HAZARD IDENTIFICATION AND RISK ASSESSMENT IN BOILER

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ABSTRACT

Work place a central role in people's lives since most worker spend at least eight hour a day in the work place, whether it is on a plantation in an office, factory etc. Work environment should be safe and health. Occupational health issues are often given less attention than occupational safety issues because the former are generally more difficult to confront. The important point is the issues of both health and safety must be addressed in every work place. In this project operational mechanical and human factors are to be are to be considered in safety management system to avoid accident. Study of various accident during reasoning days. Prevention will be main scope for accidents in various industries. Since more methodology has been desired for the critical process like (equipment, boiler compress reactors power equipment) and operating procedure, handling of boiler.

INTRODUCTION

A Hazard Identification and Risk Assessment (HIRA) is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The HIRA technique was initially developed to analyse chemical process systems, later been extended to other types of systems and also to complex operations such as boiler operation and to record the deviation and consequence. A HIRA is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HIRA team) during a set of meetings. [1].Malaysia produces a minimum of 168 million tonnes of biomass, as well as timber and palm waste, rice husks, coconut trunk fibres, municipal waste and sugar cane waste annual. The biomass industries started using biomass wastes as fuel for energy sources due to the low rates of pollution and they can cut back the number of waste drop [2].The literature review showed that in some countries, steam boilers cause high range of accidents amongst the other equipment.Shortage of water and high pressure are failures, which can lead to the explosion in boilers[3].Thus this paper takes a sincere attempt to explain the advantages the companies will face by implementing automation into them. In order to automate a power plant and minimize human intervention, there is a need to develop a SCADA (Supervisory Control and Data Acquisition) system that monitors the plant and helps reduce the errors caused by humans. While the SCADA is used to monitor the system, PLC (Programmable Logic Controller) is also used for the internal storage of instruction for the implementing function such as logic, sequencing, timing, counting and arithmetic to control through digital or analog input/ output modules various types of machines processes [4]. Boiler components are being subjected to high temperature and pressure. Which could give rise to overheating and high thermal stresses of tubes, malfunctioning of units, tripping and ultimately failure of the units. This failure is referred to as boiler rupture. Plant age, temperature sensitivity, variation in quality and quantity of steam and water chemistry, contribute to the failure of steam boilers [5].The rate based on hazard sources in the boiler division has Extreme Risk levels (8%), High Risk (14%),

Moderate Risk (35%) and Low Risk (43%). Risk assessment based on the type of hazard in the boiler division have risk levels ranging from high to the lowest score is the danger of Mechanical (25%), Electrical hazard (10%), chemical hazards (6%) and physical hazards (59%).The result showed the sources of the dangers are charcoal dust, sparks, heat radiation, falls, pinched, charcoal sprinkle, noise, electric high pressure, explosion, fire, hot material, exposed to chemicals, inhaling chemicals, steam, leaks in drum steam, hotwater, excess gas pressure and embers[6].A Boiler Interlock & protection is a system that monitors the safe running state of a boiler operation and if the state becomes unsafe the interlock will trip the boiler to prevent unburnt fuel from entering the furnace.This paper highlighted some of today's design improvements which target reduced emissions and expanded operability, and explores some of the boiler design implications for the ultra-supercritical conditions needed to achieve the high cycle efficiencies for the future[7].

LITERATURE REVIEW

Operation and Control of Boilers from PLC which is consist of the internal storage of instructions for implementing functions such as logic, sequencing, timing, counting, andcontrol various parameters like water level, pressure, Temperature. PLC are used in Chemical and petrochemical industry to measure and monitor the level of liquid substances products in tanks and different types of storage places, in this process we must know the level of the storage tanks. So most of the process industries used PLC/SCADA system to measure and display of their volume of storage tanks, the process industries have some of liquids too expensive and flammable so the during the loading and unloading operations, leakage control, continuous monitoring of liquid storage tanks[2]. This boiling section produces the high temperature water of the steam level temperature. This steam level temperature is used for power generation and the steam waters are applied to the turbine section. After the power is generated, steam waters are supplied to various plants for reuses. The study was conducted to investigate the causes, effects and controls of Boiler rupture in Steam. Thermal power plant, Lagos State. Three classes of boiler rupture were investigated for twenty-nine cases of boiler rupture. The cases were grouped into classes through stratified sampling technique. Analysis of Variance (ANOVA) at 95% level of significance was used to test the two research questions set for the study[5]. The **NTPC power plant explosion** was a boiler explosion that occurred on 1 November 2017 at a newly commissioned 500-megawatt unit of the Feroze Gandhi Unchaharcoal-fired power plant. The plant is operated by government-owned National Thermal Power Corporation (NTPC) Limited, in Unchahar, Uttar Pradesh, India.[3] The explosion killed 32 people who may have been cleaning ash from the boiler's interior[10]. On May 7, 2020 there was a gas leak at LG polymers private limited in Vishakhapatnam plant which nearly kill 12 people and injured more than 1000 people. The gas leak was due to the negligence of the LG polymer plant where the chemical substance of styrene was evaporated as the temperature increased and spread over a radius of three kilometres affecting five villages. Hundreds of people rushed to hospitals for breathing difficulties and sensations of burning eyes, and most of them were found lying unconscious on the ground as the result of gas exposure. The plant manufactures polystyrene, co-polymer products and engineering plastic compounds[11]. Trough 2016, the research team at the Kaspersky lab found that there are 220,558 SCADA components that can be accessed through the Internet. These components have been distributed across 170 countries. All these components represent entry points for human agents attacking SCADA systems. They can be exposed to different types of natural phenomena, such as flooding and lightning. To need for a powerful and collaborative risk management framework for SCADA systems has become urgent to identify, evaluate, and treat various types of risks targeting SCADA systems. All possible scenarios that may happen and affect the system either directly or indirectly should be welldescribed according to a set of parameters. These parameters could be defined in paper [12].

TYPES OF BOILER

There are two types of boilers

1. Fire-tube boiler
2. water-tube boiler

Which are used in power generation and steam generation, which are most essential in

chemical processing industries, petroleum refinery & Pharmaceuticals..

Fire-tube boiler

In a fire-tube boiler, combustion gases pass through tubes with water surrounding the outside of the tubes. The advantages of a fire-tube boiler are its simple construction and less rigid water treatment requirements. The disadvantages are the excessive weight-per-pound of steam generated, excessive time required to raise steam pressure because of there natively large volume of water, and inability to respond quickly to load changes, again, due to the large water volume[2].

Water-tube boiler

In a water-tube boiler, the water is inside the tubes and combustion gases pass around the outside of the tubes. The advantages of a water-tube boiler are a lower unit weight-per-pound of steam generated, less time required to raise steam pressure, a greater flexibility for responding to load changes, and a greater ability to operate at high rates of steam generation. This type of boiler is mostly used by bio power plants due to ability to handle higher pressures up to 5,000psig and faster recovery time than fire-tube boiler [2].

In modern days,the operation and controlling of boiler being done in Automation to safeguard the equipment and personnel. More control in operation with safety interlock.

PROGRAMMABLE LOGIC CONTROLLER

Programmable Logic Controller (PLC) is a digital computer used for the automation with ability to re-program the logic as per requirements of user in industries.It can be done with by developing a PLC &SCADA system that helps to reduce the errors caused by humans and able to provide the better control and monitoring of the plant or process operations through SCADA system which is a centralized system used to supervise a complete plant and ongoing process and provide the require data respective to process changes [13].

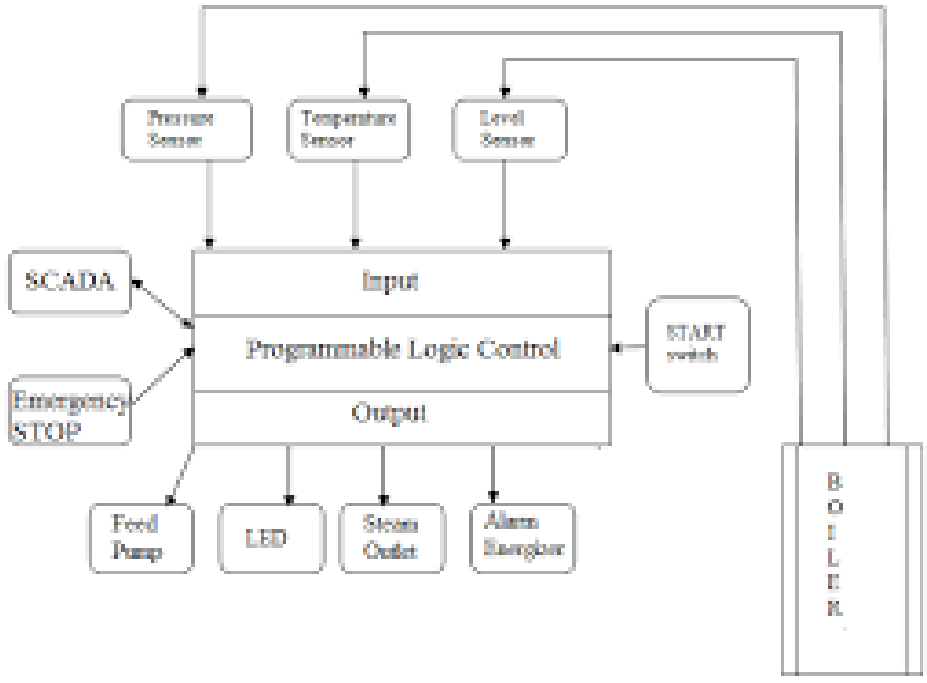

Fig 1.Programmable logic controller in boiler

Supervisory Control and Data Acquisition System

SCADA stands for Supervisory Control and Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level, it is used to monitor and control plant or equipment. The control may be automatic or initiated by operator commands. The data acquisition is accomplished firstly by the PLC scanning through field inputs connected to the PLC. SCADA provides several unique features that make it a particularly good choice for many control problems[4].

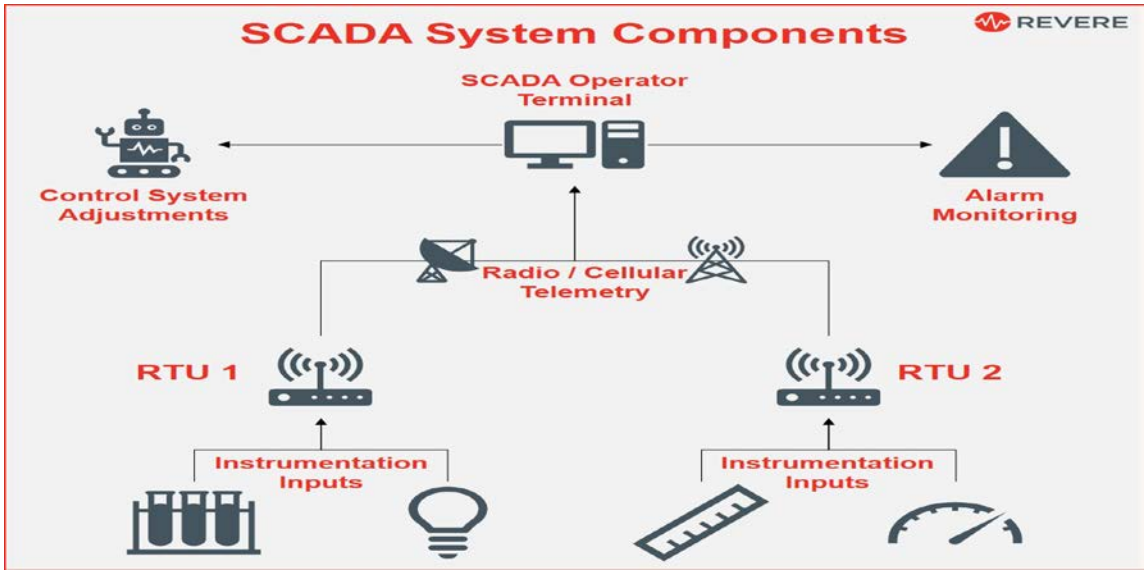

Fig 2. SCADA system components

BOILER LOGIC INTERLOCKS.

Interlock system consists of 1.Fuel trip system. 2. Master fuel trip system. 3. Flame monitoring and trip system. 4. Ignition subsystem.5. Main burner subsystem and 6. Elevation logic system. The modular based Smart logic system consists of the following: 1) Signal conditioning and input module, 2) Microcontroller interface module, 3) Start-up/shutdown module, 4) Output module, 5) Display module, 6) Alarm module and 7) Protection module[7].The start-up interlock monitors the pertinent parameter only during start-up and once that parameter is satisfied it allows the boiler to continue in the start-up sequence. Running interlocks are active once the boiler begins firing. These interlocks use a continuously measured signal to shut the boiler down if the pertinent measured parameter does not meet its requirement [14].

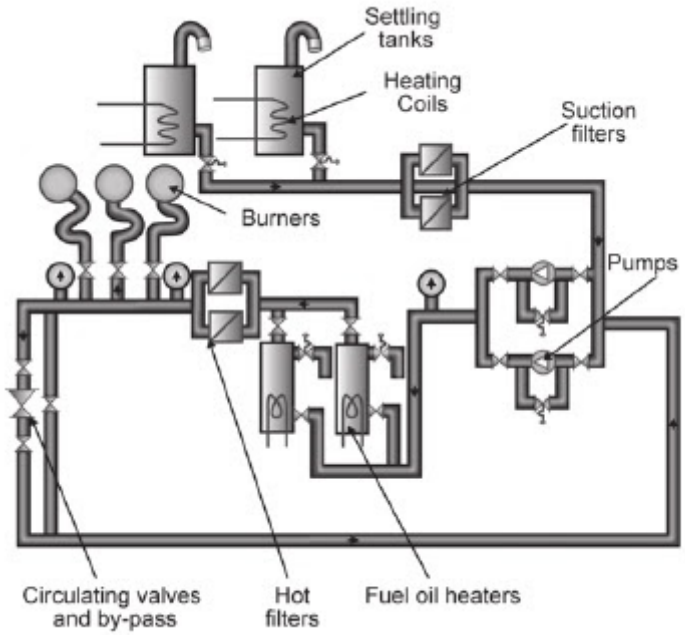

Fig 3.BOILER LOGIC INTERLOCKS

SOFTWARE IMPLEMENATATION

Ladder Logic Programming (LLP) and Functional Block Diagram (FBD) Language has been used to program the PLC. For this purpose Unity pro XL Simulation Software (PLC) and SCADA has been used as simulator. The programming logic has been set according to the process flow and Tantalizer (TOT) has been used in the program to tantalize the cumulative liquid Quantity while liquid flows through the Flowmeter [7].

HAZARD IDENTIFICATION IN BOILER

• Pitting
• Erosion
• Vibration
• Rupture
• Corrosion fatigue
• Thermal fatigue
• Over temperature
• Maintenance damage
• Material flaws
• Welding flaws

Operation should be monitored around the clock; therefore, the operators work in heavy-duty shifts. Studies showed that shift work has negative impacts on the operators' performance and safety additionally, occupational health risks, like high noise, are common in most boilers .Considering the possible incidents and consequences, it is important to identify the steam boiler hazards of each industry. This study investigated hazards related to health, safety, and environment that had significant roles in risk generation [3]

The following table gives an overview of commonly used guide word - parameter pairs and common interpretations of the.

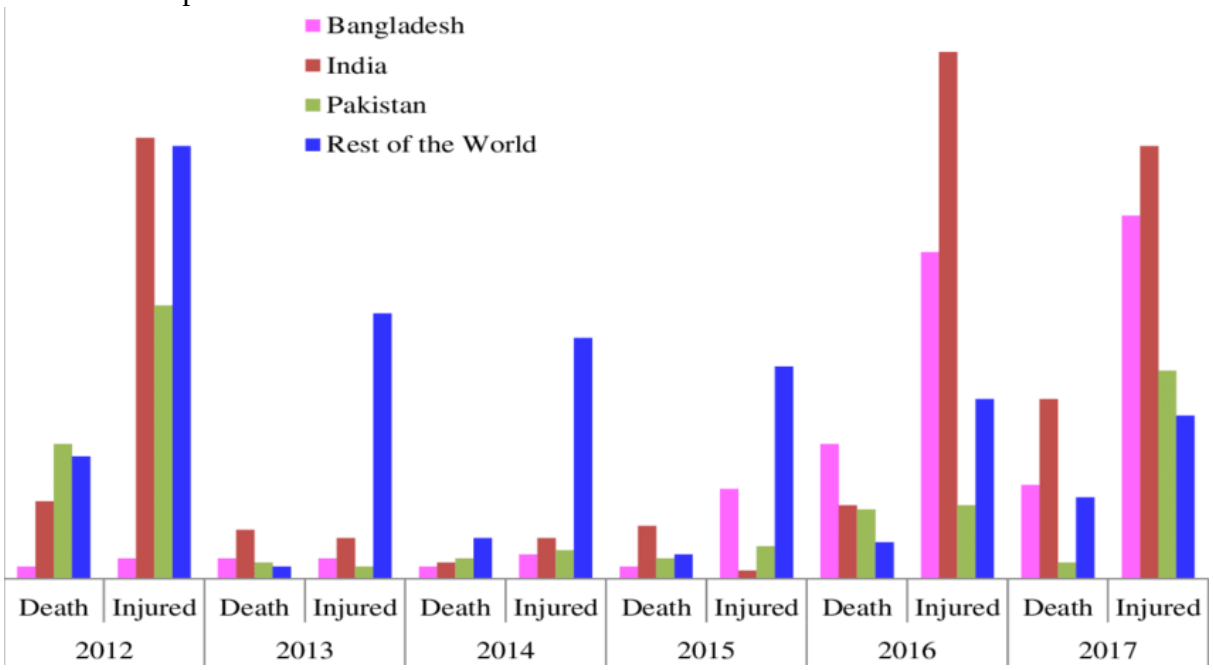

Fig 4.World-wide boiler explosion fatalities from 2012 to 2017

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Risk Identification Problem in SCADA System

So many researchers have tried to study the risks in SCADA systems. Tier trails are short and suffer from describing an efficient algorithm in identifying the risk class. Moreover, a correct definition for vulnerability in SCADA is missed. Tis paper tries to map the relation between the effective parameters that identifying the SCADA risks and the whole scenario for specific risks. The whole scenario for risks is targeted through rebuilding a significant database collected from previous resources and then analysing the results. The problems that face other researches are assumed in the DB and summarized in the following points. Giving a detailed level of identifying the risks and classifying them based on the nature of the risk agents, their action's motivation, and the penetration tools/techniques that can be used to cause a risk on a SCADA system [12].

Boiler Process and operation

• Economizer
• Boiler
• Super heater
• De-super heater
• Re-heater
• Steam Distribution header
• Condenser
• Cooling tower[16].

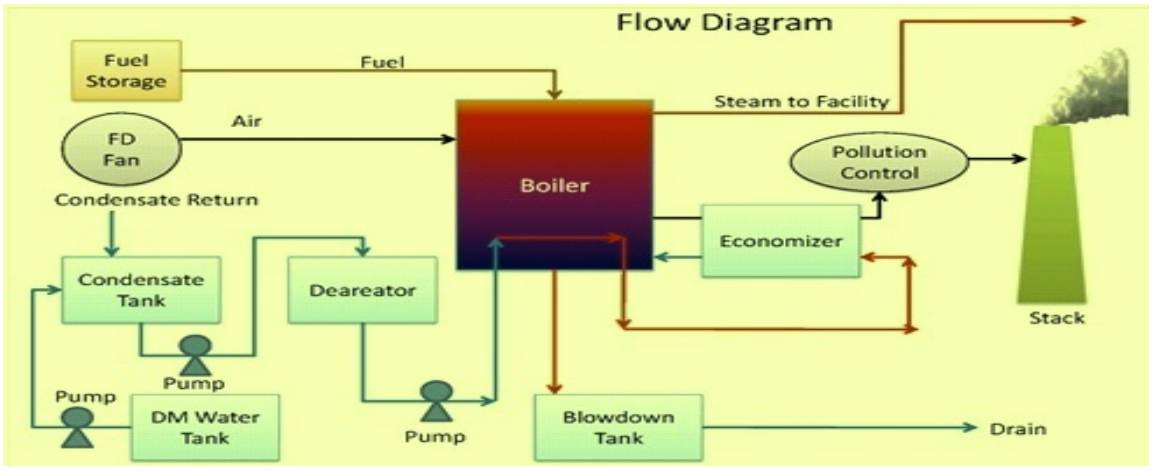
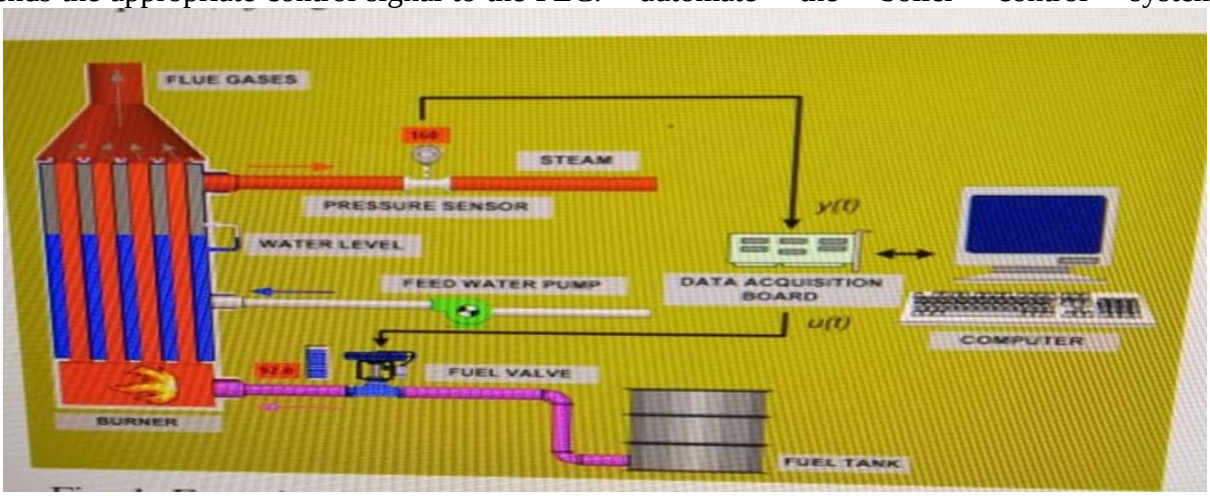


Fig 5.process in stream boiler

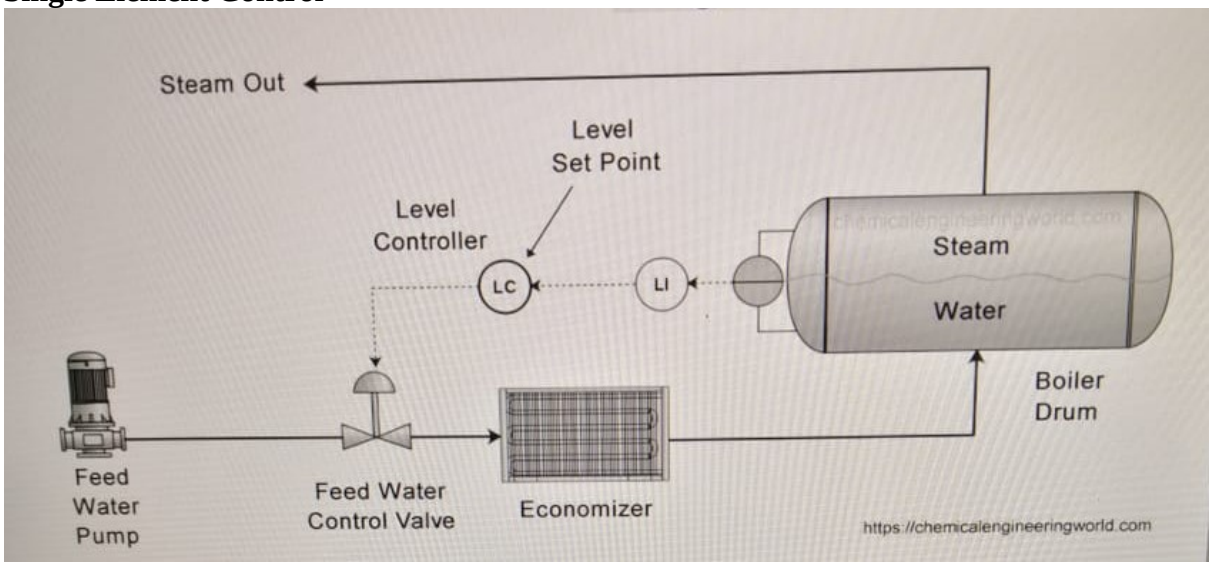
Water plays a major part in the generation of steam. Initially Pushbutton is switched ON then the PLC, SCADA, different sensors are switched ON. Feed water pump is switched ON by using feed water pump switch. Coal from the coal chamber passed to the water tube boiler. And the water from the water tank is allowed to pass through two parallel pipes to boiler and its temperature is measured. In one pump the flow rate is maintained at 130% and in another it is 75%. Thus the failure of any one pipe does not affect the boiler operation. Heater is switched ON by using PLC. Forced draft fan is used to force the air into the boiler to improve the combustion efficiency and its corresponding temperature and pressure are measured by sensors. The water is passed through economizer, thus the heat in the outgoing gases is recovered, by transferring its heat to the water. Then the heated water is made to flow through steam and water drum. In this, water should be maintained at least at 50%. For sensing water level Float switches are used. When the level is lesser than or greater than 50%, Float switches senses the level change and sends the appropriate control signal to the PLC. Thus, in spite of any changes in disturbance variable, the water level can be maintained at 50% by proper tuning of PID controller. Water in the water drum is maintained at more than 75% [17].Boiler Drum Automation using PLC and SCADA is designed and implemented in respective software's for real time monitoring. Different sensors and field devices are used to measure the critical parameter such as water flow, steam flow rate water level. SCADA visuals are used to monitor the parameters and PLC used to control the operation. If the feed water flow rate, water level and steam flow exceed predefined value then the entire setup will shut down and automatic check valves are opened to release the steam and pressure [14].

Implementation OF PLC AND SCADA in Boiler Control System

The parameters such as temperature, flow, level, and pressure has to be controlled proficiently to achieve greater efficiency. Compared to manual operation, automation prevents human errors and makes the process more efficient. So there is a need for automating the boiler control system. PLC is made use of to automate the boiler control system[16].

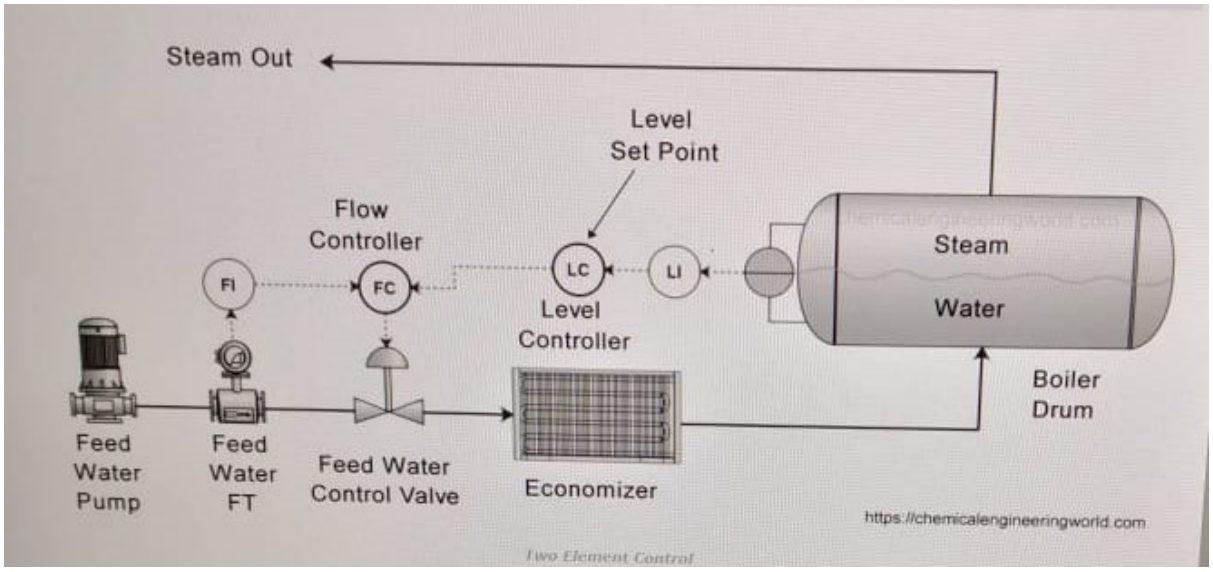


Single Element Control



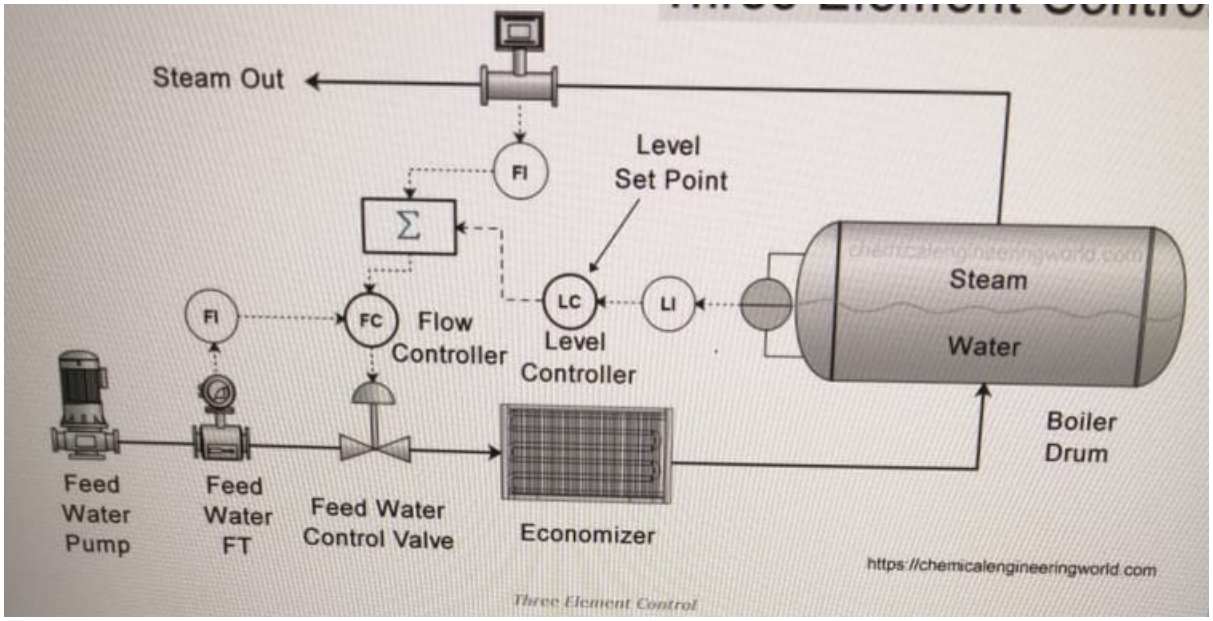
In this type of control mechanism, water is fed into into the boiler drum through a single or multiple pipes and thus a single for multiple control valves. Only the level in the drums is measured through a level transmitter and the information is sent to the controller. Based on the obtained information if is compared to the set point and then control valves are manipulated in order to increase or decrease the flow rate of the water inside the boiler drum. It takes some time to effect changes in this type of mechanism thus it is only used wherever the residence time is very large.

Two Element Control



In this mechanism, one or more variable is controlled in the process apart from the level. That variable is the flow rate .The flow rate could be feed water or the stream, any one of them. They a cascade control system with the level controller being in the primary loop and the input from it is used to set the secondary loop which consists of flow rate controller .The accuracy is much better and also faster than single element control

Three Element Control



In themechanism, the drum level is controlled, the flow rate of feed water and the stream flow rate is controlled .It forms cascade plus feed forward system .The output from the level control is input into the feed forward steam floe rate and the measurement of the steam floe rate is used to set the feed water flow rate. This combination is the most accurate among all three. The only drawback is that three element controls cannot be used for low boiler load conditions because at such conditions it is very difficult to measure steam flow rate accurately .At high boiler load,this mechanism is most useful

Conclusion

It is very important to control the water level in the boiler drum. The level should not be too high or too low .The water enters the boiler drum after passing through economiser for this: usually the water from the bottom of the boiler drum is transported around the furnace and then input back into the boiler drum,if the water level becomes low then it may cause the boiler to run dry thus causing Mechanical damage.

If the water level is allowed to be too high then steam purity may get affected.It may cause more droplets of water to pass through the demister and then enter the super heater along with the saturated steam.In order to vaporise those water droplets more heat will be required, the effect will be that the thermal load will increase; this also implies that life of tubes may get reduced. If the water level gets too high, it may be possible that such amounts of liquid enter or transported downstream that they damage the equipment's.

Usually it is a standard to maintain the boiler drum level at 50%, during operation.The designs for boiler drum level control are referred to as single element, two element and three element control.

Hence the Maintaining water level in the drum is must to avoid the equipment damage and safe handling of boiler. Other parameters like temperature and pressure control also have an impact in safety of Human. Operation and controlling of Boiler using PLC and SCADA is more safety and avoiding number accidents.

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