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Designing a SCADA system simulator for fast breeder reactor

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Abstract. SCADA (Supervisory Control and Data Acquisition) system simulator is a Human Machine Interface-based software that is able to visualize the process of a plant. This study describes the results of the process of designing a SCADA system simulator that aims to facilitate the operator in monitoring, controlling, handling the alarm, accessing historical data and historical trend in Nuclear Power Plant (NPP) type Fast Breeder Reactor (FBR). This research used simulation to simulate NPP type FBR Kalpakkam in India. This simulator was developed using Wonderware Intouch software 10 and is equipped with main menu, plant overview, area graphics, control display, set point display, alarm system, real-time trending, historical trending and security system. This simulator can properly simulate the principle of energy flow and energy conversion process on NPP type FBR. This SCADA system simulator can be used as training media for NPP type FBR prospective operators.

1. Introduction

Nuclear Power Plant (NPP) type Fast Breeder Reactor (FBR) uses Metal Oxide Fuel (Uranium and Plutonium) as fuel. Plutonium is placed in the center of the reactor core, and then its outer side is surrounded by U-238. This Uranium-238 absorbs neutrons coming from the fission reaction in the central part of the reactor, thus it is transformed into Pu-239. The production of Pu-239 is known as fuel breeding. Since there is no moderator in the reactor to lower the neutron energy, this reactor is called fast breeder. The coolant used in this process is liquid metal, sodium (Na), which is not moderate and resistant to extreme temperatures inside the reactor [1]–[4].

Supervisory Control and Data Acquisition (SCADA) is a communication system and control system used to monitor, control operation and maintain infrastructure on the network and can acquire data [5]. SCADA is widely used in large and medium-sized systems, so there are many types of software in the development of SCADA [6]. SCADA software functions as a link between HMI (Human Machine Interface) and MTU (Master Terminal Unit).

This study refers to previous research, about Role of Animated Human Machine Interface in Nuclear Power Plant Simulation [7] and Development Strategies of an Intelligent Human Machine Interface for Next Generation Nuclear Power Plants [8]. The Advantages of this research process simulator can visualize the flow energy nuclear power plant such as the type FBR actual conditions in the field.

Nowadays, SCADA system is inseparable from the software application that is used to view, monitor and control industrial processes. Many types of HMI software are used in the development of SCADA. With the recent developments of industrial computing systems and Human Machine Interface (HMI) software packages, engineers and researchers that develop electric power systems encountered the opportunity to produce simulator tools that can be used to process the electric power system [9].

Wonderware Intouch is a Human Machine Interface (HMI) program that meets all the needs of an integrated process, namely visualization, data access, history, event handling, alarm logging, reporting and analysis tools. Human Machine Interface is an equipment that serves to present the process data to the operator and provide input control in various formats on the monitor, including graphics, schemes, windows, screen touch pull down menu and so on. Using HMI, the operator can monitor and control the industrial processes. [10]–[12]. Wondeware intouch consists of three main constituent components, including; Intouch application manager, Intouch windowmaker, Intouch window viewer.

The Application of SCADA system is intended to simulate the dynamic real time data of Nuclear Power Plant (NPP) type Fast Breeder Reactor (FBR), and the operation is aimed for training. The increasing demand for trained power plant operators has created awareness that simulator is the most effective tool for training. An actual nuclear power plant cannot be used for such extensive training, such as start-up, shutdown, damage, incident, etc., because of security considerations and the reactor availability [7]. Therefore, a simulator that can be used as training material for power plant operators is needed.

2. Research and Methodology

This Research is a design research that produced products in the form of SCADA system simulator visualization for NPP type FBR. The designing of this simulator was conducted using Wonderware Intouch software. In order To make it easier to understand the steps involved in this study, the research procedure is shown on Figure 1.

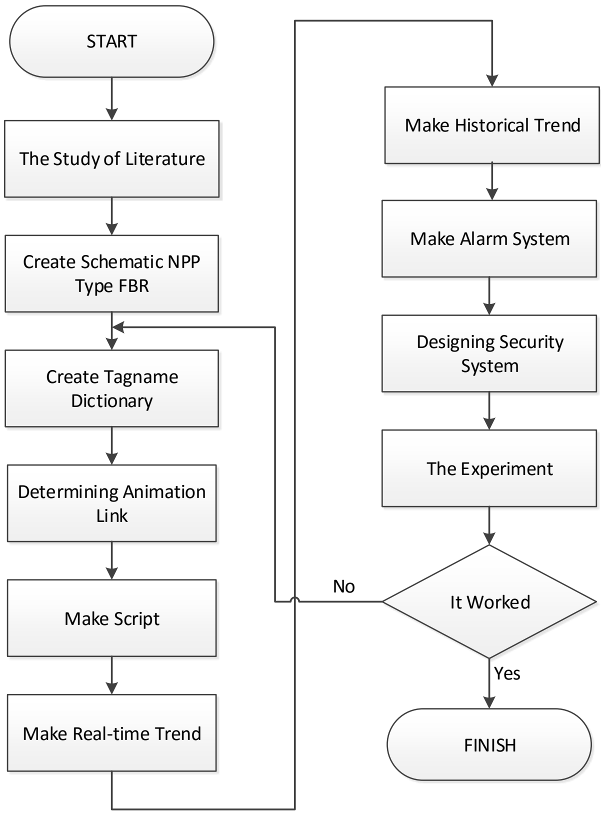

Figure 1. Flowchart Designing a SCADA System Simulator for NPP type FBR

The First step in doing this research was conducting literature study from various reliable sources, such as journals from International Institute of Electrical and Electronics Engineers (IEEE), technical reports from International Atomic Energy Agency (IAEA), technical data from Indira Gandhi Centre for Atomic Research, etc. The second step was creating schematic by inputting the components existing at NPP type FBR. The third step was creating tagname dictionary that was given to each component. The fourth step was determining the animation link on each component in order to identify the working principle of the link, so that when it is runtimed it will look alive like the real situation in the field.

After determining the animation link, the fifth step was creating a script that functioned to execute commands and logical operations based on the criteria for each component. The sixth step was creating real-time trend to display data in real time. The seventh step was creating historical trend to graphically display stored past tagname data. The eighth step was creating alarm systems that will give a warning in an unsafe process conditions on the system. The ninth step was creating security system that aims to keep the system safe from operator's working fault which is not in accordance with the setpoint system that had been made.

The next step is performing test to the system using intouch windowviewer, starting from the process of energy flow at NPP type FBR, real-time trend, historical trend alarm system and security system in order to know wheter these components work as expected or not. If there is a function that does not work, then go back to step three, which is giving tagname and, follow the next steps until the system works as expected.

3. Results and Discussion

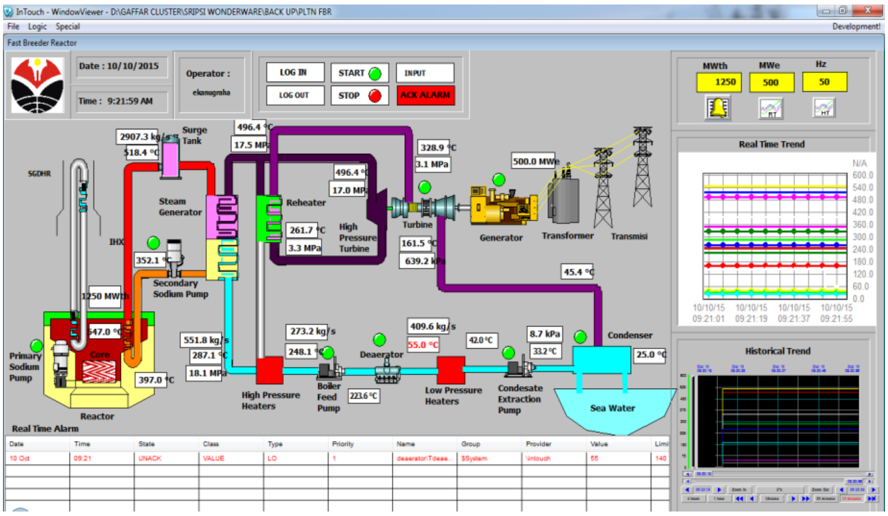

Figure 2. Visualization of Human Machine Interface SCADA System Simulator for NPP type FBR.

3.1. The Process of Electric Energy Generation in NPP type FBR

Nuclear Power Plant type Fast Breeder Reactor has a capacity of 500MWe pool type that utilizes sodium as a heat transfer medium. Nuclear Power Plant type Fast Breeder Reactor contains three main systems of heat transfer, namely primary sodium system, secondary sodium system and steam system [13]. The heat coming from the reactor core is circulated by primary sodium pump, then the heat is transferred to the steam generator through Intermediate Heat Exchangers, the hot sodium from the steam generator is recirculated to the reactor using secondary sodium pump. The steam from the steam generator is generated from the combination of hot sodium and sea water that has previously been through the heating stage, starting from condensate extraction pump, low pressure heater, deaerator, boiler feed pump and the high pressure heater. The steam generated from the steam generator is subsequently used to rotate the high pressure turbine, then the rest of the steam is heated back through the reheater to rotate the intermediate pressure and low pressure turbines which are mounted coaxially with the generator, thereby producing electrical energy. Steam from the rest of the turbine is condensed back into water in the condenser. Condensate water flows back into the steam generator through the heating process starting from the condensate extraction pump and so on.

3.2. Designing a SCADA System Simulator NPP type Fast Breeder Reactor

Design SCADA system for NPP type FBR have relatively many indicators that can facilitate the process of monitoring and controlling the generation process. Figure 2 shows the visualization design of the SCADA system simulator fo NPP type FBR.

SCADA system simulator is equipped with a security system that aims to safeguard the system security so that it cannot be run by those who do not possess access rights to the system. To be able to operate the system, the operator must LOG IN by inserting username and password via the LOG IN button. START button is used to begin running the system, and INPUT button is to display the working parameters for each component.

When the START button is pressed, the system will begin to visualize the generation process at NPP type FBR. Components that are working are marked with green light indicator. In addition, there is also a visualization of blink-blink animation on the components. Working parameters, such as temperature, pressure and mass flow rate of the component will appear or change when the flow of energy passes through the components. The generation process at NPP type FBR consists of several types of energy flow. First, the sodium in the reactor, intermediate heat exchanger, steam generator and pipe are colored red, beige and brick red. Second, the pipe water that comes from sea water is colored light blue. Third, the steam generated from the steam generator which will rotate the turbine is colored purple.

Real-time trend is a graph that displays the working parameters of the components in real-time according to the specified time interval. The maximum time range displayed in a trend is 60 seconds and the update rate is every one second. Historical trend is a graph of past (historical) data that occur at a specific time. Real-time alarm is a warning if the process condition is abnormal or beyond the parameters that have been determined. If the alarm works, there will be a red colored description on the alarm box. To normalize the real-time alarm, the operator can press the ACK ALARM button, so that the information displayed on the alarm box will turn black, indicating that the alarm that occurred has been acknowledged by the operator.

4. Conclusions

The components of Human Machine Interface (HMI) for NPP type FBR can be designed using the symbol factory in Intouch Window Maker in Wonderware Intouch software, and the results of other supporting software. The system is simulated using Intouch Window Viewer. This system can visualize the energy flow, can display energy conversion at NPP type FBR, and is equipped with manual book for each component, real-time trend, historical trend, real-time alarm and security system. Therefore, SCADA system simulator that had been designed can be used to function as instructional and training media operators prior to actual implementation in SCADA system and the process of electric energy generation at NPP type FBR.

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