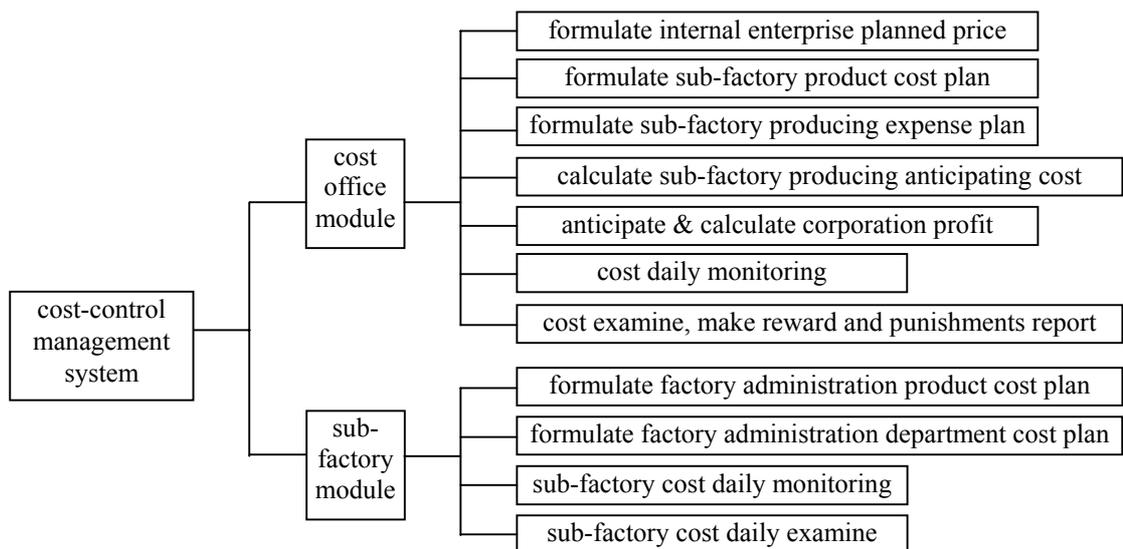


Fig.7 the function tree of cost control management system

Combined the optimization setting control method (T.Y.Chai and Shouping Guan, 1998) in industry process with the cost control technology of Handan iron & steel Corporation, a new on-line cost control technology was put forward. The

method to control cost in Handan iron & steel Corporation is based on the control system. Under the circumstance of profit target, by using the optimized setting control technology, dynamic tracking and collecting are used in cost data of

every working procedure and circle to build target cost setting model, target cost decomposition, product real cost model, and cost controller. Thus feed-forward and feedback multistage dynamic cost control system is accomplished, shown in figure6. The function of dynamic cost control system was shown in figure 7.

The exploitation of CCMS strengthens the informatization in corporation, improves the efficiency of cost-control management in whole staff and whole process, and consolidates the characteristic management & administration of HanDan iron & steel corporation (simulating market accounting, exercising cost veto). The quick and accurate treatment in cost and correlated data make the collecting, handling and analyzing of cost data more quickly and accurately. The more rapid feedback among cost control office, the more efficiency and promptly is in cost-control.

4.2 Application effect

The employment of cost control system makes it possible to define target cost rapidly and accurately. It can also lay a foundation for decreasing cost and increasing profit. Rapid and accurate feedback can transform cost monthly account into anticipating weekly analysis. Thus it's easy to establish daily cost control and retrieve the lose caused by deviated plan target about 20,000,000 Yuan (RMB)/year. Materials balance controls quantity materials consuming, strengthens the management of every sub-factory, puts the evaluation of output on the base of quantification, and ensures the validity of data among sub-factories. It can also adjust production through analysis of quality index in sub-factory, decrease loss and cost about 15,000,000 Yuan (RMB)/year. The linking net of selling and accounting offices can share the common data, tighten the rules and stop up all loopholes. It can also keep informed on all kinds of sales information (including production stores, sales channels market analysis, price, profit, etc). Thus corporation is able to adjust its production by selling more production that meets the market needs, by producing more high attached value production to increase profit, decrease stock money and deserved funds, and speed up capital turnover. According to enterprise profit analysis report, the first step of IAS in HanDan iron & steel Corporation brings about the profit about 127,000,000 Yuan (RMB).

IAS in HanDan Iron & Steel Corporation improves the traditional working method, strengthens the supervision, improves the efficiency and accuracy, and improves the dispatching of human. Monitoring and controlling on the production process it decreases unnecessary waste, expending, and decreases the cost in every aspect, and increases enterprise competitive power. IAS in HanDan iron & steel corp. will give great impetus to promote the experience in our country.

5. CONCLUSION

Combined the ERP, MES & PCS with the advanced management technology of HanDan iron & steel Corporation, the Integrated Automation System in industry process is founded, and applied in HanDan iron & steel Corporation successfully. The application of IAS should be combined with specific management characteristics of enterprise. And the level of management, technology should be also considered. IAS in HanDan iron & steel Corporation not only makes the advanced-management-experience more informational and systematic, but also integrates the material flow, value flow and information flow, at last on-line cost control is accomplished.

ACKNOWLEDGEMENTS

The author would like to thank the National 863 high technology Project and the Natural Science Foundation (60074116) for their financial support.

REFERENCES

- T.Y.Chai, Shouping Guan (1998), "Object-Oriented Integrated Control Technology of Complex Industrial Processes", *5th IFAC Symposium Low Cost Automation*, PS P1, 3-11.
- Li Bohu, Dai Zhonghai (1998a), Decade Retrospect and Prospect of CIMS Application Reference Sites (CIMS- ARS), *Computer Integrated Manufacturing System CIMS*, No.3, Jun, P3-9 (In Chinese)
- Li Bohu, Wu Cheng (1998b), The Development of contemporary Integrated Manufacturing & The Implementation strategy of 863/CIMS Subject, *Computer Integrated Manufacturing System CIMS*, No.5, Oct, P7-15 (In Chinese)
- CIM Reference model committee (1989), Purdue University, A reference model of computer integrated manufacturing from the viewpoint of industrial automation, *Computer integrated manufacturing Vol.2*. No.2. P114-127
- M.Nakamura and K.Masada (2000), *MES Introduction*, Kogyo Chosakai Publishing Co., Tokyo (In Japanese)
- M.Nakamura (2000), The development trend of MES function, *Chemistry Equipment*, Jan, P93-101 (In Japanese)
- O.araif (1995), The Integrated Production Planning and Scheduling System in Kashima Steel Works, *Proceeding of IBM International Steel & Metals Conference, Belgium*, P433-438
- Chen Zhenyu (1994), The development and prospects of CIMS of Chinese iron and steel industry, *Metallurgical Industry Automation*, Vol.18, No.6, P3-6, 25 (In Chinese)