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A New Workstation Based Man/Machine Interface System for the JT-60 Upgrade

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Abstract

Development of a new man/machine interface system was stimulated by the requirements of making the JT-60 operator interface more "friendly" on the basis of the past five-year operational experience. Eleven Sun/3 workstations and their supervisory mini-computer HIDIC V90/45 are connected through the standard network; Ethernet. The network is also connected to the existing "ZENKEI" mini-computer system through the shared memory on the HIDIC V90/45 mini-computer. Improved software, such as automatic setting of the discharge conditions, consistency check among the related parameters and easy operation for discharge result data display, offered the "user-friendly" environments. This new man/machine interface system leads to the efficient operation of the JT-60.

I. INTRODUCTION

The former JT-60 supervisory control system named "ZENKEI" consists of seven mini-computers and a CAMAC system for controlling tokamak machine operating conditions, discharge sequences and plasma equilibrium control.[1] Although been adequate the performance of "ZENKEI" has heavily worked, its limitations such as memory size, calculation speed, word length reached its limitation due to the option of the lower X-point operation and pellet injection system.

The new "ZENKEI" has to provide the long pulse operation (up to 15 sec), high speed plasma position feedback control (250μsec) and more user-friendly man/machine interface. [2],[3]

To satisfy the above requirements, we modified the plasma feedback control system of the two mini-computer system to that of a VME system. The man/machine interface system was changed from that of simple terminals to workstations. These workstations provide UNIX operating system with features of a multi-window system, network file system and many application tools for data handling and graphic interfaces. The improvements of the man/machine interface system have been made for the setting the discharge condition parameters, operation of the discharge and displaying of the discharge result data waveforms on the basis of the "friendly".

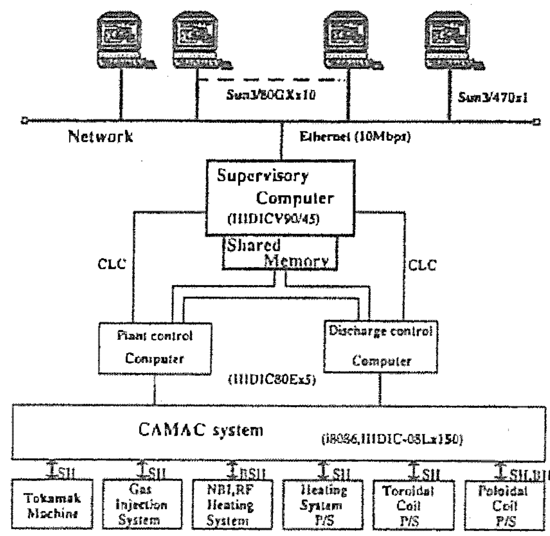

Fig.1 Man/machine System configuration in ZENKEI

II. SYSTEM CONFIGURATION

A. System Overview

The ZENKEI was composed of five mini-computers for discharge control and monitoring of plant operations. The CAMAC modules are used for data acquisition and control. Two mini-computers for high speed plasma position and shape control. The 14 CRT displays with keyboard and push-button switches had been prepared as the operator interface. This system had contained the following major functions;

- set discharge condition parameters,
- execute a discharge sequence,
- monitor the subsystem's operating status, and
- display the discharge result data.

The modification of many discharge condition parameters within a short period of time placed a big burden to the operator. Furthermore, the operator had to move back and forth from a certain console with a certain function to another with another. In addition, only a small memory had remained as a result of many modifications.

In order to improve the man/machine interface, computer hardware had to be replaced. The new man/machine interface

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system consists of 10 workstations as the operator's terminals. In addition one workstation acts as a file server. Every workstation replaces all 14 of the former CRT consoles. Figure 1 shows the new man/machine system configuration in ZENKEI.

B. Outline of the data flow

All data (including plant monitoring and discharge result data) are archived in a temporary file by the SVP (supervisor computer) from the HIDIC-80E (H-80E) system (former mini-computer system of ZENKEI) using data communication interface. There are two different communication routes between the SVP and the H-80E system. One is a DMA-controlled 16 bit, parallel interface. CLC (computer linkage controller) is assigned to small amount of data such as alarms and event signals. The other communication through a shared memory in SVP is assigned to a large amount of data such as discharge result (8Mbyte/shot).

Each workstation transfers a comparable large amount of data from a common file in SVP and SunSV (a server workstation) by using NFS (network file system) through the Ethernet.

TCP/IP protocol is also used for short data transfer, such as alarms and sequence event data.

The discharge condition is sent from a workstation to the SVP with NFS.

The discharge condition in SVP buffer file is sent to H-80E by the operator's mouse operation.

III. SYSTEM CHARACTERISTICS

A. Design principles

The major functions of the man/machine interface system are mentioned in the previous section.

The requirement of the system is to fully utilize the resource in the H-80E system which had "survived" for five-year operation in JT-60. For example, concerning the discharge sequence control, when the operator hits the sequence start button on the workstation, the message is sent to the H-80E and kicks the discharge sequence logic in the discharge management computer (1b) through the SVP → CLC.

As for setting the discharge condition, drastic improvement had been required to reduce mis-set of the parameters. As for the discharge result data display, simple and more user-friendly operation had been also required. Another principle is to be "more flexible", because user friendliness is inevitably completed after frequent modifications. The new system must interface with H-80E system which is linked to each subsystem controller composed of JT-60. It minimized the cost of modification, and reduced the risk in the software development.

B. Setting of the discharge condition parameters

The requirements for setting the discharge condition parameters are a) minimize the number of parameters set by the operator shot by shot, b) set the parameters as easy as possible and c) hold consistency among the each discharge condition parameters. To satisfy the requirements we made the histogram of the parameters used among the previous 10000 shots.

As the result,the discharge condition parameters were found out to be classified into 3 groups corresponding to procedure to decide the parameters.

a) group 1; the parameters set by the operator directly.

The parameters such as plasma current, magnetic configuration (limiter/divertor), heating/joule experiment and intensity of the toroidal field were arranged as main parameters.

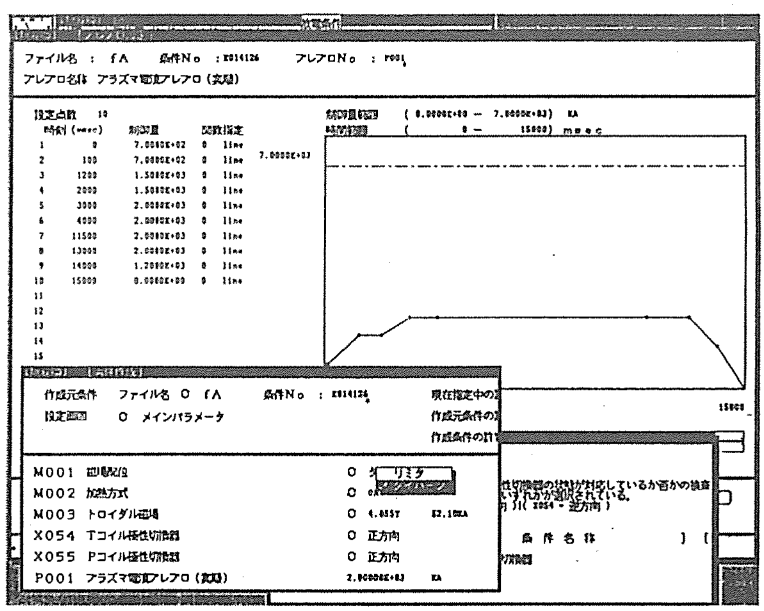

Fig.2 Display of the preprogramed waveform, discharge condition parameters set by the operator directly and it guidance.

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Hereafter,the parameters of the five poloidal field coils, such as the initial excitation current value and pre programmed current waveforms are arranged on the next screen. The gas injection valves and pre programmed pre filling, gas puffing waveforms are arranged in the same way.

b) group 2; automatic setting

The structural analyses and operational experience showed that quite a few discharge condition parameters can be uniquely decided by the group 1 parameters.Simple algorithms are developed in combination with the status or selection of devices set by the operator as group 1 items.

For example, when the operator selects the divertor configuration, the divertor coil power supply is automatically set by algorithm. The beam current parameters of NBI are automatically set by the beam acceleration voltage.

The timing parameters of NBI control system are also automatically set by the data of the initial NB injection timing of the NB injection power waveform. The MG acceleration time is automatically set by information of the present rotating speed and the maximum currents of the coils. These algorithms are performed whenever the group 1 item is set.

c) group 3; fixed discharge condition.

The discharge condition parameters in the group 3 are changed only in modification of the system configuration and commissioning of the initial phase of the operation. It contains the data set of coefficient for the electro-magnetic probes, data sampling pitches and the value of operational limitation such as the maximum coil current and the vessel wall temperature.

Limitation/consistency check are performed when the operator selects the discharge condition parameters. And "user-friendly" consideration for displaying each discharge condition item such as guide for setting, menu selection , graphic user interface reduce the risk and load of setting the discharge condition. Using the mouse, the operator can access to a brief guidance for the discharge condition parameters; the names of items, rated value of setting, related consistency check and automatic setting algorithm.

After the completion, the operator may compare the complete set of the discharge condition with another to recognize the different parameters.

Anyone can make a different set of the discharge condition at the same time. A completed discharge condition file is registered to a buffer file.

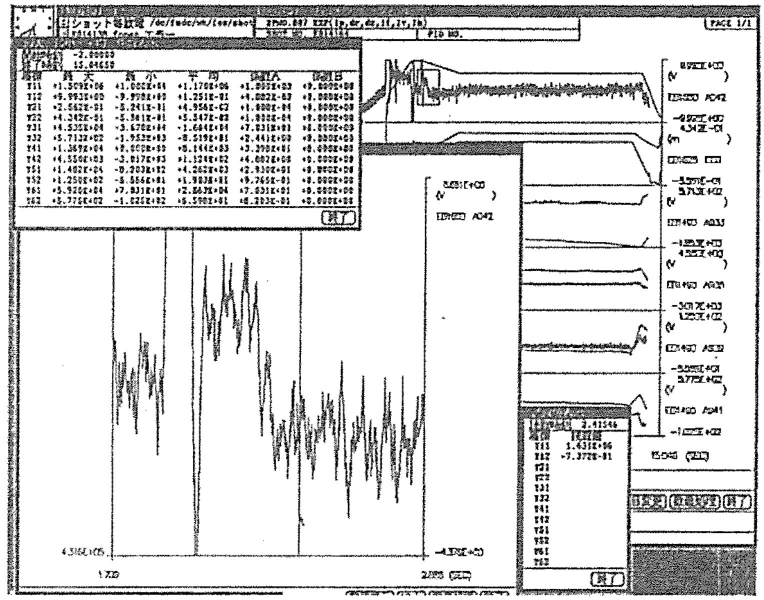

Fig.3 Discharge result data waveform with digital value display and enlargement of the waveform.

Then the chief physics operator selects a discharge condition and submit it to the next discharge sequence. The chief physics operator's approval is necessary to start the next sequence. Figure 2 shows the typical discharge condition parameter setting display.

C. Graphics

GKS and SunView software packages are used for graphics, because they have many tools for screen operation and multiwindow application. Figure 3 shows an example of the discharge result data display.

Icon selections are located in the lower position of a screen. They provide special functions; enlargement of the graphs, digital value display at the cursor(minimum, maximum , average values within the all sampled data or pointed out times by the mouse operation and calculated values of integration, differentiation through the pointed area), etc.

A graph specification table makes it possible to display the graphs quickly. The ID number of the measured data(PID.No) is listed in the utility file. The operator simply selects the PID.No to make the graph specification table.

Initially we had used simple text-based interfaces where the operator had to type using the keyboard.These primitive interfaces were replaced by using the SunView package. This enables the design of graphical interfaces with icons and menus.

The operator interface should be as simple as possible to prevent confusion. So, for instance, in mouse operation, the only left button is used for application software. Menu is also used for quick access to objective display.

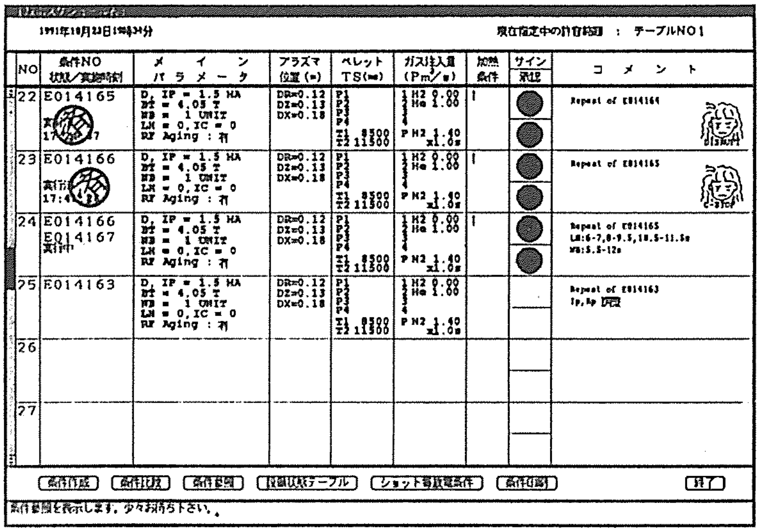

Fig.4 Shot schedule display

D. System design for graphical user interface

The effort of "quick response " in graphics and copies was made by applying the SPARC station in the network.

Another effort was made to design each "picture layout" in detail to satisfy the requirements of simpler operation.

For example, "shot schedule" screen provides entire information to all of the people in the control room , as shown in Fig 4. In this screen, the chief physics operator can modify the discharge condition parameters from the previous shot and able to confirm the main parameters and shot result. The duty manager decides to execute the discharge condition after the chief physics operator approves the discharge condition. After that the duty manager recognizes the discharge condition, together with both of the limitation check and consistency check of the error is detected, the sign becomes void.

In addition , the screen displays the progress of the discharge sequence. The status of the discharge sequence can be seen by changing the characters correspond to the progress of time sequence.

IV. LESSONS LEARNED

Some important lessons were learned from initial phase of the operation.

- In a few tens of seconds of delay , the operator can not wait for the discharge display without irritation.
- Although the window size can be changed, it is seldom used. Icon is very useful and overlapping window is not so hard to see.
- Automatic photo copy of discharge result data display is seldom used. We provide automatic copy for quick information, but the operator just display objective graphs.
- The Japanese error messages system is useful for the operator. The detailed information is also available by the mouse operation.
- The remote maintenance function for each workstation has developed to maintain the system availability high enough.

V. FUTURE PLAN

More workstations are planned to be added to the network. It enables us to see the same information at the office as in the control room. Improvement of computer capability of the workstation and the SVP is desired.

Especially speed-up of the message transfer between the SVP and the H-80E is important for more quick response.

VI. SUMMARY

The new ZENKEI, workstation-based operator interface, has been operated for more than half a year. It is accepted by the operator using mouse operation instead of typing . An improved features of the new man/machine interface system are summarized;

1)The setting of the discharge condition parameters is drastically improved by adoption of automatic setting algorithm and fixed parameters.

2)The consistency check and graphical user interface reduce the risk and load of setting the discharge condition.

3) The shot schedule screen has been widely used as information; modification of the discharge parameters, status summary of the discharge sequence execution and discharge result summary.

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