LIQUID COLUMN LEVEL MEASUREMENT USING LOAD CELL

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***Abstract*: The said research is composed of level measurement using load cell and its indication in terms of liquid column height. The height of the liquid column is displayed on lcd display. Moreover this data is been converted in to standard 4 to 20 m A signal. The parameters are inserted with the help of matrix keypad. PID control action is been implemented to get steady state response along with special type of alarm configuration to set the limits. Main purpose of this paper is to simplify the complexity in the level measurement using basic concepts of mechanics and electronics.**

***Keywords:* Load Cell, Level Measurement, Liquid Column, HX711, Display.**

I. INTRODUCTION

Traditionally the sensors used for the level measurement requires special type of mounting such as flanges, etc. this increases the manufacturing cost of the process equipment. In addition to this the risk environment is been created due to this special mounting which may results into cause of hazard. In non-contact type of level measurement there is a little maintenance work is required. To reduce this problems the following concepts is used. As we know that every element in this universe consist some mass this mass is directly proportional to the volume with density as a constant. This relation between the mass and the volume is been used as a primary concept in this research. Every material has specific density and the mass so the only changing parameter is volume. Thus as the mass increases the density remains same and volume increases. All equipment needed some support for its stability. As the weight of the system increases it directly exerts some reaction forces on the base, if we introduce some measuring device in this base we could measure the mass of the system as well as if density is defined then we get the height of the column. In our research we are using load cell to measure the mass of the system.

II. LITERATURE REVIEW

1. The Engineer's Guide to Level Measurement by Emerson Process Management.

This Level Handbook is written as a user guide for level projects in various industries. Level is a wide subject and it is impossible to cover everything in one single book, but they have aimed to include information they know users struggle with. They have also included a wide range of level applications, and even if not all are included, users should be able to find an application that is similar enough to give guidance on their own application. This is important literature for this project, the basic concepts of level measurement such as need of level measurement, volume level equations and level terminologies- indication vs. control, contacting vs. non-contacting etc. are studied from this literature.

<u>Indication vs. control</u>

Level measurement indicators enable an on-site level check. Indicators require the operator to interpret the measurement and take the appropriate action. Systems with level measurement indicators are referred to as open-loop control systems. Indicators are also frequently used to help calibrate automatic control systems. Automatic control systems, or closed-loop systems, are able to control level in a vessel electronically. A level-measurement device, combined with a transmitter, generates an electronic control signal that is proportional to the level in the vessel. The signal is received by a controller that operates other devices (e.g. valves or pumps), which, in turn, control the amount of product flowing in and out of a vessel. Automatically controlled vessels may also include level measurement indicator

<u>Contacting vs. non-contacting</u>

In a contacting measurement, part of the measurement system is in direct contact with the contents of the vessel. Examples of contacting measurement techniques include guided wave radar, floats and dipsticks. In a non-contacting measurement, no part of the measurement system directly contacts the contents of the vessel. Non-contacting methods are preferred when the measured fluid is especially abrasive, solidifying, viscous, dirty or corrosive.

<u>Bottom-up vs. top-down measurement</u>

A top-down measurement poses less potential for leakage (Figure 1) and enables level measurement devices to be installed or removed without emptying the tank (e.g. radar gauge). Top down measurements may or may not contact the process fluid. Level devices that use pressure transmitters are bottom-up measurement systems. A bottom-up measurement typically contacts the process fluid (e.g. DP level).

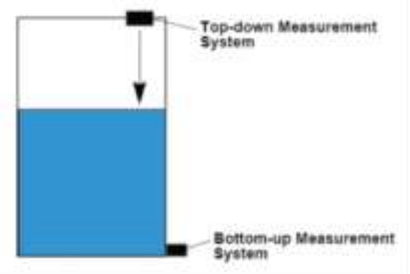

Figure 1: Bottom-up vs. top-down measurement

III. MECHANICAL SYSTEM:

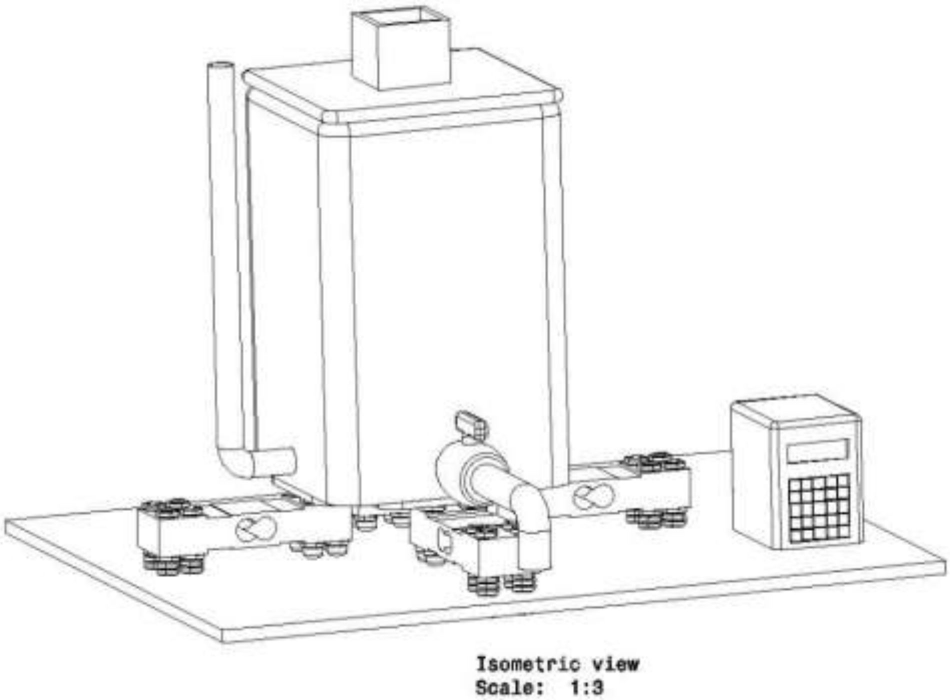

Figure 2: Isometric View

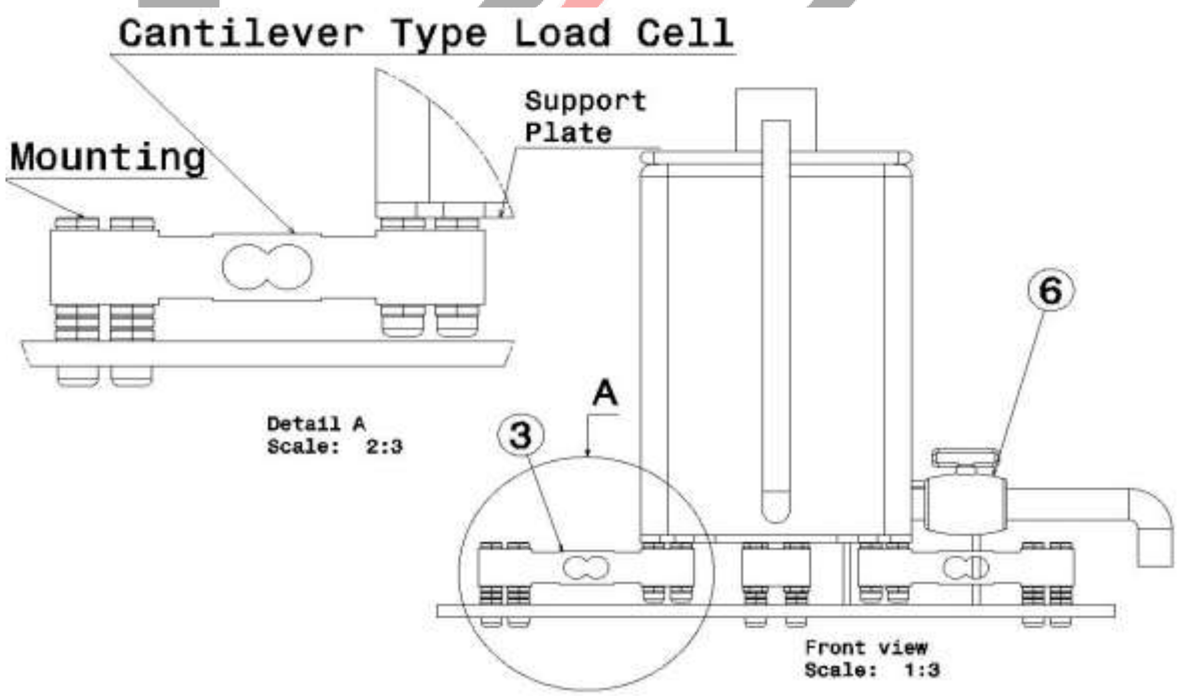

Figure 3: Side View and detailed view of load cell mounted.

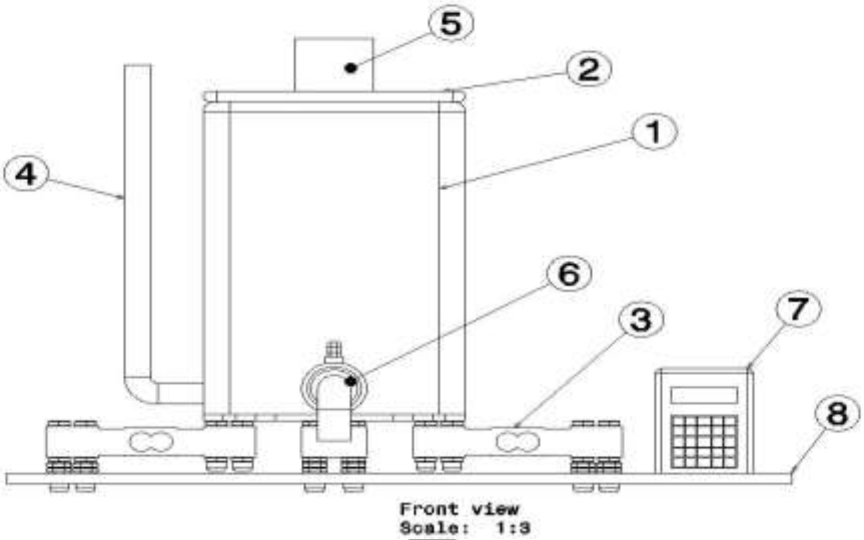

Figure 4: Front View

IV. CONSTRUCTION:

Figure 2 shows the isometric view of the total system. From figure 3 we get the side view and detailed view of the load cell mounted. Figure 4 shows the front view of the system. Figure 4 shows the parts where the description of parts are as follows:

Part 1 Liquid Tank:

The tank is used to store the liquid and are connected to the part 6 (outlet valve) and part 4 (level checker). The volume of liquid tank is 0.2 X 0.2 X 0.8 meter. It is a cuboidal type of box, holly inside and edge filleted at the corners. The tank is opened at the top and closed from the 5 side. The tank is made up of plastic and is corrosion resistant. The wall of the tank is thin 5 mm. the weight of the tank is less in order to keep the dead weight as low as possible. The dead weight is the weight of the empty tank loaded on the load cell. The weight is kept low because the more the weight the less the weight of liquid we could measure from the load cell since the load cell has some finite amount of load which they could lift.

Part 2 Liquid Tank Lid:

It is nothing but the cover plate used to cover the tank to avoid the dust particles to enter the tank and to avoid the physical contact between the atmosphere and the liquid itself. Since there might be some liquid which is reactive to the atmosphere. The lid is placed on the top of the liquid tank (part 1) and on the top of the lid there is a vent known as Liquid tank inlet valve (part 5).

Part 3 Load Cell:

The load cell is a cantilever type of load cell. The load cell is mounted on the base plate (part 8). There are 4 load cell mounted perpendicular to each face of the liquid tank. The load cell mounted collects the value from all the four load cell which is then transfers the value to control panel (7). The load of the liquid is equally distributed on all the four load cell. There are four holes mounted on the top section of the load cell at both the corners. One of the corner is used to mount to load cell above base plate (8) at specific level. On the other corner there is base plate mounted to hold the tank on it.

Part 4 Physical Level Checker:

The level checker is a transparent pipe with some readings printed on it. The amount of liquid contained in the edge filleted section of the tank is converted into the pipe volume. The length of the pipe is equal to the length of the tank. Connected to liquid tank (part 1) on the left side of it.

Part 5 Liquid Tank Inlet Valve:

The liquid is poured inside the liquid tank from this valve. It is mounted on the top of the lid (part 2). The Inlet valve is having function of funnel.

Part 6 Liquid Tank Outlet Valve:

The liquid inside the tank (part 1) is taken out from this valve and having the flow control valve mounted at the end of the pipe.

Part 7 Control Panel:

The control panel is mounted on the base plate this control panel I equipped with the HX711 a load cell amplifier, Arduino as a microcontroller, V2I converter, 1 X 4 membrane Keypad, Rectifier circuit, voltage regulator and 16 X 2 LCD display. LCD and membrane keypad is mounted at the front surface to control parameters. First button is for the menu selection, second button is for menu selection third button is for value increment and fourth button is for exit from the menu.

Part 8 Base Plate:

The base plate is used to carry all the component listed above.

V. ACTUAL MODEL

Figure 5: Actual Model

VI. METHODOLOGY

Use of the Arduino Micro-controller Boards

In this method use the Arduino Micro-controller Boards in order to reduce the system complexity and produce vary high accuracy. The block diagram for this method is as shown below.

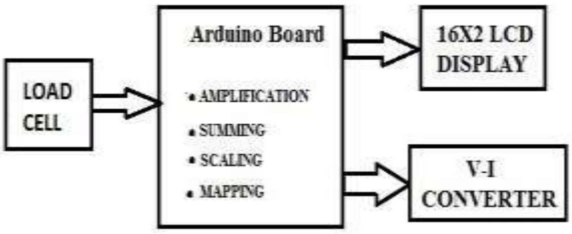

Figure 6: Block Diagram for the Arduino Micro-controller Boards

The all steps were performed by the Arduino, hence we can reduce system integrity with high accuracy output. The system can be programmed for the different liquid densities, by predefining them or providing the 4x4 matrix keyboard.

The block diagram of the system we have implemented are shown in figure below.

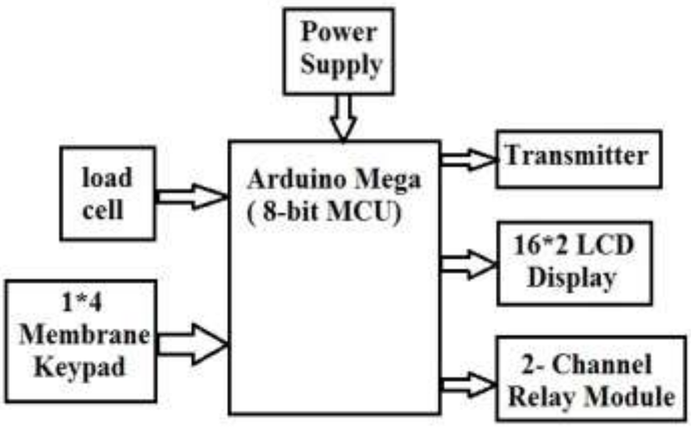

Figure 7: Block diagram of the system

The block diagram of the system is as shown in above figure. Load cell, membrane keypad, LCD display, relay module and transmitter are connected with arduino.

The load cell measures the weight of the system and sends the data to arduino. The membrane keypad is used to set the different parameters such as density, cross sectional area etc.

After the processing and calculating the level value in arduino; it is displayed on LCD display. The value of level is also sent to the transmitter which standard 2 wire transmitter used to transmit the level values.

The 2- channel relay module is connected to arduino to provide basic ON/OFF control and to provide the alarm signal.

The regulated power supply is connected to arduino, through which it is provided to all other components.

In this way, we overviewed the block diagram of this project, in this chapter.

System Specification

The system specification is important part while the application of the system in the industry. In this chapter we will discuss the overall system specification and the individual component specifications for this project.

System Specification

The system we developed in this project is the level transmitter system. The detailed system specification is tabulated below;

Inputs	2 4-wire Load Cell
Output	2-wire transmitter
	Relay Contact for ON/OFF Control
	LCD display for local indication
Power Supply	24 V DC

Table 1: System Specification

VII. THEORETICAL CALCULATION

Liquid inside Tank: Water

Density of Liquid: $1000 \frac{Kg}{m^3}$

Width of Tank: 0.2 m

Length of Tank: 0.2 m

$Density = \frac{Mass}{Volume}$

$Volume = Area\ X\ Height$

$Area = 0.2\ X\ 0.2$

$Area = 0.04\ m^2$

$Unknon\ term\ is\ height, put\ the\ value\ of\ density, area\ and\ mass\ in\ the\ equation\ 1$

Volume = Mass / Density

Area X Height = Mass / Density

Height = Mass / (Density X Area)

= (1 Kg) / (1000 X 0.04)

= 1 / 40

Height = 0.025 m

Height of liquid column = 25 mm

VIII. RESULTS & DISCUSSION

Testing is the important phase in project life cycle. In this chapter we will discuss the various testing procedures used for this project.

After purchasing the components, it is essential to check them for their proper working and compatibility with our project requirement.

Tests are carried out in three different phases which are listed below:

1. Testing of load cell

2. Testing of keypad

3. Testing of all components

After carrying out all these test, a final test is carried out in the company.

Testing of load cell

In this 1st phase of testing, the load cell in connected to arduino through Hx711 weighing sensor module.

The program is developed to find the correct calibration factor, which gives linear and accurate output.

After finding the correct calibration factor, the system validated by keeping the standard weight on the load cell.

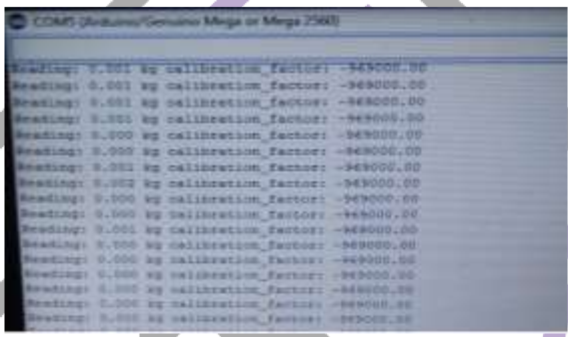

Figure 8: Load cell testing

Testing of Keypad

In this 2nd phase of testing, the keypad and LCD display are connected to arduino. The program is developed to create the menus. The keys are assigned to perform particular action. After completing this test we are able to set different parameters in the arduino by using matrix keypad.

Figure 9: Basic Keypad Testing Circuit

Testing of all components

In this last phase of testing, all components i.e. the keypad, LCD display, load cells, relay module, transmitter are connected to arduino. The programs developed in the previous phases are combined to build new final program.

At the end of this phase all components are tested together and a final program is created. This all tests are carried out on the test circuits.

A final test is carried out in the company with developed prototype. The all components are placed inside the enclosure.

In this way, we overviewed the testing Results and Discussion

Testing is the important phase in project life cycle. In this chapter we will discuss the various testing results obtained in this project.

Tests are carried out in three different phases, so we will discuss the results as per phases which are listed below:

Input Weight In Kg	Calculated Level in mm	Output Level On Display in mm	Error %
0	0	0.01	1
1	1	0.98	2
1.2	1.2	1.19	1
1.3	1.3	1.28	2

Table 2: Load Calculation

1. Test results of load cell testing
2. Test results of keypad testing
3. Test results of all components testing

Test results of load cell testing

The load cell testing is carried out and we obtained the calibration factor. The obtained calibration factor and test result for system validation are shown below

Obtained Calibration Factor: -96950

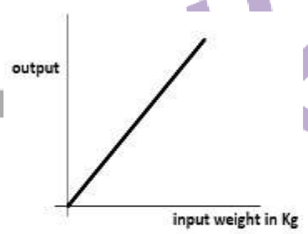

Figure 10: Graph of load cell test result

Test results of keypad testing

In this test the keypad and LCD display are connected to arduino. We developed the menu driven program. After various testing's we successfully developed the program through which we can set different parameters such as area, density, set point etc.

Test results of all components testing

In this test we successfully completed the arduino programming for our project.

We tested this program and made the corrections and obtained the program.

Through this programming we can successfully implement the ON /OFF control strategy, alarm indication, transmission of the level through the 2 wire transmitter.

The test is carried out keeping the some constant values of other parameters which is listed below

Constants: Area =1 m^2 Density =1000 kg/m^3

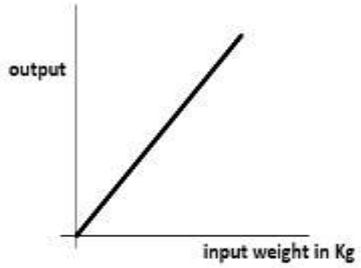

Figure 11: Graph of Complete test result

Input Weight	Output Weight on Display	Error
0 kg	0.01 kg	1%
0.5 Kg	0.498	1%
1 kg	0.98 kg	2 %
1.2 kg	1.19 kg	1%
1.3 kg	1.28 kg	2 %

Table 3: Final Results

IX. CONCLUSION

In this project we came across various level and weight terminologies and proposed the various implementation methods. We implemented this project by using microcontroller method.

The system we developed is cheap, highly accurate and uses non-contact principles. The cost of the system can be further reduced by single PCB designing and by mass production.

The mechanical design can vary application to application, we can measure with single load cell with support or with multiple load cell.

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