The instrumentation and its importance in the industry engineering essay

Food & Diet

This document contains what is the instrumentation and its importance in the industry. This also contains that what are the sensors, level sensors, method of measurement of the level and selection of suitable sensor for the solid level measurement. This document also contain the different type of the solid level measuring sensors, how they work , their advantages and disadvantages.

Importance of instrumentation:

Instrumentation is the basic process control in industry. In industrial control a wide number of variables temperature, flow, level, pressure, and distance can be sensed simultaneously. All of these can be interdependent variables in a single processing require a complex microprocessor system for total control. Due to more advancement in technology and the efficient measurement techniques instruments that we are using today may be obsolete in future.

During specifying the instrumentation the main objectives of the designer are

Safe plant operation

High production rate

To maintain the product composition within the specified quality limits.

Lowest production cost

Sensors:

Sensor measure the physical quantity and converts into signal which can be observed by observer or by an instrument. e. g., thermocouple measure the temperature and converts it into the voltage which can be observed by voltmeter.

Level sensors:

The accurate measurement of level is of great importance in the industrial process during the processing of materials or in the storage of materials. for this purpose level sensors are used to detect the level of the liquid or solids.

Sensing of levels can be done by the two ways point sensing and continuous sensing.

Point sensing:

In point sensing the actual level is measured when it reaches the predetermined level, so that action can be taken to prevent the overflow or to refill the container. Point sensing measure the level that are extremely high or low.

Continuous sensing:

Continuous level monitoring measures the level without any interruption. In continuous level sensors measure the level constantly within the specified range.

There are two methods to measure the level direct method and indirect method.

Direct method:

Direct method of measuring the level sense the surface or interface of solid and liquid and is not affected by the changing in the density or specific gravity of material.

Indirect method:

In this method level is measured by some other physical parameter such as pressure, weight, or temperature. It involves the conversion of measurement into other quantity such as pressure to level by determining how much pressure material exerted on the specific location.

The suitable level sensor for the given application depend upon the different factors.

Whether you are the level of solid or liquid

Is point level or continuous measurement required

Specific gravity or density of the material

Dielectric constant of the material

Temperature

Pressure

Vessel composition

Vessel size and shape

Agitation or movement

Solid level measuring sensors:

There are different types of the sensors that are used for measuring level of the solid.

Vibrating point level sensors

Rotary paddle level sensors

Capacitance level sensors (also called RF)

Weight and cable system (plumb bobs)

Ultrasonic level sensors

Laser sensors

Load cell

Radar sensors

Microwave level sensors

float level sensors

optical level sensors

Vibrating point level sensors:

Vibrating point level sensors are used for the point level measurement of different types of solids according to the nature or densities of the materials. They have the ability of point level measurement of the very fine powders which have the bulk density in the range of (0. 02 gm/cm3 to 0. 2 gm/cm3)

[1]. These sensors are also used for the point level detection of the fine powders. These level sensors also have the ability to detect the level of granular solids. The level of the electrostatic material and very fine powders can be measured with suitable adjustment of the selectivity and with the proper selection the vibration frequency.

Working principle:

In the vibrating level sensors two piezoelectric crystals are present in the base of the probe. A signal is sent at the frequency equal to the probe's self resonance to one crystal. Probe vibration occur due to the electrical excitation which cause the physical deformation of the crystal. The second crystal felt the vibration of probe in the absence of the material. Physical deformation occur in second crystal due to this vibration and the voltage generates which can be detected by the electronic circuit. The vibration is dampened in those cases when the material is present around the probe and therefore voltage generated by the second crystal is minimized. The relay status changes accordingly due to the change in the output voltage in the circuit.

Advantages:

Working of vibrating probe level sensor is independent of temperature, humidity and material.

It requires no calibration.

Single probe removes the problem of material packing and the false conditioning which is commonly observed in dual pong " tuning fork".

Limitations:

Vibrating level sensors are the costly.

Vibrating level sensors are not used in case of the sticky material.

Rotary paddle level sensors:

Rotary paddle level sensors are the oldest sensors and these sensors use the established technique for the measurement of the point level of the bulk solids.

Working principle:

The working principle of the rotary paddle level sensors is very simple. This level sensor is installed through the vessel wall so that it can easily rotate in the vessel. A small electric motor is installed to drive the paddle with the help of the gear box arrangement and in the absence of material it rotates freely. When the material come in the path of paddle the rotation of the shaft stops and signals the presence of material at that level in the vessel or alarms the unit or to control the situation.

Applications:

Rotary paddle level sensor is used to measure the level of the particulate material, wood, cement, grains powder and plastics.

Rotary paddle level sensors are used for the detection of the high level materials and for the low level materials.

Limitations:

Rotary paddle sensors are not working properly in case of the power failure.

Capacitance level sensors:

Capacitance level sensors are also known as the radio frequency level sensors or admittance level sensors. These sensors are used for both point measurement or continuous measurement of level. Point level measurement is mostly used in the plastic industry. These sensors work on the principle that admittance of the alternating current circuit change with the change in level and they measure the admittance of the alternating current circuit.

Working principle:

The working principle of the capacitance level sensor is that a radio frequency is applied to the probe and continuously observed to measure the change caused by the surroundings. When the probe of the sensor encounters with the material the capacitance increased due to the shift in the radio frequency. The wall of the vessel and the active probe of the sensors form the two plates of the capacitor having area (A) and have the fixed distance between two plates (d). In the absence of the material surrounding air and insulator provide dielectric having dielectric constant (K= 1). when any material displaced the air having dielectric constant greater than one (K > 1). The capacitance increased. This change is measured and compared with the reference.

Application:

Capacitance probe level sensors are used for the high and low level measurement of solids in bins, silos, hoppers and other vessels.

Capacitance probe level sensors give the accurate result in case of powder, liquids, granular solids an viscous material.

Limitation:

Capacitance probe level sensors have one limitation that they require the calibration and recalibration in case of materials having different dielectric constant and incase of different vessels.

Weight and cable systems:

The weight and cable system is one of the oldest method of measuring the level of solid. The other name of this system is the plumb bobs. In the beginning these are the simple electromechanical devices but with the passage of time the sensor using the optical techniques and microcontrollers have replaced these sensors. Weight and cable systems are mostly used for the level measurement of the dry solids.

Working principle:

Working principle of the weight and cable systems is simple. In these devices the cable which is fastened with the weight is sent into the vessel and it stops when it encounters the material present in the vessel. Then it is pull away and send into the sensor which is at the top of the vessel. In the sensor casing electronics control the direction of the motor and the distance is measured in the both direction as the weight and cable system goes upward or downward direction.

Advantages:

Working of Weight and cable system is independent of the dust, humidity, temperature, material density and dielectric properties.

Weight and cable systems require no calibration

Limitations:

Weight and cable system are used only for the point level measurement of the solids.

Ultrasonic level sensors:

Ultra sonic level sensors are used for both point and continuous level measurement. The point measuring ultrasonic sensors are used for the measurement of gas liquid, liquid liquid, or gas solid interfaces.

Working principle:

Ultrasonic level detectors work either by absorption of acoustic energy as it travels from source to receiver or by the attenuation of a vibrating diaphragm face . it works by generating an ultrasonic pulse and measuring the time it takes for the echo to return. In case when ultrasonic level sensors are mounted on the top of the tank . The time of travel is an indication of the depth of the space above the material in the tank. In case when it is mounted on the bottom of tank , the time of travels reflects the depth of material in the tank.

In order to measure the time of travel of echo of an ultrasonic pulse, it is necessary that some of the sonic energy be reflected. Solids particles are good reflector. Loose dirt have poor reflecting characteristic as they tend to absorb the sonic pulse . since the angle of reflection is equal to the angle of incidence. It is important the reflecting surface be flat. If it is slopping surface its echo will not be directed back and it will not reflect the vertical distance.

Advantages:

Ultrasonic level detectors are non contact type. They have ability to measure level without physical contact.

They have no moving parts

The reliability of reading is independent of change in composition, density, moisture content and dielectric constant of fluid.

Limitations:

Temperature compensation is necessary in the ultrasonic sensors.

Dirt, irregular and slope surfaces affect the accuracy of measurement.

Laser sensors:

Laser level sensor is suitable for the continuous level measurement of solid and liquid. Laser based level measurement depend on the exact measurement of time it takes for flight pulse to travel to the process material surface ad back. The velocity of light is affected by the index of refraction of vapors through which the light wave travels.

Working Principle:

It works on the principle that a transmitter mounted on the top vessel sends a signal via an antenna toward the measured level. A receiver detects the returned signal by means of a second same antenna. The laser measurement uses infrared light which can be formed as electromagnetic radiation as well as corpuscular current.

There are two types of measuring techniques that are used in level sensors for the level measurement.

Triangular measurement:

In this technique an angle of reflection of sharply focused beam is measured which is calibrated to measure the level.

Time of refection measurement:

In this technique measurement of distance using the time of reflection light is applied to the level measurement.

Advantages:

It is non contact type measurement.

Laser level sensors are well suited for the vacuum services because light does not need a medium for propagation.

As the laser beam is almost completely parallel interfering reflections from struts, welding, joints, or material build up on the walls of tank.

Limitations:

They produce a weak returning light signal very shiny surface can cause the errors by reflecting light laterally.

Laser level sensors should not be used when the vapor space absorbs the measurement signal as is case when steam, dust, or fog is present in the space.

Load cell:

Load cells are used for the level measurement of the solids. This method is well suited for the continuous level measurement of the solids. In load cell the material is not directly come into contact with the material. They are non contact type sensors. Most load cell that developed by manufacturers will state the such factors input output relationships, non linearity, drift, hysteresis and temperature senstivity. Such parameters depend upon the axial or ideal loads which are normal to cell.

Working Principle:

Load cells measure the weight of material that is present in the tank and the weight of the tank. The weight of tank is known to us. The weight of tank is subtracted from the reading and leaving the weights of the contents in the tank. By knowing the cross sectional area of tank and the specific weight of the material. The volume or the depth of the material can be calculated.

Advantages:

Load cells are non contact type sensors so that they can use for the level measurement of hazardous material.

Working of load cell is independent of dusty environment or material build up.

Limitations:

It is difficult and costly t install the load cell sensors in existing vessel.

Installation and calibration cost is high.

Radiation level sensors:

Radiation level sensors are used where other electrical methods would not survive. Radiation level sensors are non contact type sensors. Radiation level sensors have the ability to the level of solid and liquid through the wall of the vessel.

Working Principle:

It consists of the gamma rays source holder on one side of the tank and a gamma detector on the other side of the tank. The gamma rays from the source are directed towards the detector in a thin band of radiation. When gamma rays penetrate the thick wall of the vessel it’s energy level afterwards are reduced. The radiation received at the gamma detector is inversely proportional to the thickness of the tank walls and the medium between radiation source and the detector. That is the thicker the medium between source and detector , the less radiation received by the detector and vice versa.

When the tank is empty the gamma rays pass only two tank walls and air in empty tank. When the material is present in the tank and its level rises the radiation beam passes through a path in the material as well as in the tank walls. The material present in the tank reduces the radiation received by the detector. The amount of radiation received is inversely proportional to the amount of material present between the radiation source and the detector. The difference in the amount of radiation received by the detector corresponds to the material level in the tank. When the material level rises in

the tank the amount of radiation received is reduced. The radiation loss received by the tank walls is constant whether the tank is full o empty.

Advantages:

There is no physical contact with the material in radiation level detector.

They are useful at high temperature and pressure.

They have good accuracy and response.

They have no moving parts.

Limitations:

Installation cost of the radiation level sensors are high.

Radiation source holders may be heavy.

Microimpulse level sensors:

Microimpulse level sensors are non contact type sensors. Microimpulse level sensor is used to determine the level of the fine granular bulk solids.

Working principle:

In micro impulse level sensor the sensing element is the steel rope probe. An extremely short wave is passed through the steel probe and guided practically free from attenuation to the product surface. Here it is reflected back and travels along the probe rope to evaluating the electronics which then determines the level of solid by it's time of flight.

Advantages:

Microimpulse level sensors are non contact type sensors.

They have no moving parts.

The measurement is independent of temperature and pressure.

Limitations:

The microimpulse level sensor is used for the small level measurement.

Microwave level sensors:

Microwave level detectors use the electromagnetic radio waves for the level measurement of he material. Wavelength can be calculated by dividing the wavelength in a vacuum by the square root of the window's material dielectric constant. Microwaves do not pass through metal walls, but they do pass through fiber glass or plastic tank walls and through windows of plastic, ceramic, or glass that are insulated in metal vessel walls. As long as the window material has a relatively low dielectric constant and long as thickness is close to an even multiple of a half wavelength, attenuation is minimal.

Side mounted microwave level detectors are used for the level measurement of solids. Top mounted microwave level detectors are used for continuous level measurement on liquid applications using radar technique.

Beam breaker level sensors is type of the microwave level sensor that is used for the level measurement of solid.

Working principle:

In microwave beam breaker level sensors a beam is sent across the measurement zone, a signal is received at the detector. When the process

material breaks the beam path, it reduces the signal received at the detector due to signal reflection and due to beam absorption in the material caused by the molecular and ionic resonance. Beam breaker level detectors use very small antennas so that the beam include angle is fairy wide. Although signal amplitude falls off rapidly proportional to the square of distance which is considerably greater than with ultrasonic or nuclear techniques.

The beam breaker technique is useful for detecting large and abrasive materials such as coal, minerals, woodchips and vegetable pulp. It is also useful for detecting very light materials such as dry sawdust and powder materials in fluidized bed.

Advantages:

In microwave measurment the emissions are very low so health, saftey, licensing or product contamination concerns are minimal.

Pressence of dust, mist and nonmetallic foam has negligible effect on the accuracy of measurement.

By using heavy windows microwave level detectors can withstand heavy abbrsaion on solids service.

Limitations:

Beam breaker type microwave level sensor is more expensive as it requires two device to install along with the separate windows on metal surface.

Float level sensors:

Floats level sensors can also be used to measure the level of bilk solids. Float level sensors are used for the point measurement of the solid level.

Working Principle:

In float level sensors the float is wound up to the top of silo and then lowered down until the slack wire limit give the signal to the sequencing logic. The length of the supporting cable paid out than gives distance between the solid surface and the top of silo. The depth of the solid can be found by the subtraction from the silo height.

Advantages:

The working principle of the float level sensors is the simple.

Float level sensors are not cost.

Limitations:

Float level sensors give the point level measurement of the solids.

Optical level detectors:

Optical level detectors are used for the measurement of the level of solids and liquids. They are non contact type level measurement sensors. Optical level sensors can be used for either point measurement or the continuous measurement of the level of solid.

Working principle:

In optical level sensors a beam of the light is passed to the solids level and it is reflected back to the light transistor located in the same holder as the light

source. By adjusting the transistor sensitivity the unit can be calibrated in the range of point level detection on the solids services.

When the light is passing through a fixed distance in the a solid the intensity of light received at the detector can be used to determine the level of solids. The level sensors can be used as appoint sensing or continuous level detector in the sludge. The sensor can have the several light sensitive detectors permitting switch to occur more than one points.

Advantages:

Laser version of optical level sensors provide high precision on narrow span application.

Limitations:

The sensor is adversely affected by changes in reflectivity of the process.