A paper read at the recent conference:

Management and the Computer

THE PROCESS CONTROL COMPUTER

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1. INTRODUCTION

As with most things one also tends to classify computer applications into groups and I have taken three major groups.

(a) The Data Processing Computer

(b) The Process Control Computer

(c) The Scientific Analyser.

When we consider the computer in a management role we are concerned mainly with the first two groups. Other speakers have and will still consider the Data Processing Computer application in all its ramifications and I have chosen the Process Control Computer application to show how this fits into the Management-Computer aspect.

First of all let us define a Process Control Computer application. As the name implies it is concerned with the controlling of a process where the control commands to the various process elements are given by the computer. While the process is under way the computer will, via sensing elements, get feedback information to see whether the process is being carried out as programmed and if not to apply a correction. Certain parts of the command information are stored in the computer memory and called out when required, while other parts are fed into the computer via card or tape readers. This is a very broad definition but it does suit our purpose in that it does differentiate between the data processing system and the process control system.

2. PROCESS COMPUTER

The need for a digital process computer can briefly be summarised as follows:

The industry of today is confronted with increased process complexity, higher costs, higher quality requirements and closer product dimension requirements so that it becomes mandatory that these processes be controlled by a computer system.

Computer systems are very expensive, but without the aid of a computer it would not be possible to keep pace with current and future market demands.

Being associated with the steel industry my comments will obviously be coupled with processes in that industry, processes such as Arc Furnace Control and Rolling Mill Control. With these processes there are so many things happening simultaneously that it has become virtually impossible to leave the control of the entire process in the hands of the human operator. His thought processes and subsequent reactions are far too slow. The popular press has in their knowledgeable reporting turned "Automation" into a dirty word in that many people think that the computer will replace them in their jobs. One man was not so much concerned being replaced by a computer but was most upset when he was replaced by a transistor! Process computers do not, as many people believe, do away with the need for operators. These people are still required to monitor the system. Designing a system to replace the operator will require that all the things that can go wrong be programmed into the computer; this would not only be prohibitive on a cost basis but also foolish on the part of the designer.

Instead of considering the process computer as a super master brain, let us rather look at it as a very sophisticated tool assisting the operators and management in performing a production function. Some of the variables on a process line, especially a steel mill can still not be measured accurately and this is where the skills of the operator are very important. However, there are a multitude of control functions and variables that the computer can handle more rapidly and more reliably than any operator can ever hope to do.

3. TOOL TO MANAGEMENT

The computer can be a very powerful tool in the hands of management but should only remain a tool and not be made to take over management. There is the story about a computer controlled mill in the U.S.A. where, when this thing was installed, sophistication was carried out to the nth degree. Apart from the ordinary process control commands, all the possible data these people could think about were fed into the computer. This computer was going to know everything, do all the thinking, etc. Then came the day when the mill just stopped and nobody could get it going again. Fault diagnosis programs were run and the computer was shown to be in perfect health. Everything was correct but the mill would not roll. Ultimately they came to the root of the problem. The computer, with all the data possible fed into it, had done its own market research, had predicted a glut on the steel market and had stopped the mill in the process.

This is of course only a story but this sort of thing could happen when the computer no longer acts as a tool.

With the steel industry and for that matter any industry, the first link in the production chain is the receipt of orders. The orders having been received, these first of all have to be programmed, and here is meant that we have to establish the steps we have to go through in order to produce and supply the particular article to the customer. The next phase is the scheduling of the orders. This is the establishment of the time sequence of the production process. After this has been done production is started. During production we have to have status reporting. Is this thing being done as we want it done and is it done when we want it done? After production is completed the dispatch of the material to the customer and payment by the customer should take place.

The central integrated data processing system will handle all these aspects and will be a very powerful aid to management. The process control computer fits into the middle of this whole chain and on its part performs a very important function apart from the control of the process.

4. CONTROLLING THE PROCESS

The material, in our case the steel to be processed, is about to go through the particular unit controlled by a computer. In our particular case we could consider a computer controlled slabbing mill where ingots of varying dimensions are hot rolled into slabs of varying dimensions.

The computer received its primary data and instructions from information on a standard 80 column Hollerith card. Information as to the mass and linear dimensions of the ingot are given, the quality of the steel, and the dimensions of the slabs required from the ingot. The order number etc. is also contained on the card. This is important to the computer as it has to relate its data logging and reporting with relation to the order number.

These data, for operator information, are displayed on display units and cathode ray tubes.

From this information on the card, the computer calculates the pattern that it will use to perform the rolling function. The computer uses various mathematical models to calculate the reduction the mill is to do each time the steel passes through the rolls (commonly known as a mill pass). These models together with permissible limits of mill load, dimensional tolerances etc. are built into the software of the computer and can easily be changed.

The computer monitors each system variable and compares this with the predicted values as rolling proceeds and corrects for any deviations. The computer as it were updates itself and then decides what it is going to do next. By this means it is ensured that the system capacity can be used to the ultimate, at the same time realising a higher production rate, better quality and smoother plant operation.

To inform the computer of prevailing conditions on the plant various types of sensors are used, for example the presence or absence of the ingot or slab is sensed by hot metal detectors placed at various strategic positions. Positions of roll screwdown settings (Distance between top and bottom mill work roll) are obtained from a screwdown selsyn transmitter-receiver system coupled to the screwdown mechanism. The mass of the ingot being given on the card is also compared with the mass of the ingot about to go into the mill. This ingot is weighed before mill entry and if the difference in mass is beyond a certain value, the computer comes to the conclusion that somehow with the handling of the ingot the wrong ingot is about to be rolled. Under these conditions the computer will not roll this ingot but will raise an alarm.

It is obvious that certain plant occurrences require immediate attention from the computer, whereas others are less important and can be serviced at a "later" stage. In order to take care of this, the computer makes use of a priority interrupt system, whereby a program of a higher priority can interrupt the running of lower priority systems. The complete software control of this priority system is done by a program that is generally called the "executive control program". This forms the heart of the software system. It not only controls the running of programs on a priority basis but it also allows the use of defined core memory area by various programs on a time sharing basis as well as controlling the transfer of programs and data to and from the bulk memory.

During rolling the computer will also track the slabs as they pass down the line informing the operator of the status of material in process. This is displayed on illuminated displays and cathode ray tube displays.

After rolling has been completed the only job the process control computer has to do is to produce a permanent hard copy of the rolling data and this is done by various typewriters located in the plant for further use by plant personnel. Further to producing these logs, the computer also transmits these and other data to the works central data processing computer for further processing and management reporting. Figure 1 shows the overall system where the central processer unit is linked with all the peripheral equipment which goes to make up the complete process control system.

In the past certain regulators such as speed or position regulators were designed and built as separate systems being actuated by a computer. These regulators which are essentially analogue in character are now being incorporated in the computer and are becoming digital in character which would of course result in more accurate control.

Another example of a process controller is one used with an electric arc furnace. When a large arc furnace (capacity 100 - 150 ton) operates, a large amount of steel is being processed and apart from a correct chemical composition being achieved, the amount of electric power used must be controlled, as this forms a very significant item in the cost.

Briefly arc furnace operation may be given as follows: There are two to three successive loadings of scrap steel followed by a refining period. In each of these periods there are process steps where there is an adjustment to the input power to the furnace. There could be up to 18 process steps.

With the different process steps another transformer tap may be selected and for this tap there is an optimum arc length. This arc length determines the power factor, determines the furnace lining life and in general saves on electrode consumption.

The computer does this for the operator as he could not possibly control such a function himself. The computer is thus controlling the power input. In addition the computer controls the maximum demand on the power and takes into account what is to happen with regard to scrap charging etc. in planning what and how much control is to be applied.

In order to have the correct quality steel, samples have to be taken for analysis. On the analysis of this sample the computer will calculate as to what elements have to be added in order to obtain the quality steel required. This is then displayed to the operator who then adds these elements.

The computer also acts as a data logger to provide management and other information.

Computer systems are expensive from both a hardware and a software angle and represent a large capital investment. The pay off must come with higher production rates of a better quality product. This will lead to an overall economic improvement.

As an example of the size of computer the following is given.

Word length	: 24 bits + 1 parity bit.
Core memory	: 16 K
Core cycle time	: 1,6 micro seconds
Bulk memory	: 128 K (DRUM)
Number of programming instructions	: 114
Circuitry used	: monolithic integrated-circuits.

5. IMPLEMENTATION

With the implementation of process computers, or with any computer for that matter, management should take the following steps:

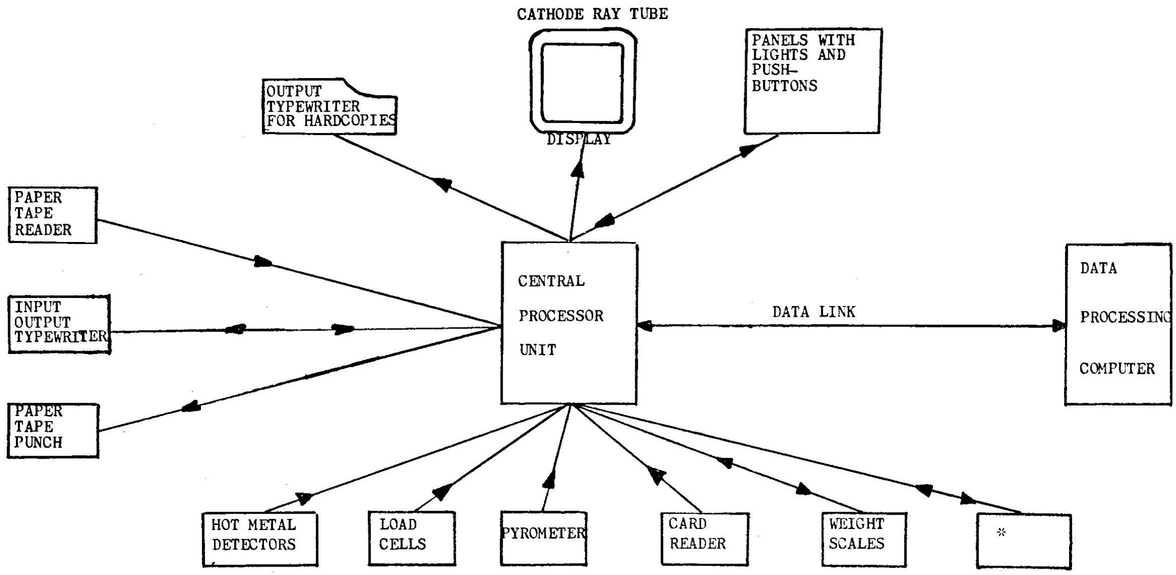
(a) They should ask themselves: Is a computer necessary?

(b) If the indication is that a computer is necessary then very active participation by the people who are to use this system is required. The computer, apart from needing very highly trained people, also constitutes a very big change in system operation, and if active participation is not secured, people, with their characteristic resistance to change, will oppose it. This resistance to change is throughout the worker management spectrum and is not only confined to the lower ranks.

If people are not fully briefed as to what is to happen, they do not see how they are to benefit by this change, and what's more they tend to be afraid that they will not fit into the new picture.

Developing a system and presenting it to people as an accomplished fact will more likely end up as a failure. On the other hand, if people were to participate in the development of the system, they might come up with some good ideas on their part and the same system which was doomed to failure could now be successful.

Computers are finding more and more use as process controllers and it is up to managemnt to make sure of painless implementation.



* SIGNALS TO AND FROM POSITION REGULATING EQUIPMENT AND DRIVES.

FIGURE 1