Monitoring And Control Of Cooler Tank Level Measurement In Gas Cleaning Plant (GCP)

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Abstract. The Cooler Tank Level plays a major role in Gas Cleaning Plants (GCP) and it is a very important parameter to be measured and controlled. If the tank level is not maintained in nominal range, the dust particles will accumulate on the Cooler Tank and affect the process. The production of copper metal at Vedanta, Thoothukudi include Blending of various grades of copper concentrates, Smelting and Refining. Sulphur dioxide is generated from during the smelting of copper and is converted to Sulphuric acid as a byproduct. This process involves three steps such as cleaning of sulphur dioxide gas from Furnace, Catalytic conversion of S02 to SO3 and amalgamation of SO3 with sulphuric acid. The conversion process is exothermic, reversible and adiabatic reaction and hence if the temperature increases it destroys the formation of sulphur trioxide. Hence in order to achieve high conversion efficiency, the converter gases need to be cooled. The SO2 gas from smelter contains metallic dust, fume, acid mist, water vapour and other impurities like halides which will contaminate the product. Therefore the gases are to be cooled and cleaned in Gas Cleaning Plant (GCP). Cooler tank used to remove water vapour from the gas and dust settle at the bottom of cooler. Cooler tank level needs to be maintained in order to avoid overflow of water into scrubber which will block the inlet gas. The level of cooler tank is to be continuously monitored and controlled to achieve the optimum results. The limitations of using Differential Pressure Transmitter for level measurement are overcome by ultrasonic based level sensor and automated using Distributed Control System and Human Machine Interface (HMI).
Key Words: Gas Cleaning Plant, Cooler Tank Level control, HMI, Ultrasonic level sensor, Distributed Control System.

1. Introduction

In industries, the storage tank holds various liquids such as oil, byproducts and other chemicals. These processes need systematic monitoring of liquid level in tank and detects the exact quantity of liquid in storage tanks [1]. In an inner part of coolant tank, the level it occupies and the flow rates they cross are independent variables. Therefore it is indispensable to control its level in the tank. There is a prerequisite of controller for the adjustment of level and maintains constant level in the tank[2, 3]. Normally, the estimation of liquid level is done by various sensors but there needs a contact with the liquid. An existing methodology uses a level sensor in an interior part of a coolant tank in Gas Cleaning Process, mounted on it. However, this method has poor efficiency and it comprises only a single sensor. The storage tanks are usually spread among huge surfaces and use manual identification and are more ridiculous. Therefore time consumption to monitor the liquid level in the tank is too high[4]. Therefore remote monitoring are necessary to collect information from the coolant tank. As a result, it is essential to attain higher accuracy [5]. The most frequently Ultrasonic sensors does this. The data acquisition senses the difference in the level and its stored [6]. A server gather information from the DCS system and output will exhibit in a LCD module. It will display the position of liquid in the tank and its volume. [7-10].

The endeavour for the design of gas cleaning plant are persistent on the difficulty of dust particles catching[11]. In gas cleaning plant it contains a broad range of dust particles that cannot be easily detached. Therefore the gas cleaning plant uses devices like vibration generators i.e., ultrasonic Sensors and programs for monitoring and predicting resonant conditions of different surface area in the tank[12]. Due Installation of transducer would provides a better results[13]

Hence there is a necessary to automate the plant thereby to avoid those drawbacks. The proposed methodology is to implement DCS to control the level of cooler tank. For that the stimulation is done using Yokogawa CENTUM Vp.

This paper is structured as follows as. Section 2 introduces the existing system, about level measurement. In section 3 the DCS Simulation and control algorithm is outlined. Experimental setups and Results are projected in section 4. Finally, conclusions and future scope are presented in section 5.

2. Existing Method

The gas coming from smelter contains many impurities like moisture, solid particles, dust, etc. During the cleaning of gas passes through mixing chamber, quencher, non-retention vessel, venturi scrubber, cooler dehumidifier, primary ESP, secondary ESP and finally Sulphuric Acid Plant. The block diagram of the cleaning process in Sulphuric acid plant is shown in the Figure 1.
2.1 Cooler Tank Level Measurement Using Differential Pressure Transmitter (DPT)

In Gas Cleaning Plant, cooler is the heart of the process because it only removes the water vapour from the gas. During suction by blower- negative pressure impact inside cooler-water sprayed on top of cooler. The sprayed water contact with Inlet gas (65DegC) -remove the water vapor and dust present in the gas reduces the temperature to 35Deg C. Dust water collected at the bottom of cooler. Level of water inside the cooler should be maintained at a height of 1meter to avoid water overflow into the venturi scrubber for non blocking the inlet gas. The schematic diagram of DPT level measurement shown in Figure 2.
2.2 Disadvantages of Existing Method

The disadvantages of existing method is inaccurate level measurement in DPT due to spray water flow into LP side in cooler, Calibration range varies often due to this problem. In order to avoid the above said limitation, Water filled manually inside the LP side of DPT. There is an inaccuracy due to suction pressure by blower.

3. Ultrasonic Based Level Measurement

The drawbacks in using conventional level measurement techniques are eliminated with the help of ultrasonic based level sensor is used for level measurement in cooler tank. This sensor mainly reduces the inaccuracy and produces higher efficiencies. Ultrasound can be used to measure the wind direction, the speed, the tank or channel fluid level, and the speed through air or water. The speed and direction can be measured with the help of multiple detectors and by measuring the relative distances speed will be calculated. To determine tank level, the sensor detects the distance to the surface of fluid. The schematic diagram of proposed method of Ultrasonic sensor based Level measurement is given in Figure 3.
Ultrasonic sensor is used in side column of the tank for measuring the level of the tank. The ultrasonic pulse transmitted to side column of the tank and reflected. The reflected pulse distance is measured and displayed by using micro controller. The level was continuously measured by measuring the speed and time travel of ultrasonic pulse. The output of level was indicated by LCD DISPLAY.

3.1. Ultrasonic Sensor

The HC-SR04 type of ultrasonic sensor utilizes a sonar to start distance to object as such of bats do. It provides tremendous exposure without physical contact with high level of accuracy. It is not affected by any rays i.e mainly ultraviolet rays. The ultrasonic pulse is accurately reflected by water and the level is measured easily.

3.2 HC-SR04 Ultrasonic Module Working
The basic principle of the sensor uses an IO trigger for about 10us signal. Therefore, the Module automatically detects whether the signal is back or not. The working diagram of the module is shown in Figure 4.

![Ultrasonic Module Operations](image1)

**Figure 4** Ultrasonic Module Operations

### 3.3 Magnetic Float Switch

The level of water in the tank is continuously measured ultrasonic sensor and display unit. For controlling the level of water in tank, two float type magnetic switches connected at top and bottom of the tank. The schematic diagram of float type magnetic switch is shown in Figure 5.

![Magnetic Float Switch](image2)

**Figure 5** Magnetic Float Switch

### 3.4 Distributed Control System

A Distributed Control System (DCS) is a digital control architecture which monitor and control the entire process and operations of various plants and series of process in Industry. It has autonomous controllers and supervisory data acquisition system in a central control room which can be able to control, optimise and monitor the complete operation in a plant. Human machine Interface and controllers in DCS system used to increase reliability of the process and minimise installation
costs. Monitoring from distant places and supervisory control are achieved with the help of HMI and DCS.

- Here level was controlled by using Distributed Control System. When the level goes high, magnetic switch turned ON the solenoid valve opened to drain water in the tank by using DCS.
- If the level falls down, another solenoid valve is activated to fill the tank.

4. Results and Discussion

The Function Block Diagram (FBD) is a programming language for DCS used to design sequential and logical programme of various input and output parameters. With the help of the set of predefined blocks the sequential operation is programmed in CentumVp DCS system. The input and output parameters used for the process are defined by the basic blocks and connected through connection links both by software and hardware. The simulation of program was created using CENTUM VP software. And the hardware are interfaced with DCS input and output ports. The function diagram with the sequence table of measurement and monitoring of level using controller is shown in Figure 6.

![Figure 6 Function Block Diagram and Sequence Table](image)

The accurate values of the variable Gas cooler tank level is measured using ultrasonic based level sensor and the sequential function of float switches 1 and 2 with various level is given in the following Table 1. The results of tank level control by Sequential operation using DCS is shown in Figure 7.
Table 1: Results of various Tank level and valve action

| Gas Cooler Tank Level (cm) | Condition | Action |
|---------------------------|-----------|--------|
| > 45 cm                   | Float switch 1 energise | Solenoid valve 2 (SV2) open |
| > 2 cm to < 45 cm         | Float switches 1 and 2 de-energise | SV1 and SV2 close |
| < 2 cm                    | Float switch 2 energise | Solenoid valve 1 (SV1) open |

Figure 7 Face plate View of Level Control
If the level goes high (45cm), Magnetic switch 1 is ON and drain the level of tank using solenoid valve. If the level falls down (2cm), Magnetic switch 2 is ON and fills water in the tank. This sequential process is implemented using sensors, solenoid valves and interfaced with digital I/O module of Field control System. The sequential program is developed using ST-16 in CentumVp DCS system. The Graphical system view developed using CentumVp DCS and HMI for Level monitoring and control of Cooler Tank in Gas cleaning Plant is shown in Figure 8.

The liquid level of the cooler tank is measured and controlled by using ultrasonic based level measurement and Distributed Control System respectively. Most of the real time chemical process system exhibits multiple steady states due to non-linear phenomena occurring in the systems. The ultrasonic based level measurement is the basic evaluation computational method which provides a better satisfactory result. The DCS being an effective tool in automation can automate any process logically along with the usage of I/O.

The main advantages of the proposed method using ultrasonic sensor based Cooler Tank Level measurement in Gas cleaning plant are Independent to the process and vessel pressure, Reduced manpower and Most economic.
5. Conclusion And Future Scope

The level of water in a cooler tank is measured accurately using ultrasonic based level measurement. And the level is controlled and monitored by Distributed Control System and HMI in an effective manner. The proposed method is cost efficient and minimises manual work for continuous monitoring and recording. The ultrasonic based level measurement and control using distributed control system improves plant efficiency, reliability and maximum optimization of the measured variables. It also provides continuous monitoring of level in storage tank and maintains the variable at a predetermined value in response to various load and fluctuations during the process. It also totally records the data in HMI which will be useful for further design and analysis of the system during different loading conditions. DCS based sequential programming reduces complexity, improves speed of response and present accurate output within the stipulated time.

In future, this work can be extended by using the interface tank with magnetic level gauge. If a level gauge is used the wiring can be reduced and its efficiency is high. So that accurate settling time can be achieved this improves economy of the process. Advanced control algorithms such as Fuzzy based controller and Model predictive controllers can also be used with various parameters for efficient operation of the plant.

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