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Steelmaking Raw Material Planning and Purchase Management System

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Synopsis:

To assist the ongoing re-engineering, Raw Materials Department in Kawasaki Steel has developed the planning and purchasing management system. With existing systems, this system, which is composed of four separated subsystems, namely, the ore and coal purchase planning subsystem, metallic material purchase planning subsystem, supply and demand management subsystem, and office automation subsystem, is now supporting all kinds of operations in the department, ranging from purchase planning, vessel assignment planning, contract/purchase/payment operation to the information analysis. In the process of this system development, the client/server system has been established with an expanded information network and the downsized computer processing. And through setting up the personal computer "one to one person," the efficiency of management and operation, both in the Head Office and in the steelworks, has been improved drastically.

1 Introduction

The environment which surrounds the recent-year Japanese iron and steel industry is in a severe condition difficult to maintain profit, owing to the drop in international price competition of Japanese goods due to the progress of a sudden high evaluation of the yen, dull domestic demand due to slackened business condition in Japan, and sudden rushes by electrical furnace mills and overseas mills. Kawasaki Steel also is deploying all-company restructuring of business since two years ago in continuation to the second five-year plan since 1991, in order to cope with these strict environments.

The Raw Material Department aimed, as the basic principle, at the lowering of raw material costs, and at making the raw material purchasing and business slimmer, simpler and speedier and carried out reviewing and reconstruction of the business with the related departments, such as trading firms, steel mills, etc., and the total business of the Raw Material Department. In addition, the Raw Material Department carried out renovation of the information system, has fully activated various information techniques including the current raw material purchasing information system,[1] and constructed the client/server system, which includes the down-sizing of processing, network including EDI (electronic data interchange), and allocating the department server and one personal computer to all of the Raw Material Department staff.

This new system consists of the following sub-systems: (1) ore and coal purchase sub-system, which plans the annual purchase quantity of ore and coal and the optimum raw material distribution to the mill, (2) supply and demand management sub-system, which plans ship-allocation on the basis of the said distribution plan and carries out daily vessel planning adjustment with the mill, (3) metallic material purchase planning sub-system, which plans the purchase of raw material other than ore and coal, (4) raw material purchase sub-system, which carries out contracts, purchases and payments of raw materials, and (5) raw material department OA (office automation), which efficiently supports information activities including the obtaining, storage and processing of necessary information, and these sub-systems were put into full operations during the period from January through April, 1995.

In the following, the background and purposes of the system development, the outlines and features of the

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respective sub-systems, applied new techniques, and their effectiveness will be explained.

2 Background and Purpose of System Development

2.1 Conventional Systematization Condition Together with Problems and Tasks

The currently working system, which is based on the three pillars of the ore and coal purchase planning work, supply-demand and vessel-allocation works and daily business processing work, mainly utilizes the host computer at the Head Office to link to the mills, and supports all business of the Raw Material Department ranging from planning to contracting, purchasing and payment, thereby achieving many effective results. However, because more than 8 years have passed since it began operation, it has become difficult to sufficiently cope with changes of the business environment, thereby revealing the problem of insufficiently covered information, etc. In the following, major problems and tasks will be described:

(1) The ore and coal purchase sub-system used the linear programming to formulate a cost minimum plan with raw material resources, mine-side trend, markets for raw materials and transportation and production operation conditions as premises. However, the current model itself became obsolete, and it became difficult to cope with new facilities and new techniques of the mill.

(2) For vessel planning for each term, calculations of the number of voyages according to vessels and voyages to minimize the transportation costs were made through the linear programming on the basis of the transportation quantities of ore and coal, characteristics of the vessel, and the bunker oil price. However, the automatic scheduling of the vessel for one mill model did not necessarily match with the actual situation, and manual operation was used to firmly establish the scheduling of vessels. Further, in order to use the fixed schedule of a steamer in the daily navigation control, re-inputting was necessary.

(3) Daily supply and demand adjustment with the mill was made by "give-and-take" on a paper base, and as the operation load became larger, the discrepancy between the operation and information existed. Further, since the using plan at the mill was not timely reflected on the Head Office, urgent changes in the ship allocation and in the unloading port occurred.

(4) The formulation of metallic material purchase subsystem was made by manual operation, and the work by the person in charge was too heavy.

(5) In the purchasing and paying for imported raw materials, bills and vouchers from trading firms were received on paper, and all cases were checked; hence the work load by the person in charge was heavy.

(6) On the side of active use of information, necessary information was received by mail and fax from the related department in the company and the outside trading firms, etc., but the control of such mail and fax were too complicated, and the common possession of the mail, etc., among groups in the department and among persons in charge were not made possible. Further, the collected information was re-processed by the current personal computer and word processor. This was inefficient and also lacking in the speediness of work.

2.2 Aims of System Renovation and Its Settlement Direction

In order to solve the problem of the aforementioned systematization condition, and in order for the staff of the Raw Material Department after business reconstruction to carry out business execution effectively and efficiently, it has become necessary to renovate the information system. At the time of renovation, for the daily-work processing duty, the current system will be used after its improvement, and for other duties, namely, purchasing plan formulation and supply-demand and vessel allocation duties, it has been decided to construct them in the client/server systems, which use the latest information techniques, from the viewpoint of making these duties very adaptable to easy-to-use systems, which are closely related to actual duties. In the following, the aims of the applicable duties and the resolution direction of applicable duties will be described with the client/server system as the center.

2.2.1 Formulation of ore and coal purchasing sub-system

The targets are the entire-company-total pursuit of the cost minimization of ore and coal, and the realization of timely-and-all time planning of optimum distribution of ore and coal to the two works at Chiba and Mizushima. Major directions of solutions are as follows:

(1) Models of main raw materials will be arranged in order, so that pig iron can be evaluated comprehensively, so as to make it possible to select the cost-minimum brand in the short-, medium- and long-term purchase plans.

(2) In order to improve calculation accuracy, new facilities and new techniques such as CMC (coal moisture control plant) and PCI (pulverized coal injection plant) shall be incorporated into the model, and an optimum algorithm is to be constructed which obtains the solution by the non-linear type solution method. Further, sensitivity analysis shall be made possible, which evaluates the effects of various restraint conditions on the optimum purchase quantity.

(3) In the setting-up of the case study, the analysis results regarding the grade, etc., concerning inputs of various operation conditions of the mill shall be automatically collected. Further, the system shall allow

the copying of case data.

(4) The optimum raw material distribution to the mill shall be made possible, and at the same time, distribution results shall be offered to the formulation of vessel planning at each term.

2.2.2 Formulation of vessel planning and daily adjustments of supply and demand

After receiving the optimum factory distribution plan of raw materials and the using plan by the mill, the system carries out the securement of the grade and quantity, formulates vessel planning that will minimize the transportation cost, and carries out the daily supply and demand adjustment at any time and timely. Main directions for solution are as follows:

(1) Vessel planning for each term shall be a system capable of planning automatically the schedules of vessels as delivery by using mill distribution plan, taking the using plan and various conditions necessary for transportation, etc., into consideration.

(2) The daily supply and demand adjustment based on the vessel planning for each term shall have the system which can easily carry out the simulation of vessel planning, following the unified control indices which have been set up by the Head Office and the mill, such as vessel coming-in schedule, using plan and expected stocks as well as taking the daily vessel movements and using schedule into consideration.

(3) Various tables for supply and demand control such as the inventory transition and the navigation schedule, which are controlled accordingly, are timely exchanged between the Head Office and the mill to be used by both of them.

2.2.3 Formulation of purchase plan of items other than ore and coal

A system is constructed, in which the planning duty of the metallic material purchase plan formulation to the analysis, report, and supply and demand control can be effectively carried out on the basis of the personal computer.

2.2.4 Information activities of the department

A system will be constructed, in which information necessary for the department can be commonly possessed by all the members, taking out the information and working on it are easy, and various reference material preparation work can be carried out without duplication and speedily. The main solution directions are as follows:

(1) Information which is to be controlled by the Raw Material Department is systematically arranged, and the information is constructed as the data base and its common possession is planned.

(2) A system that can easily carry out the work ranging from acquisition to storage, retrieval and processing of information using spreadsheet software is constructed by distributing multi-functional personal computers to each of the department staff.

(3) In order to independently carry out EUD (end user development) in actual business, its infra-structure shall be incorporated.

(4) A system, which is constructed to easily carry out the storage and retrieval of information after processing.

3 System Outline and Features

The entire picture of the raw material plan and purchase control system is shown in **Fig. 1**. This system has, in order to accomplish the aims of aforementioned system renovation, constructed the following four sub-systems, namely, (1) ore and coal purchasing plan, (2) supply and demand management, (3) metallic material purchase planning, and (4) raw material department OA. These sub-systems have respectively organic connections with each other through department data bases on the server, and share the responsibility of processing. Further, basically, these sub-systems exchange various kinds of information with the mill by electronic mail. Furthermore, with the trading companies, Kawasaki Steel collects mainly outside-the-company information through the personal-comptuer communication in order to obtain useful information about negotiation duties and for preparation of various reference materials, thus constructing the system in the client/server system which permits wide-range information processing by way of the network.

On the other hand, the hardware to support these sub-system is constructed in such a configuration that the department server (UNIX) is connected to the multi-functional personal computers, which are distributed to each member, via LAN (local area network). Outline and features of each sub-system is described below.

3.1 Ore and Coal Purchasing Sub-system

The functions of this system can be roughly divided into two functions, namely, formulating function of purchase plan and planning function of optimum distribution to the mill. The former function is to fix the annual optimum brand and purchasing quantity by utilizing case studies with the aim of cost minimization of pig iron. The latter is, based on the result obtained from the former, to fix the optimum brand and distribution quantity to both the Chiba and Mizushima Works through the case studies with the aim of total cost minimization in the company. These are constructed by a model with one mathematical planning to search for the optimum solution for each case.

(1) For the execution and evaluation of the case study, the interactive method which was used in the current system is followed, but for speedier processing and for decreasing the load of the host computer, down-sizing has been used.

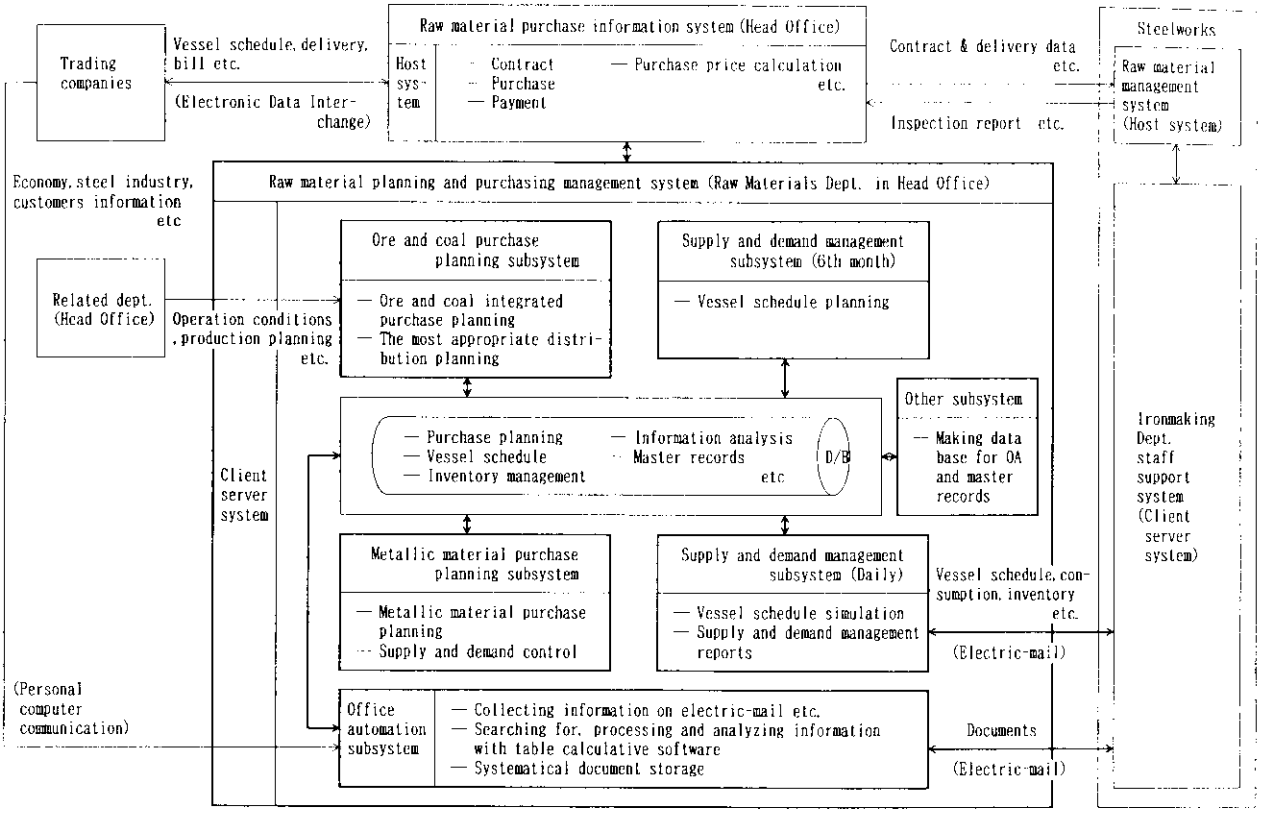

Fig. 1 Outline of the raw material planning and purchasing management system

(2) Regarding the model, taking-in of the newest facilities and newest material flow, unification of iron ore and coal, and improvement in the sensitivity analysis, etc., have been achieved, and in order to improve calculation accuracy, a new algorithm, which has applied the latest nonlinear programming technique,[2] has been developed and used.

(3) For the compilation of the case data, the grade analysis information has been automatically collected by a computer, in order to decrease the input load. Further, in the execution result of case studies, the quality of the solution is automatically indicated, and if it is satisfactory, a system is used in which the output is performed, following the various evaluation indices.

(4) In order to realize information offering to the supply and demand duty, the system has been applied also to the optimum distribution plans of the respective mills. By this method, it has become possible that plannings ranging from purchase plan to vessel planning have come to be carried out by a series of system proceedings.

3.2 Supply and Demand Management

This system is composed of in-coming vessel plan formulation and daily supply and demand plan, which performs daily vessel allocation. In the in-coming vessel plan formulation, in addition to various conditions of the conventional vessel planning, on the basis of the raw material distribution data from ore and coal purchase planning sub-system in each mill, vessel automatic scheduling for each term is carried out, using the expert system.[3] In the daily supply and demand function, the adjustment of the in-coming vessel (vessel planning simulation) is carried out on the basis of the in-coming vessel plan formulated by the above-mentioned procedure, depending upon the vessel-operation actual results and the alteration due to changes in the using plan of mills. At this time, through the electronic mail, there are several transmissions from Head Office about in-coming vessel plan information and there are several receptions from mills about using plans, thereby firmly deciding in-coming vessel plan. Further, for the alteration instructions of the vessel schedule or for the indications on the gantt chart and the navigation schedule, GUI (graphical user interface) tool is actively used to ease operation and judgment. In the following, the main features of the system are shown:

(1) In formulating the in-coming vessel plan for each term, semiannual vessel allocation schedules are automatically prepared by the expert system on the bases of distribution quantities classified by brands, which

have been received from ore and coal purchase plan sub-system, by taking into consideration the optimum vessels classified by the routes such as the ore and coal carrier and spot vessels, and other various conditions. To the expert system was applied the domain shell, which has been developed by Kawasaki Steel,[4] for solving the transportation plan problems, thereby achieving shortening of system development period and facilitating maintenance.

(2) Personal computers at Head Office and the staff-supporting personal computers at the steelmaking department of the mill are connected by the network, and the in-coming vessel schedule information from the Head Office and the using plan, inventory actual record information, etc., from the mill are sent and received by the electronic mail, thereby realizing the common possession of information.

(3) In the daily supply and demand, in order to make the vessel planning simulation easier, the alteration input of the in-coming vessel schedule, and various tables (gantt chart, navigation schedule, inventory transition etc.), which will be the unified control indices at Head Office and mills, are realized by personal computers by adopting the GUI tool, thereby achieving easy operation of them. **Figure 2** shows the gantt chart of vessel allocation, and **Fig. 3** shows the inventory transition graph.

3.3 Metallic Material Purchase Planning Sub-System

Plan formulation duties are made into patterns and standardized according to items, and for each of them, automatic collection of the actual records, purchase plan formulation and analysis-and-evaluation functions are developed, thereby summarizing them "from the plan of the person in charge" to "the plan of the entire department" in the "from bottom to top" manner. The applicable scenes of this sub-system are at the times of plan formulation at the beginning of the term and plan reviewing at the term-middle and term-end as well as at the time of monthly supply and demand plan formulation. The main features of this sub-system are as follows:

(1) The sub-system collects the production plan, actual-result information, etc., of the mill through the currently working system, and while performing base-unit calculation, the purchase plans of the term (at the beginning of the term, at the middle of the term, and at the term-end) are automatically prepared.

(2) Purchase plan, which has been automatically prepared, is corrected at necessary locations, using the correction function and is fixedly determined by carrying out various kinds of comparisons and evaluations using the analysis function. These real functions have been developed all by the spreadsheet software.

(3) A system has been made to plan the monthly supply and demand plan, by reflecting the actual results (in purchse, use, and inventory) about the above-mentioned purchase plan.

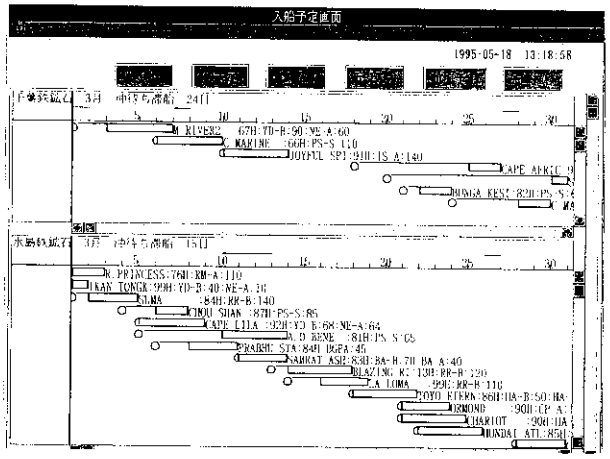

Fig. 2 Gantt chart of vessel schedule

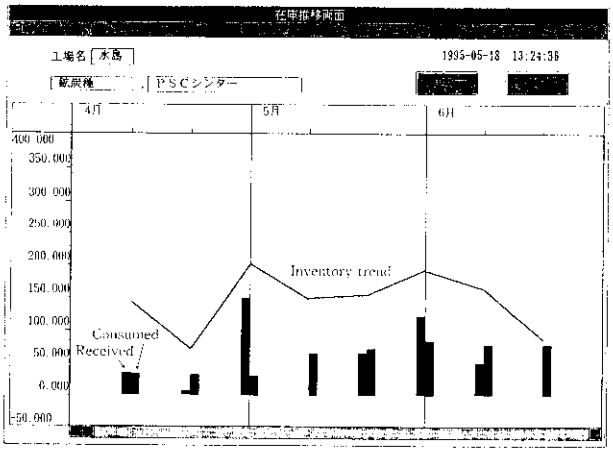

Fig. 3 Inventory trend

3.4 Raw Material Department OA Sub-System

In order to carry out staff duty effectively, the control indices of the Raw Material Department have been made clear, and the department data base has been constructed, which has achieved systematic arrangement of necessary information. By making these information common possession by way of personal computer, an environment has been constructed, in which the total staff members can carry out quick retrieving and processing of necessary information and actions can be quickly made. In the following, its main features are described:

(1) Departmental data bases are collectively controlled by the server, and they are divided into two groups:

Information which is downloaded from the current system and stored (developed by the system department), and information which is obtained from trading companies by personal computer communication and stored (EUD).

(2) According to the systematic storing of necessary information, the routine OA duty menus are kept, and retrieval and processing of various information have been made possible by EUD, using the spreadsheet software. The OA duty menus are either common to all departments or divided into various groups.

(3) Documents, tables and graphs prepared by the personal computer are systematically filed, using the document control system, which has been independently developed by Kawasaki Steel, thereby permitting easy retrieval and utilization. Further, Kawasaki Steel is also storing documents from trading companies using personal computer communication.

4 Application of System New Techniques

As, in the aforesaid system outline and features, the contents of applying various new techniques have been introduced, here examples of other application of new techniques are introduced in summary.

(1) Kawasaki Steel has developed many personal computer-use programs, and in order to make its maintenance easier, the company has made possible the automation for despatching programs to the personal computer at any time. By this, the time necessary for program changes by the floppy disk has been omitted.

(2) A series of processign work ranging from vessel allocation instruction for importing raw materials to the payment of price to trading firms has all been made in EDI, and automation of the processing and "less paper" have been realized.

(3) Department server has, in addition to its real functions, a function of reservation batch processing on the execution of the case study and vessel planning simulation. The reservation batch processing is to actuate by arbitrarily specifying the execution time in business, and we have newly developed this technique including the control function for this new system, and has opened computer operation to actual business.

(4) An information active-use tool, which Kawasaki Steel has developed to promote the active-use of non-routine work information as a link of raw material department OA, has been applied. This tool has the function to download information at any time to the spreadsheet software, and the information can be arbitrarily processed and reused at the personal computer side.

5 Effects

These systems sequentially started working since January 1995. Further, since April 1995, the current-working daily work processing system which is based on EDI action with trading companies also started working, and all the planned system renovation have been completed. The effects of the purchase plan, supply and demand management, and the entire OA business, which have been aimed at, are shown below.

(1) Ore and Coal Purchase Planning Sub-System

In addition to the conventional interactive-type real processing, by the development of the new algorithm utilizing nonlinear programming method, calculation accuracy has been made higher, and also by modeling in unifying ore and coal, a total evaluation method for the brand selection of the total raw material aiming at the pig iron cost minimum has been realized. By the above, brand evaluation and various analyses can be carried out with the pig-iron-making technical trend and the market trend of raw-materials as premises. Thus it becomes possible to carry out formulations of medium- and long-term raw material policies and the short-term purchase plan which has sought after pig iron cost minimization. Futher, on the basis of the determined purchase quantity and on the basis of the production plan of the mill, the optimum raw material distribution plan, which has aimed at the entire company pig iron cost minimization, has become possible. In addition, easement of the convergence judgment and maintenance of constant quantity of pig-iron production towards the shortening of the calculation time has been carried out, and more number of case studies has been executed in a shorter time, and a large effect has been achieved.

(2) Supply and Demand Management Duty

As vessel planning for each term and the daily supply and demand adjustment are carried out using the raw material distribution plans of each mill, Head Office and mills have been able to realize the pursuit of entire company pig-iron cost minimization jointly. Further, the raw material inventories of mills and the demurrage condition of vessels can be immediately grasped, so that urgent change in the unloading port, and the demurrage which have occurred in the past have been decreased. In addition, automatic scheduling of vessel allocation by the expert system, giving and receiving supply and demand information with mills by the electronic mail, and vessel allocation simulation using the GUI function have become possible, and hence work can be executed with a small number of personnel quickly. Besides, duplication of supply and demand in the entire company has become nil and a great efficiency has been demonstrated.

(3) Metallic Material Purchase Planning Sub-System

Covering the entire items of metallic material purchase plan, purchase plan duty has been standardized, and purchase plan formulation has come to be easily accomplished by small number of staffs. Further, in the past, "paper processing" was carried out between

the mill and Raw-Material Department, but now by the connection of systems, the processing speed of the entire planning jobs has been improved. Further, monthly supply-and-demand and contract duty, which are based on planning, the quick processing by the personal computer has been possible, thereby contributing to the efficiency of the work.

(4) OA Sub-System

In addition to the aforementioned hardwares, by the construction of the raw material department database, and by the introduction of the necessary software, the common possession of information as the entire department can be realized, and the speeds of retrieval, processing, analysis, and preparation of various reference material have been increased. Further, regarding information collection, the electronic mail and personal computer communication are actively used, and not only the communication to the relating department, but also that from outside of the company has been made possible, thereby contributing to efficiency of routine work and non-routine work. Information, which the department top requires, is shown as a menu, and since the menu can be easily operated by one touch, it is favorably accepted.

6 Conclusions

The raw material plan and purchase control systems at the Raw Material Department of Kawasaki Steel have been developed as the client/server system. The features of this system can be summarized as follows:

(1) This system is composed of the ore and coal purchase plan, supply and demand management, metallic material purchase plan, and raw material department OA sub-systems, and for the server, the UNIX machine is allocated and for the client, a personal computer, and LAN-connected composition is used. In addition, data give-and-take with pig-iron department staff-supporting system is carried out by the electronic mail.

(2) In the purchasing plan system, nonlinear programming technique was adopted so as to improve the operation accuracy, and ore and coal for coke making were integrated for modeling, so that the brand selection of total materials could be evaluated generally to aim at the minimization of pig iron cost.

(3) In the supply and demand management system, automation of vessel allocation schedule by the expert system and "give-and-take" of supply and demand information with the mill by the electronic mail have been implemented. Through these, it has become possible to pursue the entire company pig-iron cost minimization and to perform the work speedily.

(4) In the department OA system, by the construction of the raw material database and allocation of one personal computer to each department staff, collection of information, retrieval, processing, analysis, etc., have come to be carried out speedier, thereby contributing to the increased OA action and to promotion of active use of information.

This system after renovating the covering scope of the system, from its function and easiness in use, are evaluated as the system with the higher level compared with the conventional system. Future tasks will be to establish the use of this new system in the new set-up organization and to increase and expand the use and improve by EUD and to improve the literacy of information in the Raw Material Department. The system department will continue its support in the future for that purpose.

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