



宝钢学术年会  
Baosteel Annual Academic Conference

# 首届宝钢学术年会论文集

第二分册：冶金设备及自动控制

## Baosteel AAC '04 Proceedings

May 27-28, 2004  
Shanghai, China

**Volume 2**  
Equipment and Automation

上海宝钢集团公司  
Shanghai Baosteel Group Corporation

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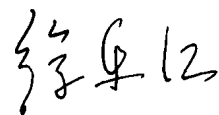
# 前 言

首届宝钢学术年会(Baosteel AAC'04)于2004年5月27~28日在上海宝钢召开。这是宝钢第一次举办这样的开放式、大型国际学术交流会。中国钢铁市场及钢产量的快速增长已成为举世瞩目的焦点,宝钢作为中国最大的钢铁制造企业,在中国和世界钢铁工业的舞台上扮演着重要的角色。我们希望通过积极认真地举办宝钢学术年会,搭建起世界钢铁科技进步的交流平台,为推动世界钢铁业的技术进步和可持续发展作出更积极、更有价值的努力和贡献。

全球钢铁工业的快速发展引发了一系列“能源”、“资源”和“环境”等方面的问题。如何正确理解和实施科学发展观,是宝钢长期以来十分重视和致力去完成任务,我们也有着较多的认识和实践,我们将本届年会的主题定为:“可持续的钢铁,可持续的未来”。宝钢十分愿意面向世界,博采众长,加强技术交流与协作,坚持可持续发展观念,共同推动冶金科技进步。

非常感谢国内外广大专家学者对本届学术年会的大力支持和热情参与,也非常感谢宝钢内外的广大科技工作者在较短时间内为大会提供大量高水平、有价值、有影响力的学术论文。对于来自国内外的430篇论文,我们组织专家认真筛选,确定170余篇结集出版。本《论文集》共五册,包括主题报告分册、碳钢生产工艺技术及其产品研发(第一册)、冶金设备及自动控制(第二册)、节能技术、环保和可持续发展(第三分册)、不锈钢和特殊钢生产工艺及其产品研发(第四分册)。希望我们的工作能得到广大科技工作者的理解和肯定。特别感谢本届年会学术委员会成员和顾问专家们为大会成功召开所做的努力和贡献,衷心感谢本届年会的筹备人员和本《论文集》编辑人员所做出的努力。

由于时间和水平有限,《论文集》中疏漏与错误难免,恳请读者批评指正。



2004年5月

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## Customer-driven Agile Manufacturing System of Baosteel

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**Abstract:** Since the very beginning of 1990s, agile manufacturing as well as its methodology has aroused great attention all over the world, becoming key target for research in such areas as machining, controlling system, IT industry and management. With the quickening pace of world economy globalization, the competition of the markets for iron and steel products are getting much more severe. Under these circumstances, it is becoming imperative to construct a highly efficient agile manufacturing system conforming to the specifications of iron and steel products' R&D, manufacture, sales and service, with the aim to survive the fierce market competition. The production of Iron & Steel Enterprises is a long-term manufacture mode mixed with chemical process and physical process. The processing mode of iron and steel manufacturing has its own unique style. Developing agile manufacturing system in iron and steel enterprise, people will inevitably meet some difficulties and have to work in line with its conditions. Based on the actual manufacturing and management strengths and by means of modern IT technology, since 1996, Baosteel Group has developed four crucial agile manufacturing subsystems, namely integrated manufacturing subsystem, data warehouse subsystem, quick responding subsystem and on-line sales subsystem, catering to the requirements of various customers with quick response. Till the end of 2003, the whole system has basically been completed. By using this system, Baosteel has so far achieved high efficiency, decent economic profits as well as good feedbacks from customers. In accordance with the managerial characteristics of Iron and Steel enterprises, this paper briefs design concept, usage, application and realization of agile system of Baosteel Group. To make things clear, one case in point is also included.

**Key Words:** Agile manufacturing; Baosteel Group; Iron & Steel

### 1 Introduction

In early 1990s, agile manufacturing as well as its methodology has aroused great attention around the world, becoming key target for research in such areas as machining, controlling system, IT industry and management. Great achievements have been attained in machining industry over a decade long research. Particularly, cutting-edge technologies such as Flexible Manufacturing System (FMS), Flexible Manufacturing Center (FMC), Machining Center (MC), Numeric Controlling (NC), Materials Requirement Plan (MRP), Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) contribute direct to the improvement of manufacturing and assembling.

As is known to all, The production of Iron & Steel Enterprises is a long-term manufacture mode mixed with chemical process and physical process. The pro-

cessing mode of iron and steel manufacturing has its own unique style. Normally, the processing sequence of iron and steel making is just the reverse of that of assemblage, thus in terms of management method, which is different from those traditionally based on MRP/BOM. Besides, hardly has any study analyzed managerial methods of iron & steel enterprises in detail.

Due to the acceleration of world economy globalization, more fierce competitions in the market of iron & steel products is inevitable, no wonder it's imperative to develop the highly efficiently agile manufacturing system in accordance with the specifications of R&D, manufacture, sales and after service of iron and steel production to survive the market competition. Based on the actual manufacturing and management strength and by means of modern IT technology, with vital information from both Baosteel and other companies, since

1996, Baosteel Group has been developing four crucial agile manufacturing subsystems, namely integrated manufacturing subsystem, data warehouse subsystem, quick response subsystem and Baosteel-online-sales subsystem, catering to the requirements of various customers with quick response. Till the end of 2003, the whole system has basically been completed. By using this system, Baosteel has so far achieved high efficiency, decent economic profits as well as good feedbacks from various customers.

In the light of the managerial characteristics of Iron and Steel enterprises, this paper briefs core design idea, module and application of agile system in Baosteel Group. To make things clear, one case in point is also included.

## 2 Main features of agile manufacturing system of Baosteel

### 2.1 Analyses of customers' different requirements to Baosteel

After China's entering into the WTO, Chinese enterprises will inevitably face the real challenges brought about by the world economy globalization. Because customers have a wider option, they are becoming more critical to the iron & steel products as well as its service: mainly this criticalness could be summarized in five categories as follows:

**Time:** Quick response to ordering; accurate delivery time; shortest manufacturing cycle; fast and easy inquiry.

**Quality:** products with high quality; catering to customers' special requirement; critical testing condition and standard (international certification and third party testing).

**Cost:** loan and interest settlement with great precision; categorizing manufacturing cost.

**Service:** high-level service to customers (manufacturing products according to customers' special requirement, flawless transaction, on-time delivery).

**Optimization:** collecting information in time; continuous optimization of products types; keeping on improving product quality and service; optimization of manufacturing process and upgrading core competitiveness.

Needless to say, the five categories mentioned above are integrated each other, which will be import factor to evaluate the capability and competitiveness for every iron & steel enterprise. Respectively, the main design idea of the agile system in Baosteel conforming to these categories is to satisfy customers' requirements with quick response in a close loop.

### 2.2 Operation mode of the customer-driven agile manufacturing system in Baosteel

In order to satisfy customers' need, following steps depict the major operation mode of the agile system concerning on information processing:

**Step 1:** Collect customers' requirement for products through Internet or receive customers' requirement through Baosteel's website on the Internet, then evaluate customers' order with quick response.

**Step 2:** For those received order, organize and optimize production procedure according to customers' requirement on product quality and quantity.

**Step 3:** Make sure the production process strictly in tune with sales process and on-time delivery.

**Step 4:** Provide customers with excellent service, including the continuous improvement of product quality, new production development together and quick information communication.

All the business data above will be integrated into Baosteel's data warehouse so as to be analyzed and processed in time. With data processed, data warehouse provides various useful information and KPI with analyzed report of different categories, contributing to the effective operation & management in Baosteel, lowering cost, improving efficiency and upgrading customer service standard by using new technology, thus forming the PDCA (Plan-Do-Check-Assess) cycle of production and management (Fig.1).

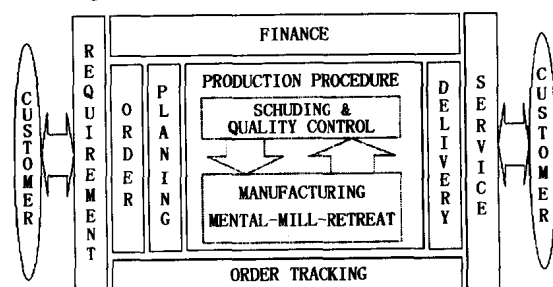


Fig.1 Cycle of production and management



From the figure we can see the main functions of the agile system in Baosteel include:

(1) Management of customers' requirement, including two modes:

a) Requirement forecasting mode: With management and forecast of customers' requirement and laying out strategic customer as features.

b) Sales and planning mode: With price management, sales planning, products group optimization and profit forecast as features.

(2) Response to customers' order and order signing, mainly including:

a) Responding to customers' inquiry: Quick responding to customers' inquiry based on technology standard and production capacity.

b) Order signing and management: Designing and printing customers' order and managing customers' order and tracking customers' record.

c) Managing production capacity in real time: Showcasing actual situation of every procedure during manufacturing of iron & steel products and production capacity.

d) Delivery time inquiry and confirmation.

(3) Sequencing customers' orders, mainly including:

a) Order optimization with production batch

b) Order optimization with Sequence plan

c) Materials allocation.

(4) Production controlling

Mainly including operation schedule management and quality control. The crucial technological difficulty of operation planning management is to strictly carry out the schedule throughout the whole working procedure, from steel making to continuous casting till to hot rolling, just as train running chart.

(5) Final products delivery

Mainly including such businesses as the storage, delivery, distribution and tracking of the final products, i.e. managing everything in respect of final products delivery on the basis of warehouse capacity and transport capability as well as the transport means, delivery time and place decided by customers' order.

(6) Tracking customers' order

This part mainly concentrate itself on tracking all

the information including order receiving, signing, sequencing, manufacturing, delivering and settling to make sure fulfilling the order with precise, in-time production and delivery time.

(7) Financial management

Including capital management throughout every manufacturing process, such as order signing, sequencing, manufacturing, delivering and settling as well as cost management. Every manufacturing process will be accountable by means of relating each process with the respective account.

(8) Customer service

This part includes on-line info service (such as order production progress, product quality certificate, financial settlement and products en route information, etc), quality dispute management, products usage support and after service and customer relation management.

### 3 Main function of agile system of Baosteel

The customer-driven agile manufacturing system in Baosteel is a large-scale one, which subcategorizes in four subsystems, namely integrated manufacturing subsystem, data warehouse subsystem, quick response subsystem and on-line sales subsystem. Eight main functions mentioned above would be realized by relative subsystems through overall planning, different stage construction and putting into operation step by step. As depicted by table 1.

#### 3.1 Integrated manufacturing subsystem

Main function of integrated manufacturing subsystem includes real-time management from contract signing to fulfillment and from raw material for iron & steel making to final product delivery, covering all main production lines throughout Baosteel, that is, iron-making, steel-making through converter with the capacity of 250 tons and 300 tons per hr, steel-making through arc converter, blooming, wire coil making, hot rolling with the maximum width of 1580mm and 2050mm, cold rolling with the maximum width of 1420mm, 1550mm and 2030mm respectively. Two units, i.e. production implementing unit and production managing unit, realize the major functions of the integrated manufacturing subsystem.

**Table 1 Main function of agile system of Baosteel**

Code	Main function	Integrated manufacturing subsystem	Data warehouse subsystem	Quick response subsystem	On-line sales subsystem
1.1	Requirement forecast			☆	△
1.2	Sales planning		△	☆	
2.1	Inquiry answer		△	☆	△
2.2	Order signing and management	☆	△		△
2.3	Managing production capacity in real time	△		☆	
2.4	Delivery time inquiry and confirmation	△		☆	△
3.1	Order optimization with production batch	△		☆	
3.2	Order optimization with Sequence plan	△		☆	
3.3	Materials necessary for the order fulfillment	△		☆	
4	Products manufacturing and controlling	☆	△		
5	Final products delivery	☆	△		
6	Order tracking	☆			△
7	Financial management	☆	△		△
8	Customer service	△	△		☆

☆ : Core management system; △ : Business supporting system

(1) Production implementing unit: Each production-implementing unit in any plant is composed of various computers of different levels, among these.

a) Computer level 1: Mainly including equipment operation controlling and real-time data collecting such as loop controlling and sequence controlling as well as equipment condition monitoring covering electric controlling and instrument controlling.

b) Computer level 2: Mainly fulfilling instructions for production, running mathematic modes, and collecting production data.

c) Computer level 3: Including management of production standard, adjusting of production schedule, generating and delivering production instruction, quality management and product quality controlling, production controlling, production performance analyzing and result statistic, warehouse management, data regarding to manufacturing cost collecting, working procedure controlling and equipment condition monitoring.

(2) Production managing module: With sales management, quality management, manufacturing management, product delivery management, financial management, equipment management and transportation management functioned as an integrated one, this unit mainly controls some key elements, for instance, contract, materials and products. Following points further explain all the management above mentioned.

a) Sales management consists of contract management, resource planning management, customer manage-

ment, loan management and accounts management, with five in total.

b) Quality consists of products standard management, metallurgy standard management, quality design, testing management, product quality test and guarantee making, with six in total.

c) Manufacturing management is composed of contract handling, order planning, order merging, materials substitution, order tracking, materials allocation, products delivery allowing, operating plan of iron-making, plan for molten iron dispatching, operating plan of steel-making, operating plan of coil wire, operating plan of hot rolling mill, operating plan of cold rolling mill, manufacturing planning, stock of iron-making, stock of steel ingot, stock of coil wire, stock of billet and pipe, stock of slab, stock of hot rolling mill and cold rolling mill, with 21 items in total.

d) Products delivery management is composed of products storage, final products delivery, monthly planning management, warehouse transfer management, items relating to products delivery management, resource balancing management, products delivery planning management, dispatching, settlement and management of transportation expense and charges of various sorts, ten totally.

e) Financial management consists of accounting, settlement and payout system, fixed assets management, project of scientific research management, account for stock of final products and byproducts, cost accounting

management, administrating accounting, with 7 in total.

f) Equipment management covers almost all the business including equipment property and repair standard setting, equipment parts examining, equipment maintaining, contract regarding to equipment management (including such business as outsourcing, repairing, maintaining, etc), spare parts (including spare parts purchasing), materials management, fixed assets management, cost management, equipment condition analyzing and assessing as well as default image pictures warehouse.

g) Transportation management includes all kinds of management such as the transportation planning from raw materials import to final products delivery, transport equipment condition monitoring (including equipment parts examining, repairing and spare parts management) and transport cost controlling (including transport by vessel, transport by vehicle and railway transport), covering every plant in Baosteel.

By implementing this four-level structure computer process system, Baosteel eliminates the phenomenon of information isolation, i. e. information not shareable by all people concerned and guarantees the smooth information transfer from on-site workers to managers, also realizes the integration of two automations, respectively, information processing automation and equipment con-

trolling automation, leading to large-scale benefits and effective implementation of integrated management promoted by Baosteel for a long period.

### 3.2 Data warehouse subsystem

Main function of this system is:

Form different technical reports and indices.

Provide technicians with a means for data analyzing and mining.

Develop customer service supporting system to realize continuous improvement on the basis of large quantity data relating to manufacturing.

By using data analyzing and data mining method to process and reorganize large quantity of data from main production line collected by integrated manufacturing subsystem (including such working procedures as steel-making, hot rolling and cold rolling) as well as data from various business relating to manufacturing management and customer service, i. e. from order input, order processing, production to order fulfillment, this system is capable of providing premier service to customers on the basis of expert knowledge, improving product quality continuously and analyzing product delivery cycle.

Data warehouse is featuring with analysis, whose data structure is subject-oriented, as table2 depicts.

**Table 2 Description of date structure**

Code	Subject	Description
1	Quality management	Including product quality data center catering to needs from technical department for analysis and report and needs from technology center for research and study, this center includes data relating to product and production quality and other data supporting these data.
2	Logistic and manufacturing management	Mainly including logistic data center and production management data center used for analysis and report by manufacturing department, these two centers include data relating to logistic and production and other data supporting these data.
3	Financial and cost management	Including budget analyzing data center, payment analyzing data center, balance sheet analyzing data center, profit and loss analyzing data center, profit data center, etc, all these centers are used for analysis and report by financial department, each data center includes financial data and other data supporting these data.
4	Sale	Including purchase order data center and customers' complaints data center used for analysis and report by sales department. Purchase order data center includes every item of the order and data supporting these items; Customers' complaints data center includes data relating to customers' complaints and other data supporting these data.
5	Energy	Including energy consumption data center for analysis and report by energy department.
6	Equipment	Including equipment maintaining data center and spare parts data center, which include data relating to equipment maintain and amount of spare parts in stock and other data supporting these data.

The application system based on data warehouse subsystem illustrates the transformation from data to information and then from information to expert knowl-

edge, with its crucial applications classified into three categories, a. k. a. data category, information category and expert knowledge category described as follows:

### (1) Data category: Data warehouse system

The aim of this system is to implement data based management including the creation and maintain (referring to the data inquiry, process and theme data forming) of data warehouse themes, providing complete data to technicians concerned, data downloading, authorization as well as to implement a platform for information distribution by means of web and to let all the people in Baosteel share with these information, that means, any employee of Baosteel is entitled to use the application software based on data warehouse subsystem on condition that he is authorized and whatever the computer he uses connecting to the intranet.

### (2) Information category: Report relating to specific profession and operating-regarding information distribution system

Various reports relating to specific profession are mainly used for routine manufacturing management. Every day the data warehouse subsystem will automatically form thousands of reports of specific profession according to the time setting, which, in combine with the production condition the day before and from different perspective and different level, evaluates various performance from sales, technology, production, products delivery, equipment condition to financial and cost management as well as the performance of the main production line such as steel-making, hot rolling, cold rolling, blooming mill, etc, thus to provide managers of different levels with useful information to support decision-making. According to the specification of information distribution system, all reports above-mentioned should be merged together to form the manufacturing information distribution system, which can be further divided into manufacturing dispatcher info system, statistic info system and report of specific profession info system.

### (3) Expert knowledge category: Customer service supporting system by means of data analysis and data mining

In this category, by summarizing and extracting the essence of working procedure based on data and information collected, a unique expert knowledge system is created featuring with Baosteel's own characteristic, mainly including customer service system based on expert knowledge and product quality analyzing system.

When we mention customer service system based on expert knowledge, it collects a large amount of contract and order records and data regarding to manufacturing performance. To certain customer's special requirement, the system will find the most suitable products gearing to this need out of its large quantity of data and will support production selection with speed, whereas product quality analyzing system is a supporting system on product quality standard design and optimization through KIV-KOV model, i. e. when certain customer has some requirement for product quality improvement, by using this system, technicians could find key processing indices (KIV) quickly to improve the working procedure design and adjust data (KIV) related, so as to meet this requirement as soon as possible.

### 3.3 Quick response subsystem

Main function of quick response subsystem is to allocate limited sales resource beforehand and to optimize plans for order fulfillment based on customer requirement forecast. Then, once the customer requires product purchasing, the system will showcase the type, quantity and delivery time of the products immediately and the fulfillment of the contract happens right after the signing of the contract with batch production according to customers' requirement on delivery time, product quantity and product quality. Mainly, this subsystem consists of two modes called integrated sales resource management mode and contract fulfillment optimization mode.

#### (1) Integrated sales resource management mode

This mode covers sales plans of various products kind in Baosteel, including optimizing sales resource allocation and satisfying customers' requirements as well as optimizing products structure, which means deciding the best products structure and stipulating the plan for sales resource allocation conforming to the changing face of customers' requirement, limitation of manufacturing capacity, products profitability and production strategy, and solving the problem of production capacity surplus or shortage, which means keeping the load of the production line in balance and lowering the possibility of production bottleneck and making sure the smooth running of production despite ups and downs of customer's need. This mode includes such main func-

tions as customer's requirement management, planning management and allocating sales resource dynamically.

#### (2) Contract fulfillment optimization mode

This mode covers all major production lines from steel-making to final products manufacturing, concerning itself on the stipulating of weekly manufacturing plan and plans for contract fulfillment and analyzing the percentage of on time products delivery for further improvement. Main functions of this mode include plans for materials optimization, sequencing and optimizing customer's order and ensuring on time products delivery based on production capacity.

### 3.4 e-sales subsystem

"Baosteel online", an on-line sales subsystem, bridges Baosteel and its customers with more information interaction. Along with integrated manufacturing subsystem and quick response subsystem, all three subsystems form an inseparable unit to satisfy customer's need with quick response and provide production information to customers. This subsystem boasts strong features such as:

(1) Emphasizing on business coordination, especially viewing customer's purchase plan as the guidance to every plan in Baosteel, valuing strategic customers, improving information interaction between Baosteel and its customers on R & D, manufacturing and logistics.

(2) Promoting information communication, providing customer service through cutting-edge technology, providing customers with a variety of internet-based application, sharing information with customers.

(3) Encouraging customer to use information service to their own need, providing special service tailored to strategic customer and customer of strong financial strength in his own business circle.

Main function of "Baosteel online" system is as follows:

#### (1) Sales management

Either native customer or customer from overseas can make an inquiry or order through this sales system. Management efficiency of both parties is increased by means of integrating the on-line sales system with the manufacturing management system to make sure the real-time manufacturing information interaction.

#### (2) Logistics management

Mainly including locating the position of vehicle or vessel used for product transport by means of Global Position System (GPS) and General Packet Radio Service (GPRS), sharing sales-relating logistic information with customer, managing third party carrier through information technology, quickening the transfer of packaging-related data, production instruction, invoice-related information, waybill-related information and speeding up the contract settlement.

#### (3) Customer service management

Online sales subsystem provides service throughout sales procedure including product recommendation, product standard inquiry, quality guarantee inquiry, quality dispute, customer hotline, questionnaire of customer's satisfaction, etc, whereas strategic-customer-oriented coordination commerce aims to further satisfy the strategic customer through providing special-tailored, thoughtful service, which has also laid a solid foundation for establishing a more compact relation with strategic customers.

## 4 Construction of agile manufacturing system of Baosteel and its main achievements

### 4.1 Two-stage system developing under an overall plan

The customer-driven agile manufacturing system of Baosteel is developed under the guidance of "overall planning and implementing step by step". In every stage, several targets are preset based on capital and personnel available, business condition and management requirement. Mainly, construction of this system can be divided into the following two stages:

(1) Stage One: Constructing integrated manufacturing subsystem and data warehouse subsystem, completing the network facilities and realizing the system integration from bottom up.

This stage started from 1996 and ended in 2000 with the main work as: merging all the production line related information of different projects, namely project phase I, project phase II and project phase III of Baosteel to realize real-time management, implementing financial-centered management to improve the managerial environment inside Baosteel, automatic designing of

product quality, production and steel-making working procedure, collecting and processing on real time all the order-related information by means of Internet, tracking and monitoring order fulfillment.

(2) Stage Two: Constructing quick response subsystem and "Baosteel online" on-line sales subsystem, subcategorizing network facilities according to various functions and importing different safety strategies according to distinct importance level of the information, realizing the system integration by means of subsystem of same level interacting with each other.

This stage started from 2001 and ended in 2003 with the main work as: realizing quick response to customer requirement and two transformations, i. e. from emphasizing on resource management within Baosteel to emphasizing on resource management and utilizing outside Baosteel and from business integration within Baosteel to business coordination between Baosteel and its customers, implementing customer-centered management concept, further optimizing the manufacturing capacity gearing to different requirement, shortening customer delivery cycle, realizing the quick response to customer's need and providing customers with premier service.

#### 4.2 Main achievements of agile manufacturing system

The realization of customer driven agile manufacturing system will provide a technological means to support the quick response to customer's need, make the implementation of strategic-customer-oriented coordination commerce possible and improve management efficiency continuously. This system is not only a key one supporting daily operation, but substantially upgrading core customer-oriented capabilities as well, for instance, fast customer requirement responding capability, technology supporting capability, precise manufacturing capability, which are of great importance in areas of product research and development, sales management, product quality improvement, production organizing, logistics and financial settlement. So far, excluding investment for system construction, the entire system has created direct profit up to one billion RMB yuan. Main achievements of this system are:

Manufacturing according to customer's need

Shortening response time to customer's need

Substantiating the concept of centering on product quality

Intensifying logistic controlling

Substantiating the concept of production with great precision and agile manufacturing

Enhancing the capability of handling unexpected events

Standardized management and management with high interaction

Displaying the operation performance in time

Improving the capability of mastering core technology and continuous improvement

Constructing a platform for coordinating with strategic customers

#### 5 Case in point: strategic-customer-oriented coordination commerce between Baosteel and FAW-Volkswagen

Usually, the former purchase mode between FAW-Volkswagen and Baosteel was that every month FAW-Volkswagen signed a contract with Baosteel for steel products supplyment. after signing the contract, Baosteel organized production and delivered products in accordance with the terms of the contract on product quality, product quantity and on time delivery. With this mode, Baosteel didn't care whether the steel products has reached FAW-Volkswagen or whether there were enough steel products for product line in FAW-Volkswagen, whereas it was also extremely difficult for FAW-Volkswagen to obtain the information on contract fulfillment. In order to make sure there were enough steel products for the car-making product line, FAW-Volkswagen had no choice but increase the stock level, even so, it often happened that FAW-Volkswagen asked Baosteel for extra product supplement in case of emergency. Needless to say, this mode is not designed for the ever-changing car-making plan.

Things changed as year 2003 witnessed the signing of strategic agreement between Baosteel and FAW-Volkswagen striving for constructing the coordination commerce. Since then, steel product warehouses in FAW-Volkswagen have been entrusted to Baosteel's management (so called "resource outsourcing"), a

method to make sure there were enough steel products for product line in FAW-Volkswagen. By this means, Baosteel extends the warehouse management form within its own corporation to the production line (steel product warehouse) of its customer. So far, Baosteel has basically completed the computer system for its coordination commerce with FAW-Volkswagen, with the main function as:

(1) Products research and development with high efficiency

Baosteel has been sparing no effort in surveying customer's production technology and taking part in their research and development process. By this, Baosteel's steel product is well tailored for its customer's equipment, designing and production process, which also means the product quality of Baosteel gearing to customer's production has substantially improved. New steel product type research in Baosteel is strictly keeping in line with the car type upgrade in FAW-Volkswagen. Once FAW-Volkswagen confirms its new car type, the coordination commerce system will at the very meantime form a plan for new steel product research with its property catering to the new car type requirement. To implement this plan, Baosteel will adjust its product designing and manufacturing methods immediately and then organize production to provide new product type for probation. Thanks to the support from FAW-Volkswagen, this system will track the new steel product trial time in such working procedure as cutting, punching and welding, and based on the information collected by this system, Baosteel could further improve the product quality. The process of new steel product development mentioned above is never stopped till FAW-Volkswagen certifies this new type.

(2) Dynamic production adjustment

By creating mathematic mode for supply chain from Baosteel to FAW-Volkswagen and according to everyday manufacturing plan and actual manufacturing performance in FAW-Volkswagen, Baosteel is able to balance the steel product stock both in Baosteel and FAW-Volkswagen and adjust manufacturing plan in time and organize the contract sequencing, production, product transport. All these methods are to satisfy Volkswagen's requirement.

(3) Customer order calculation with high precision

With the help of mathematic mode mentioned above, quantity of products available (including stock in the warehouse, product en route, product in car-making product line) for various car types can be calculated with high precision, which provides certain guidance to FAW-Volkswagen for steel product purchase.

(4) Convenient information tracking method

By means of e-commerce, staffs of FAW-Volkswagen could just stay at their office to inquire information such as contract fulfillment, product transportation, product quality and settlement. This method not only brings great convenience to customers, but brings standard management into Baosteel as well.

(5) Premier after-sales service

In case of product quality dispute occurred, by submitting application asking for quality dispute arbitration, customer could get all kinds of information throughout dispute registering, arbitration, compensating, working procedure rectifying and case ending. Usually dispute arbitration could be finished in one week, so customers feel satisfied with such a fast speed.

At present, it has become a routine for FAW-Volkswagen to order product and for Baosteel to deliver product on a weekly basis. Manufacturing management with high precision has created tremendous benefits. Due to the efforts from both parties, the steel product stock has been decreasing dramatically, creating benefit as high as tens of millions RMB yuan. By lowering cost for the customer, Baosteel also win a royal strategic customer.

## 6 Conclusion

Today's global economy is a fast developing one, it's almost impossible for any company to achieve good performance through one advantage, only by means of finding all its strengths and adding these strengths up to a more powerful one, promoting innovation and effectively using resources inside and outside the company, can this company gain competitive edges continually and adapt itself to the ever-changing market.

From 1996 till now, based on satisfying customer and improving its own competitiveness and striving for

promote three core capabilities, i. e. market responding capability, technology supporting capability and low cost product manufacturing and management capability, Baosteel has spent eight years completing the customer driven agile manufacturing system. To achieve this, Baosteel first regulated and integrated information from both inside and outside and then completed four crucial subsystems respectively, i. e. integrated manufacturing sub-system, data warehouse sub-system, quick responding sub-system and on-line sales sub-system, in two stages.

By developing this agile system, Baosteel has cre-

ated itself a brand-new, high efficient operating system. Till now, this system is running smoothly and has achieved substantial benefits and appreciations from its customers. All these lay a solid basis for the further development of Baosteel.

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## Stress Analysis of Shell of Blast Furnace by Digital Correlation Method

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**Abstract:** BF (Blast Furnace) is one of the most important metallurgical equipment. The shell of BF has to subject very complicated loads and it is difficult to measure the stress of the shell directly. The BF can not stop work until its life come to end. The digital correlation method is one of the optical measure methods, which has been developed in recently years and this method could be used on line. In this study, it is taken time of cutting intake of the BF to make the project precision reposition. On the other hand, in order to resolve the key problem, the soft program is also edited. Then digital correlation method and electronic measure method are advanced to be powerful for investigating the global stress of the shell of a BF with volume of 4063 cubic meters. On the basis of the result, the stress concentration distribution from a variety of holes in shell is obtained with the method of Finite element analysis. Two series of datum is compared with each other. The satisfied results have been gained. The analysis result is used to guide and supports estimate the life of shell of BF.

**Key Words:** Blast Furnace; Digital correlation; Finite element analysis; Stress analysis

### 1 Introduction

Today's metallurgical industry demands high quality component designs within a very short period of time to meet the toughest mechanical features and ultimate safety standards. Currently, many companies are looking for other new advanced strain/stress experimental techniques to improve the cost efficiency, and to overcome the limitations of the classical methods. BF is one of the most important equipment in metallurgical industry. The shell of BF has to subject very complicated loads. It is difficult to measure the strain/stress of the shell directly for its harsh environmental condition and continuous work until its life come to the end. These tough requirements and demands of the market have led the industry invent a new optical measuring tool, which could overcome these problems.

The digital correlation method is one of the optical measure methods, which has been developed in recent years. It could be used on line. This method, as a non-contact measuring technique offers a cost effective, fast and highly accurate measuring technique. In this study, it is taken time of cutting intake of the BF to make the project precision reposition. On the other hand, in order

to resolve the key problem, the soft program is also edited. Then digital correlation method and electronic measure method are advanced to be powerful for investigating the global stress of the shell of a BF with volume of 4063 cubic meters. On the basis of the result the stress concentration distribution from a variety of holes in shell is obtained with the method of Finite element analysis.

### 2 Principles of Operation

The shell of BF under loads is viewed by one CCD camera. A regular pattern with good contrast is applied to the surface and is deformed along with the shell (Fig. 1). The deformation of this structure under different load is recorded by CCD camera during the test set in front of the sample and evaluated using digital image processing. The lens axis of the camera is kept fixed with reference to the frame of the testing machine, perpendicular to the surface of the sample. The image processing is realised after the test itself, and can be split up into two steps. First, the displacement field is estimated. The displacement of each material particle is decomposed into 2 in-plane components. The two first can be computed by a correlation technique, and the last