The ISCOR real-time industrial data processing system

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A real-time industrial data processing system collects information, processes it, and responds to the user in sufficient time to influence or control the production processes, material distribution and accounting records.

At ISCOR (South African Iron and Steel Corportation) a comprehensive real-time industrial data processing system is being installed. This system will utilize 'in-plant' communications terminals and automatic data logging units to gather and display data. It will respond to remote terminals and the Mills process control computers to initiate and control production flow through the manufacturing process. Batch processing jobs will also be initiated through the real-time system to provide production reports and accounting records.

In view of the number of production centres involved it was decided to divide the system into two major application areas, namely customer order control and production control. It was also decided that the customer order control application would be installed on a corporate wide basis, while the production control application would be further subdivided into works and mills areas.

This paper will discuss the approach to the development of the system and its installation at the ISCOR Works, Vanderbijlpark, South Africa.

The computer system to be employed consists of two large Control Data 3300 Central Processors located at the Vanderbijlpark Works. Each processor will have its own operating system. One system will be primarily dedicated to the real-time programs while the other handles batch processing programs and also serves as a standby system for real-time programs in the event of failure of the real-time system. Furthermore process control computers will also be installed to control the actual processing of material on the mills.

The real-time system will capture and process data at the actual time the steel is passing through the different phases of production while the batch processing will be carried out according to a preset schedule. All commercial applications and reports emanating from the data processed by the real-time system will be processed into reports periodically in the batch processing system. The real-time processor is also capable of processing batch jobs whenever its real time load permits.

Since the real-time operations require a high degree of processor, peripheral, and terminal reliability, each system will monitor the condition of the other. Should the real-time processor not be functioning properly the batch processor will abort all its jobs and assume the real-time load. In order to accomplish this interchangeability of work load, the system is configurated so that each processor may access all peripherals and terminals via alternate data input/output routes.

The failure recovery procedures to be employed, in the event of the 'in-plant' terminals or real-time system peripherals not being in operation, have been carefully laid out in order that the highest degree of back up possible is obtained with a minimum of manual operation or recording. For example, when a message is transmitted to the central processor from a mill process control computer or data logger, the central processor must acknowledge the receipt of the message within five seconds. If the acknowledgment is not received by the sending unit, the message is transmitted again. Should the second message not be acknowledged, the transmitting unit assumes there has been a failure within the communications network and will automatically dump the data into punched paper tape for later entry via a tape reader in the computer centre.

Remote 'in-plant' terminals are being designed and located in such a way that a terminal situated in close proximity, can be used should a unit be out of operation. Maintenance of the 'in-plant' terminals units will generally follow the policy of replacing a unit with a spare rather than to repair it on site.

In order to create a smooth running system, essential 'on-line' files, which cannot be re-established quickly and efficiently, are maintained in duplicate on separate disc units each of which is accessed through different channels and controllers. 'On-line' files are available to the real-time system at all times, usually without requiring computer operator action.

Overall the dual system approach is the one followed, with at least two routes provided from the processor for each type of input or output.

The order control system provides for the direct entry of orders into the computer system from the various sales offices via papertape transmission and teleprinter units. The system receives the order and accepts it commercially and industrially and confirms the order status with the initiating sales office.

Acceptance of the order includes validating it from the standpoint that all of the data required to process the order are present and correct. Such items as customer data and product specifications are also vetted by the system. The order is then priced and the customer credit arrangements are checked. Assuming that the order is correct and complete and that the product specifications are acceptable, the order is forward loaded on a mathematical model of the works and a forecast delivery period for the material is computed. If the delivery period arrived at is not within the limits specified by the customer, the sales organisation is notified and may adjust priorities if it so desires. Should the sales organisation change the priority, the order will be reloaded on the mathematical model. In the event of the order failing a specific test, a query is generated and the appropriate section is notified automatically. For example, if order data is missing or invalid, the originating sales office is advised. When product specifications are new or unusual, the works metallurgist is notified. Should credit arrangements be inadequate, the credit department is called. In order that all computer-generated queries receive prompt attention, and that no information is lost, each query is followed up with a reminder if the response has not been received within a set time limit.

Once the order has been accepted, and forward loaded on the plant, it remains in the system until its entire life cycle is complete. An order's life begins with its entry by sales, matures when it has been dispatched by the works, and dies when it has been paid by the customer. After that, it becomes another statistic for use in the operations research or sales forecast system.

Periodically, blocks of forward loaded orders are passed from the order control system to the production control system. The production control system then schedules these forward loaded orders on the works production units, and reports their progress through the units until the order is complete and ready for dispatch.

Blocks of orders are transferred from the order control system at intervals which will maintain a sufficient pool of orders to provide an adequate product mix for scheduling. The system schedules the orders based on existing conditions within the mill, and issues recommended schedules in advance for approval by the production planner.

Preliminary schedules are prepared several days in advance of their actual production data, but the final scheduling is 'on-line' in the case where the mill is controlled by a process control computer. For example, an ingot to be rolled at the slab mill is on a preliminary schedule several days in advance. The actual detailed rolling instructions, however, are issued only when the ingot is charged into a soaking pit to be heated to rolling temperature, approximately six hours in advance of the actual rolling. The rolling instruction is in the form of a punched card which is read by the mill control computer when the mill operator is ready to roll the ingot. The card is produced by the real-time system on a remotely located card punch at the mill production office.

The major real-time function of the computer system is the collection and display of data from a large number of 'in-plant' terminals. This enables the system to do accurate production and management reporting, and the scheduling of production.

To illustrate how the production control system functions, let us consider the steel melting plant and slab mill complexes. The steel melting plant produces casts of steel. A cast is a ladle of about two hundred tons of molten steel tapped from a furnace. The molten steel is teemed from the ladle into molds which form ingots. The molds are stripped from the ingots after they have hardened, and the ingots are rolled and sheared into slabs at the slab mill. An ingot is a block of steel weighing between ten and twenty five tons, depending upon the mold size. A slab is a smaller flat block of steel, usually weighing around five tons. Its size and weight depend upon the requirements of the rolling mill which will use it.

Starting with the forward loaded orders taken from the order control system, the production control system computes the number and specifications of the slabs required to satisfy the orders over a production cycle. Once it has determined the slab requirement, it computes the number and specifications of the ingots from which the slabs will be rolled. It then computes the number and specifications of the cast of steel that must be made at the steel melting plant to produce the required ingots. As each computation is done an 'on-line' file of slab, ingot and cast requirements is built up. When these computations are complete, the computer prints preliminary schedules for the slab mill and a steel order for the steel melting plant. Once approved, the schedules and steel order are issued to the production units by the production planner.

The steel order specifies the cast and ingots to be produced, but does not stipulate the sequence in which they are to be manufactured. Thus, the actual slab mill schedule and rolling instruction cannot be prepared until the ingots have actually arrived at the mill.

The progress and specifications of the cast and ingots are reported to the computer system by personnel using 'in-plant' terminals at the steel melting plant, the ingot weigh bridges and the soaking pits. The terminals are also used to display information and instructions regarding the steel flowing through the production facility.

Once the ingots reach the soaking pit, where they are heated to proper rolling terperature, their arrival is reported through an 'in-plant' terminal. The system then refers to its 'on-line' files to provide the necessary rolling instructions. The specifications of each ingot are checked, and insturctions are generated which will use the ingot for the highest priority order having the same specifications.

When the ingot is drawn from the soaking pit and enters the mill, the rolling instruction card, which was prepared on an 'in-plant' terminal card punch, is read into the mill control computer by the mill operator. The mill control computer then controls the process of rolling the ingot into a slab, and the shearing of the rolled slab into smaller slabs. At the same time, the mill control computer logs the particulars about each slab rolled, and automatically transmits the data to the real-time computer system. After each slab has been rolled, sheared, and moved to the slab stocking yard; information about its condition, treatment, and location is reported to the real-time computer through 'in-plant' terminals. The system updates'on-line' disc files so that up-to-date records of material stocks, production status, and order progress are available at all times.

These 'on-line' disc files are used to satisfy inquires for remote terminals, and as the basis for scheduling and production reporting.

Periodically, the 'on-line' disc files in the real-time computer are dumped onto magnetic tape. The magnetic tape is transferred to the batch processor, and production and management reports and accounting records are prepared daily, weekly, monthly, or as required. The periodic dumping of the data from disc to tape also provides an added measure of back-up, should it become necessary to reconstruct an 'on-line' file.

The design of the data collection and display network is an area which involves a tremendous amount of preplanning. Since the average 'in-plant' terminal operator will not be highly trained or educated, it was necessary to develop techniques and methods which would enable the system to capture the data with a minimum of operator action.

To do this, communication methods are employed that involve basically three types of remote terminals: standard keyboard send-receive teleprinters; numerical data entry devices, which are standard keyboard send-receive teleprinters with the addition of a modified push button keyboard; and cathode ray tube display units.

To use the standard keyboard send-recieve teleprinters, the operator contacts the computer by transmitting a call code. This action steps-up the communications and program linkages, and starts a 'computer to operator' conversation that is controlled by the computer. The computer asks a series of questions, and the operator answers each question sequentially. The first question must be answered before the second is asked. Each response to a computer generated question is validated by the system to make certain the data received are reasonable before the conversation is continued. Normally, an 'in-plant' terminal will be utilizing only one communications program. However, the ability to conduct several simultaneous conversations with a terminal has been incorporated into the system.

When using the numerical data entry devices, the terminal operator is provided with a preset message format. He sets up his entire transmission on the push button keyboard. The terminal operator then sends the message to the computer by depressing a 'transmit' button. This type of unit reduces the number of messages required to collect the data, and makes it possible for the terminal operator to check the data before he sends them.

The cathode ray tube display units are used for both data collection and as display terminals. To collect data, the technique of displaying a form on the unit for the operator to fill in, is most commonly used. To obtain a display of data, the operator calls for a specific display by sending a call code. The computer automatically presents the latest data on the files regarding the request.

Normally, all conversations between the computer and the 'in-plant' terminals are on an immediate response basis. On the other hand, provision has been made for terminal operators to request information which they will collect at a later time on the same terminal, or on a different 'in-plant' terminal. Provision has also been made for the computer to advise the terminal operator that there will be a delay in displaying the data requested. At all of the 'in-plant' terminals, the programs have been designed so that the operator can converse with the computer in either Afrikaans or English.

When an order has been produced and is ready to be dispatched, the real-time processor is advised through the data collection terminals, and the order control system is brought back into action.

The order control system will produce, on remotely located 'in-plant' terminals at the dispatch area, the necessary documents for shipping the product to the customer. Such items as consignment notes, gate release note, loading particulars, and special handling instructions are printed on remote units.

The order control system also prepares the invoices and customer accounts on a batch processing basis.

In order to provide an adequate pool of data so that queries about orders can be answered promptly, all of the data relative to an order are retained in the 'on-line' files for thirty days after the order has been dispatched. Accounting and statistical data are retained in off-line files indefinitely.

The system outlined has been installed and tested. All of the necessary software has been developed. The order control system and the first portions of production control system are now operational.