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## International Journal of Intellectual Advancements and Research in Engineering Computations

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### Boiler Drum Level Control using Three Element Strategy

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#### ABSTRACT

The main objective of our project is to maintain the boiler drum level, feed water flow and outlet steam flow from the boiler using cascade controller by applying a bias calculation and an compensated steam flow. It controls the ATmega controller, the boiler drum level control unit is one of the main parameter in an industry. In the proposed system the boiler drum parameters such as temperature level, flow level and water level are measured and controlled using embedded controller. Temperature sensor is used to check the steam that comes from the boiler. Pure steam is required to run the turbine so temperature sensor checks whether the steam is wet or dry. If it is wet steam, then turbine blades gets damaged. So it identifies the wetness or dryness of the steam. In order to meet out the steam requirement, to safeguard the boiler water tubes and turbine blades, the boiler water drum level control plays an important role in thermal power station.

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#### RECOVERY BOILER

Recovery boiler is the part of Kraft process of pulping where chemicals for white liquor are recovered and reformed from black liquor. Recovery boilers are also used in the (less common) sulfite process of wood pulping.

#### Boiler drums level controls

A very common control problem, and one used in many examples elsewhere, is that of controlling the level in a boiler drum. Many industrial plants have boilers for generating process steam, and of course boilers are central to thermal power generation. The boiler drum is where water and steam are separated. Controlling its level is critical – if the level becomes too low, the boiler can run dry resulting in mechanical damage of the drum and boiler piping. If the level becomes too high, water can be carried into the steam pipe work, possibly damaging downstream

equipment. The design of the boiler drum level control strategy is normally described as single-element, two-element, or three-element control. This article explains the three designs.[1-3].

#### PROPOSED METHOD

In order to overcome the existing problem the conventional proposed system is employed. In the proposed system, it is to monitor and control the boiler parameters by using the ATmega microcontroller ATmega8. The ATmega8 microcontroller for embedded applications is automotive for industrial control. The embedded processor is used for real time monitoring of data. In this conventional type of monitoring if there is a chance of fault it takes to knowledge before the occurrence of fault[ 4-6].

Data are maintained only in log book so there is no possibility of effective data analysis for taking preventive action leading to production loss,

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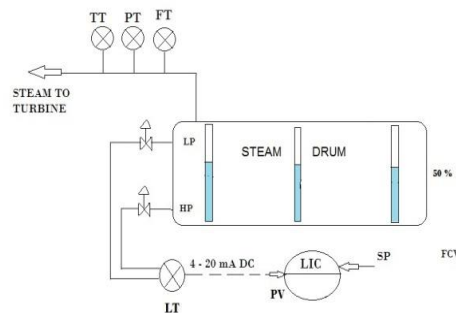
workman .For automatic monitoring of boiler drum parameters such as water flow, water level and temperature being measured and it is displayed in the liquid crystal display. The temperature level is measured using temperature sensor. The Water level to the boiler is one of the main parameter; it can be measured using water level sensor. All the output is given to the controller and the output is displayed in the LCD screen [8-10].

## EXISTING METHOD

In current industries, the boiler parameter such as water level only is monitored. These parameters are controlled manually. In this conventional type of monitoring, if there is a chance of fault it can taken to knowledge only after the occurrence of fault. Immediate alert system is not available. The data are maintained only in log book so there is no possibility of effective data analysis for taking

## SINGLE-ELEMENT CONTROL

### (Feedback control)



One or more boiler feed water pumps push water through one or more feed water control valves into the boiler drum. The water level in the drum is measured with a pressure and temperature-compensated level transmitter. The drum level controller compares the drum level measurement to the set point and modulates the feed water control valves to keep the water level in the drum as close to set point as possible. Variable-speed boiler feed pumps are sometimes used to control the level instead of valves. The simple feedback control design described above is called single-element control, because it uses only a single feedback

preventive action leading to production loss, workman hour.

## HARDWARE REQUIREMENTS

- ATmega8 microcontroller
- LCD
- Temperature sensor
- Level sensor
- Flow sensor

## THREE ELEMENT STRATEGIES

The term “3-element control” refers to the number of process variables (PVs) that are measured to effect control of the boiler feed water control valve. These measured PVs are: Liquid level in the boiler drum, Flow of feed water to the boiler drum and Flow of steam leaving the boiler drum.[9,10].

element for control – the drum level measurement. With multiple sources and multiple pumps, the supply pressure of the feed water will change over time. Every time supply pressure changes, the flow rate through the valve, even if it remains fixed in position, is immediately affected.

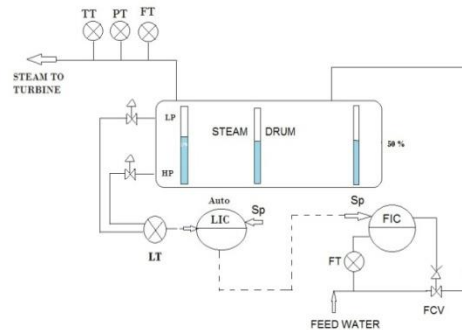
So, if the boiler drum liquid level is low, the level controller will call for an increase in feed water flow. But consider that if at this moment, the feed water supply pressure were to drop. The level controller could be opening the valve, yet the falling supply pressure could actually cause a decreased flow through the valve and into the

drum. Thus, it is not enough for the level controller to directly open or close the valve. Rather, it must decide whether it needs more or less feed flow to the boiler drum. The level controller transmits its target flow as a set point to a flow controller. The flow controller then decides how much to open or close the valve as supply pressure swings to meet

the set point target. Single-element drum level control can work well only if the residence time of the drum is very large to accommodate the large deviations, but this is seldom the case – especially in the power industry. For this reason, the control strategy is normally expanded to also include feed water and steam flow.

## TWO-ELEMENT CONTROL

### (Cascade control)



**Fig:1 Single-Element Control**

Many boilers have two or three feed pumps that will be switched on or off depending on boiler load. If a feed pump is started up or shut down, the total feed water flow rate changes. This causes a deviation in drum level, upon which the drum level controller will act and change the feed water control valve position to compensate. As explained above, the level controller's response is likely very slow, so switching feed pumps on and off can result in large deviations in drum level. A faster control action is needed for dealing with changes in feed water flow rate. This faster action is

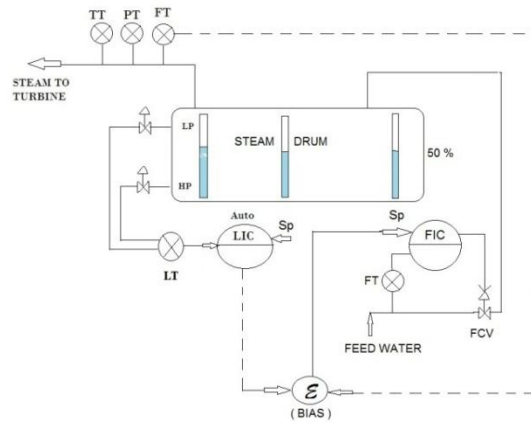
obtained by controlling the feed water flow rate itself, in addition to the drum level.

The drum level controller becomes the primary controller and its output drives the set point of the feed water flow controller, the secondary control loop. This arrangement is also called two-element control, because both drum level and feed water flow rate are measured and used for control.

The level controller is the primary controller (sometimes referred to as the master controller) in this cascade, adjusting the set point of the flow controller, which is the secondary controller (sometimes identified as the slave controller).

## THREE-ELEMENT CONTROL

(Cascade + feed forward control)



**Fig:2 Two-Element Control**

Similar to feed flow, changes in steam flow can also cause large deviations in drum level, and could possibly trip the boiler. Changes in steam flow rate are measurable and this measurement can be used to improve level control very successfully by using a feed forward control strategy. For the feed forward control strategy, steam flow rate is measured and used as the set point of the feed water flow controller. In this way the feed water flow rate is adjusted to match the steam flow. Changes in steam flow rate will almost immediately be counteracted by similar changes in feed water flow rate. To ensure that deviations in drum level are also used for control, the output of the drum level controller is added to the feed forward from steam flow.

The combination of drum level measurement, steam flow measurement, and feed flow measurement to control boiler drum level is called three-element control. By measuring the steam flow, the magnitude of demand, changes can be used as a feed forward signal to the level control system. The feed forward signal can be added into the output of the level controller to adjust the flow control loop set point, or can be added into the output of the flow control loop to directly manipulate the boiler feed water control valve. The majority of the boiler level control systems add the feed forward signal into the level controller output

to the secondary (feed water flow) controller set point. This approach eliminates the need for characterizing the feed forward signal to match the control valve characteristic.

Actual boiler level control schemes do not feed the steam flow signal forward directly. Instead, the difference between the outlet steam flow and the inlet water flow is calculated. The difference value is directly added to the set point signal to the feed water flow controller. Therefore, if the steam flow out of the boiler is suddenly increased by the start up of a turbine, for example, the set point to the feed water flow controller is increased by exactly the amount of the measured steam flow increase. Simple material balance considerations suggest that if the two flow meters are exactly accurate, the flow change produced by the flow control loop will make up exactly enough water to maintain the level without producing a significant upset to the level control loop. Similarly, a sudden drop in steam demand caused by the trip of a significant turbine load will produce an exactly matching drop in feed water flow to the steam drum without producing any significant disturbance to the boiler steam drum level control.

The most common of these are boiler blow down and steam vents (including relief valves) ahead of the steam production meter. In addition, boiler operating conditions that alter the total

volume of water in the boiler cannot be corrected by the feed forward control strategy. The level controller itself must correct for these unmeasured disturbances using the normal feedback control algorithm.

## BLOCK DIAGRAM

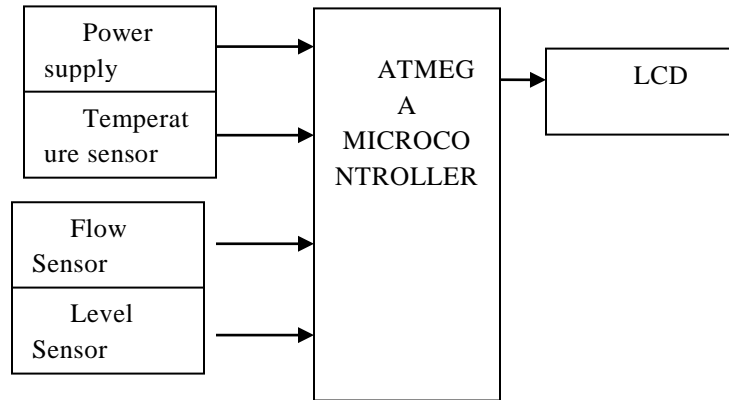


Fig:3 Block Diagram

## INSTRUMENTATION

### MICROCONTROLLER – ATMEGA 8

#### FEATURES

##### High-performance, Low-power AVR

8-bit Microcontroller

##### Advanced RISC Architecture

130 Powerful Instructions – Most Single-clock Cycle Execution

32 x 8 General Purpose Working Registers

Fully Static Operation

## CONTROL VALVE

Control valves are used to control conditions such as flow, pressure, temperature, and liquid level by fully or partially opening or closing in response to signals received from controllers that compare a "set point" to a "process variable" whose value is provided by sensors that monitor changes in such conditions. The opening or closing of control valves is usually done automatically by electrical, hydraulic or pneumatic actuators.

## MAJOR DISTURBANCES

Drum level is affected by changes in feed water and steam flow rate. But because of the very slow response of the feedback control loop, changes in feed flow or steam flow can cause very large deviations.

Petitioners are used to control the opening or closing of the actuator based on electric or pneumatic signals. These control signals, traditionally based on 3-15psi (0.2 -1.0 bar), more common now are 4-20 mA signals for industrial standard.

## CONSTRUCTION

This is an air operated valve which controls the flow through an orifice by positioning approximately a plug. The plug is attached at the end of a stem which is supported by a diaphragm at the other end. The air controller output above the diaphragm increases, the steam moves down and consequently the plug restricts the flow through the orifice. The control valve function is of two types,

Air fails to close ,

Air fails to open .

## AIR FAIL TO CLOSE

- The controller output above the diaphragm increase, the steam moves downward means air to close function.
- It is also known as fail to open.

## AIR FAIL TO OPEN

- In ordering condition the control valve close the function.
- If the pressure increases, automatically open the valve is called air to open.
- It also known as a fail to close.

## CIRCUIT DAIGRAM

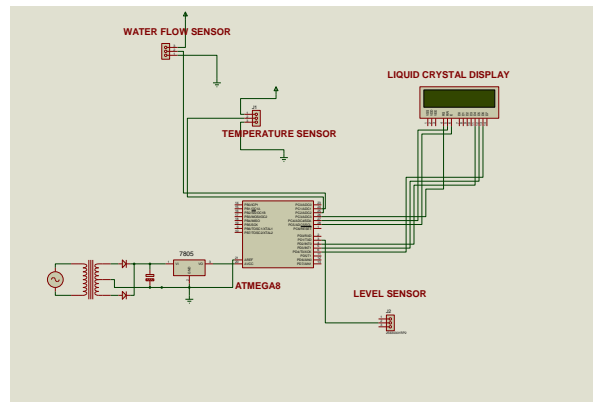


Fig:4 Circuit Diagram

## CONTROL CHARACTERISTICS

- Linear
- Equal percentage
- Quick opening

### LINEAR

- Linear type control valve means the positioned output increases or decreases simultaneously control output changes.
- This is plug arrangement of linear type control valve.
- $F(x) = x$

### Equal percentage

- Equal percentage means the stem movement is slow then the output gives a slow response.
- $F(x) = \alpha^{x-1}$

## VALVE

### Quick opening

- Quick opening also known as on-off function.

### Sensitivity

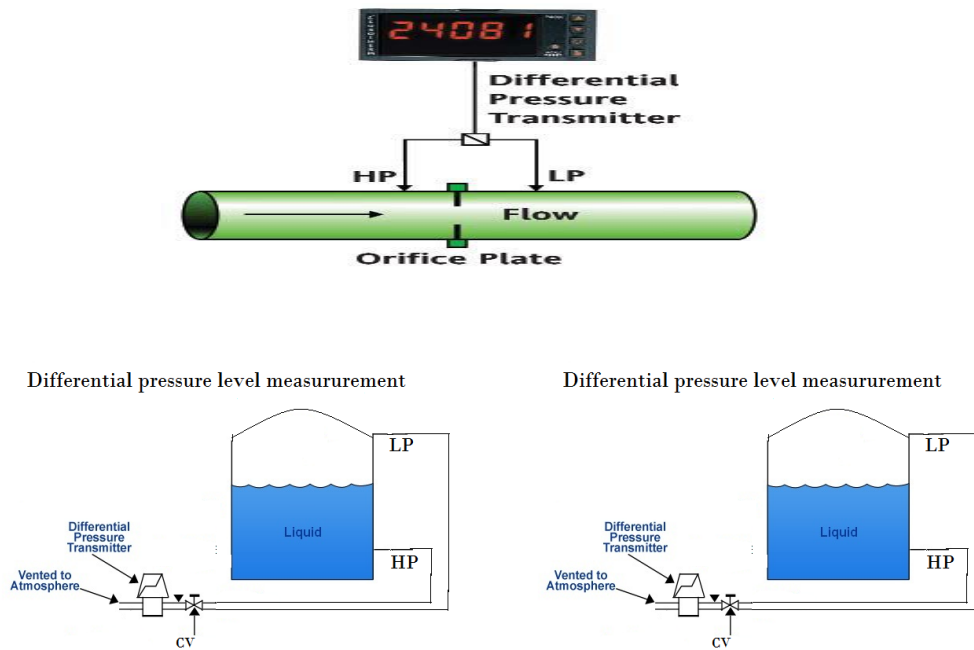
- Sensitivity =  $df(x) / dx$
- $X$  = fraction of open ( Stem position )
- $F(x)$  = fraction of maximum flow.

In feed water flow control, in soda recovery plant, Globe valve is used which is of Equal percentage characteristics where the flow increases , sensitivity also increases.

## DIFFERENTIAL PRESSURE LEVEL MEASUREMENT

This method is especially applied to steam boilers for designing auxiliary level gauges. Mercury filled U – tube manometer is used as a differential pressure sensor. It measures the pressure difference between two columns of liquid.

## Flow sensor



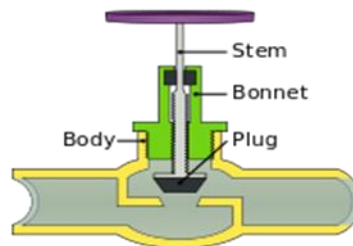
**Fig: 5 Flow Sensor**

In the Differential Pressure Transmitter, as flow increases, the differential pressure increases, and when flow decreases the differential pressure decreases. For example, an orifice plate is placed in a pipe to restrict the fluid flow. This restriction creates a pressure drop that can be converted to flow rate. The differential pressure transmitter

measures the pressure drop created, by measuring pressure at two different points, upstream and downstream.

Differential pressure then is the difference between the higher pressure or upstream reading and the lower pressure or downstream reading.

## GLOBE VALVE



A globe valve is a type of valve used for regulating flow in a pipeline, consisting of a movable disk-type element and a stationary ring seat in a generally spherical body. Globe valves are named for their spherical body shape with the

two halves of the body being separated by an internal baffle. This has an opening that forms a seat onto which a movable plug can be screwed in to close (or shut) the valve. The plug is also called a disk. In globe valves, the plug is connected to a

stem which is operated by screw action using a hand wheel in manual valves. Typically, automated globe valves use smooth stems rather than threaded and are opened and closed by an actuator assembly.

## STEM

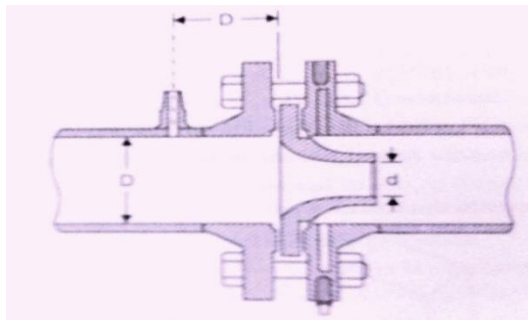
The stem serves as a connector from the actuator to the inside of the valve and transmits this actuation force. Stems are either smooth for actuator controlled valves or threaded for manual valves..

## CAGE

The cage is part of the valve that surrounds the plug and is located inside the body of the valve. Typically, the cage is one of the greatest determiners of flow within the valve. As the plug is moved more of the openings in the cage are exposed and flow is increased and vice versa Cages are also used to guide the plug to the seat of

## FLOW NOZZLE

### Flange type flow nozzle



The flow nozzle is a smooth, convergent section that discharges the flow parallel to the axis of the downstream pipe. The downstream pipe end of a nozzle approximates a short tube and has a diameter of the vena contracta of an orifice of equal capacity. Thus the diameter ratio for a nozzle is smaller or its flow coefficient is larger. Pressure recovery is better than that of an orifice. Flow nozzles are usually made of gun metals, stainless steel, bronze or Monel metal. They are frequently chromium plated. Sometimes steatite coating is provided to have abrasion resistance.

the valve for a good shutoff, substituting the guiding from the bonnet.

## CAPACITIVE TRANSDUCERS

Capacitive transducers are nothing but the capacitors with the variable capacitance. These are mainly used for the measurement of displacement, pressure etc. It is a Passive type of Transducer.

## PRINCIPLE OF OPERATION

The capacitive transducers works on the familiar capacitance equation of parallel plate capacitor, which is given by:

$$C = \epsilon_0 \times \epsilon_r \times A / d$$

Where C is the value of the capacitor of the capacitance transducer

$\epsilon_0$  is the absolute permittivity

$\epsilon_r$  is the relative permittivity .

The product of  $\epsilon_0$  &  $\epsilon_r$  is also called as the dielectric constant of the capacitive transducer. A is the area of the plated is the distance between the plates.

## ADVANTAGES

- Permanent pressure loss lower than that of an orifice plate.
- It is suitable for fluids containing solids that settle.
- It is widely accepted for high pressure and temperature steam flow.

To control through digital or analog inputs & outputs, various types of machines or process”.

## CONCLUSION

In this project the boiler drum parameters like temperature, flow and water level can be monitored and controlled automatically by using microcontroller ATmega8. The parameter variations of normal and abnormal conditions are represented numerically represented by using LCD screen. If the drum level goes below the desired lower level, there will be a possibility of starvation

of water tubes inside the furnace and if the water level in the drum rises above the desired drum level, there will be a carryover of water particles in the dry steam flowing to the turbine. In order to meet out the steam requirement, to safeguard the boiler water tubes and turbine blades, the boiler water drum level control plays an important role. In future, droplet identifier parameters are enhanced and the values can be sending to the users by sending an SMS.

## REFERENCES

- [1]. Rajkumar “Boilerdrum level control by using wide open control with three element control system” International Monthly Refereed Journal of Research In Management & Technology, 2013.
- [2]. Anish Mathew” Internal Model Control of pressure process using ARM Microcontroller”International Conference Computing, Electronics and Electrical Technologies (ICCEET), 2012.
- [3]. Gowri Shankar “Control of Boiler Operation using PLC – SCADA” International MultiConference of Engineers and Computer Scientists(IMEC), 2008
- [4]. Hari Krishnan "optimization of main boiler parameters using soft computing techniques “International Journal of Research And Tecnology.
- [5]. Rahul Malhotra “Boiler Flow Control Using PID and Fuzzy Logic Controller” International Journal of Computer Science & Engineering Technology (IJCSET), 2011.
- [6]. RoopalAgrawal ,UmeshC.Pati “Internet Based Boiler Drum Level Control System Using LabVIEW”
- [7]. Sanjoy Kumar Chakraborty, Nilotpal Manna and SurodhDey” Importance of three-elements boiler drum level control and it installation in power plant”International Journal of Instrumentation and Control Systems (IJICS), 2014.
- [8]. Sauravkumar “Multi parameter monitoring & controlling for a boiler using pic controller”International Journal of Scientific & Engineering Research, 2014.
- [9]. Shital S. Chopade, PradhumanVerma, PrashantVerma” Simulation of Boiler Control using PLC & SCADA”International Journal of Engineering and Advanced Technology (IJEAT), 2013.
- [10]. SubodhPanda,Bikash Swain ,Sandeep Mishra “Boiler Performance Optimization Using Process Neural Network” Indian journal of applied research paper, 2013.