

THE ARCHITECTURE OF MANUFACTURING EXECUTION SYSTEM IN IRON & STEEL ENTERPRISE

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Abstract: Manufacturing execution system (MES) is a bridge that connects the top layer of planning and the bottom layer of control. In integrated automation system (IAS) whose structure is 3-layer BPS/MES/PCS, MES is the key circle to realize the integrating of integrated automation system in iron & steel enterprise. According to the characteristics of production management in iron & steel enterprise, the system structure of MES in iron & steel enterprise has been brought about, the function of each part is introduced, and at last the integrated function of MES is also analyzed in detail. The application of the MES structure in Shanghai steel company has acquired outstanding economical profits.
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1. INTRODUCTION

Because of the current intense competition, the steel enterprises are now increasing their investments in information technology to meet the higher demands in profits, flexibility of the plant, and the time for products to be on the market, etc. With the development of information and modern management technology, the steel enterprises switch their management style from pyramid to flat. The integrated automation system suitable for flat management style becomes a hot field in high technology for industry automation^[1-3]. The research of computer integrated production system is the frontier project in 90's last century. The foreign giant flow process enterprises, especially petroleum & chemical take into account the application of information integrating technology, pay their enthusiasm and energy to construct plant scale, corporation scale or even super corporation scale information integrated system.

The execution management style in our internal steel corporation is undeveloped at present. Manufacturing execution systems have not been paid enough attention during the process of R&D in integrated automation system for Steel Corporation. The functions of planning and scheduling are simplistic in exploited software. The integration scale with quality design, process optimization and environment is not high. It is difficult to share in common due to unsmooth information transmission. Since production plans are man-made in most enterprises, it is difficult to improve the level of management because of low efficiency, unreasonable arrangement, difficult in adjustment, high working intensity for scheduling man, and so on. There is rare application in design &

control for product quality, dynamic supervising of producing cost and optimized control for process of production.

2. CHARACTERISTICS OF PRODUCTION MANAGEMENT

The steel is produced in a mixed mode which lies between the discrete flow industry and the continuous flow industry. Its main characteristics are as follows:

Complexity: The production of steel is a complicated problem because there are many modes, many routes, many equipment and many disturbance factors in producing steel. And it has been proved that many steel producing is NP-hard problem. The amount of calculation is strengthened sharply with the increasing of the scale of question. And the question often has no accurate solution; usually we seek the optimization solution.

Randomicity: Fluctuate greatly, great uncertainty, possible to revise plan midway, and some unexpected accidents in steel producing; Such as the damage of equipment, repair, the charge of delivery date of task, composition of the molten steel not up to standard, and so on. All of these increase the difficulty and random of management.

Restriction: The craft process of steel producing must be finished before the process of making irons; the waiting time of each stove should be less than the limited time that craft required. In order to increase the output, the casting machine should work continuously as long as it can; and some equipment need to be maintained regularly, such as, the updating of the inside layer of converter, the updating of converter and ladle water mouth, etc. They are all

sorts of restraint of scheduling problem.

Multi-object: The hitting rate of molten steel composition, temperature and time should be improved because they are the most important goals we should consider in dynamic management of steelmaking. In addition, utilizing resource effectively, reducing costs, satisfying customer's delivery date, and so on are usually used as objects in dynamic management of steelmaking. Different goals have different influence on the concrete mode of solving problem.

Continuity: In the production process of iron & steel enterprises, materials flow should be operated in a successive high-efficient state; the upper process and the lower process should be linked closely; the multi-parallel of process and the superincumbent decomposed structure should be fully considered in order to realize the balance of material flow, that is, to realize the harmony of production plan and production patch. Realizing the balance of resource includes the task allocation among different steel-making stove, finery, casting machine, hot-rolling machine and heat furnace. Realizing time balance, such as the establishment of train schedule in product line, can eliminate the production bottleneck as soon as possible to improve the utilization rate of equipment; Realizing the integrated planned management of every process, making burden balance and making material flow link closely can guarantee production flexibility, product quality and delivery on time; Choosing the best route of material flow can, reduce material cost, energy consumption and other consumption, thus reduce the production cost and increase economic efficiency.

3. THE STRUCTURE AND FUNCTION OF MES

The producing process as a whole entity takes the most important part in iron & steel enterprise according to its characteristics of producing flow. It is insufficiency when there is only local optimization in every process and equipment. There may be conflicts between local optimized arrangement and integration optimization unless the optimization comes from the points of whole administrative and producing process to ensure optimized result in producing cost and administrative profit. Thus it is natural to employ the principle and method of CIM to fulfill the whole integration among design, administration, processing, etc and whole entity optimization through synthetic automation system.

The construction of integrated automation system should not depend on improvement of equipment automation control level and enterprise administration management. There exists functional demand in integration of production process control and management as a whole entity between equipment & process control and enterprise administration management^[4-5].

3.1 System Structure

In allusion to the problems that producing operation

and control largely depend on experience, information is not prompt and comprehensive, production isolates with management, production command delay in practical iron & steel enterprise, MES whose core is to produce optimized operation is applied to work out and treat the integrated production plan, optimize dynamic scheduling during the period of production, anticipate and optimizes on-line production cost, design and dynamic trace quality in production flow, supervise and maintain equipments. MES plays an important role as a connecting link between the preceding and the following in integrated automation system. It realizes the high efficiency and harmony control & management on the whole process of production. MES in iron & steel enterprise includes integrated operation scheduling system (IOS), resource allocation management(RA), material tracing management & control(MTMC), product quality detection & analysis(PQDA), equipment diagnosing & maintaining management (EDM), production process management(PPM), dynamic production cost control(DPC), and so on. Fig.1 shows the structure of MES in iron & steel enterprise.

3.2 Function

Integrated operation scheduling system

The production process is characterized by long production line, too many processes, and complicated equipments. It is a mixed production process exhibiting features of continuous and discrete. There are many restrictions in every process among operation and management. Every aspect of influential factors should be taken into account when the operation scheduling is being drawn. The task of operation scheduling is to work out the detailed production plan for enterprise, plan and adjust production plan according to different priorities, quality and features of different products, fulfill simulating optimization and real-time adjustment which is based on process model. Its aim is to arrange a reasonable alignment to further reduce auxiliary time in the process of production. According to practical production conditions, practical production requires some order to customization and could change flexibility following the practical production condition to make the production line well-distributed in burden, harmonious in rhythm, efficient in production. The target to improve profit is attained finally.

Resources allocation

Resources allocation management system achieves its goal for production dispatching through planning and allocating following resources, such as equipments, tools, mineral resources, other equipment, relating files, etc. Resources allocation management system provides detail information about resources and ensures good state for equipment before it runs. It also provides real-time information about operating conditions.

Material tracing management & control

The aim of material tracing management and control system is to supervise the whole process of materials flow from raw materials to final products, set up process model of materials' balance, realize the control on the process of materials flow. The materials balance is employed to achieve increment in income and profit by resolving the problems of materials transformation between each production process and problem in the connection of materials flow. The style of materials balance during the whole process is step-by-step. It reflects, collects, analysis and examines the real-time production conditions of every producing plant through checking stock, checking inter-plant conditions, tracing the consumption of raw materials and states of final and semi-final products. It provides foundations based on above information for financial cost account and producing plan.

Product quality detection & analysis

The functions of product quality detection and analysis system are to analysis collected real-time production data, guarantee correct control on quality of product, deal with problems promptly; realize the tracing and quality analysis of products. According to the customers' demands and the principles which emphasize quality management

all the time, the system makes continuous design, management, detection, analysis and control for product quality from the point of every process in iron and steel enterprise. Thus it has the ability to provide knowledge platform for enterprise's decision and control set value orientating on-the-spot operation. It also has the ability to find out the spot and reason of quality problem, and vulnerable spot in the process of production, adjust the production to guarantee percentage of qualified products.

Equipment diagnosing & maintaining management

The equipment diagnosing and maintaining management system is used to trace operation state of equipments and tools, provide regular or preventive maintaining operation guides for equipments and tools, preserve information of historic accident or malfunction, offer fault diagnosing database and provide alarm or treatment for malfunction from forecast of equipment requirement, the equipment allocation plan includes dairy operation, maintenance plan, malfunction diagnosing, spares management to operation supervising of equipment. It is necessary for this system to considerate interface with systems of producing plan and safe management.

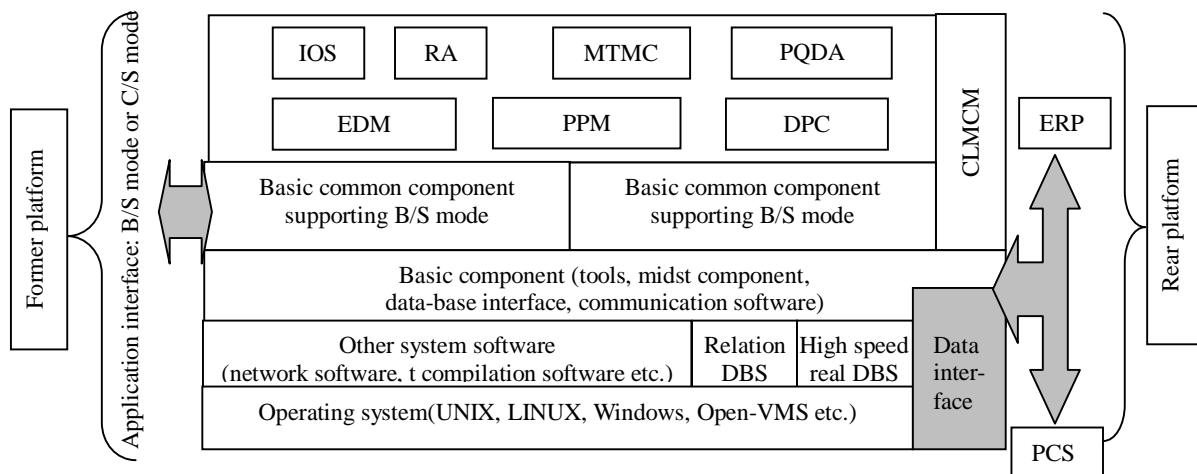


Fig.1 The architecture of MES in iron & steel enterprise

Production process management

The production process management system accomplishes supervising on production process, collection and statistics of data, real-time production efficient analysis based on database, supports of knowledge and information provided for MES, correct translation of production data, detection data and control parameters from the layer of MES to the layer of PCS. It eliminates the crisscross state where the department statistics locates among overall, professional and grass-roots statistics. It also clears up serious problems, such as various statistics forms, duplicated statistics index, not standardized statistics calculation and repeated input data, etc. It makes the enterprise have the ability to grasp the conditions of production & administration and make the correct decision. In addition, it realizes share data and shortens the period of data's disposing.

The process optimization control technology should be employed in iron & steel enterprise in order to accomplish the following task: stabilizing the important technological index during the process of production, fully utilizing the treatment capability of equipment, improving output as many as possible, making the production process of steel stable and optimized controlled.

Dynamic production cost control

The dynamic production cost control system is utilized to forecast and analysis cost during the process of the whole production, account and trace dynamic production cost, realize associated value assessment and control, and finally ensure optimization of materials flow. The base for cost accounting in enterprises' production is the cost in every production process. The data from other sub-system should be collected and translated into this system promptly and correctly. After cost

calculation, all kinds of cost analysis reports are exported; the information of resources' consumption is provided in time to carry out dynamic cost supervising.

Component library of metallurgical technics and control model

Obtaining the mathematics model and algorithm of metallurgical course are the core of process control. There is a large number of technical know-how from multi-field, such as craft, equipment, control, etc; it is extremely important technological resource of modernized iron & steel enterprise; it is one of the important signs of enterprise's inherent potentiality. For the mathematics models of metallurgical course that have been mastered, the system uses the experience which has been accumulated for a long time to coordinate, encapsulate and build the model storehouse. The model storehouse includes a lot of models which are used in process optimization, such as smelt model of converter, smelt model of blast furnace, hot rolled model and cold rolled model, RH decarburized model, hot rolled model of force model, recursion analytic model of hot rolled band temperature model, process control model of cold rolled force model and scheduling model of steelmaking, continuous casting and hot strip rolling model, etc. The common algorithms from all kinds of mathematics model are encapsulated in the system. It is a set of platform software for metallurgical automatic models, which offers a unified systematic interface. It is very convenient for MES.

MES platform of iron & steel enterprise

Because of different structure among hardware, operating system and database, structure design is made according to function structure model. A uniform and normative interface has been provided for application system developed on the basic establishment supporting platform in iron & steel enterprise. It can make product software applicable to isomerization platform and isomerization database.

3.3 Characteristic

The characteristic of this technological scheme include:

- (1) General applicability to iron & steel industry and flow manufacturing industry; having function of great integrative plan-making and real-time dynamic optimization.
- (2) High integration with ERP system and PCS system, fully considering the link with the ERP system function, ability to be connected with the custom-built ERP or joining with the existing ERP software(such as SAP, ORACLE).
- (3) Widely used in different product line, including strip, wire, profile steel and tube, etc.
- (4) Satisfying the character of real-time in agile manufacturing; adopting a large amount real-time treatment technology; either plan scheduling and quality judgment or the production data acquisition and cost accounting are touched off by the event in production. Meeting the uncertainty of the event.

This project has adopted integrated technology of function based on process and time, integrated technology of function based on agile manufacturing and functional software development technology based on structural design. These make the scheme more suitable, flexible and effective.

4. INTEGRATION OF MES

The core of integrated automation system is integration. The production and administration become a high automatic entity through physical integration, information integration, function integration and process integration^[6-7]. The lower layer of process control system and the upper management information system are isolated island in conventional enterprise automation system because there is not enough vertical integration. The production divorces from administrative management that has effects on the overall efficient. For example, if the correct feedback is not given back to the application of production plan, it is difficult to adjust plan reasonably, coordinate each working department, arrange production, and ensure high efficient operation. It is necessary to study and set up integration resolving scheme of integrated automation for enterprise.

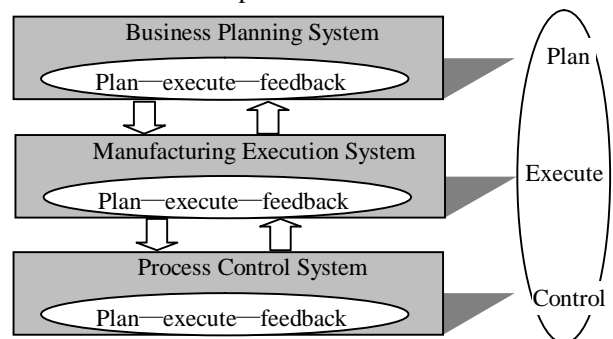


Fig.2 The integrated function of MES

The function of MES is to connect the on-the-spot control equipment and enterprise management platform, realize the integration of data, bring about integrated design for product and quality, integrated plan and materials flow dispatching, integrated production control and management. So MES is the key to the integration of integrated automation system.

Among the three-layer structure of BPS/MES/PCS in integrated automation system for iron & steel enterprise, manufacturing execution system-MES locates in the middle of information-integrated structure. As shown in Fig.2, MES is a bridge between BPS and PCS. It provides a communication passageway for business planning system and process control system to connect logical data from administrative plan system with practical production data from process control system.

4.1 Function integration

The target of complicated continuous production

process in iron & steel enterprise is to achieve stable technological index, improve equipment reliability, reduce the cost on equipments maintaining and operation, fully utilize capabilities of equipments to increase output, reduce production cost and increase economical profits. That requires higher-level control and management of production process. The MES based on the knowledge should be set up to improve quality of control and operation during the process of steel production. The studies on information integrated method in MES of iron & steel enterprise that regards plan dispatching as its main route, cost control as its core would be helpful to realize optimized operation and management during the process of production.

(1) Operations Scheduling as the main line

According to the production plan based on ERP, the operations scheduling system resolves itself into executive scheduling to guide practical production considering the conditions of contracts, the resources conditions of production spots, practical capabilities of equipments and human resources. At the same time, MES collects treats and analyses the real information during the process of productions through production management system. The operation scheduling system will carry out dynamic adjustment, transmit new operations scheduling to adapt new production conditions and ensure stable production when there is abnormal phenomenon's happening. It also transmits production statistic information into plan management system as the base for the following plan.

(2) Cost Control as the core

The financial plan based on financial management system of ERP will be formed further and transmitted to dynamic cost control system of MES, at last divided into detailed operation cost as a cost checking standard for departments at all levels to accomplish cost supervising during the whole process of production. The data of energy and materials' consumption consumed in the practical process of production will be transmitted to dynamic cost control system through data collecting system in process control system, the real production cost calculated by dynamic cost control system is going to be compared with planed cost (target cost or standard cost). When the real cost is higher than the planed cost, the information about resources consumption will be transmitted to corresponding financial management, energy management, plan management in order to take emergency measures, reduce production cost and provide base of following plan for these management system.

From above analysis, to the control and management of steel production, for one thing, manufacturing execution system brings about optimized control and optimized operation in the process of steel production through tight connection with process control system, technologies of process model and optimized control, development of sub-systems for equipment diagnosis & analysis and for products quality detection & analysis. Its aim is to stabilize technological index,

improve the production capabilities and productivities of making steel and rolling, and reduce the cost of production. For another, MES connects the bottom process control system with the top business planning system through established production management system, dynamic cost control system and materials balance system. In another words, the main production plan from business planning system of MES arrange and schedule production through production scheduling; Collect, transmit and treat information during the process of steel production through production statistics, materials balance and real cost control, reflect practical production problem to the top business planning system as a base for the following production plan promptly.

4.2 Information integration

Fig.3 shows the information relationship of business planning system, manufacture execution system and process control system [4,7-11]. MES provides production process information for enterprise resources plan system, supply chain management system, products and technology design system, sale service management and process control system. It provides real production data about manufacturing cycle, anticipating output time, product cost, material balance and energy consumption for enterprise resource plan system. It offers real conditions of work orders, real production capabilities of current enterprise and restraining relations of change shifts for supply chain management system. It provides real and reliable production data for quotation price system and on-time product delivery management in sale service management. It offers real data about product output and quality for production technology control system. At last it provides guides for process control management and obtain necessary data at the same time to ensure regular operation of administrative actions in enterprise. The operation scheduling of MES is based on the plan information of resources plan system. The supply chain management system controls the production plan and production conditions of some products through raw materials' purchasing and supplying time. The sale service management provides product distribution and price for practical production orders as basic reference data. The technology management provides operation guides for practical production. The real time production status data from process control system is used to analysis production properties and judge operation conditions.

From the above analysis, it is obvious in integrated automation system of iron & steel enterprise; the data from PCS should be treated and transmitted by MES to the top administrative plan layer. The administrative decision information towards market should be treated, transmitted and transformed response actions by MES correctly and promptly. MES is central link of integrated automation system

in MES, and plays an important roll in connecting production line and data. Unless MES is integrated with BPS and PCS as a whole organic entity, can it realize data's effective transmitting and sharing,

provide support for management based on knowledge and information, bring potential into play of integrated automation system in iron & steel enterprise.

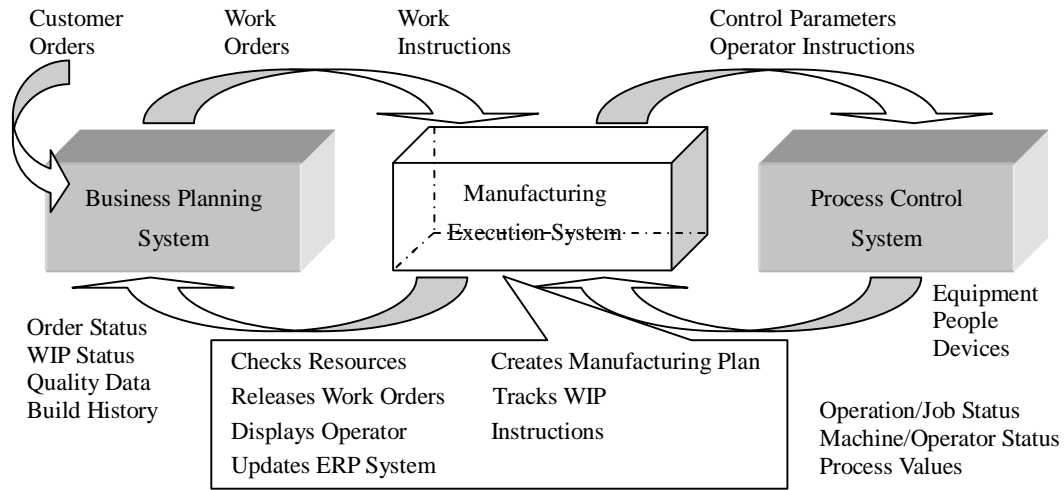


Fig.3 Data Flow of ERP, MES and PCS

5. CONCLUSION

The architecture of manufacturing execution system for iron & steel enterprise is studied in this paper. The model of integration in MES whose main line is scheduling and core is cost control has been brought about through analysis of characteristics in iron & steel enterprise management. Among the three-layer structure BPS/MES/PCS of integrated automation system MES is the key circle. MES resolves the synthetically integrated problem of production and management information from production process that is difficult to be handled. It plays a transforming, treatment and transmitting rolls for information between production process and administrative actions, and the key circle in integrated automation system of iron & steel enterprise that based on 3-layer structure. Certain Shanghai steel corporation has already applied this steel corporation MES structure and adopts the concerned production management technology, finally acquired more than ten million economic profits.

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