Sudan University for Science & Technology

College of Engineering

School of Electrical & Nuclear Engineering

Distributed Control System of Boiler in Steam Power Station

نظم التحكم الموزع للمرجل في محطة القوى البخارية

A Project Submitted in Partial Fulfillment for the Requirements of the Degree of B.tech (Honor) in Electrical Engineering

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November, 2020

الآية

بسم الله الرحمن الرحيم

﴿اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونَةٍ لَّا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُّورٌ عَلَىٰ نُورٍ يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاءُ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ﴾

صدق الله العظيم

سورة النور الآية (35)

Deduction

To My Family

Acknowledgement

To my Teachers and the Staff of Khartoum North Power Station, Engineers and Technical Staff, Especially Engnier Abd Alwhab Esmaeel, and our supervisor Mr. Mr. Gaffar Babeker Osman and every One who Supported us to complete our Journey.

Abstract

The Objective of this Project the Distributed Control Systems system in the boiler in Khartoum north steam power station, by Control the level of the boiler water drum by implementing optimum logic using the proposed program designed by DCS.

Used there is call OC400, the research conclude that the DCS system is very important program in the in power station and the industrial Facilities to prevent the equipment from damage, arise the safety of the workers.

OC400 is very flexible program, and our recommendation to keep up study the DCS Extend the control to include the feed water flow, steam flow and steam temperature Three element control) for more accuracy.

المستخلص

هدفت البحث لدراسة المتحكم الموزع في الغلاية في محطة بحري الحرارية. وآلية البحث هي القيام بزيارة ميدانية لمحطة بحري الحرارية لدراسة البرنامج المستخدم في المحطة والبرنامج المستخدم هو OC4000 يتميز هذا البرنامج بالمرونة.

وتوصل البحث لعدد من النتائج اهمها: أهمية استخدام برنامج المتحكم الموزع في الممحطات الحرارية والمنشاءات الصناعية مهم جدا لما يتميز به من سرعة وكفاءة في الآداء وايضاً زيادة سلامة العاملين في المنشاءات الصناعية والمحافظة على المعدات الصناعية من الدمار في حالة حدوث اي من الاعطال الكبيرة. أن برنامج OC400من البرامج المرنة جداً .

ويوصي البحث بزيادة الاهتمام بدراسة برنامج المتحكم الموزع خاصة لطلاب الهندسة الكهربائية والمكنيكية. دراسة المتحكم الموزع يحتاج الى مزيد من الدراسة وذلك لاهمية الغلاية في المحطة الحرارية حيث انها تعتبر من الاجزاء الرئيسية في المحطة.

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Chapter One

Introduction

1.1 General Concepts

Automatic control system has played an vital role in the advancement of Science and Engineering. Generally several automation techniques are implemented to control and monitor the industrial plants which include petrochemical plants, oil refining, and thermally electric generation plants. Examples of these techniques include Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA) and (DCS). In this project the DCS software is used to make optimal controlling in boiler such as level of water in Power Station (PS) [1].

Boiler is a very important equipment in any process industry .The control of a boiler is very complicated because it involves the measurement and control of a number of parameters like drum level, air fuel ratio, steam pressure ,steam temperature ,oxygen content in flue gas , air flow into the furnace and the firing rate etc. The control was initially done manually for small capacity boiler but, as the capacity of steam increased the process demanded computer based automation to be done which was done by magnetic relays and the controllers were all pneumatic based systems it was then replaced by electrical controller which reduced the size and complexity of the hardware involved .The latest automation techniques like which involved microcomputers made the controls easier but was not redundant all the task was assigned to a single computer [1].

The latest automation technique in the field of process automation is the distributed control system is redundant and also is a decentralized control which makes the implementation of complex controls possible. The distributed control system consists of a central computer which is assigned with the main task the work is shared among different systems. The DCS is the most feasible technique for control of complex systems like boiler. There are different types of designs available in boiler based on the specification we have taken a water tube boiler for our analysis .The automation is done using the OC4000 software. The boiler water/steam drum is an integral part of the boiler's design. This vessel has three specific purposes; provide a volume space to hold the boiling water in the boiler, provide enough water volume to allow for good thermal mixing of the cooler bottom drum water with the hotter surface interface water and provide surface area and volume for the efficient release of the entrained steam bubbles from the boiler water. The surface area and volume of the vapor space in the water/steam drum is critical to the efficient separation of the steam bubbles from the water. Too small an area can result in an excessive surface tension and high velocities, which result in wasted heat and drum water carry-over. Too large an area is simply a waste of materials and labor to construct the vessel.

The boiler water/steam drum also provides a logical location for addition of feed water, addition of chemical water treatment and surface blow down, which helps reduce the surface tension of the water/steam interface to allow better steam release. Because all of these task involve the removal and addition of some mass (water or steam) the water/steam interface is always in a state of flux. Maintaining a stable interface level is critical to the safe and efficient operation of the boiler.

Low water levels affect the internal thermal recirculation of the boiler water resulting in cold spots in the boiler water and steam collapse. This lack of circulation also reduces the effectiveness of the chemical water treatment and can cause precipitation of the chemicals as chemical salts or foams. High water levels raise steam exit velocities and result in priming or boiler water carryover in to the distribution system. Priming results in wet dirty steam while carry-over can result in dangerous water hammer and pipe or equipment damage [1].

1.2 Problem Statement

An increase in the humidity percentage in the steam leads to a gradual damage in the turbine blade, this might happen if the water level in the water drum increases above a predetermined level. In contrast, if the water level decreased below a minimum level, it will lead to damage in the inner tubes of the boiler. To avoid this problem we need an optimal control system with a high response and redundant ability.

1.3 Objectives

The primarily objectives of this Project are to:

- Maintain the water/steam interface at its optimum level to provide a continuous mass/heat balance by replacing every pound of steam leaving the boiler with a pound of feed water to replace.
- Control the level of the boiler water drum by implementing optimum logic using the proposed program designed by DCS.
- Deal with DCS basic components, hardware configuration and the software.
- To learn how to prepare a research proposal and projects.

1.4 Methodology

By visit the Khartoum north power station and the study the plants, to achieve the objectives of this research, DCS program is constructed by using optimal control (OC 4000) DCS software that is produced by American company named Generation Electrical (GE). The FBD program designed to control and monitors the water steam drum level.

1.5 Project Layout

This study contains five chapters: Chapter One includes the research introduction. Chapter Two stem power station. On the other hand Chapter Three includes the distributed control systems. Chapter Four presents the DCS in boiler in north Khartoum power station. Finally, Chapter Five shows the conclusion and the future recommendations.

Chapter Two

Steam Power Station

2.1 Introduction

The Steam power station is a power station in which the electric generator is steam driven. Water is heated, tunes into seam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser; the greatest variation in the design of steam- electric power plants is due to the different fuel sources.

Reciprocating steam engines have been used for mechanical power sources since the 18^{th} century with notable improvements being made by James watt. The very first commercial central electrical generating stations in New York and London, in 1882, also used reciprocating steam engines. As generator sizes increased, eventually turbines took over due to higher efficiency and lower cast of construction. By the 1920s any central station larger than a few thousand kilowatts would use a turbine prime mover.

2.2 Condenser

Figure 2.1Shows Surface Condenser

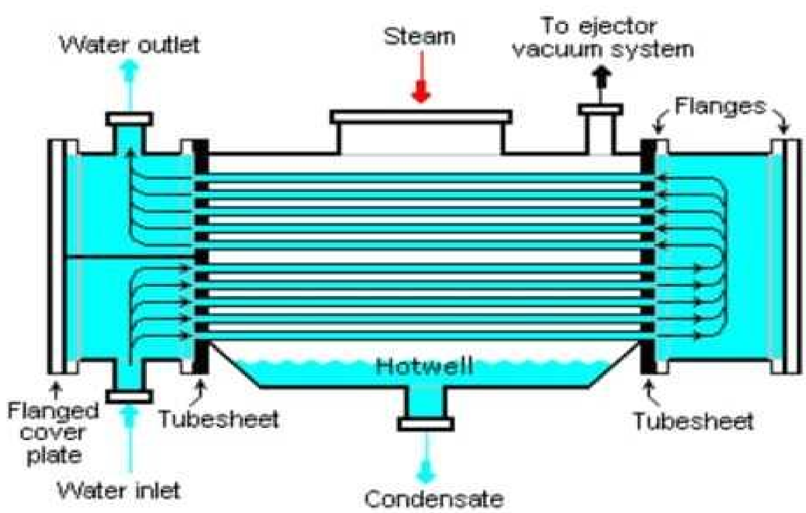

Figure 2.1: Diagram of a typical water – cooled surface condenser

Steam electric power plants use a surface condenser cooled by water circulating through tubes. The steam which was used to turn the turbine is exhausted into the condenser and is condensed as it comes in contact with the tubes full of cool circulating water. The condensed steam commonly referred to as condensate. Is withdrawn from the bottom of the condenser. The adjacent image is a diagram of a typical surface condenser.

2.3 Superheated

After the steam is conditioned by the drying equipment inside the drum, it is piped from the upper drum area into an elaborate set up of tubing in different areas of the boiler, the areas known as superheater and reheater. The steam vapor picks up energy and is superheated above the saturation temperature. The superheated steam is then piped through the main steam lines to the valves of the high pressure turbine.

2.4 Boilers

A boiler is an enclosed vessel that provides a means of converting water into steam the steam under pressure is then used for transferring the heat to a process. Water is a useful and cheap medium for transferring heat to a process. When water is boiled its volume increases by about 1600 times. Producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous and must be treated with a lot of care [1].

2.5 Types of Boiler

There are infinite number of boiler designs but generally they fit into one of the two categories:

2.5.1 Fire Tube

Fire tube or “fire in tube” boilers, contain long steel tubes through which the hot gases from a furnace pass and around which the water to be heated circulates. In a fire tube boiler the heat (gases) from the combustion of the fuel passes through the tubes and is transferred to the water which is in a large cylindrical storage area. Common types of fire tube boilers are scotch marine, fire box, HRT or horizontal return tube. Fire tube boilers typically have a lower initial cost, are more fuel efficient and easier to operate but they are limited generally to capacities of 50000pph and pressures of 250psig [1] . Figure 2.2 Shows Fire tube boiler [6].

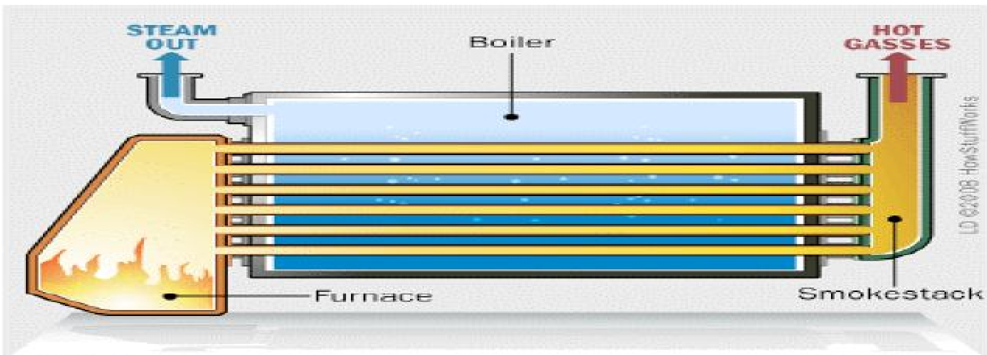

Figure 2.2: Fire tube boiler

2.5.2 Water Tube

Water tube or "water in tube" boilers have water passing through the tubes and the steam circulates around it. The common water tube boilers are "D" type, "A" type, "O" type, bent tube and cast-iron sectional. All fire tube boilers and most water tube boilers are packaged boilers in that they can be transported by truck, rail or barge. Large water tube boilers in industries with large steam demands and utilities must be completely assembled and constructed in the field and are called "field erected boiler" Figure 2.3 Shows Water tube boiler [6].

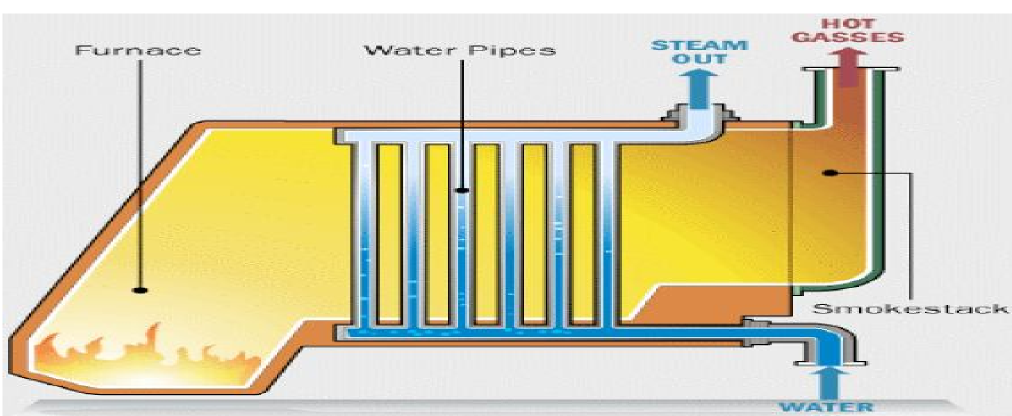

Figure 2.3: Water tube boiler

2.5.3 Other Combustion Boilers

Cast iron boilers are fabricated from a number of cast iron sections that are bolted together. The design of each section includes integral water and combustion gas passages. When fully assembled, the interconnecting passages create chambers where heat is transferred from the hot combustion gases to the water. These boilers generally produce low-pressure steam (15 psig) or hot water (30 psig) and burn either oil or natural gas. Only about 12% of the cast iron boilers in the United States are fired by coal.

Because of their construction, cast iron boilers are limited to smaller sizes. Only 37% have heat input capacities greater than 0.4 MBtu/h (Ref. 5). Because the components of these boilers are relatively small and easy to transport, they can be assembled inside a room with a conventional-size doorway. This feature means that cast iron boilers are often used as replacement units, which eliminate the need for temporary wall removal to provide access for larger package units. Cast iron boilers represent only about 10% of the ICI boiler capacity in the United States. The configuration of a cast iron boiler is shown in Figure 2.4.

Another boiler that is sometimes used to produce steam or hot water in known as a tubeless boiler. The design of tubeless boilers incorporates nested pressure vessels with water located between the shells.5 Combustion gases are fired into the inner vessel where heat is transferred to water located between the outside surface of the inner shell and the inside surface of the outer shell. For oil-fired and natural-gas-fired vertical tubeless boilers, the burner is typically located at the bottom of the boiler and fires into the inner pressure vessel. The configuration of a vertical tubeless boiler is shown in Figure. 2.5.

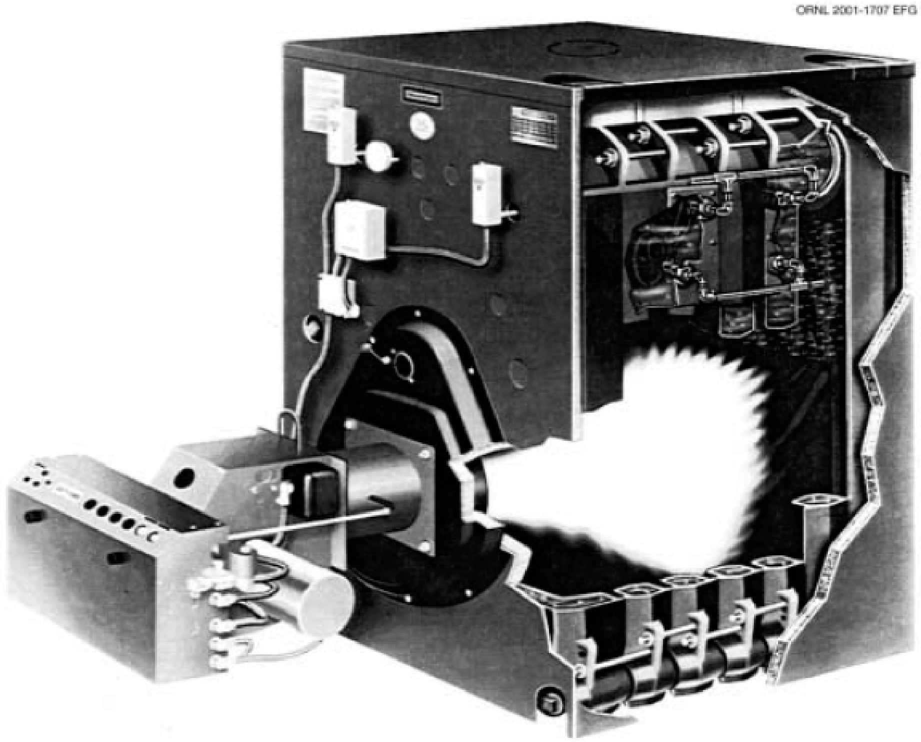

Figure **2.4: Configuration of cast iron boiler.**

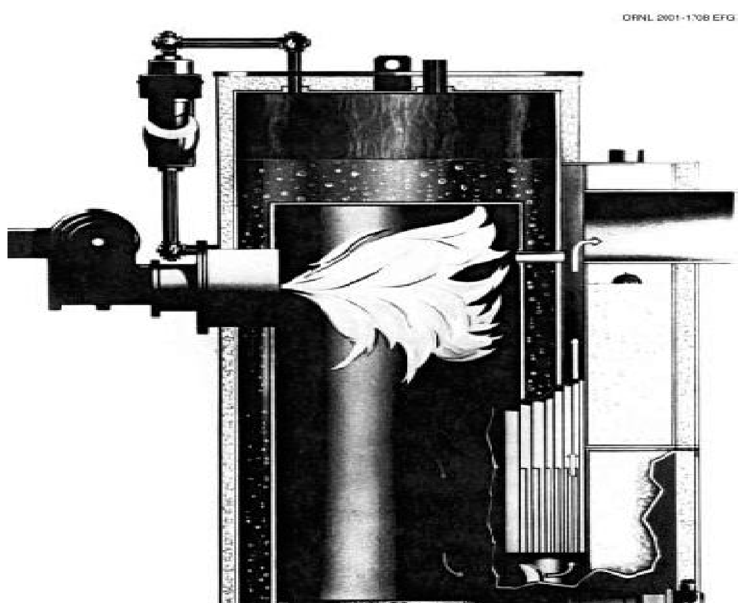

Figure **2.5: Configuration of vertical tubeless boiler.**

2.6 Burners

A burner is defined as a device or group of devices for the introduction of fuel and air into a furnace at the required velocities, turbulence, and concentration to maintain ignition and combustion of fuel within the furnace. Burners for gaseous fuels are less complex than those for liquid or solid fuels because mixing of gas and combustion air is relatively simple compared to atomizing liquid fuel or dispersing solid fuel particles.

There is no formal classification system for burners, but attempts to combine desirable burner characteristics have given rise to a rich diversity in burner designs.13 Terminology used to identify burners that have been in existence for a long time as well as advanced burners that are based on emerging technology is listed in Table 2.3.

The ability of a burner to mix combustion air with fuel is a measure of its performance. A good burner mixes well and liberates a maximum amount of heat from the fuel. The best burners are engineered to liberate the maximum amount of heat from the fuel and limit the amount of pollutants such as CO, NOx, and PM that are released. Burners with these capabilities are now used routinely in boilers that must comply with mandated emission limitations. Emission control techniques that are effective in reducing NOx, CO, SO2.

2.7 Fuel Feed Systems

Fuel feed systems play a critical role in the performance of low-emission boilers. Their primary functions include (1) transferring the fuel into the boiler and (2) distributing the fuel within the boiler to promote uniform and complete combustion. The type of fuel and whether the fuel is a solid, liquid, or gas influences the operational features of a fuel feed system.

Gaseous fuels are relatively easy to transport and handle. Any pressure difference will cause gas to flow, and most gaseous fuels mix easily with air. Because on-site storage of gaseous fuel is generally not feasible, boilers must be connected to a fuel source such as a natural gas pipeline. Flow of gaseous fuel to a boiler can be precisely controlled using a variety of control systems. These systems generally include automatic valves that meter gas flow through a burner and into the boiler based on steam or hot water demand. The purpose for the burner is to increase the stability of the flame over a wide range of flow rates by creating a favorable condition for fuel ignition and establishing aerodynamic conditions that ensure good mixing between the primary combustion air and the fuel. Burners are the central elements of fuel preparation and air-fuel distribution as well as a comprehensive system of combustion controls.

Like gaseous fuels, liquid fuels are also relatively easy to transport and handle by using pumps and piping networks that link the boiler to a fuel supply such as a fuel oil storage tank. To promote complete combustion, liquid fuels must be atomized to allow thorough mixing with combustion air. Atomization by air, steam, or pressure produces tiny droplets that burn more like gas than liquid. Control of boilers that burn liquid fuels can also be accomplished using a variety of control systems that meter fuel flow.

Solid fuels are much more difficult to handle than gaseous and liquid fuels. Preparing the fuel for combustion is generally necessary and may involve techniques such as crushing or shredding. Before combustion can occur, the individual fuel particles must be transported from a storage area to the boiler.

Mechanical devices such as conveyors, augers, hoppers, slide gates, vibrators, and blowers are often used for this purpose. The method selected depends primarily on the size of the individual fuel particles and the properties and characteristics of the fuel. Stokers are commonly used to feed solid fuel particles such as crushed coal, TDF, MSW, wood chips, and other forms of biomass into boilers. Mechanical stokers evolved from the hand-fired boiler era and now include sophisticated electromechanical components that respond rapidly to changes in steam demand. The design of these components provides good turndown and fuel-handling capability. In this context, turndown is defined as the ratio of maximum fuel flow to minimum fuel flow. Although stokers are used for most solid fuels, PC combustion, which consists of very fine particles, does not involve a stoker.

Coal in this form can be transported along with the primary combustion air through pipes that are connected to specially designed burners.

The following discussions about stokers and burners are only intended to provide background information about these devices. Because the characteristics of stokers and burners are very complex and highly technical, the information does not address detailed issues associated with their design, construction, theory of operation, or performance. Because of concerns about revealing proprietary information, these discussions are intentionally generic in nature. Specific details about a particular product or design should be obtained from the manufacturer.

Chapter Three

Distributed Control Systems

3.1 Introduction

Generally, the concept of automatic control includes accomplishing two major operations; the transmission of signals (information flow) back and forth and the calculation of control actions (decision making). Carrying out these operations in real plant requires a set of hardware and instrumentation that serve as the platform for these tasks. (DCS) is the most modern control platform. It stands as the infrastructure not only for all advanced control strategies but also for the lowliest control system. The idea of control infrastructure is old. The next section discusses how the control platform progressed through time to follow the advancement in control algorithms and instrumentation technologies.

To fully appreciate and select the current status of affairs in industrial practice it is of interest to understand the historical perspective on the evolution of control systems implementation philosophy and hardware elements. The evolution concerns the heart of any control system which is how information flow and decision making advanced.

1. Pneumatic Implementation: In the early implementation of automatic control systems, information flow was accomplished by pneumatic transmission, and computation was done by mechanical devices using bellows, spring etc. The pneumatic controller has high margin for safety since they are explosion proof. However, There are two fundamental problems associated with pneumatic implementation:

Transmission: the signals transmitted pneumatically (via air pressure) are slow responding and susceptible to interference.

• *Calculation*: Mechanical computation devices must be relatively simple and tend to wear out quickly.

Electron analog implementation: Electrons are used as the medium of transmission in his type of implementation mode. Computation devices are still the same as before. Electrical signals to pressure signals converter (E/P transducers) and vice verse (P/E transducers) are used to communicate between the mechanical devices and electron flow. The primary problems associated with electronic analog implementation are:

Transmission: analog signals are susceptible to contamination from stray fields, and signal quality tends to degrade over long transmission line.

Calculation: the type of computations possible with electronic analog devices is still limited.

Digital Implementation: the transmission medium is still electron, but the signals are transmitted as binary numbers. Such digital signals are far less sensitive to noise. The computational devices are digital computers. Digital computers are more flexible because they are programmable. They are more versatile because there is virtually no limitation to the complexity of the computations it can carry out. Moreover, it is possible to carry out computation with a single computing device, or with a network of such devices.

Many field sensors naturally produce analog voltage or current signals. For this reason transducers that convert analog signals to digital signals (A/D) and vice verse (D/A) are used as interface between the analog and digital elements of the modern control system. With the development of digital implementation systems, which DCS are based on, it is possible to implement many sophisticated control strategies on a very fast timescale.

3.2 Modes of Computer control

Computer control is usually carried out in two modes: *supervisory control* or *direct digital control*. Both are shown in Figure 1. Supervisory control involves resetting the set point for a local controller according to some computer calculation. Direct digital control, by contrast, requires that all control actions be carried out by the digital computer. Both modes are in wide use in industrial applications, and both allow incorporating modern control technologies. Measurements are transmitted to computer and control signals are sent from computer to control valves at specific time interval known as sampling time. The latter should be chosen with care.

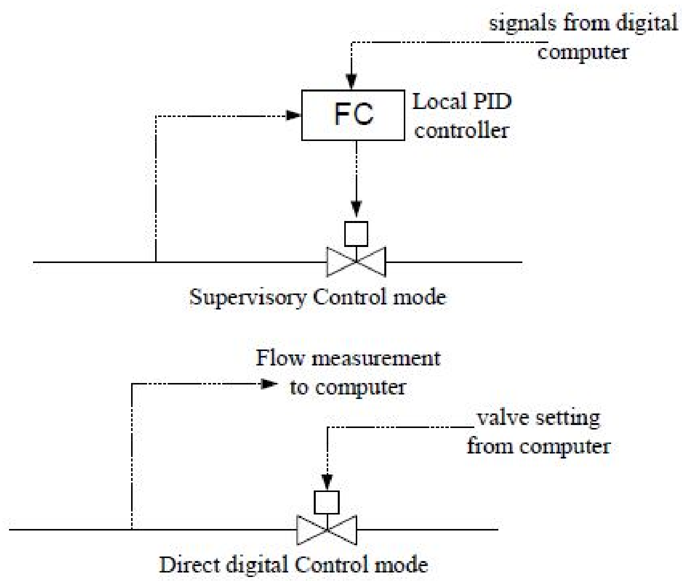

Figure 3.1: Computer control modes.

3.3 Computer Control Networks

The computer control network performs a wide variety of tasks: data acquisition, servicing of video display units in various laboratories and control rooms, data logging from analytical laboratories, control of plant processes or pilot plant, etc. The computer network can be as simple as an array of inexpensive PC's or it could be a large commercial DCS.

3.3.1 Small computer network

In small processes such as laboratory prototype or pilot plants, the number of control loops is relatively small. An inexpensive and straightforward way to deal with the systems is to configure a network of personal computers for data acquisition and control. An example configuration of a PC network control system is depicted in Figure 2. The network consists of a main computer linked directly to the process in two-way channels. Other local computers are linked to the main computer and are also connected to the process through one-way or two-way links. Some of these local computers can be interconnected. Each of the local computers has a video display and a specific function. For example, some local computers are dedicated for data acquisition only, some for local control only and some other for both data acquisition and local control. The main computer could have a multiple displays. All computers operate with a multitasking operating system. They would be normally configured with local memory, local disk storage, and often have shared disk storage with a server.

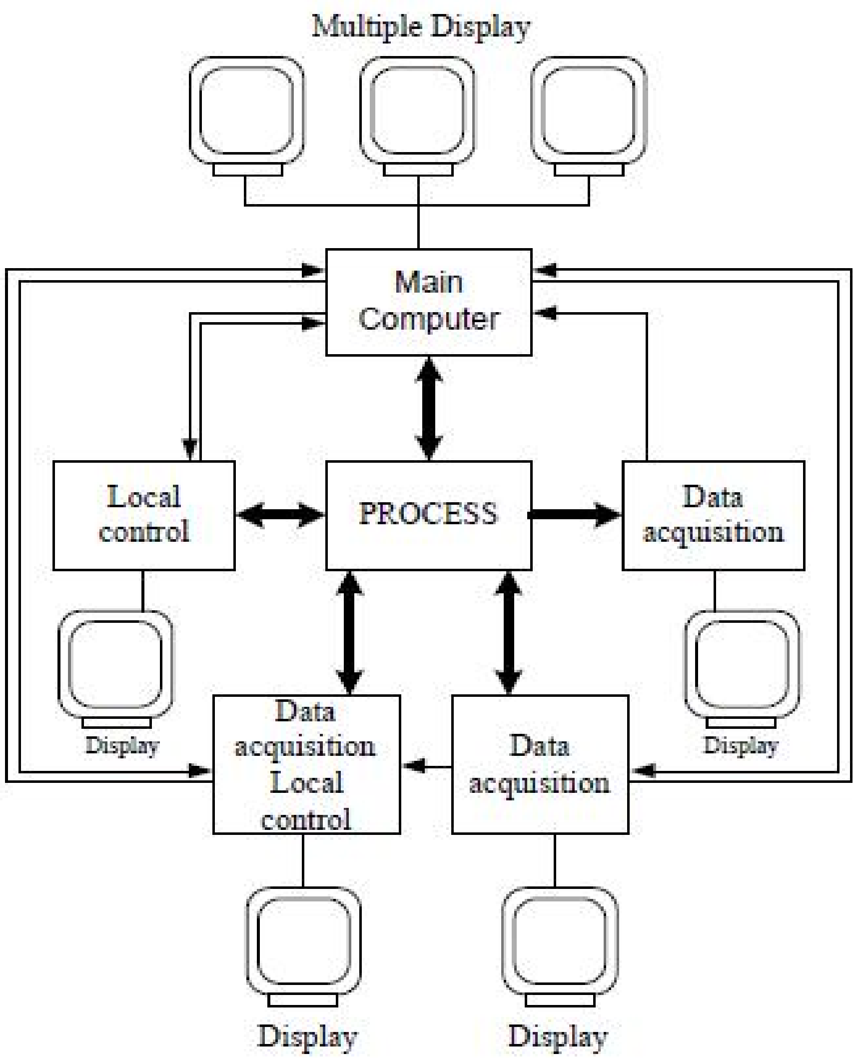

Figure 3.2: PC network

3.3.2 Programmable logic controllers

Programmable Logic Controller (PLC) is another type of digital technology used in process control. It is exclusively specialized for non-continuous systems such as batch processes or that contains equipment or control elements that operate discontinuously. It can also be used for many instants where interlocks are required; for example, a flow control loop cannot be actuated unless a pump has been turned on. Similarly, during startup or shutdown of continuous processes many elements must be correctly sequenced; that is, upstream flows and levels must be established before downstream pumps can be turned on.

The PLC concept is based on designing a sequence of logical decisions to implement the control for the above mentioned cases. Such a system uses a special purpose computer called *programmable logic controllers* because the computer is programmed to execute the desired Boolean logic and to implement the desired sequencing. In this case, the inputs to the computer are a set of relay contacts representing the state of various process elements. Various operator inputs are also provided. The outputs from the computer are a set of relays energized (activated) by the computer that can turn a pump on or off, activate lights on a display panel, operate solenoid valve, and so on.

PLCs can handle thousands of digital Input/output and hundreds of analog I/O and continuous PID control. PLC has many features besides the digital system capabilities. However, PLC lacks the flexibility for expansion and reconfiguration. The operator interface in PLC systems is also limited. Moreover, programming PLC by a higher-level languages and/or capability of implementing advanced control algorithms is also limited.

PLCs are not typical in a traditional process plant, but there some operations, such as sequencing, and interlock operations, that can use the powerful capabilities of a PLC. They are also quite frequently a cost-effective alternative to DCSs (discussed next) where sophisticated process control strategies are not needed. Nevertheless, PLCs and DCSs can be combined in a hybrid system where PLC connected through link to a controller, or connected directly to network.

3.4 Commercial Distributed Control Systems

In more complex pilot plants and full-scale plants, the control loops are of the order of hundreds. For such large processes, the commercial distributed control system is more appropriate. There are many vendors who provide these DCS systems such as Bialy, Foxboro, Honeywell, Rosemont, Yokogawa, etc. In the following only an overview of the role of DCS is outlined.

Conceptually, the DCS is similar to the simple PC network. However, there are some differences. First, the hardware and software of the DCS is made more flexible, i.e. easy to modify and configure, and to be able to handle a large number of loops. Secondly, the modern DCS are equipped with optimization, high-performance model-building and control software as options. Therefore, an imaginative engineer who has theoretical background on modern control systems can quickly configure the DCS network to implement high performance controllers.

A schematic of the DCS network is shown in figure 3. Basically, various parts of the plant processes and several parts of the DCS network elements are connected to in practice there could be several levels of data highways. A large number of local data acquisition, video display and computers can be found distributed around the plant. They all communicate to each other's through the data highway. These distributed elements may vary in their responsibilities. For example, those closest to the process handle high raw data traffic to the local computers while those farther away from the process deal only with processed data but for a wider audience.

The data highway is thus the backbone for the DCS system. It provides information to the multi-displays on various operator control panels sends new data and retrieve historical data from archival storage, and serves as a data link between the main control computer and other parts of the network.

On the top of the hierarchy, a supervisory (host) computer is set. The host computer is responsible for performing many higher level functions. These could include optimization of the process operation over varying time horizons (days, weeks, or months), carrying out special control procedure such as plant start up or product grade transition, and providing feedback on economic performance.

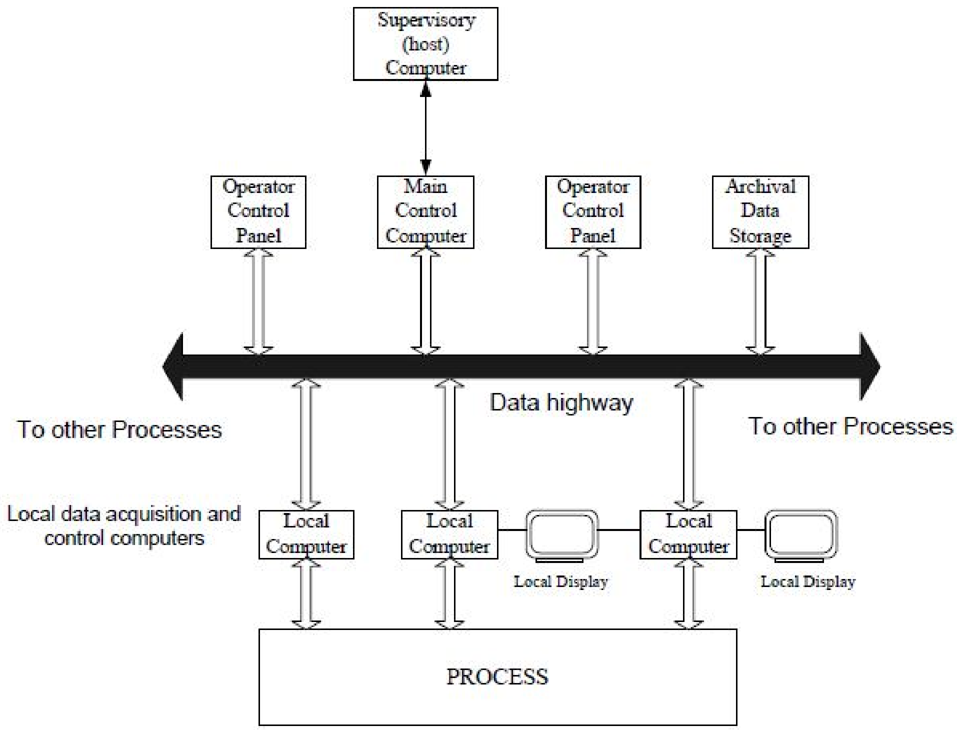

Figure 3.3: The elements of a commercial distributed control system network

A DCS is then a powerful tool for any large commercial plant. The engineer operator can immediately utilize such a system to:

Access a large amount of current information from the data highway.

See trends of past process conditions by calling archival data storage.

Readily install new on-line measurements together with local computers for data acquisition and then use the new data immediately for controlling all loops of the process. Alternate quickly among standard control strategies and readjust controller parameters in software. A sight full engineer can use the flexibility of the framework to implement his latest controller design ideas on the host computer or on the main control computer.

In the common DCS architecture, the microcomputer attached to the process are known as front-end computers and are usually less sophisticated equipment employed for low level functions. Typically such equipment would acquire process data from the measuring devices and convert them to standard engineering units. The results at this level are passed upward to the larger computers that are responsible for more complex operations. These upper-level computers can be programmed to perform more advanced calculations.

3.5 Information Presentation and Accuracy

The modern digital computer is a binary machine. This means that internal data and arithmetic and logic must be represented in binary format. Therefore all process information flowing into and out of the computer must also be converted to that form. Traditionally, the computer memory location is made up of a collection of bits called a word (register). A typical computer word consists of 16 bits (new computers carry 32-bits word). Consider, for example, the following machine number:

16-bit computer word: 1011001100010100

The base for this word is 2. Therefore, each bit has the following decimal equivalent:

Table One Shows Converting from Decimal to Mache Number of 16 bit

Bit 1	Bit 2	Bit 3	Bit 4	…	Bit 16	
Machine number	0	0	0	0	…	0
Decimal equivalent	20	21	2	23	…	216

Each single bit consists of binary elements, i.e. 0 or 1. Therefore, any integer number from 0 to 7 can be represented by a three-bit word as follows:

Table Two Shows Converting from Decimal to Mache Number of 7 bit

Contents of a 3-bit word	Digital Equivalent
0 0 0	0(20)+0(21)+0(22) = 0
0 0 1	1(20)+0(21)+0(22) = 1
0 1 0	0(20)+1(21)+0(22) = 2
0 1 1	1(20)+1(21)+0(22) = 3
1 0 0	0(20)+0(21)+1(22) = 4
1 0 1	1(20)+0(21)+1(22) = 5
1 1 0	0(20)+1(21)+1(22) = 6
1 1 1	1(20)+1(21)+1(22) = 7

as mentioned earlier. Then it is converted to digital form by an electronic device called analog to digital converter (A/D). Similarly, digital information is converted to analog form (Voltage or current) by a digital to analog converter (D/A). The accuracy (resolution) of such digitization process depends on the number of bits used to for representation. The degree of resolution is given by:

121 range] scale [−×=mfullresolution

Where m is the number of bits in the representation. Obviously, higher resolution can be obtained at higher number of bits. For example, consider a sensor sends an analog signal between 0 and 1 volt and assume only a three-bit computer word is available, and then the full range of the signal can be recognized as follows:

This means that eight specific values for the analog signal can be exactly recognized. Any values interim values will be approximated according to the covered analog range shown in the fourth column of Table 1. In this way, the error in resolution is said to be in the order of 1/14. Assume now a 4-bit word is available for the same analog signal. Then the full range will be divided over 15 points, i.e. sixteen equally spaced values between 0 and 1 can be recognized, and the error in resolution will be in the order of 1/30.

Most current control-oriented ADC and DAC utilize a 10 to 12 bit representation (resolution better than 0.1%). Since most micro- and minicomputers utilize at least a 16-bit word, the value of an analog variable can be stored in one memory word.

New computers are capable of using 32-bit word. Therefore, new generation of ADC and DAC with higher resolution (up to 16 to 20 bit) are emerging.

Table Four Representation of a 0 to 1 volt analog variable using a 3-bit word

Binary representation	Digital Equivalent	Analog equivalent	Analog range covered
0 0 0	0	0	0 to 1/14
0 0 1	1	1/7	1/14 to 3/14
0 1 0	2	2/7	3/14 to 5/14
0 1 1	3	3/7	5/14 to 7/14
1 0 0	4	4/7	7/14 to 9/14
1 0 1	5	5/7	9/14 to 11/14
1 1 0	6	6/7	11/14 to 13/14
1 1 1	7	1	13/14 to 14/14

3.6 Process Interface

A typical plant with large number of variables contains abundance of process information (data). Therefore, process information can be classified under several classes (groups). Then a specialized device can be used to transfer all information of a specific class into and out of the computer. This way designing different I/O interface for each I/O device to be connected to the computer is avoided. In fact, most process data can be grouped into four major categories as listed in Table 2.

Table Five Categories of process information

Type	Example
1. Digital	Relay Switch Solenoid valve Motor drive
2. Generalized digital	Laboratory instrument output Alphanumerical displays
3. Pulse or pulse train	Turbine flow meter Stepping motor
4. Analog	Thermocouple or strain gauge (millivolt) Process instrumentation (4 – 20 mA) Other sensors (0 -5 Volt)

The digital input/output signals can be easily handled because the match the computer representation format. The digital interface can be designed to have multiple registers, each with the same number of bits as the basic computer word. In this way a full word of 16-bit can represent 16 separate process binary variables and can be transmitted to the computer at one time and stored. Each bit will determine the state of a specific process input lie. For example, a state of 1 means the input is on and 0 means off or vice verse.

The generalized digital information usually uses binary coded decimal and ranges from 0000 to 9999. Hence, a 16-bit register can be used as interface device to transmit 4 digits of result because four-bits are necessary to represent one digit (0-9) of binary coded decimal.

In the input pulse information case, a single register (interface device) is designed for each input line. The register ordinarily consists of pulse counter. The accumulated pulses over a specified length of time are transferred to the computer in binary or BCD count. The output pulse interface consists of a device to generate a continuous train of pulses followed by a gate. The gate is turned on and off by the computer.

The analog input information must be digitized by ADC before fed to the computer. Since the process has a large number of analog sensing devices, a multiplexer is used to switch selectively among various analog signals. The main purpose of a multiplexer is to avoid the necessity of using a single ADC for each input line. The DAC devise performs the reverse operation. Each analog output line from the computer has its own dedicated DAC. The DAC is designed such that it holds (freeze) a previous output signal until another command is issued by the computer.

3.7 Timing

The control computer must be able to keep track of time (real time) in order to be able to initiate data acquisition operations and calculate control outputs or to initiate supervisory optimization on a desired schedule. Hence, all control computers will contain at least one hardware timing device. The so-called real-time clock represents one technique. This device is nothing more than a pulse generator that interrupts the computer on a periodic basis and identifies itself as interrupting device.

3.8 Operator Interface

The operator interface is generally a terminal upon which the operator can communicate with the system. Such terminals usually permit displaying graphical information. Often these display consoles are color terminals for better visibility and recognition of key variables. The operator will use the keyboard portion of the terminal to perform specific tasks. For example, the operator can type in requests for information or displaying trends, changing controller parameters or set points, adding new control loop, and so on.

3.9 Digital Control Software

To make the best use of a DCS system, an advance control strategy or supervisory optimization can be incorporated in the main host computer. In the past, computer control projects are written in assembly language, an extremely tedious procedure. Nowadays most user software is written in higher-level languages such as BASIC, FORTRAN, C etc. In many cases, the user is able to utilize the template routines supplied by the vendor, and is required only to duplicate these routines and interconnect them to fit his own application purposes. Another way is to write his own complete control program and implement it.

Other software in the form of control-oriented programming languages is supplied by the vendor of process control computers. A simpler approach for the user is to utilize vendor-supplied firmware or software to avoid writing programs. Currently, most DCS manufacturers develop their own advance control and optimization software, which can included in the package as options. Similarly, many control algorithm developers; (DMC, ASPEN, etc) design a special interface to allow incorporating their own control programs into most of the commercial DCS network.

Chapter Four

DCS of Boiler in North Khartoum Power Station

4.1 Introduction

Khartoum north station considered the one of Oldest station consequently from Sudan generation thermal and it support the network high relativistic by electrical energy and compensate decrease of water generation when attributable become low while summer period.

Location:

In Bahri east industrial area and had chosen it position because not against with aeronautic safety and across to railroad that lead to easily transmission material have to operate this station.

Stages to establish:

Stage1:

Include two units each one has capacity 30MW, started working in March 1981.

Stage2:

Include two units each one has capacity 60MW, started working in august 1988.

Stage3:

Include two units each one has capacity 100MW, after complete total capacity will become 380MW.

4.2 Boiler Operation

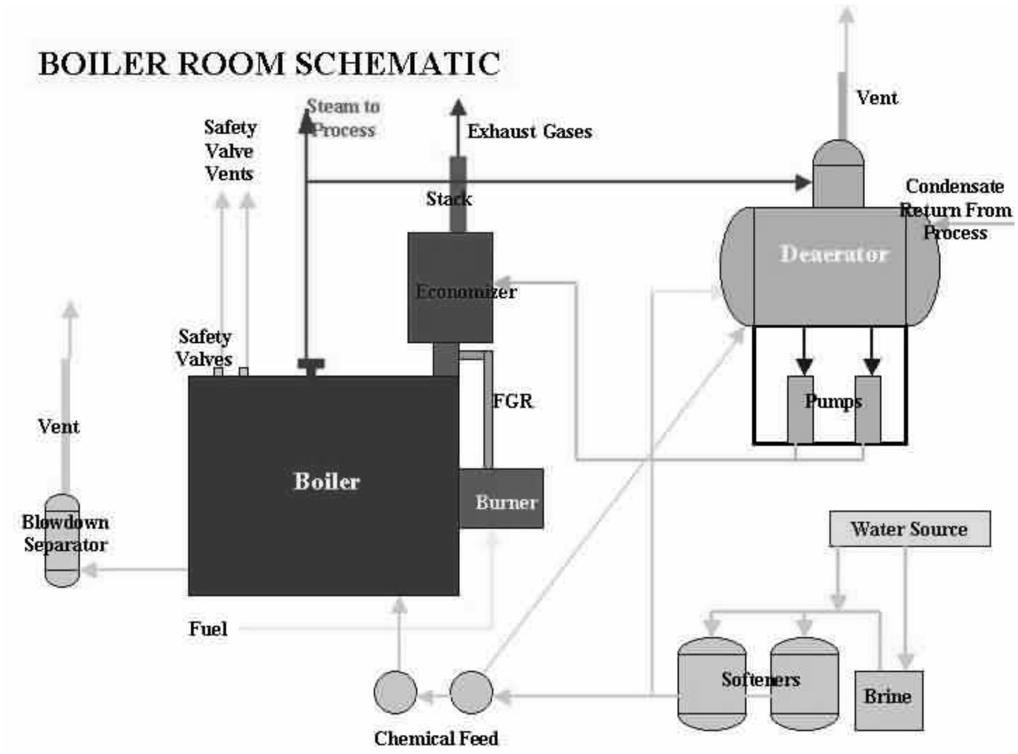

Figure 4.1: Boiler room schematic [1].

The drum- type water tube boiler is the fundamental steam generator for both industries and utility applications. The steam generated by a boiler may be used as a heat transfer fluid for process heating, or it may be expanded in steam turbines to drive rotating machinery such as fans, compressors, or electric generators. Schematic representation of drum type boiler: The steam drum and mud drum are mounted in a furnace and are interconnected with water tubes called risers and down comers. The furnace includes one or more burners for the combustion of an air and fuel mixture. The heat of combustion is transferred to the water tubes to generate steam. Steam bubbles form in the tubes (risers) closest to the burner and rises to the steam drum where they are separated from the water. The steam in the risers is replaced by water in the down comers to provide natural circulation in the water tubes.

A continuous supply of feed water is necessary to replace the steam leaving the boiler. In most cases, the saturated steam leaving the steam drum is returned to the furnace for superheating. A forced draft (FD) fan provides combustion air to the wind box from which it is delivered to the burners. The induced draft (ID) fan draws the flue gases from the furnace and drives them up the stack. Heat from the flue gas is used to preheat the combustion air to improve efficiency.

The primary purpose of any boiler control system is to manipulate the firing rate so that the supply of steam remains in balance with the demand for steam over the full load range. In addition it is necessary to maintain an adequate supply of feed water and the correct mixture of air and fuel for safe and economical combustion [1].

4.3 Boiler drum level

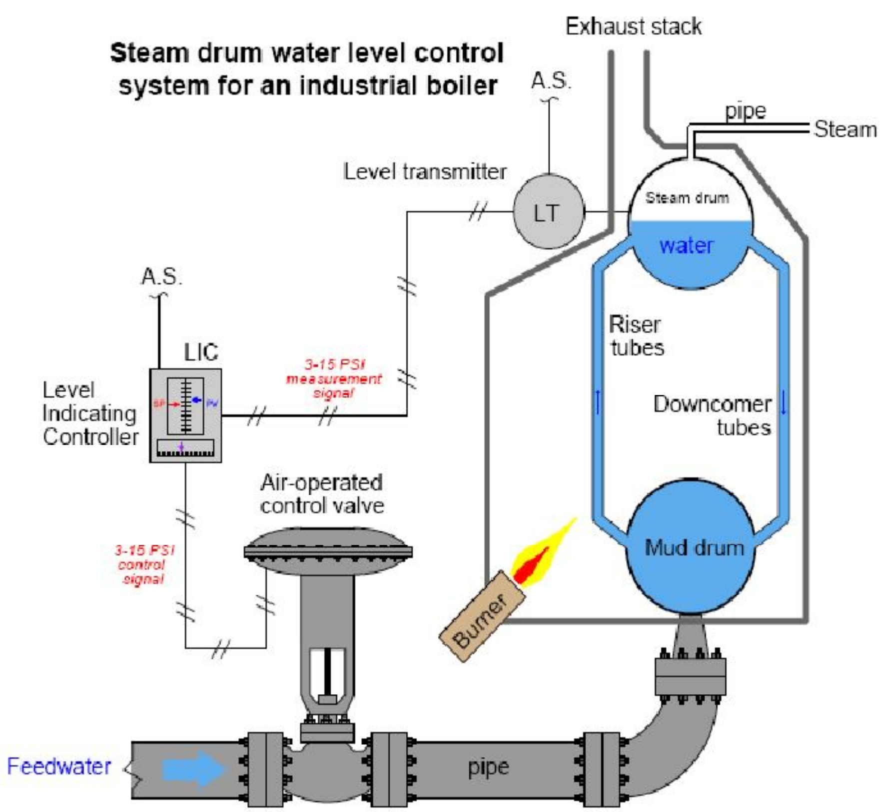

Figure 4.2: Steam drum water level control

The cylindrical vessel where the water- steam interface occurs is called the boiler drum. Boiler drum level is a critical variable in the safe operation of a boiler. A low drum level risks uncovering the water tubes and exposing them to heat stress and damage. High drum level risks water carryover into the steam header and exposing steam turbines to corrosion and damage. The level control problem is complicated by inverse response transients known as shrink and swell. Simply put, shrink and swell refer to a decreased or an increased drum level signal due to the formation of less or more vapor bubbles in the water and not a change in the amount of water in the drum. The drum level calibration will only be accurate at a single boiler drum pressure. The drum level signal can be compensated for all pressures by using a drum pressure transmitter. Generally, both industrial and utility boilers run at constant drum pressure. Pressure compensation is typically employed with utility boilers which operate much higher pressures than industrial boilers [1].

4.4 Transducers

Device converting one standardized instrumentation signal into another standardized instrumentation signal, and/or performing some sort of processing on that signal. Often referred to as a converter and sometimes as a “relay.” Examples: I/P converter (converts 4- 20 mA electric signal into 3-15 PSI pneumatic signal), P/I converter (converts 3-15 PSI pneumatic signal into 4-20 mA electric signal), square-root extractor (calculates the square root of the input signal). in general science parlance, a “transducer” is any device converting one form of energy into another, such as a microphone or a thermocouple. In industrial instrumentation, however, we generally use “primary sensing element” to describe this concept and reserve the word “transducer” to specifically refer to a conversion device for standardized instrumentation signals [7].

4.5 Transmitters

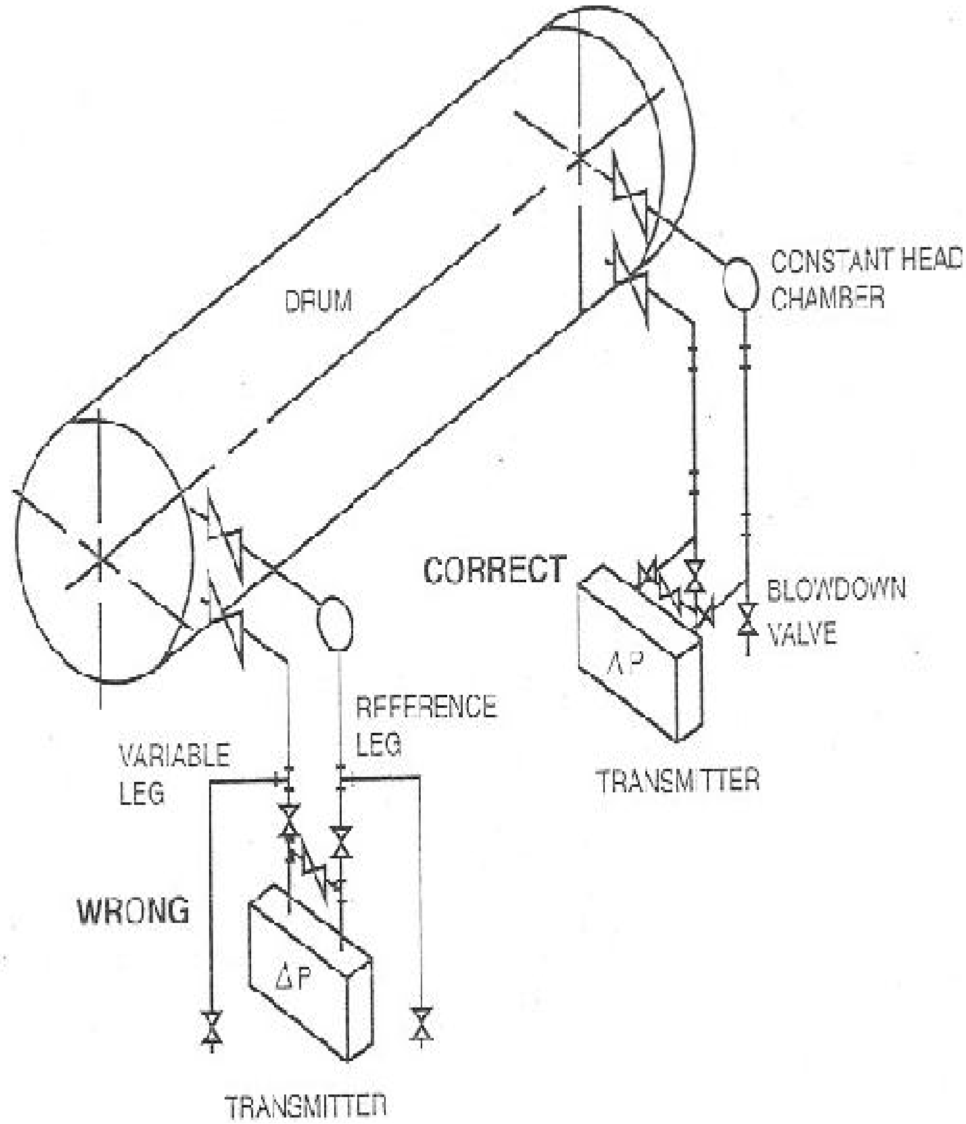

Figure 4.3: Water drum transmitter.

A device translating the signal produced by a primary sensing element (PSE) into a standardized instrumentation signal such as 3-15 PSI air pressure, 4-20 mA DC electric current, Field bus digital signal packet, etc., which may then be conveyed to an indicating device, a controlling device, or both.

Lower- and Upper-range values, abbreviated LRV and URV, respectively: the values of process measurement deemed to be 0% and 100% of a transmitter's calibrated range. [7].

4.6 level Sensors

Level sensors detect the level of liquids and other fluids and fluidized solids. The substance to be measured can be inside a container or can be in its natural form (e.g., a river or a lake). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally the latter detect levels that are excessively high or low. There are many physical and application variables that affect the selection of the optimal level monitoring method for industrial and commercial processes. In short, level sensors are one of the very important sensors and play very important role in variety of consumer/ industrial applications. As with other type of sensors, level sensors are available or can be designed using variety of sensing principles. Selection of an appropriate type of sensor suiting to the application requirement is very important [2].

4.7 Ultrasonic Sensor

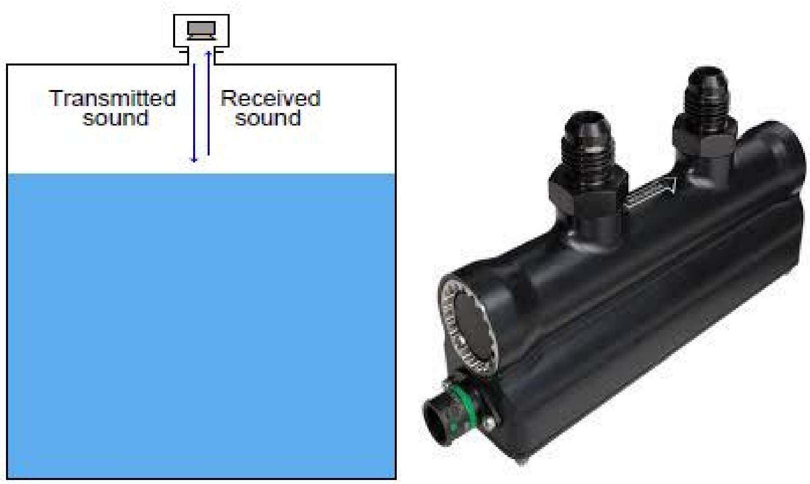

Figure 4.4: Ultrasonic Sensors.

Use ultrasonic level sensors for non-contact level sensing of highly viscous liquids, as well as bulk solids. The sensors emit high-frequency (20 to 200 kilohertz) acoustic waves that are reflected back to and detected by the emitting transducer. Turbulence, foam, steam, chemical mists (vapors) and changes in the concentration of the process material also affect the ultrasonic sensor's response. Turbulence and foam prevent the sound wave from being properly reflected to the sensor. Steam and chemical mists and vapors distort or absorb the sound wave. Variations in concentration cause changes in the amount of energy in the sound wave that is reflected back to the sensor. Use stilling wells and wave guides to prevent errors caused by these factors. Proper mounting of the transducer is required to ensure best response to reflected sound. In addition, the tank should be relatively free of obstacles such as brackets or ladders to minimize false returns and the resulting erroneous response, although most modern systems have sufficiently "intelligent" echo processing to make engineering changes largely unnecessary except where an intrusion blocks the "line of sight" of the transducer to the target. The requirement for electronic signal processing circuitry can be used to make the ultrasonic sensor an intelligent device. Ultrasonic sensors can be designed to provide point-level control, continuous monitoring or both. Due to the presence of a microprocessor and relatively low power consumption, there also is capability for serial communication to other computing devices, making this a good technique for adjusting calibration and filtering of the sensor signal, remote wireless monitoring or plant network communications. To summarize, the ultrasonic sensor enjoys wide popularity due to the powerful mix of low price and high functionality [2].

4.8 Pumps

Boiler feed pumps, transfer pumps; condensate pumps - all of the pumps in the system-should be inspected. Piping connections to the pump suction and discharge ports should be checked. Adequate provisions should be made for proper expansion to prevent undue strains imposed on the pump casing. Drain lines, gland seal lines, recirculation lines, etc., should all be checked to determine if they are in accordance with the manufacturer's recommendations. The coupling alignment should be checked to ensure no misalignment exists.

If the coupling alignment is not up to the pump or the coupling manufacturer's recommendations, they must be realigned so they are within the manufacturer's recommended tolerances. After all of the above precautions have been carried out, check the pump for proper rotation. The appropriate pump motor starter can be momentarily energized for this operation. Be careful not to hold the starter in too long .Note: Care should be exercised when checking for proper rotation.

Some pumps may be seriously damaged if the pump is rotated in the wrong direction. Where the possibility of damage to the pump does exist (refer to the manufacturer's instruction manuals), it is advisable to disconnect the coupling before checking the motor rotation. The coupling can then be reconnected and aligned after it has been determined the motor rotation is correct [2].

4.9 Safety and Control Valves

Another extremely important safety check that should be performed is the testing of all safety and relief valves. How frequently the test should be done is an extremely controversial subject. Everyone seems to agree that safety and relief valves should be checked or tested periodically, but very few agree as to how frequently they should be tested. The ASME book on "Recommended Rules for Care and Operation of Heating Boilers," Section VI, states that the safety or relief valves on steam or hot water heating boilers should be tested every thirty days. A try lever test should be performed every thirty days that the boiler is in operation or after any period of inactivity. With the boiler under a minimum of 5 psi pressure lift the try lever on the safety valve to the wide open position and allow steam to be discharged for 5 to 10 seconds (on hot water boilers hold open for at least 5 seconds or until clear water is discharged).

Release the try lever and allow the spring to snap the disk to the closed position. An optional method that may be preferred by the owner or operator is to slowly build up the pressure in the boiler until the popping point of the valve or valves is reached. As soon as the valves pop, cut back on the firing rate or shut the burner off and allow the pressure to drop back to its normal operating range. This procedure should be followed once or twice a year. When a safety valve fails to operate at the set opening pressure, do not attempt to free it by striking the body or other parts of the valve.

The valve may be opened with the lifting lever and allowed to close, after which the pressure of the boiler should be raised to the selected pressure for which the valve is set to pop. If the valve does not then pop, the boiler should be taken out of service and the safety valve cleaned or repaired, by an authorized repair station for the valve manufacturer. Figure 2-7(a) represented the control valve with main parts a Figure 2-8(b) shows the typically control valve used in system [2].

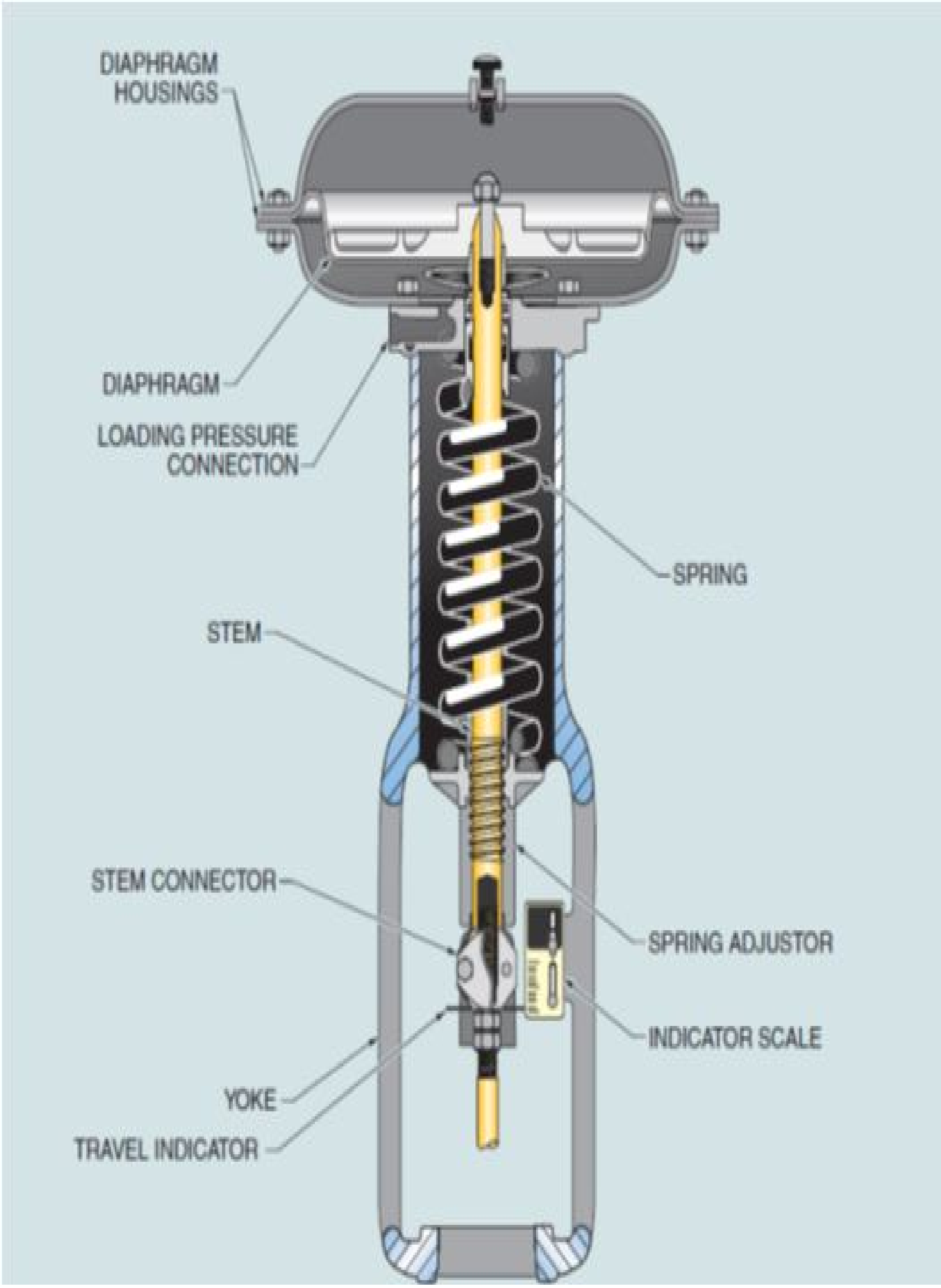

Figure 4.5: (a) The control valve with main parts.

Figure 4.6: (b) Typically Safety valve used in system.

4.10 Distributed Control System

DCS refers to control system architecture in which control elements are not centrally located but are rather distributed across manufacturing process. More specifically, control functions are performed by a number (tens, hundreds, thousands) of distributed microprocessor-based units (controllers) situated near to the devices being controlled or the instruments from which data is being gathered. First DCS systems appeared around 1975. These were TDC 2000 (from Honeywell) and CENTUM (from Yokogawa). Their development was largely due to the increased availability of microcomputers and proliferation of microprocessors in process control [3].

4.11 DCS Components

DCS normally consists of the following units

- Input/ Output Modules (interface between sensors/actuators and controllers).
- Controllers (perform control functions such as PID algorithm, logic control or sequential control).
- Operator Workstations (PC-like computers that allow users to interact with DCS controllers).
- Database (collects and stores all the data related to DCS operations history.
- Communication Network (allows all of the above elements of The DCS to communicate information between each other) [3] .Figure 2-9 shows the main structure of DCS system

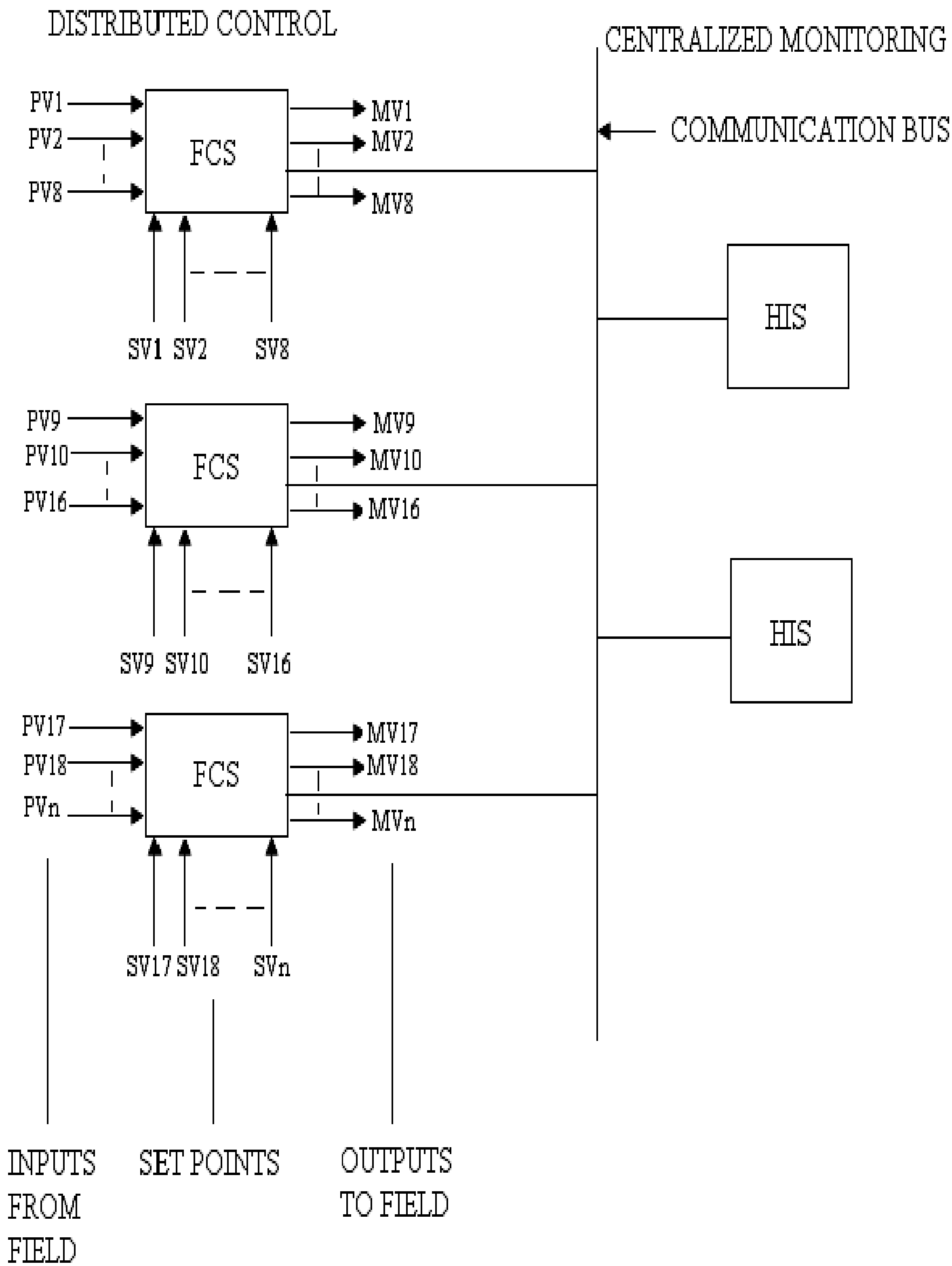

Figure 4.7: Main structure of DCS system.

4.11.1 Factors Effect DCS System Reliability

- Task partitioning
- Redundancy
- Software Back up
- Hardware Back up
- Diagnostics
- Spare parts
- Power sources
- External influences.

4.12 OC4000

OC4000, distributed control system, is developed by GE Energy Xinhua Control Solutions, it features stable performance, reliable quality, flexible configuration, and it is easy to be manipulated and expanded. OC4000 has been applied widely to distributed control of power station, load dispatch, information management, also to substation monitoring, power grid atomization, and other industries' process control such as iron, chemistry, paper production, etc [3]. OC4000 adopting redundant data communication net connects with all stations directly which avoids communication delay resulted from information formats conversion among multi-stage nets; bottle-neck and can avoid reliability from reducing. MMI station also connects with process control unit directly, which meets the real time and reliability requirement by central control mode used by industry process control presently. The communication net, MMI and control unit of OC4000 adopting international standard and main stream industrial products is an open-type industrial control the system net structure is shown in Figure2.10[3].

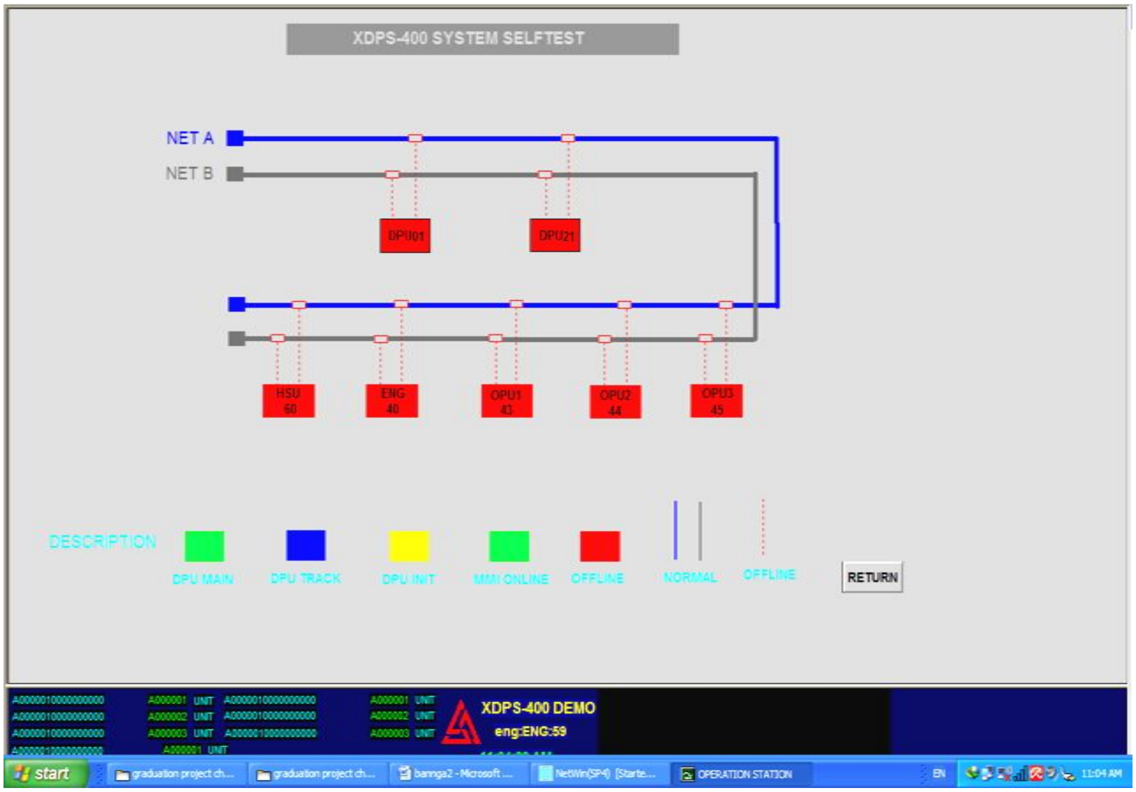

Figure 4.8: System Net Structure [3].

4.12.1 System Net Structure

OC4000 system consists of three integral parts basically: process control system, net control system and operating management system. System structure is shown in Figure2.10 [3].

4.12.2 Process Control System

Process control station is basic unit of OC4000 automatic processing and control; it can realize such functions as data acquisition, data process, loop control and communication. It is also of self-diagnosis and redundant fault-toleration ability. Field control station, also called remote station, is put on site of running equipment. It connects with OC4000 system via shielding twisted pair line to control the equipment on site. This kind of equipment generally is far away from cabinet room, and adopts field control cabinet which can save a great deal of signal cable.

OC4000 connects with other system via communication interface unit. The communication cable of other system connects with processing unit of process station directly, (station No.-card No.-channel No.). Application of communication interface unit can secure communication better [3].

4.12.3 Network System

OC4000 network system consists of two kinds: real time network, information network.

Real time net adopts dual-loop fast Ethernet for connecting DPU and operation management system, fast transmitting real-time data, configuration data and control commands.

Information network uses the single network to connect units in the operation management system, providing the units with fast and effective data transmission channel, transmitting non real-time file and realizing printing share.[3]

4.12.4 Operation Management Subsystem

The operation management subsystem is oriented towards the operator and engineers. Through this system, the operator can directly get real-time operating data during the production a monitor, operate, control and manage the whole production process in a safe and effective way.

Operation management subsystem include the engineer unit(ENG), operator unit (OPU), historical data recording unit (HSU), the performance calculation unit (CAL), the gateway interface unit (GTW), etc.

•**ENG**:

It is used to monitor the configuration, commissioning and maintenance of the system.

- **OPU**:

It is used to display the real-time data, alarm information, print reports and receive the commands from the operator. It is the man-machine interface between operator and the control system. The it used to monitor and manage the whole unit and it is called shift leader station.

- **HSU**:

It is used to collect and store historical data, create report sheet and output it.

- **CAL**:

It consisting of calculation units, subsystem, devices efficiency and power consumption can be used guide production optimization.

- **GTW**:

It is used to communicate with third party system [3]. The complete OC 4000 structure is shown in Figure 2.11

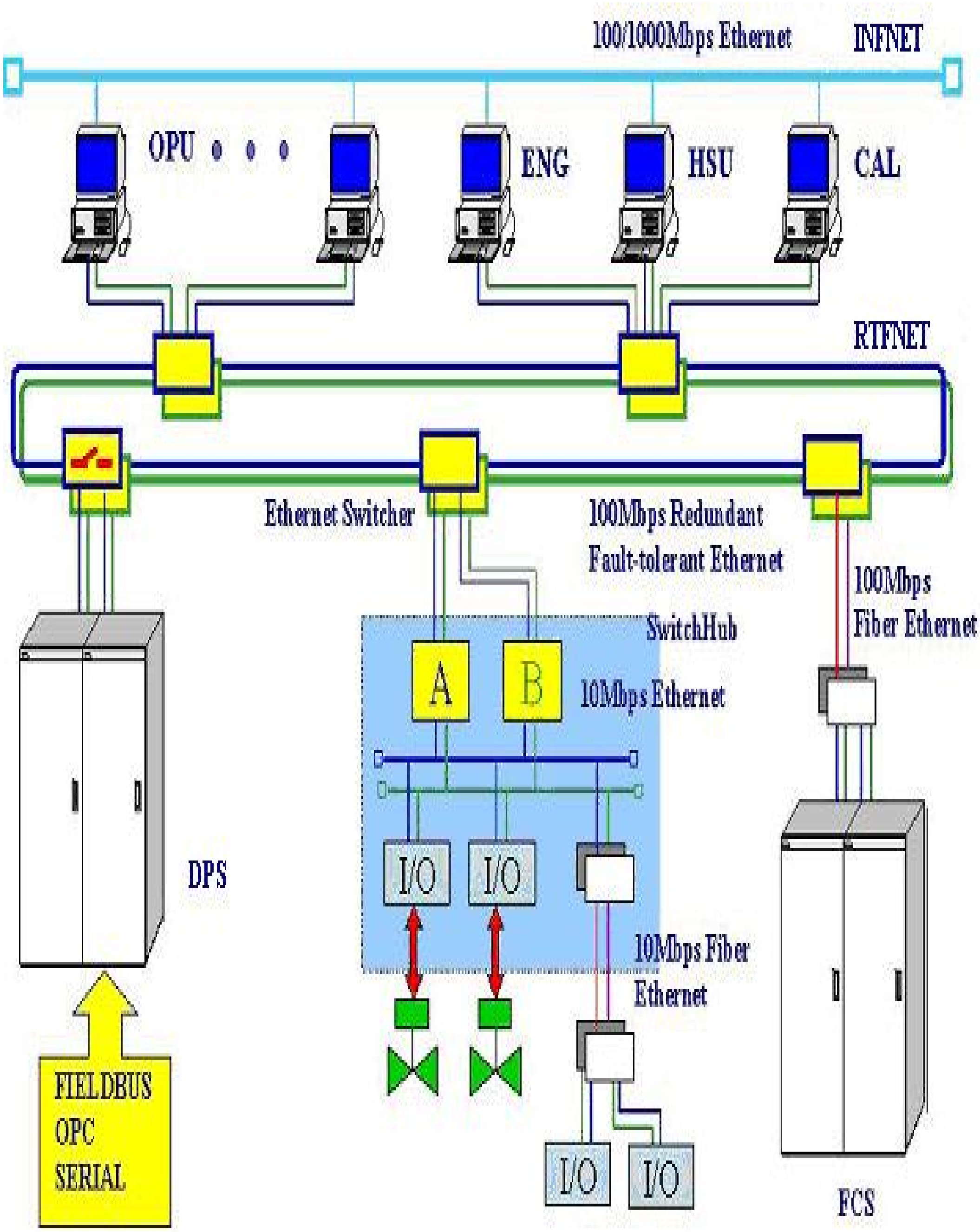

Figure 4.9: OC4000 structure [3].

4.12.5 Hard Ware Components

OC 4000 Consist of many hardware components. Each component will be discussed in details and shown in the following sections:

4.12.6 Power Supply Assembly

Two options of power supplies are available. These are DC and AC power supplies:

- **DC power**

Process control unit has three types of DC power, all of which are switch power supplies, the power supply module should be inserted into power supply rack box to run. Voltage class and power output of three types of power supply module. Two power supplies of the same voltage level can be paralleled to form mutually redundant supply pattern to ensure the reliability of DC power system the switch-over between the redundant DC power supply is conducted through diode high selection.

- **AC Power Supply**

240VAC Power supply two lines of power supply 240VAC from UPS are applied to the normal instrument such as DCS device, DEH device, and other control system. When the running power supply is off, the back-up power supply will be switched on [4].

4.12.7 Data Processing Unit Cabinet

As the core part of process control station, Distribution processing unit (DPU) is used to store system information and process control strategy and data, it connects to other DPU and operation management system via redundant real-time network, and connects to I/O station via I/O network, provides mutual information exchange to realize each advanced control strategy, complete data acquisition, analog modulation, sequence control, advanced control and meet the special function requirement of various consumers [3] .

Figure 4.10: DPU cabinet

4.12.8 DPU Software

DPU is the basic unit of information self-process and control of OC4000. it obtains the real-time data of input measuring point from input card or network, after being processed by control algorithm, the calculated result is sent to output card or network to form closed loop operation of control information. Whilst DPU receives operating command from OPU, and adjust the control. The control strategy and algorithm inside DPU is realized by configuration software used by engineers, it allows modifying the configuration data or setting parameters on line or off line. Many different input/output drive programs can be loaded for connecting and driving different input/output devices. DPU software can also run on MMI station of windows as virtual DPU. VDPU bears the same characteristic, it has its own node number, redundant configuration, option to bear input/output drive or not, as well as DPU graphic configuration. In addition, DPU connects with TCP/IP through real-time communication network, which can be configured as either redundant or single-net. DPU software has the feature of configurability. It can be connected with various drive programs, and the node number, user name and password, etc. can also be configured according to different application requirements. The restrictions on operate level can prevent mal-operations on DPU. In addition, DPU software can be upgraded both online or offline for the convenience of maintenance [3].

4.13 DPU15

The DPU15 contained five pages to represent the configuration of the close loop control system, level's set point, the simulation of the feedback of the control valve status, the H,HH,L and LL alarms ,the simulation of the actual water level ,full and reset command and Control valve alarm for high alarm.

4.14 DPU Configurations

The configurations of DPU mean all the logic functions that must be used until system working properly. These functions are working together and constructed by engineer unit based on the system requirements The Figures below shows the DPU configurations:

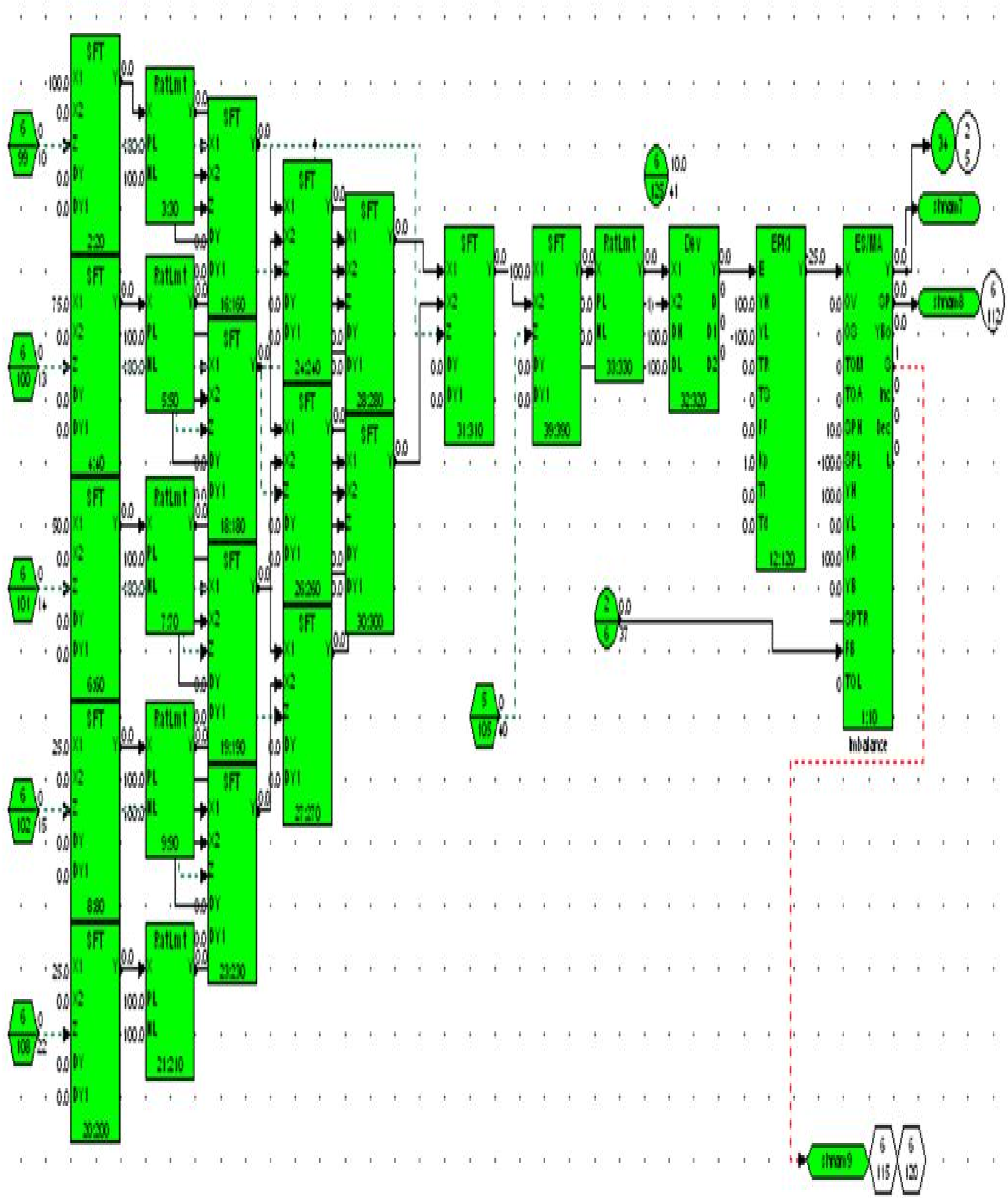

Figure 4.11: The close loop control system

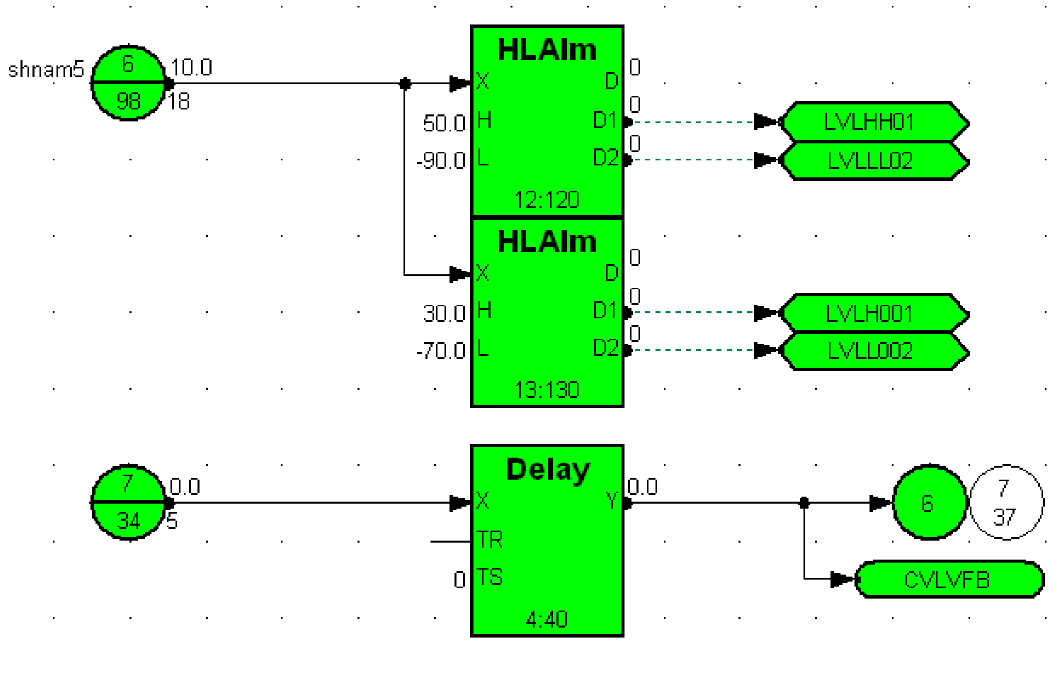

Figure 4.12: The Feedback of the Control Valve Status and Alarms

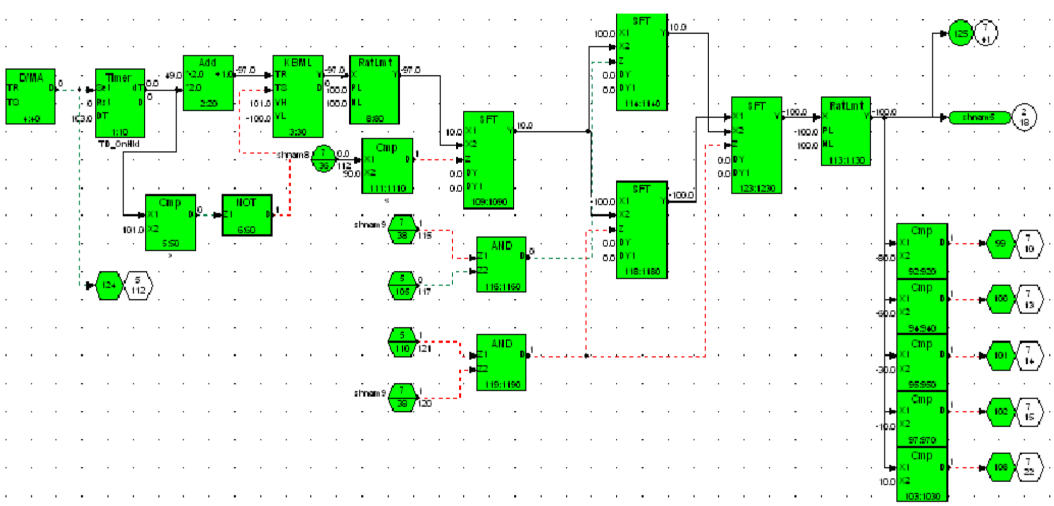

Figure 4.13: The Simulation of the Actual Level

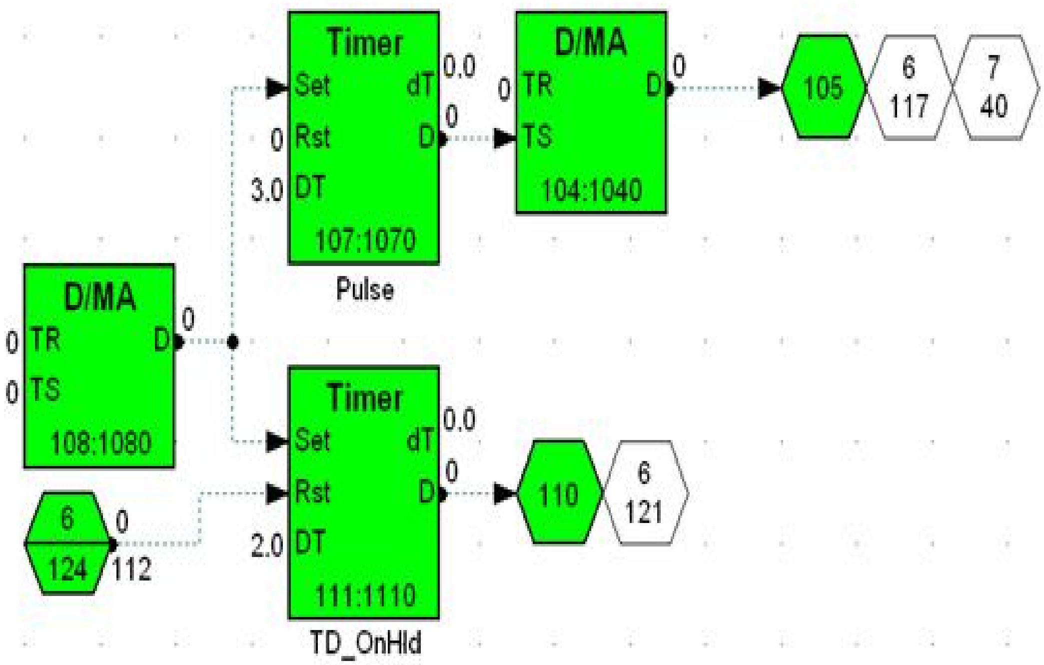

Figure 4.14: Full and reset command

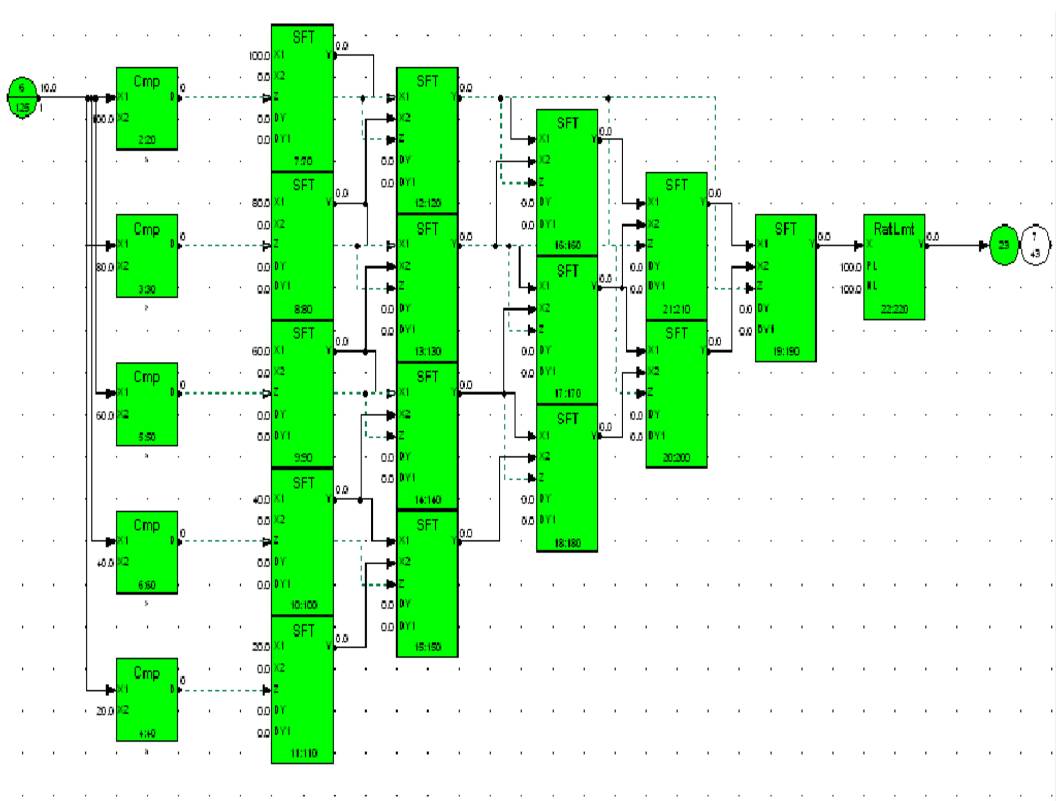

Figure 4.15: Control Valve Respons For High Alarm

DPU configuration software on OC4000 software has the following main functions DPU off-line configuration. DPU can be configured off line and saved on ENG disk DPU or VDPU configuration download, online configuration and commissioning, the configuration file on ENG disk can be downloaded into DPU. And the user also can directly modify, operate, debug the DPU as well as observe the trend on graphic configuration interface. Configuration in DPU can be uploaded into ENG and saved to ENG disk. [3].

4.15 DPU Composition

DPU consists of the following parts:

- One CPU card
- Two network interface cards
- One redundant DPU switch card.
- One bus motherboard.
- One power supply module.
- One shell.

4.16 Characteristic of DPU

- 32-bit high performance micro-processors.
- Single DPU or 1:1 redundant DPUs are selectable, redundant DPUs can undisturbed switch to the other within one period.
- The connection of DPU with input/output interface adopts Ethernet protocols.
- Redundant real-time data network interface.
- Redundant input/output network interface.
- Support remote input/output, when using shielded twisted pair wire, the

Mac. Length is up to 100m; when using optical cable, the max. Length can reach 40km.

- Rewritable permanent memory; CF card is used to store system files and
- Logic configuration data and support upload and download of control strategy.
- Various algorithm modules are available and customized algorithm is supported [3].

4.17 Input/output Card

Process I/O unit fulfills field data signal acquisition, process and output control. It is composed of I/O cards and terminals blocks. All I/O card are inserted inside the I/O card boxes, there are bus slots on the back of rack boxes. The power supply and communication of cards will be performed by buses. Terminal blocks are used to connect field I/O signal, the cards are connected with terminal blocks through a 37-pin pre-fabricated cable. Communication between I/O cards and station control cards (Pc-net) are carried out in the way of parallel buses, all PC-NET cards communicate with DPU through I/O network. PC net card undertakes the task of communication transfer and card management [3].

4.18 Terminal Cabinet

The terminal board is mainly used to install terminal boards for wiring of field signals. Terminal boards are located symmetrically on the back and front of the terminal cabinets.

4.19 Optical Fiber Network

The optical fiber ring network is applicable to the OC 4000 system of large-size units. Its core part is ring network switcher, which adopts 10/100M self-adaptive Ethernet

Optical fiber switchers; the ring formation media usually adopts multiple-mode optical cable with a communication rate of 100Mbps, the max. Distance between each node in the network can reach 2km [3].

4.20 Graphic Making Software

The graphic making software (Maker) is an executable program on MS windows, which can be used to make system flow charts and operation status figures. Maker is a powerful, convenient and flexible graphic making tool. For instance, the user can edit several graphic files at a time and can copy and paste different graphic files using clipboard or other drag-and-drop tools in windows. And Maker uses the object-oriented method to realize real-time animation, which provides the user with powerful tools to make and process objects [3].

4.20.1 Function Description

Maker provides the user with several convenient and flexible static-image making tools such as create, fill in, stretch, rotate, cut, copy and paste e.tc .Another main function of Maker is to set dynamic attributes of the figure such as color, position, or size variation, flash, hide, trend and bar chart. Maker edits figure according to files and each flow chart corresponds to a relevant file. The industrial flow chart includes two parts: static graph and dynamic graph. There is no difference between static graph and conventional graph in concept. And the dynamic graph, based on static graph, adds dynamic attribute or just calls dynamic graph directly. And being dynamic is also a graphic attribute of changing with the real-time value, i.e. numerical value, color, size, shape, position, or modification to real-time value [3].

4.20.2 Basic Figure Object

The basic figure object, i.e. basic graphic elements, includes: line, fill-in form, text, button and bitmap. Line, an object of one line or several lines, includes beeline (horizontal or perpendicular line), poly-line and closed lines (rectangle, round rectangle, polygon, ellipse). The graphic attributes of the line include: color, width and type, among which the width & type are not animated and only color has the animation property.

Actually fill-in form is a two-dimensional object composed of closed lines and their inner area. Specifically, it includes: rectangle, round rectangle, polygon, and ellipse. The graphic attributes of fill-in form are: color, width, type, and fill-in type, among which only color and fill-in color have the animation property and the fill-in color can also be connected with “the percentage fill-in”.

Text is an object consisting of one line or several lines of text characteristics. The attributes of text include: font, bold, underline, italic, color and the content of character string, among which only color and content of character string have the animation property. Button can be viewed as a special symbol. And its graphic attribute only includes the initial text on the button, which can only be connected by touch connection [3].

4.20.3 Dynamic Attribute Connection

Dynamic attribute connection includes color, output, position and other links. None of them can function alone and they must be attached to one basic object. One dynamic attribute connection can only be attached to one basic object while one basic object can connect too many dynamic attributes. When several. When several dynamic connections of the same type are attached to the same basic object, only the last one has the effect. . The explanation of all kinds of dynamic connection object is shown as follows [3]:

- Color connection this type of connection includes: color, hide and flash, which will be changed by graphic object according to variations in expression of dynamic attribute definition or area name value of points.
- Output connection
- This connection can display real-time data or designated characters according to variants in expression or point area name.
- Position connection
- This connection can make the graphs move (horizontally or vertically), rotate and zoom according to variations in expression or point area name.

- Other connection
- Other connections include: percentage fill-in, library change and button status.
- Percentage fill-in: it is mainly available to bar chart and the liquid level display in process controlling, and the connected object can only be fill-in form.
- In all the connection above, users are required to input an expression or point. Different effect will be shown according to the calculated result.

4.20.4 System Self-Test Software of MMI

Before the operation of MMI, the engineer needs to complete MMI system configuration including MMI station number, time level, managing users, configuration self-starting program, then configure the self-test, cfg. After the completion of all the configuration of MMI, connect the network hard wards, then run general control software Net Win, detect the each system running status via self-test program [3].

4.20.5 Components of Self-Test Software

- The self-test software is made up of 2 files, the executable file self-test and the configuration file.
- Seft-test.exe is in the path D:\OC4KV6.3\ Bin\MMI. Self-test is in the path project data path\Eng\[3].

4.20.6 DPU Network Node

Instruction of DPU node status that include [3]:

- Green: DPU is in general control status and operating normally.
- Blue: DPU is in the following status and operating normally.
- Yellow: DPU is in the tracing status without consistency with general control DPU or DPU is in initialization status.

- Red: DPU is out of service or failed.

4.20.7 Human Machine Interface (HMI)

HMI is the system that presents process data to the operator and through which the human operator controls the process. It allows the user (operator/engineer) to interact ("talk/listen") with the controlled process. HMI is a software package that is normally installed on the Operator Workstation. DCS vendors provide their own HMI software. Also, PLC vendors sometimes provide their own HMI software that can interact with PLC. There is HMI software providers that are not associated with any particular PLC or DCS product but instead provide generic system that can interact with various DCS and PLC products through generic "open" interfaces [4].

4.20.8 Main functionality of HMI System

Recording and trending of measured process variables. This allows the operator to view time-domain trajectories of recorded process variables. Configuration of controller parameters. This allows the operator to modify controller parameters and then communicate them down to the actual process controller. Display mimic of the actual process. This allows the operator to see in real-time a schematic representation of the plant being controlled. Fig 4.16 shows different type of HMI [4].

Figure 4.16:

When the system is started in automatic mode the control valve is opened in order to reach the set point at (10mm). as shown in the Figure 4.16

4.21 The Process Configuration

DCS proposed program implemented to control water drum level is divided into two parts first one is include control configuration and the second to control human machine interface (HMI).

4.21.1 Control Algorithm

The OC4000 program used provides the control algorithm language which especially intensifies the graphical configuration and the debugging language that base on the graphic function blocks. The DCS software provides all kinds of common function blocks. The required blocks are selected from the tools of the functional software of the DCS. The logic and the simulation are constructed DPU15.

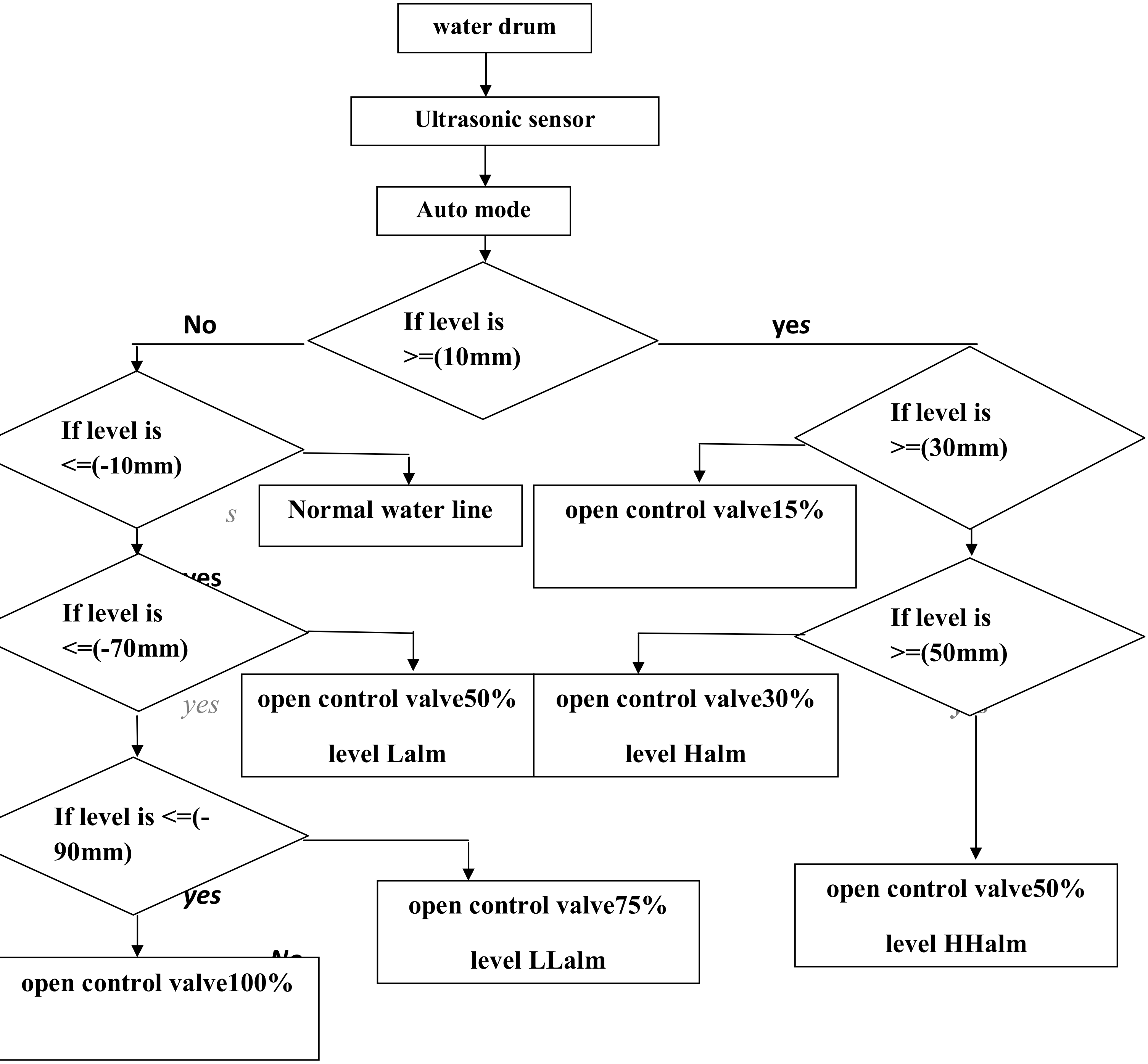

Figure 4.17: System's Flow chart at automatic mode

According to the level transmitter readings :

the Halm goes on when the level is (>=30) and the HHalm goes on when the level is (>=50).

the Lalm goes on when the level is (<=-70) and the LLalm goes on when the level is (<=-90).

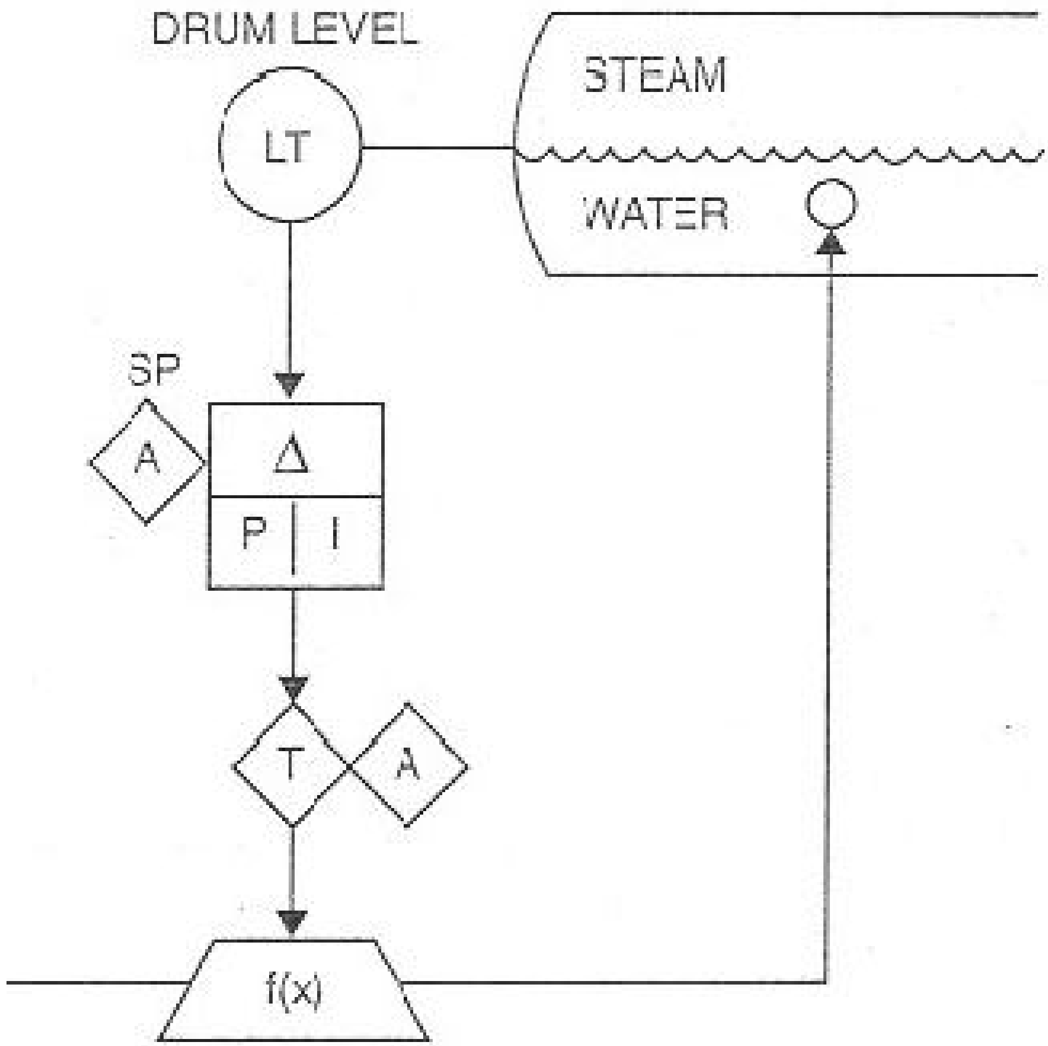

Figure 4.18: Single element control drum level [5]

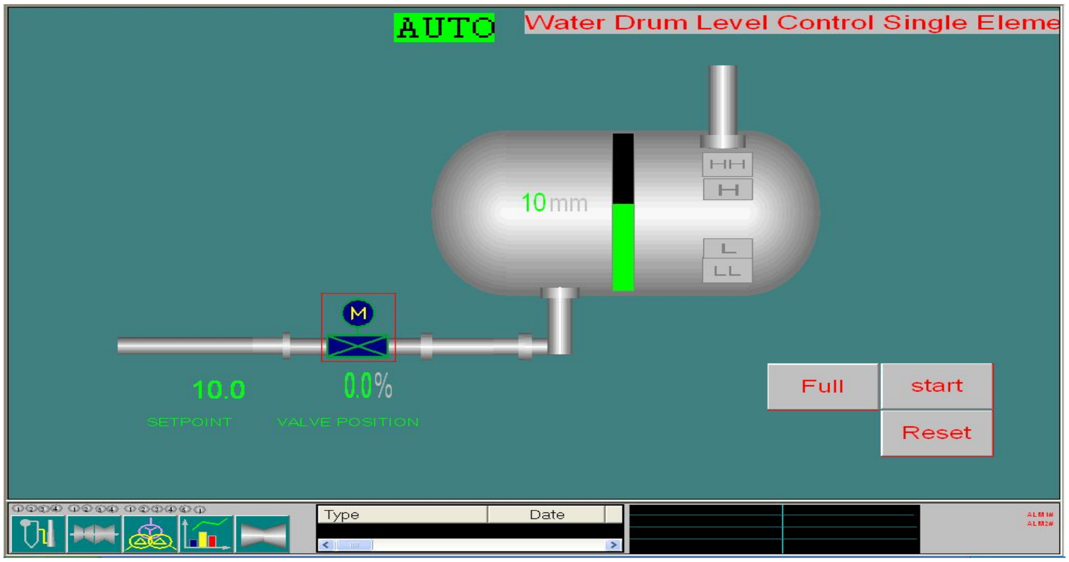

Figure 4.19: Starting system to reach set point.

4.22 Low Alarm Signal

The Lalm signal goes on to indicate the decreasing of the water level(<=-70) with a control valve response as shown in the Figure 4.2.

A status change (alarm condition) of a single low alarm occurs when the input falls below the trip point. The status will return to a non – alarm condition. A typical application of a low alarm is warning of a low tank level to avert problems with a pump running dry.

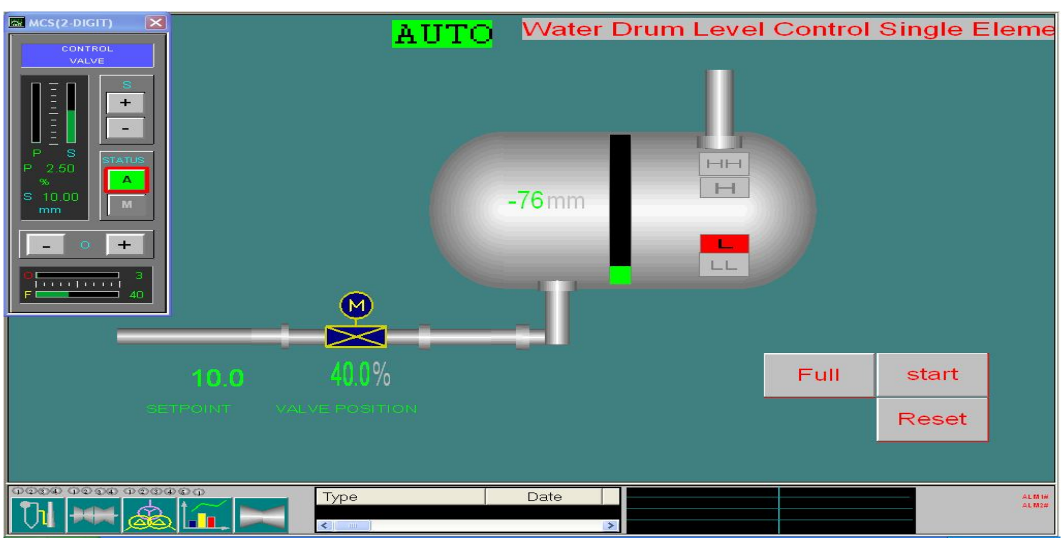

Figure 4.20: Low Alarm

4.22.1 Low Low Alarm Signal

The LLalm signal goes on to indicate the decreasing of the water level(<=-90) with a control valve response as shown in the Figure 4.3.

A dual low alarm accepts one input, but has tow relays, each with its input falls below trip point 1, the first set of contacts will change status merely to serve as a warning Should the input fall below trip 2, the second set of contacts change status, possibility initiating a shutdown of the process.

The low/ low alarm's contacts will return to a non-alarm status when the signal high alarm occurs when the input rises above the trip point. The status will return to a non-alarm condition when the input falls below the dead band.

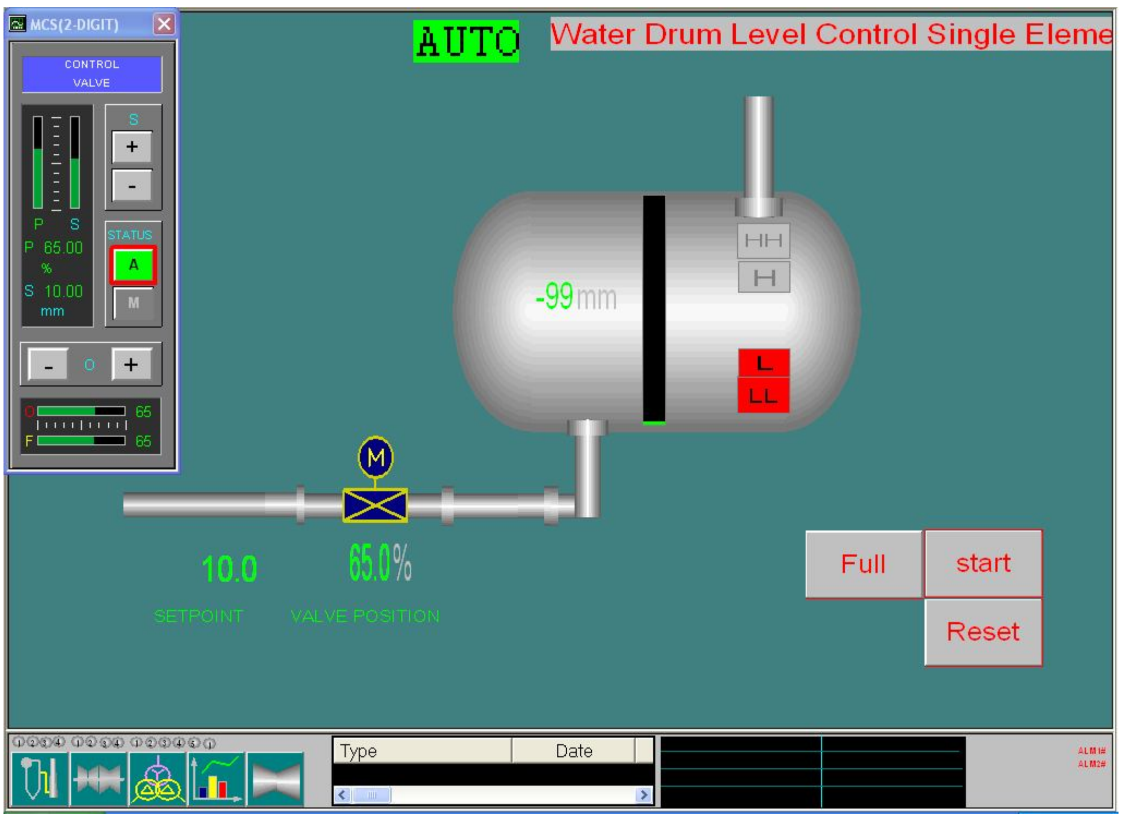

Figure 4.21: Low Low Alarm

4.22.2 High Alarm Signal-

The Halm signal goes on to indicate the increasing of the water level(>=30) with a control valve response as shown in the Figure 4.4.

A status change (alarm condition) of a single high alarm occurs when the input rises above the trip point. The status will return to anon-alarm condition when the input falls below the dead band.

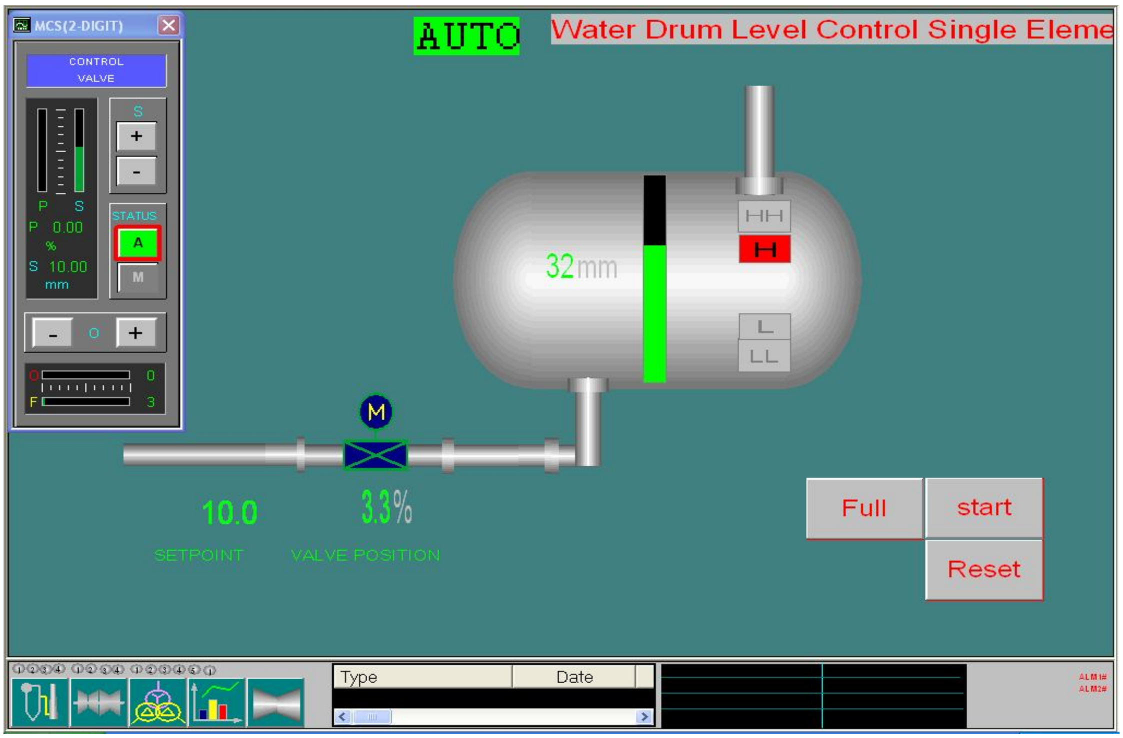

Figure 4.22: High Alarm

4.22.3 High High Alarm Signal

The HHalm signal goes on to indicate the decreasing of the water level(>=50) with a control valve response as shown in the Figure 4.5.

This alarm accepts one input, but has two high relays, each with its own trip point when the input rises above trip point. 1 (the lower trip point), the first set of contacts will change status merely to serve as a warning, however, should the input rise above Trip point 2 (the higher trip point), the second set of contacts change status, which may initiate an emergency shutdown, with four relay outputs, you can provide three levels of warning and then an emergency shutdown.

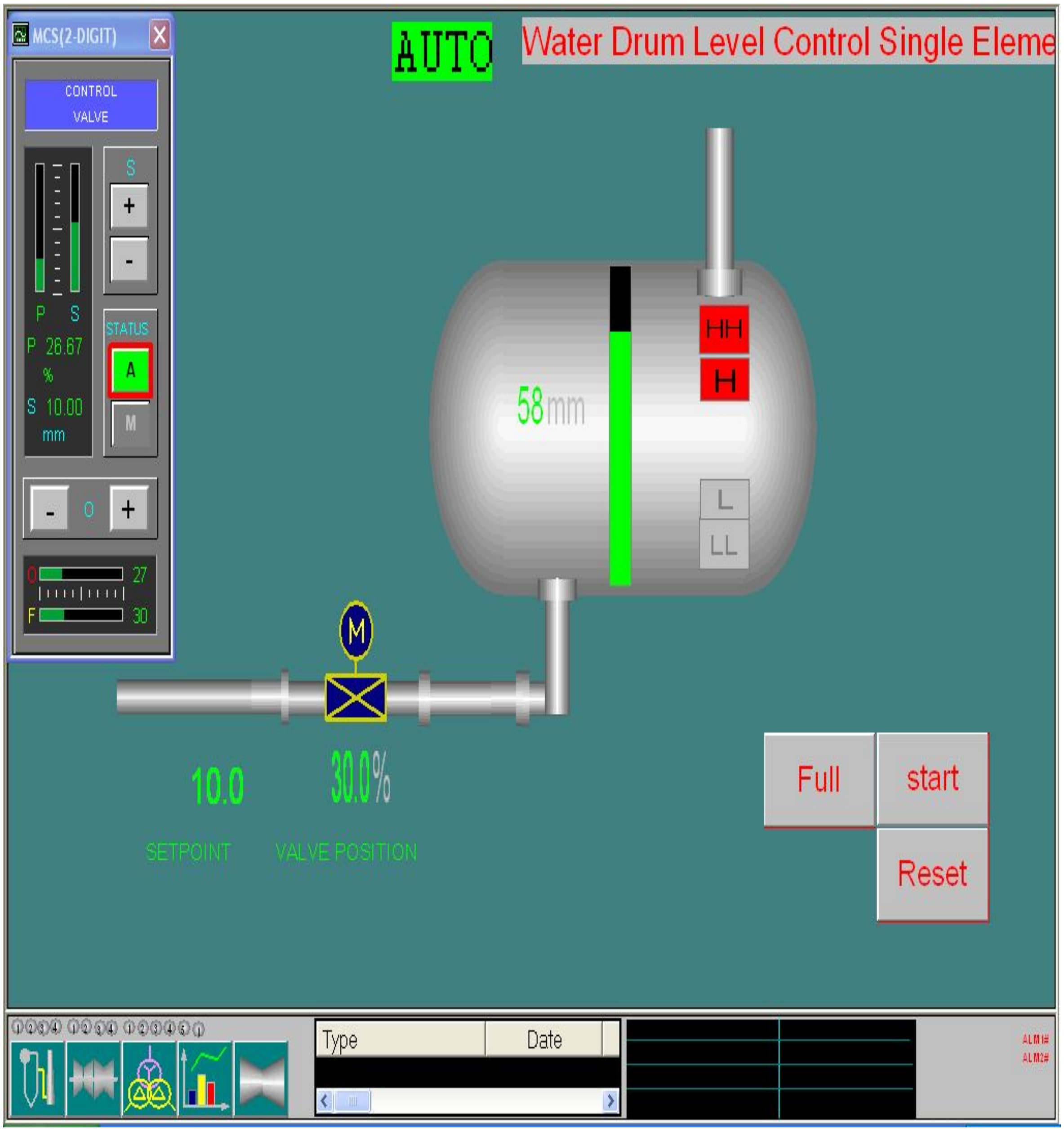

Figure 4.23: High High Alarm

4.23 DCS HMI Makers

- This section concern about how to link configuration and HMI picture with each other, HMI shown in figure 3.8.

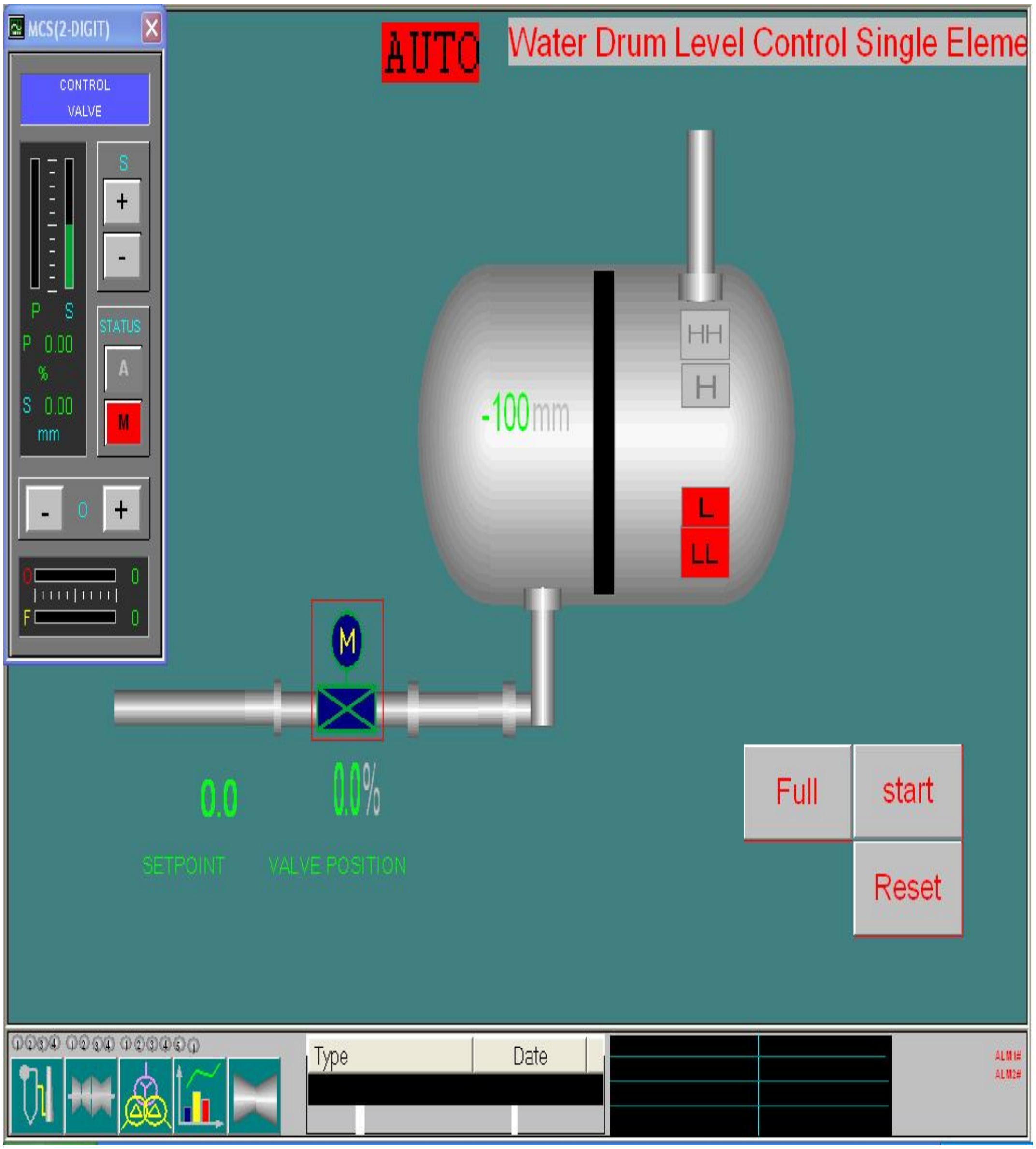

Figure 4.24: Water steam drum system HMI Picture

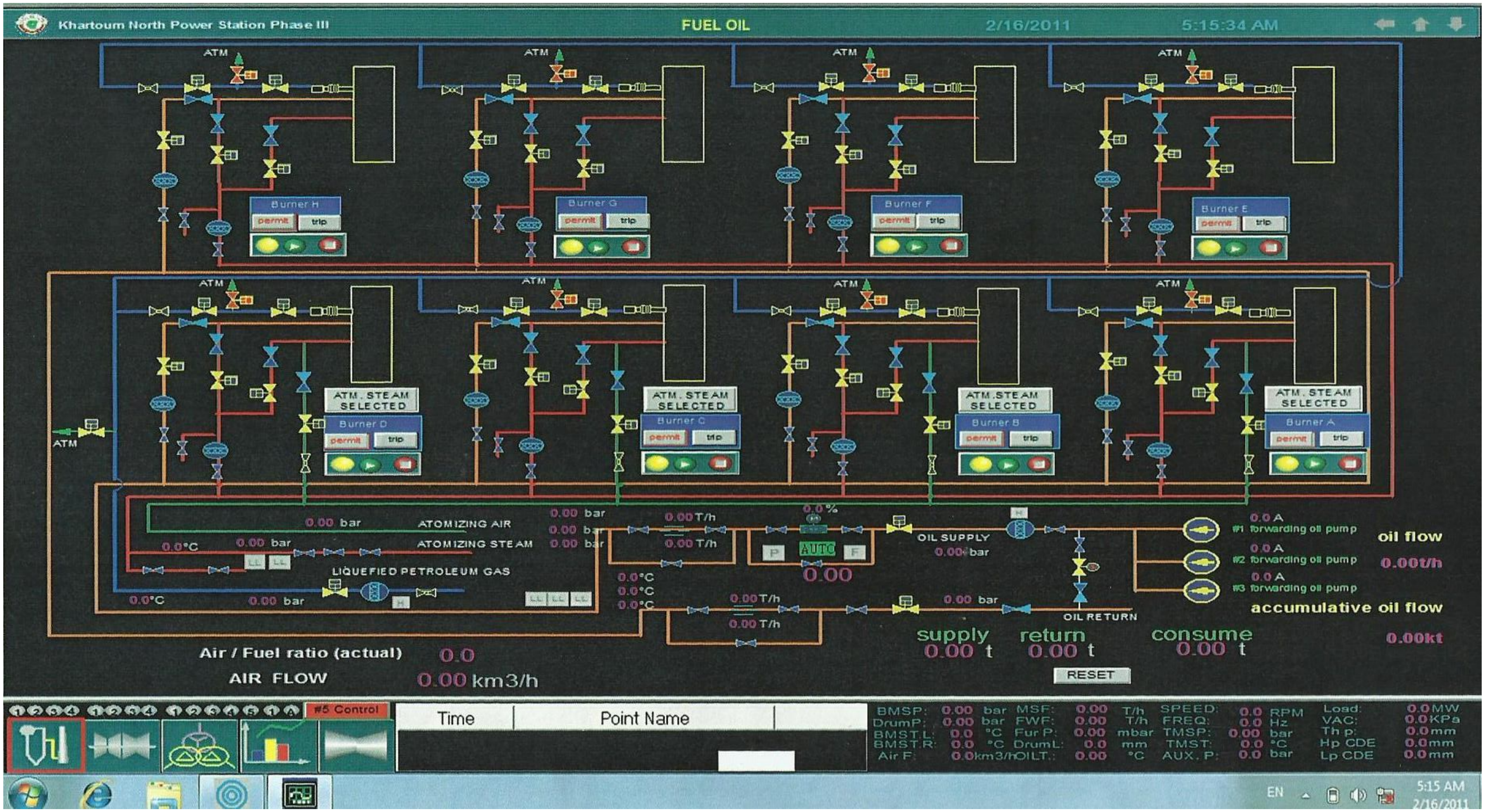

Figure 4.25 Fuel Oil

This figure represent fuel cycle electric vehicles (EVs) offer the potential for substantial reductions in energy consumption and emissions during the vehicle traveling stage

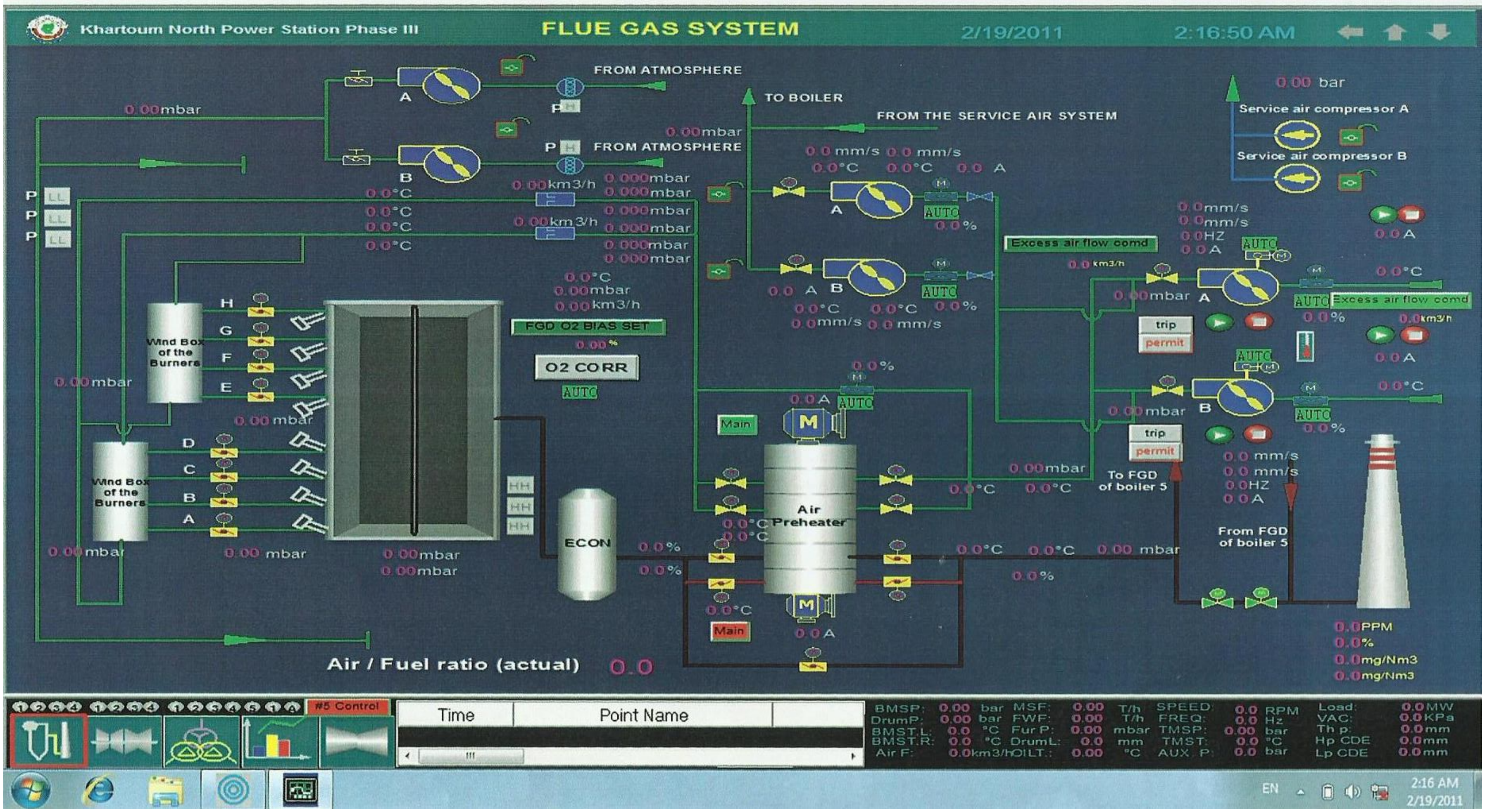

Figure 4.26: Fuel Gas System

This figure represent fuel gas system.

Filtration and heating packages are designed to deliver clean treated natural gas with the right pressure

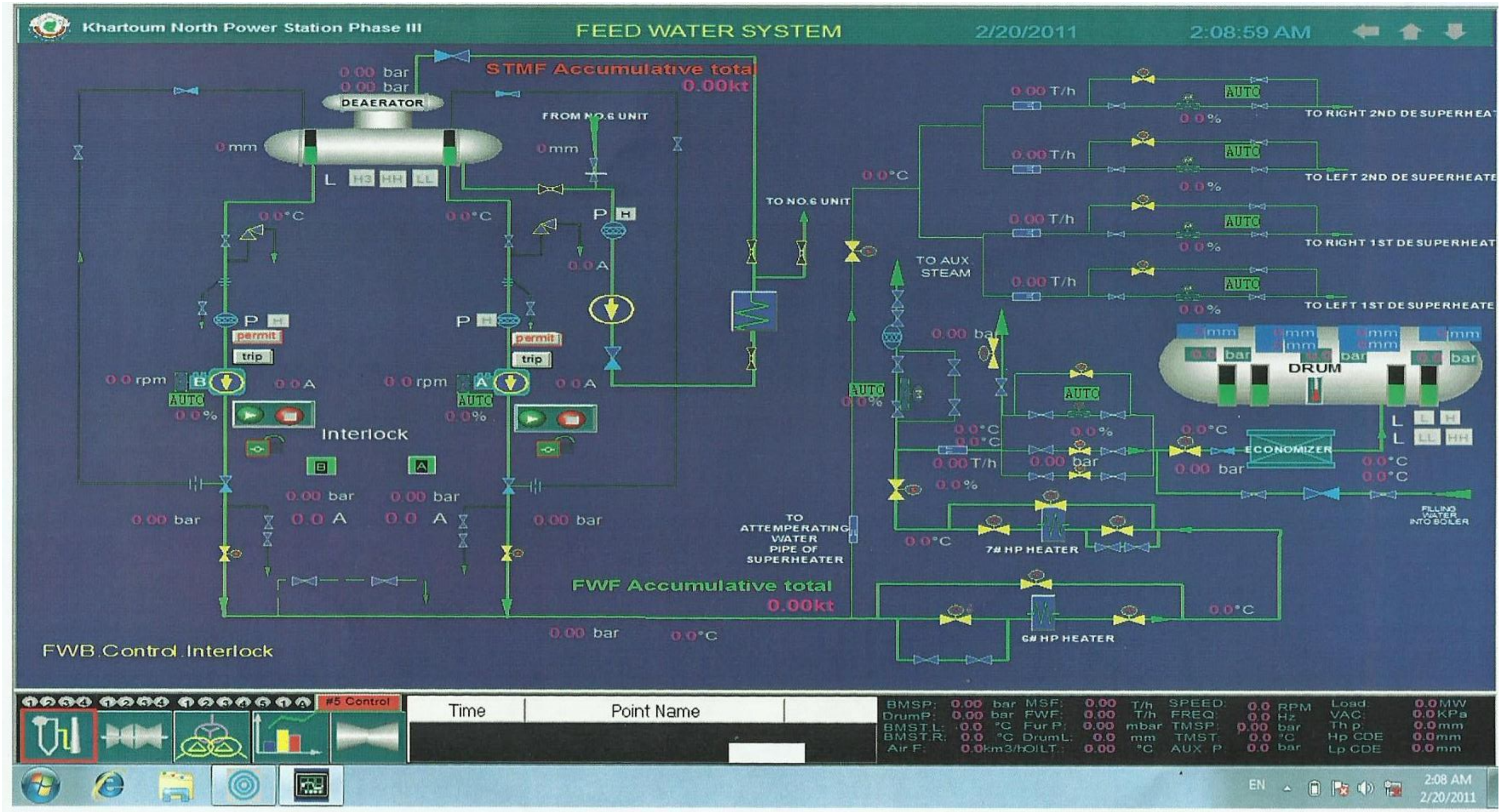

Figure 4.27: Feed Water System

This figure represent feed water system. It is an essential part of boiler operation. It is put into the steam drum from a feed pump. In the steam drum the feed water is then turned into steam from the heat it is never open t to the atmosphere. This cycle is known as a closed system or Ranking cycle

Chapter Five
Conclusion and Recommendations

5.1 Conclusion

This Research uses a controller Type OC4000 to maintain the water drum level at the normal line using the control valve position depending on measuring the actual level using ultrasonic sensor, according to the ultrasonic readings and the level set point the water must be pumped to the drum and controlled by the control valve to reach the set level (10mm). A complete modification is made in the DCS system. The results obtained by running the modified program justify the possibility of this project to be added to the main program used in MSPS.

5.2 Recommendations

- To control the overall boiler process. It's required to do more studies in the boiler main components. In order to reach the correctly process. To improve the performance of the proposed project the following recommendations could be considered:

- Eliminate the error in the sensor readings due to bubbles in the water drum by implementing fuzzy logic control.

- Extend the control to include the feed water flow, steam flow and steam temperature Three element control) for more accuracy.

References

1. John G. Webster, Lessons In Industrial Instrumentation, Handbook CRC net BASE 1999.
2. Liptak, G. 'Instrument Engineer's Handbook – Process Control', third edition, Butterworth Heine mann Ltd. (1995),
3. GE energy company, OC 4000 DCS OPERATION & MAINTEN manual for Khartoum North power station (MSPS).
4. Boiler Control Systems Engineering- By G.F(Jerry)Gilman.
5. Boiler automation -By Aizaz Hussain and Imran Tahir.
6. Johnson, Curtis D., 'Process Control Instrumentation Technology', fourth edition, Prentice Hall of India Pvt Ltd, New Delhi. (1996)
7. http://www.automation.siemens.com/searchstatic/search_en.html?gui_lang=en&q=Introdactio%20of%20HMI&ref=http%3A//www.automation.siemens.com/mcms/automation/en/human-machine interface/ Pages/ Default. aspx. Accessed:8:45 pm 15\6\2020