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Quality Assurance System for UOE Pipe Production

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Synopsis :
The Production Control System adopted by the UOE Pipe Plant in November 1983 supervises all the processes ranging from order receiving to manufacture and to shipping, It has been contributing greatly to productivity and quality control. Each pipe piece is identified at any place in the plant by automatic material tracking. The feature of this system consists in the principle that no pipe piece in processing is permitted to move from one stage to the next unless in fully meets given operating instructions and quality requirements based on all necessary data collected and product evaluation standards established for each stage. In this system, therefore, the passing of mechanical testing and nondestructive inspection is only a partial requirement for product shipping approval. Added feature of this system is the use of many automated equipment such as welding condition monitor, and pipe number readers.

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1 Introduction

UOE steel pipes are welded pipes with an inner diameter of about 500 to 1 600 mmϕ which are mainly used in pipelines. Recently, with an advance in the pipeline pressurizing techniques and a growing trend of pipeline laying under severe climates, the levels of quality assurance requirements for UOE pipes are getting increasingly rigorous.

The UOE pipe production process involves long lead time such as for size changes. It contains many subdivided processes each difficult to automate. For this reason, productivity of UOE pipes is lower than that of other steel products, and to improve it presents a difficult task. In addition, since UOE pipes are mainly used in pipelines, strict quality assurance is demanded. This demand has intensified in recent years, with products requirements increasingly diversified and sophisticated. Meeting these challenges in the areas of productivity and quality is a primary concern of producers.

To this end, UOE pipe production facilities have been enlarged, and the production control system has been renovated. The main feature of this system is that an online real-time identification process for UOE pipes has been instituted throughout the plant using automatic tracking of pipes. Through this new system, the functions of operation control and quality control in producing UOE pipes have been greatly enhanced. This report describes the basic concept, functions, and features of the new system with emphasis on the pipe tracking process and quality control in welding.

2 Basic Concept

2.1 Key Points in UOE Pipe Manufacturing Process[1~3)]

Figure 1 shows the UOE pipe production process. After being given edge preparation, feedstock steel plate passes through the C-ing, U-ing, and O-ing presses and is formed into a "can". Then it goes through tack welding and internal and external welding and becomes a pipe. Next, in-house inspection process checks any defect, and if there is one, it is repaired or removed. The pipe then undergoes the processes of mechanical expanding, the hydrostatic test, ultrasonic test and end facing. Only after passing the shipping test and witness test, the pipe is shipped.

Main points to be tackled in this process are enumerated below.

(1) A system shall be so established that each and every pipe piece will be manufactured according to proper production sequences, and no defective product shall be made or shipped.

(2) Quick response is required to a variety of sizes, grades and manufacturing specifications.

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** Chiba Works

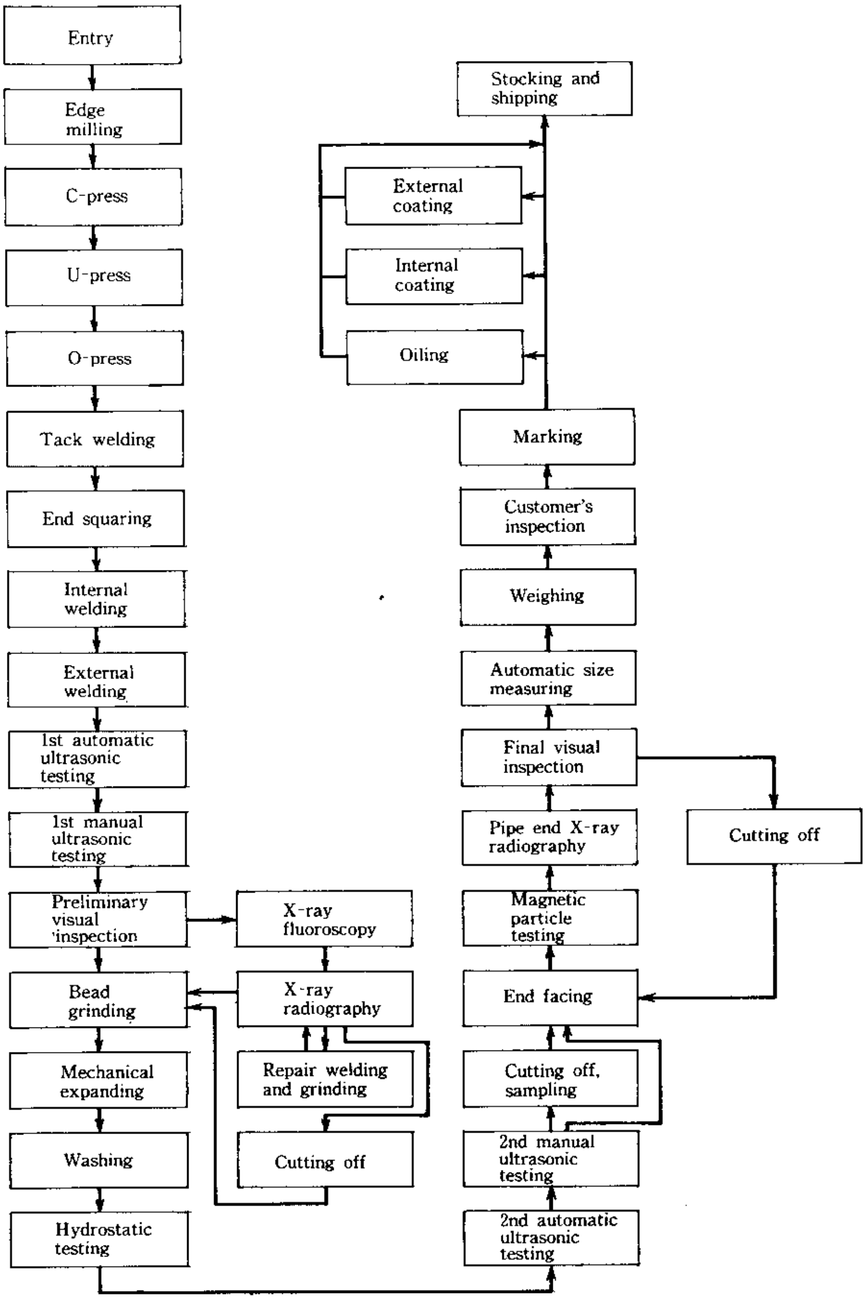

Fig. 1 UOE pipe production process diagram

(3) Operation shall be maintained in such a way that all the processings will always be in harmony.
(4) Automation shall be promoted so as to remove dangerous and heavy-work operations and attain improvements in product reliability and reduction in cost.

All the above-mentioned points are consolidated into two points, that is, improvements in productivity and intensification of quality assurance. To meet these requirements, a series of facility expansion programs have been instituted. They include an installation of four-electrode welding machines and others to balance up production capacity, the reduction of size-changing time for various production facilities including the O-press, and the introduction of automated facilities. The production control system has also been renewed to meet the above requirements.

2.2 Concept for System Configuration

The basic theme of the present quality assurance system lies in strengthening the existing production control system by computerization against the background of an increased size of computers and the development of microcomputers. This means that production control functions of UOE pipes will be improved using on-line system covering order receiving, specification design, scheduling, feedstock material procurement, setting of instructions, yard control, pipemaking, inspection, record control, progress control and shipping. To this end, an automatic pipe tracking system will be installed in the entire plant so that all operational instructions, record keeping and decision of acceptance and rejection will be performed in good synchronization with the hauling in and out of pipes to and from various production units. To improve productivity, the following items will be implemented:

(1) Process progress conditions and facility operating conditions should be grasped at all times, making it possible to take necessary actions promptly.
(2) Information processing should be performed well synchronized with hauling-in of the pipe so as to prevent the occurrence of waiting time and checking time.
(3) Computers should be connected to various automation facilities to save manpower, and data should be collected automatically as much as possible to relieve the inputting load to the computer.

To enhance the quality control function, the following items will be performed:

(1) Throughout all the stages from feedstock material procurement to manufacture and shipping, material identification control is performed, and at each production process, job contents are directly instructed by computer for each pipe piece material.
(2) Actual result data at each production process are checked by computer, and the material is allowed to proceed to the next process only when the actual results conform to the given production and inspection specifications. If the actual results do not conform to them, the computer instructs the contents of necessary processing and the process to which the material should proceed.
(3) Quality data and operation data are collected and fed back or forward to various processes and necessary information is given to operation controller and staff at site.

3 System Configuration[4)]

The system has three hierarchical configurations as shown in **Fig. 2**. The upper rank business computer is divided into the control system (batch) and operation system (on-line). The business computer is connected to a large-capacity data base, which contains about 1 800 MB of information. At the intermediate rank lies the process computer which controls the entire plant on the basis of the automatic pipe tracking process. What is demanded of this computer is high-speed response, and the computer performs real-time control at a response time of less than 2 s. At the lowest rank of the hierarchy lies a group of microcomputers which performs sensor signal processing and direct control of facilities. The greatest of the features of this system configuration lies in a total control of the entire plant by the process com-

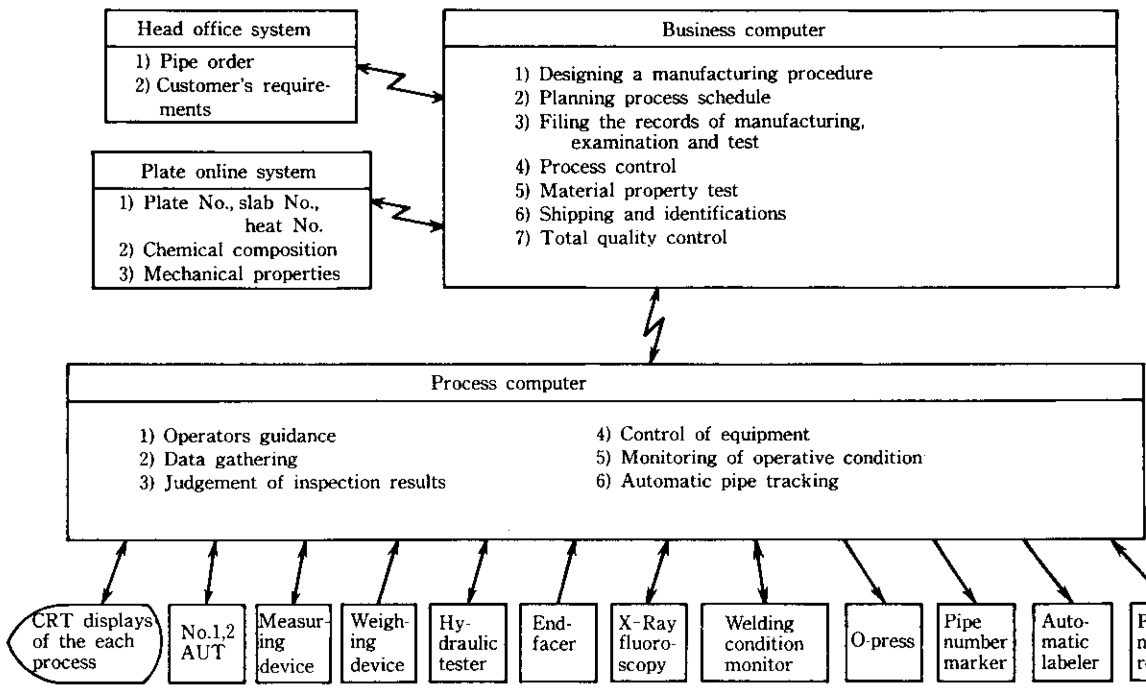

Fig. 2 System construction

puter. This feature is required for the following two reasons, namely, to prevent overlapping of hardware and software as a result of mixed presence of the process and business computers, and eliminate frequent data transfer between the two computers. Terminals of the business computer are provided at the material yard, shipping yard, office, central control room and other commodity distributing and storing locations as well as the controller and staff division, whereas the factory is provided only with terminals of the process computers for operation purposes.

4 Material Control System

4.1 Feedstock Material Yard Control

The primary feature of the feedstock material yard control in the present system lies in the control of the overhead traveling crane. Loading instructions are given by the business computer to the overhead traveling crane. The instructions contain the starting point of loading (From), ending point (To), number of slabs to be lifted, and width, length and thickness of each slab. According to these instructions, various control operations are performed such as position detection, adjustment of length of the lifting magnet hoisting beam, lifting material quantity control and winding-up control, and feedstock materials are transported by crane without the slinging worker posted on the ground. The actual operation record of the overhead traveling crane is transmitted to the business computer, operation by operation, to renew address control. **Figure 3** shows the layout of the overhead traveling crane at the material yard. To make effective use of the material yard space, a flexible address allocation control is performed according to the slab widths and lengths. It is also one of the features of this system that no skid is used for transportation and storage of slabs.

4.2 Automatic Pipe Tracking in Plant[5)]

The process computer divides the plant area into about 180 blocks, and grasps the movements of pipes. To identify the movement of each pipe piece, a three step transfer system is ordinarily used, showing instruction for transfer, and confirmation on pipe piece at the point of transfer start and transfer end. During pipe hauling, loose pipes may roll and collide with each other and bounce, causing signals to chatter. A non-steady hauling sometimes disrupts a set timing of signals. To ensure the reliability of tracking at all times, checking and correction are performed by way of primary signal processing of hauling signals by the sequencer, computerized timer check and rationality check, and the use of pipe number readers. These readers are installed at five major hauling

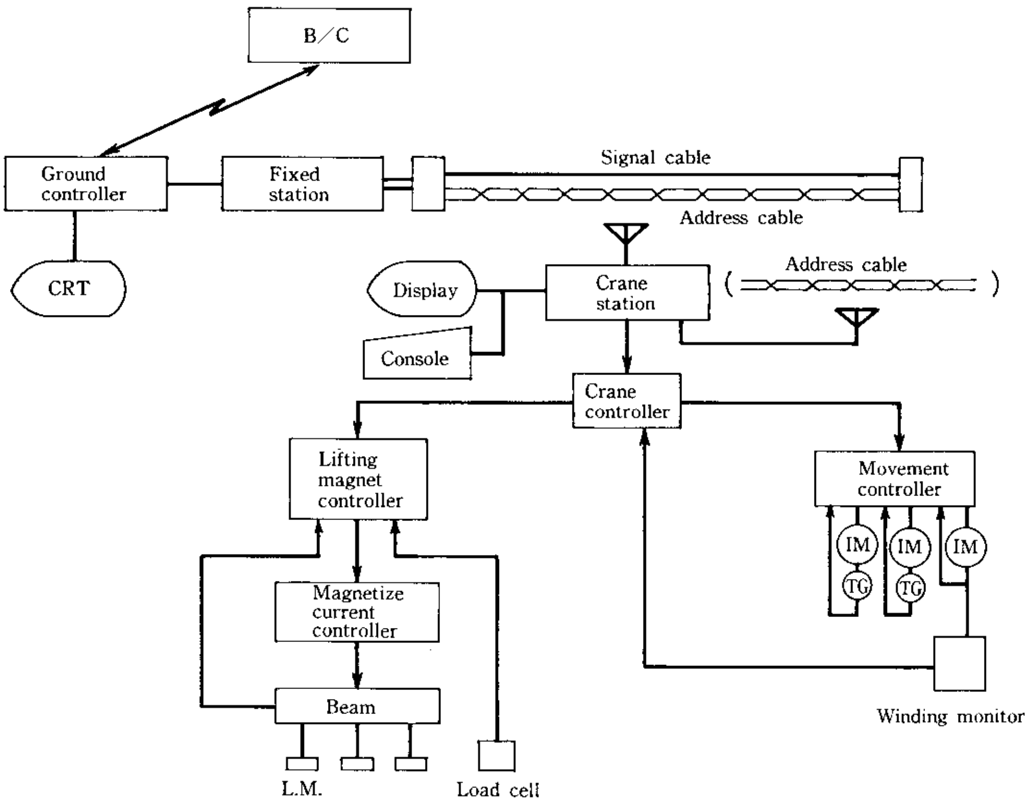

Fig. 3 System construction of material yard crane

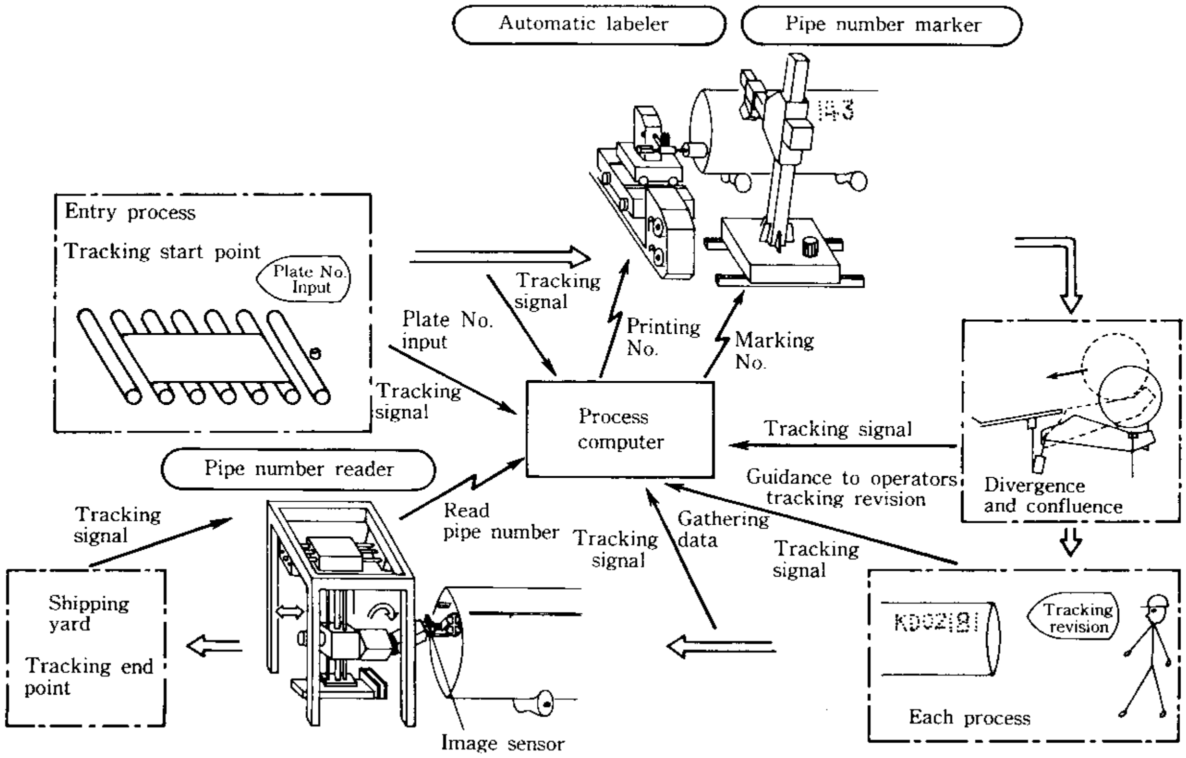

Fig. 4 Pipe tracking system

positions in the plant, reads pipe Nos. of all the pipes that pass through them, and transmit the results to the process computer. The concept of the tracking system is shown in **Fig. 4**. The seal labeler which is installed in the upstream process prints pipe No. in B-font quadruple characters of OCR on a label by the dot printer and automatically sticks the label to the inner surface of the pipe. Pipe No. consists of eight digits including two digits of check code and is printed on the label in double line. The pipe number reader inserts its camera into the pipe, accesses to the label by the rotary motion of the camera and optically reads pipe No. To prevent misreaing, the pipe number reader checks pipe Nos. on the double line to check their agreement and performs the code check of the No. it has read. This procedure has boosted the correct reading ratio of pipe Nos. by the reader to 99.99% or above. Reading becomes impossible when the label is damaged or fouled or when the pipe which was not yet expanded has developed bending, but a reading ratio of more than 95% is obtained. When the pipe cannot be read, the pipe number reader instructs the operator to confirm the No. of the pipe. The installation of the pipe number reader ensures constant check on tracking, and greatly contributes to enhancing system reliability. **Photo 1** shows the pipe number reader.

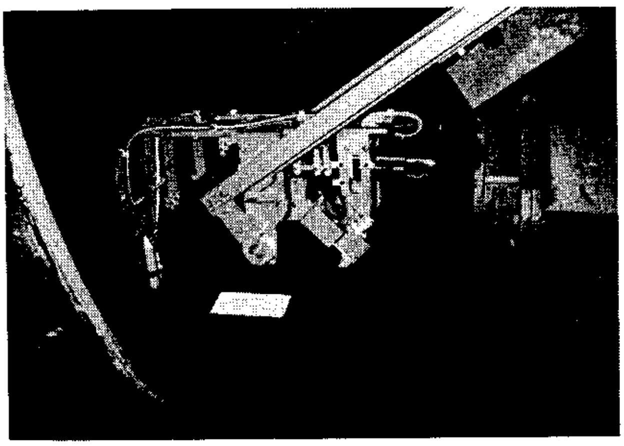

Photo 1 Pipe number reader

5 Quality Assurance System

5.1 Quality Control of Welding[6]

5.1.1 Operating instructions for each pipe piece

Welding is performed on the basis of computer instructions. At each process, welding specifications (groove dimensions and shape, current and voltage of each electrode, wire dia., flux, welding speed, etc.) per production lot together with the actual records of the forming process and upstream welding processes, piece by piece, synchronized with the hauling in and out of pipes. Simultaneously, pipe No., pipe length, amperage and voltage of each electrode, and aimed values and tolerances of welding speeds are given to the welding condition monitor by the process computer in synchronization with the hauling in and out of pipes. The welding conditions may be changed in synchronization with the pipe flow by the instructions from the office, even if the lot is in process. At each welding process, the operator sets the welding machine after confirming pipe No.

5.1.2 Record collection and evaluation

Actual values of welding conditions are checked during welding by the welding condition monitor and summed up for each pipe. Also the mean value per sec of actual values during welding is constantly compared against the tolerance value range. If any abnormality is found in this comparison, a warning is immediately given to the operator to urge correction, and the position, length, type, and number of pieces of the abnormality are summed up. The pipe which has developed abnormality is subjected to X-ray and ultrasonic tests for correct checking, and the process computer instructs the destination of the pipe for the checking and transmits the abnormality location of the pipe to downstream processes.

5.1.3 Processing of quality information

Results of the X-ray test on the weld, etc., are summed up for each welding machine and fed back to its operator. On the basis of this information, the operator judges whether or not the machine should be continuously operated or the facilities need checking, and can maintain the facilities in an optimum condition, resulting in preventing the occurrence of rejects in a large quantity. The actual results of welding are transmitted to the controller and staff at the central control room and office, contributing to a prompt and accurate trouble-shooting and corrective actions, when abnormality develops. These actual results are stored for a necessary period as voucher data for quality assurance.

The above concept of quality control of the welding machine is shown in **Fig. 5**. The welding condition monitor supervises the operating condition of two tack welding machines, and four internal and external welding machines, respectively. The monitor is composed of microcomputers, each of which takes in respective sig-

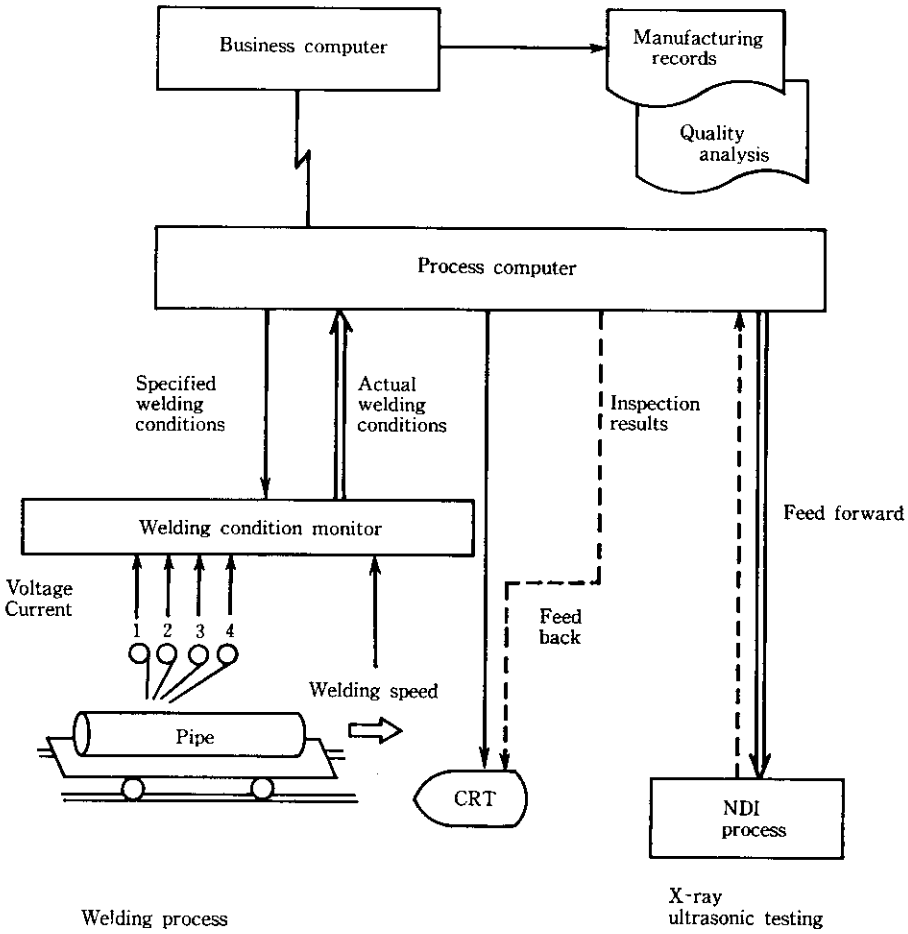

Fig. 5 Quality control for welding

Table 1 Sensors for quality control

Process	Function sensor
Tack welder, internal welder and external welder	Welding condition monitoring and data collecting……Every electrode's voltage and current, welding speed
Automatic ultrasonic tester	Ultrasonic testing and data gathering
X-Ray fluoroscopy	X-Ray fluoroscopic testing and data gathering
Mechanical expander	Hydraulic cylinder stroke setting and miss-expanding monitoring
Hydraulic tester	Hydraulic testing and judging
End facer	Cut length and pipe length measuring
Automatic size mesauring device	Length, outer and inner diameter, wall thickness, and roundness measuring
Weighing device	Weighing
External coating	Coating thickness monitoring
External coating	Pinhole testing

nal at a cycle of 100 ms.

5.2 Automatic Summing-up of Quality Data

Table 1 shows sensors for quality control of UOE pipes. Most of these sensors are incorporated in microcomputers, sum up actual results of each pipe and transmit them to the process computer. Installation of these sensors not only relieves man of the load of manual data input, but also excludes human errors and personal differences, thus permitting an early detection of abnormality occurrences. Collected data are fed back to downstream processes and given necessary treatment.

6 Concluding Remarks

Production control system has been renewed, employing a basic concept of meeting the demand for UOE pipe quality assurance through computerized piece-by-piece quality control. The actual operation of the system has enhanced quality control levels and reinforced the system of preventing mixing of rejects into acceptable products and the bulk occurrence of rejects. Together with the upgrading of operation control levels of the plant, the renewed system is greatly contributing to a smooth running of the UOE pipe production system.

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