Automation in Manufacturing
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Week – 04
Sensors
Lecture – 03
Displacement, position and proximity sensors - II

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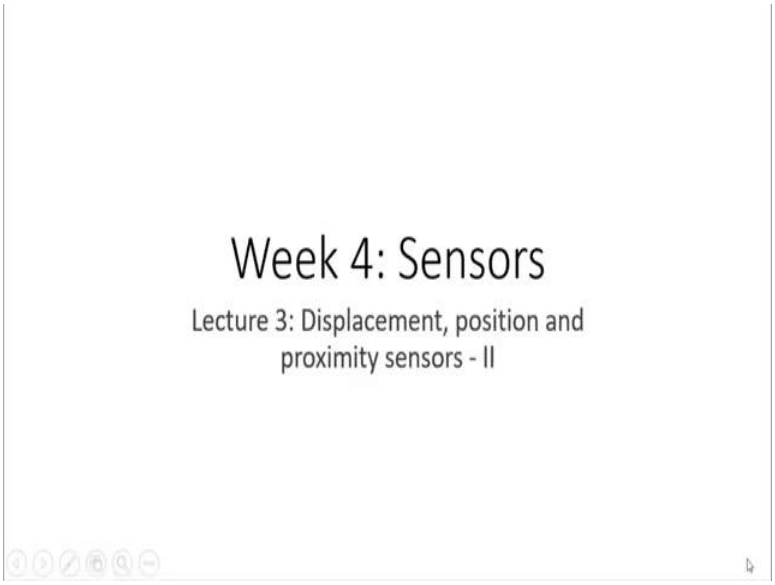

Hello friends. I once again welcome you to the Automation in Manufacturing course. We are at lecture 3 of week 4. And we are studying various sensors used in automation in manufacturing. Well in this lecture, we will be seeing some important sensors which are used for Displacement, position, proximity sensing applications.

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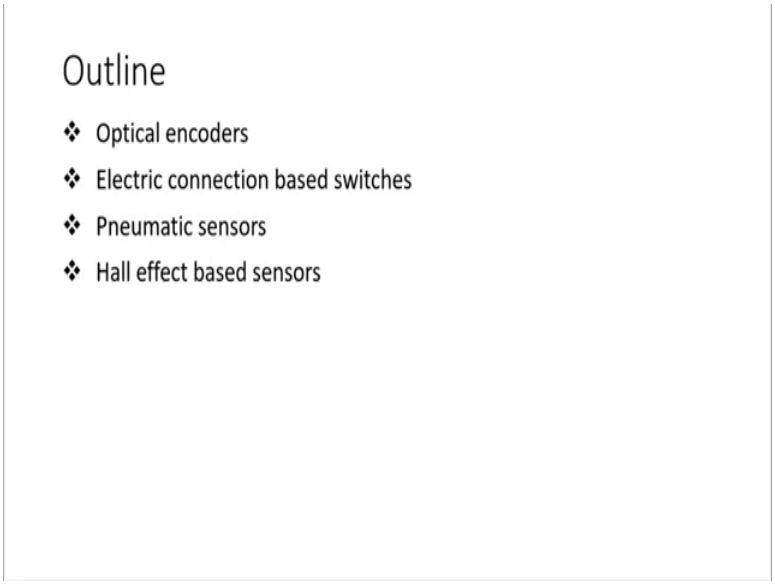

The outline of this lecture is as follows. We will be learning the principle of operation, construction details and the applications of optical encoders, electric connection based switches and pneumatic sensors. At last, we will also learn the Hall effect based sensors.

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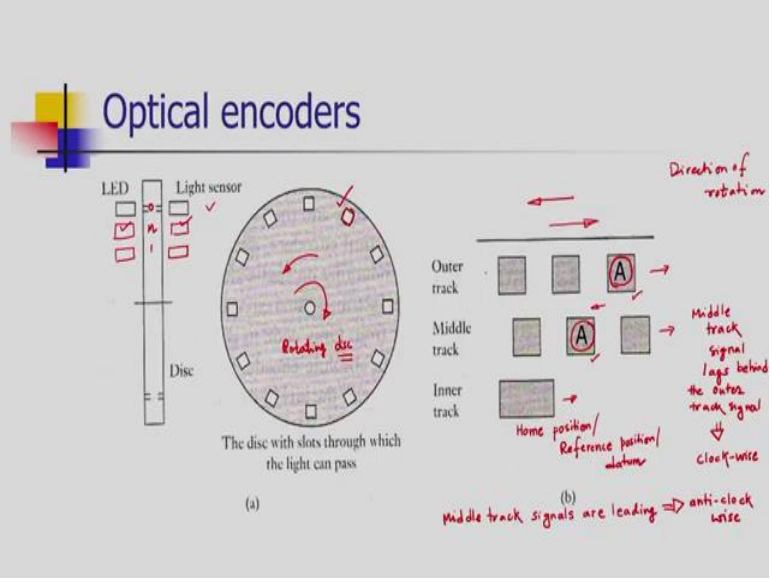

Now, we will see how to measure the motion in angular mode. For this purpose, optical encoders are used. A typical optical encoder can be seen on the slide. It has a rotating disc; this disc is mounted on the element of which we want to measure the angular motion.

The disc has perforated holes along its circumference. A track can be observed and this track has a number of square holes, which are perforated. Optical encoders have an arrangement of a LED, light source, and light receiver. There is a continuous passage of light from the LED and the light sensor is sensing it in a continuous mode.

When disc rotates, there is a obstruction for the passage of light. There is no reception of light at the light sensor. When this perforated hole come in the passage of the LED light, then the light will pass through this holes and we are getting sensing of the light at the light sensor.

When light passes through one hole, we are getting one pulse. In this way, the number of pulses are giving us the idea about the angular movement of the disc. The sequence of the pulse or the frequency of pulse will give us the angular velocity.

Now, what will happen when we want to find out the direction of rotation? Whether the disc or the element is rotating in clockwise direction or it is rotating in anti-clockwise direction? For that purpose, three tracks are used: outer track, middle track and inner track.

Inner track is having a hole and that hole is used to decide the home position or reference position or we can consider this as datum. The outer track has number of holes and the middle track also has equal number of holes. But, here we can notice, there is a change in arrangement of holes in the middle track.

Now, let us consider a hole A at the outer track. The corresponding hole A on the middle track is having an offset and that offset is about 1.5 times of its width. It can be seen that, this hole A here has been offseted in the left direction. How this will help us to find out the direction of rotation? To find out the direction of rotation as mentioned, we are having outer track, there is a middle track and there is an inner track.

For this purpose, we need two more arrangements for middle and inner track. These sets of LED and light sensors are arranged in line. There is no offset. If there is one set of LED light and that the sensor is fixed for middle track, in the same line there will be another set of light and LED sensor, for inner track again one more set, but we are not having any offset here.

When the disc is moving say from left to right i.e. in a clockwise rotation in the given figure, the light passing through the A hole of the outer track, will generate pulse of volt at the light sensor first and the corresponding hole in the middle track will generate the pulse of current or volt, due to reception of light after some time. The pulse at middle track is lagging the pulse at outer track.

We can consider when middle track signal lags behind the outer track signal,we are getting clockwise rotation. Now, considering that the disc is moving in anti-clockwise direction, the pulse which is passing through hole A in the middle track will generate the electrical signal, before or first then the signal it is produced in the outer track.

When the middle track leads, then we are getting the information that the disc is moving in anticlockwise direction. There are many advanced versions of optical encoders used in automation, but this is the very basic and the simple configuration.

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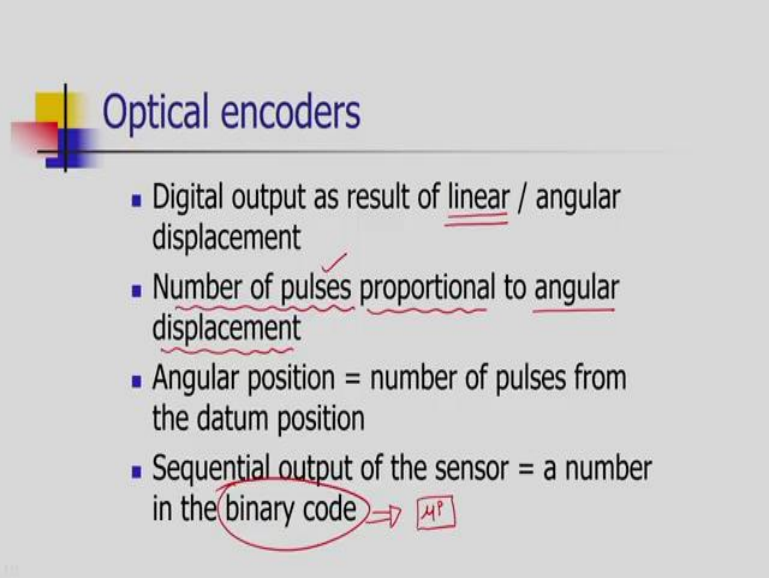

In optical encoders, we are getting digital output as a result of linear or angular displacement. Here linear means that, the same methodology can be used. Instead of rotating signal. we can have a translatory disc: a perforated disc with holes on the disc or a strip. In angular displacement, we are using a disc and in linear encoders, we are using a strip with holes.

Number of pulses generated are in proportion with the angular displacement. By counting the number of pulses, by counting the frequency of pulses, we can easily compute the angular velocity. We are getting a binary code readymade and that is the advantage of the optical encoder. It is a very good transducer, which further can directly be utilized for the microprocessor applications. Of course the assistance of signal conditioning devices is needed.

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An optical encoder which is mounted can be seen in the slide. A sectional view of a drive is also shown. Inside the drive, a shaft can be seen and the rotation of the shaft is to be measured by using an optical encoder. herein the given figure, an optical encoder disc is shown.

The disc is mounted on the shaft and we are having a PCB. PCB is printed circuit board. A lot of electrical connections , can be seen in the figure.. There is a light source, which is mounted at this location and there are receptors, which are mounted on the PCB drive.

The PCB drive is fixed to the casing of the shaft, the shaft is rotating, the disc is also rotating along with the shaft. And we are getting the signals on the microprocessor based electronic circuitry which is mounted on the PCB.

Ultimately, at output we are getting binary code, process binary signal, or that signal will further utilized for the applications. One more configuration you can see on right side of

the slide. It is having LED photodiode reader, the optical disc and the vertical configuration.

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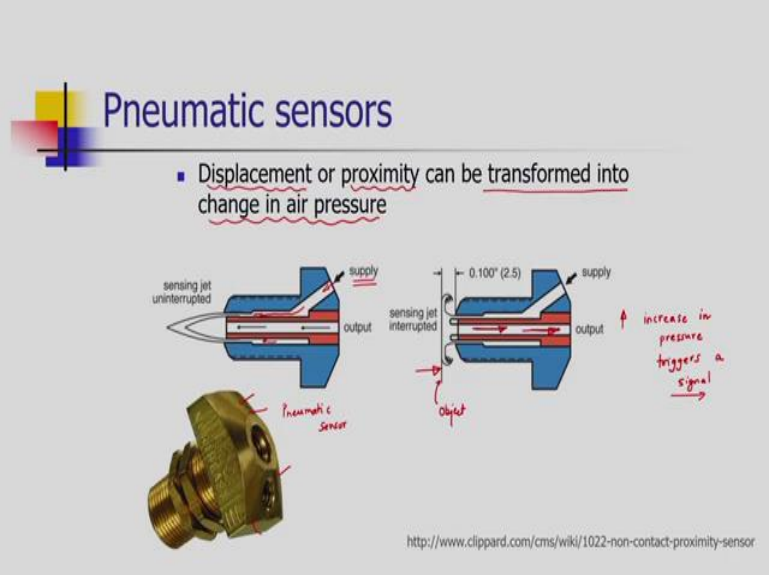

Next sensor is a very useful sensor in automation. it is working with the help of pneumatic energy, compressed air is in general used. It is used to measure the displacement or to detect the proximity of the products or the objects. Here, the principle of operation is that, the displacement will be transformed into the change in air pressure. And that change in air pressure generates the signals, that signals can be utilized for our decision making.

The construction of pneumatic sensor can be seen on the slide. It has two ports. One is the supply port, the supply port is annular one or the grow is annular. And the other is a central port inside a metal body. Pneumatic sensor in actual sense can be seen in the slide. Low pressure air is supplied from the port.

when a low pressure is supplied from the port, there is a continuous passage of the low pressure air. And there is no interruption to that, through the central port as well there is passage of air. Ultimately we are getting a smooth flow there is no obstruction everything is fine.

When the obstruction comes to the passage of air through the supply port, consider some object has come near to the end of the supply port. The object will obstruct the flow of

compressed air, which is coming out from the supply port. When there is a restriction for the flow or when there is obstruction for the flow, there is a change in pressure, the pressure inside the central port will increase.

This increase in pressure triggers a signal. With this principle of operation this sensor works. It has no rotating parts, it does not have any electrical circuit. Iit works with the simple fine compressed air. Of-course we need to have good quality compress air to operate these kind of sensors.

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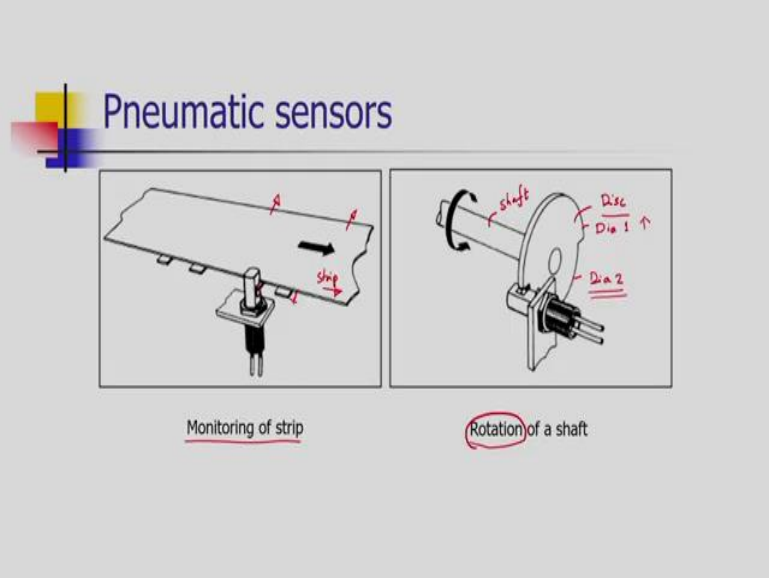

What are its applications? Now, first application we can find in orientation of the products which are moving over the conveyor. Considering a strip which is moving over a conveyor. If by mistake we have kept the strip at certain offset, that may create further problems in production.

To look at whether the strip is moving with proper orientation with proper location, for that purpose we are using a pneumatic sensor. A compressed air is flowing over here. When the strip is moving in proximity with the sensor, there is increase in the pressure and continuously, we can monitor the increase in pressure; that means, strip is in proper orientation.

When the strip is offset, there is change in pressure and that change in pressure will lead to certain signal. Then, we can measure the rotation of a shaft. For that purpose a disc is designed and developed and it is mounted on the shaft.

Here we can see the disc is having two different diameters , diameter 1 and diameter 2. Diameter 1 is larger than the diameter 2. When the diameter 1 is in contact with the sensor, then there is obstruction of compressed fluid. That is giving certain signal.

When diameter 2 is coming in contact, there is no obstruction, there is no material available for the obstruction. During this case, there is change in pressure in the sensor system and that gives different signal. That difference in the signal will lead to some information for the microprocessor.

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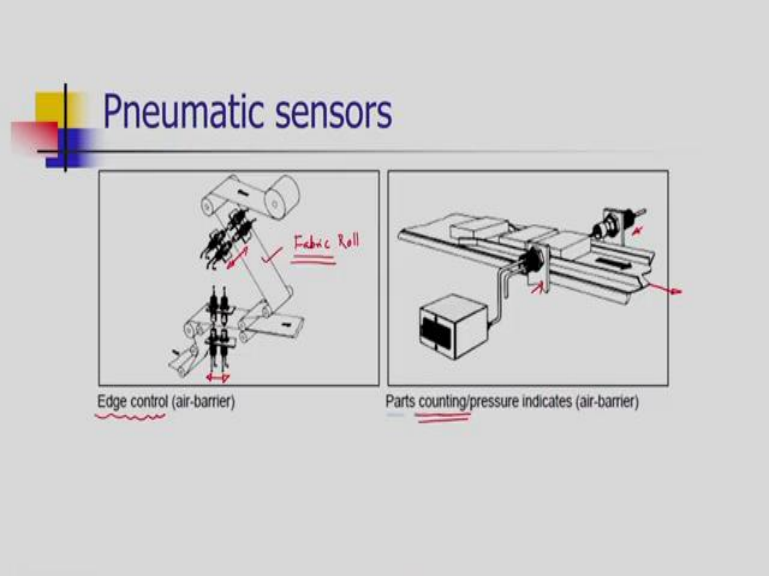

The next operation is to control the edge. Considering textile or a fabric roll and these fabric roll is feeding the fabric for further cutting operation. It is highly essential to have the proper flow of fabric through the system. For that purpose, the edge of the fabric is to be monitor continuously. For that purpose, a set of sensors are mounted. Again, the same principle is applied to monitor continuously the edge of the fabric.

Then pneumatic sensors are also used for counting purpose. If we consider a conveyor and over the conveyor, the boxes are moving and we need to just find out how many boxes are passing over a period of time over the conveyor.

For that purpose, a pneumatic sensor can be mounted. As the box come in between the passage of compress fluid, we are getting signal and when there is no box moving, naturally no signal will be generating. In this way the pulses which are generated by the pneumatic sensor will generate the number of parts or the counting of the parts.

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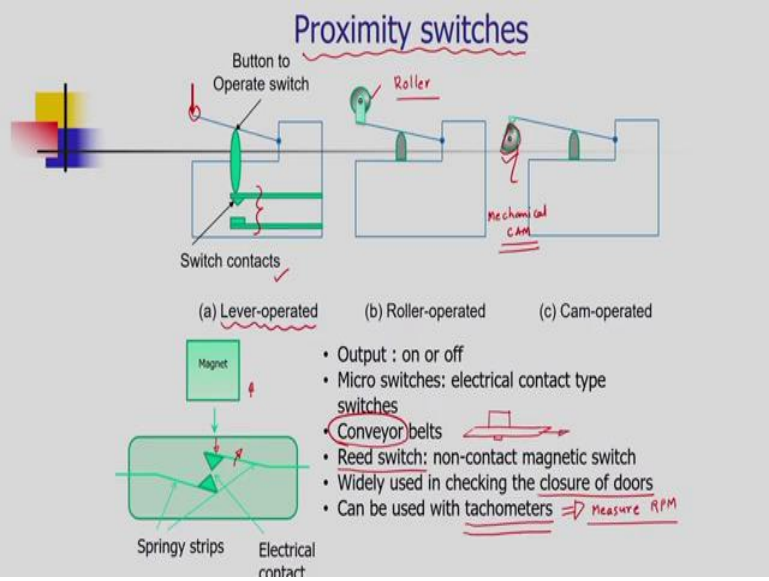

Next group of proximity switches works on the principle of the electrical connection. Now, a simple arrangement, a lever operated arrangement can be seen on the slide. It has switch contacts and these switch contacts are operated by a switch. It is a simple button switch. When we apply a force at the end of the switch, the switch contact will close, there is a contact of these two elements and then there is a flow of current inside the circuit.

This is typical switch we are using at our domestic level. Instead of having a pressure or a point load, we can also use rollers to carry out the same operation. The advantage of using roller operated switch is that, there is less wear and tear of its element. The third configuration is CAM operated. In the slide, we can see a mechanical CAM and the shape of the CAM will decide period of contact.

A circular edge will decide that for how long there would be a contact of the electrical connections inside the switch. When the lever comes into contact with this horizontal position, then there may not be any contact and the switch will be in off position. There are further advanced configurations available in the proximity switches.

We can refer the in trade literature or the industry literature, we will find many more configurations. One more useful switch which is used in conveyors is the reed switch, which is used in checking the closure of the doors for the safety operations. Reed switch is having an electrical contact and the normal position of this contact is open.

There is a magnet, when the magnet comes in the vicinity of the top strip of the reed switch, then that magnetic field will act a pressure or a force and that force will push the top strip towards the bottom strip. And there is a contact will come into existence. When the magnet moves away from the top strip the contact will open, the moment of magnet will decide the opening and closing of the electrical contacts, which will generate the number of pulses.

If we put a magnet on a rotating device and as the magnet comes near to such reed switch, we can easily count the rotation of that disc rotation of that mechanical element. In this way the reed switches are very much useful in tachometers to measure the revolutions per minute (RPM).

Electricals proximity switches are used in the conveyor belt, when we want to achieve the automatic control of movement of the conveyor belt, the automatic switch on and switch off of the conveyor belt. If object is put on the conveyor belt, then there is a depression of the conveyor belt.

If we are having a switch beneath it, that belt will move in a downward direction and that may switch on either by using lever operated or a roller operated configuration. And that signal will be given to the required drive, which will drive the conveyor.

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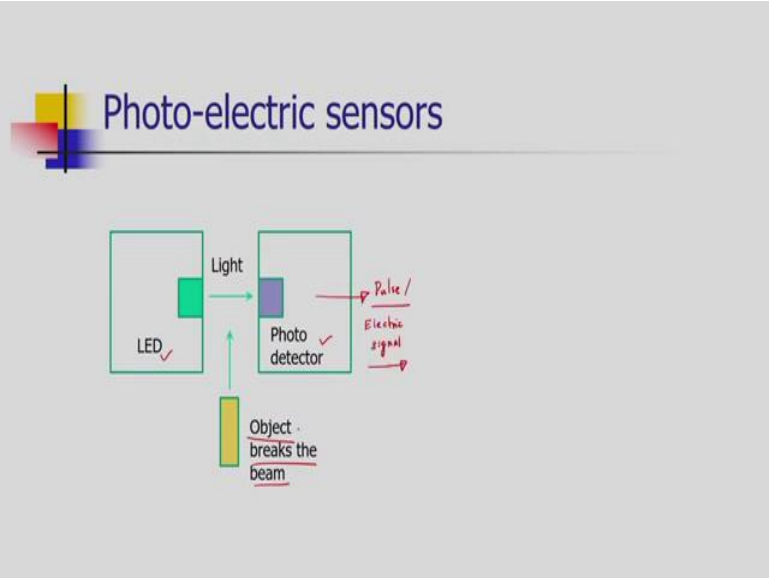

The next group of sensors is photoelectric sensors. In this group, a pair of LED and photo detector is used to detect the passage of light continuously. When an object breaks the beam of light, the passage of light from LED to photo detector generates a pulse. We get a pulse or we get an electrical signal.

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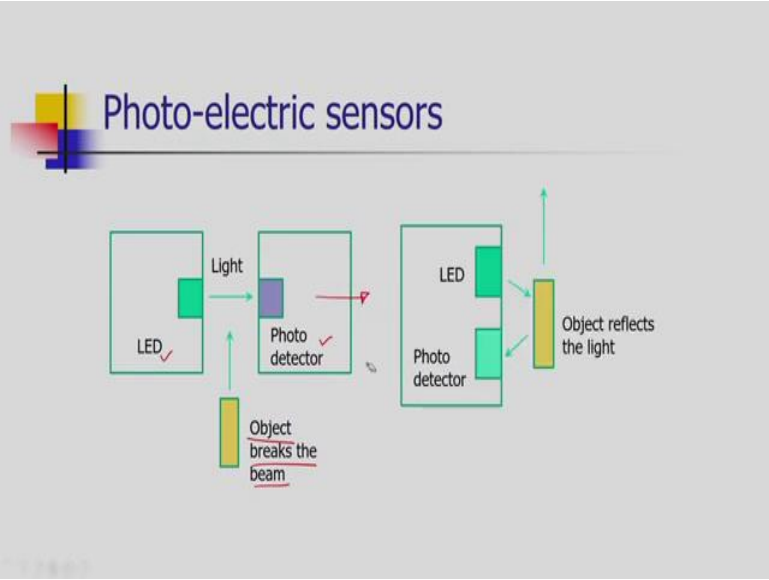

There is another configuration. In this case, the LED and photo detector are put on the same side of the moment of the object. LED is continuously emitting the light, the object reflects the light and the reflection of the object will be detected by the photo detector.

When the object comes near to the LED, there is detection of the reflected light and it will give the signal.

That senses when certain object are coming to the sensor or not. Needless to say, the object must be reflective in nature. In this way we can find out the proximity of variety of objects by using photoelectric sensor.

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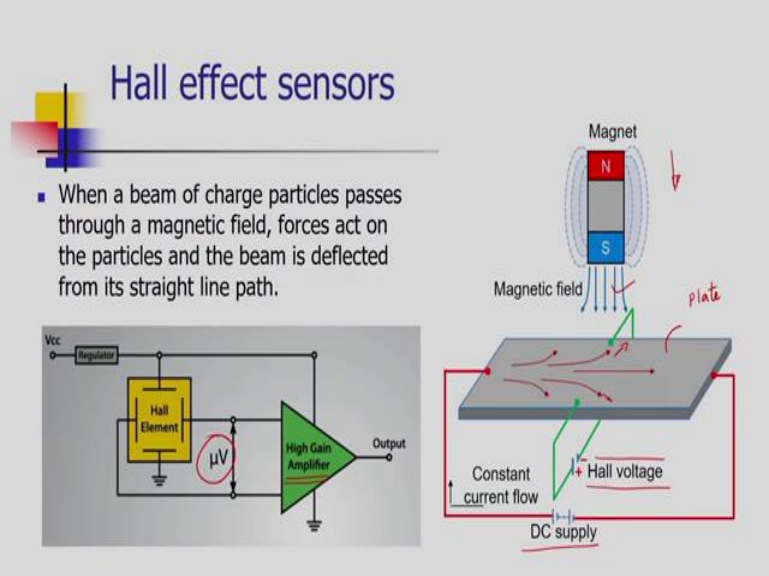

The next type of sensor is Hall effect sensor. The principle of operation is very simple. When a beam of charged particles passes through a magnetic field, forces are acting on the particles. And the beam will get deflected from its straight line path. Due to change in path of the particles, we are getting the voltage across the passage of the original path.

That small voltage which is generated due to the deviation or destruction in the original path, can be utilized for generating a pulse or a signal. How it is effective? How it is useful for us that we will see. Before that we will see the principle. Here you can see we are having a plate or a disc, this plate or a disc is attached to a DC power supply. When we apply the electrical field, there is a passage of electrons that we call the current.

When a magnet comes near to this charge plate, what happens due to the magnetic field of the magnet? There is deviation in the passage of this charged particles. The charged particles will deviate their path and due to this deviation certain voltage will be generated across the movement of the passage. That small voltage generated is called as the Hall

voltage across the passage of the current. It is very small, it is in micro volts and that micro voltage further can be utilized for our decision making.

If we put this magnet on the object as the magnet is coming near to this charge plate, we can only detect the movement of the magnet. In this way we can use the Hall effect principle for proximity sensing. As mentioned, the Hall element is generating very small amount of electrical potential, we need to amplify that signal.

We have to enhance its magnitude. For that purpose, we are using signal processing device, that is operational amplifier, which is used to amplify the signal magnitude, So that it can be used for further application.

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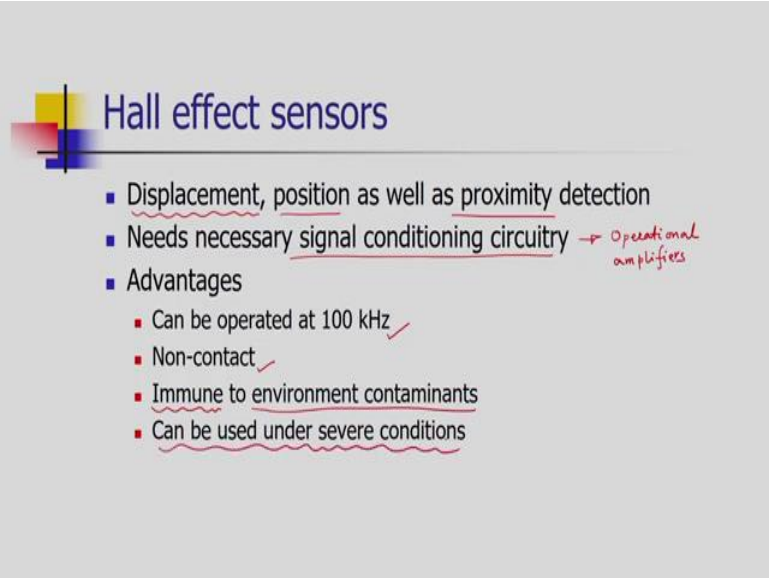

Let us see what are the applications of Hall effect sensors? Hall effect sensors are used for sensing the displacement, position as well as proximity. Of course it needs signal conditioning circuitry, as mentioned the operational amplifiers.

What are the advantage? The frequency capability is quite high around 100 kHz, it is a non-contact and it is immune to the environment contaminants. For processing of the biological fluids or for processing of pharmaceutical fluids, we can use the Hall effect sensor.

Since it is a non-contact, it is very much useful in the applications, where high flammable fluids are being monitored or controlled. The flow of high flammable fluids is

to be monitored and controlled, say petroleum products. It can be used in the applications which are having the severe conditions.

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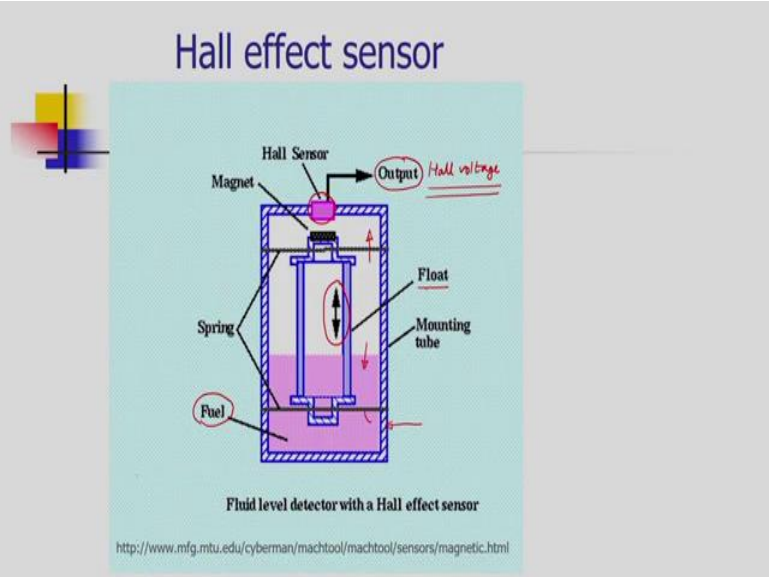

How we can use the Hall effect sensor for controlling or monitoring of fuel, that is a petroleum product. A typical arrangement is shown on the slide. It is having a container, inside the container the fuel is stored. And we need to continuously monitor the level of the fluid.

This is a closed container and at the top of the container, we are having the Hall sensor mounted, there is a continuous passage of current inside the Hall sensor and we are monitoring the Hall voltage. The output is Hall voltage.

Inside the container we are having two springs and these two springs are holding a float. On the top of the float a magnet is attached and as the fuel level inside the container changes, the float is also changing its position. If the fuel level is increasing naturally the float will move in a upward direction; as the float moves in upward direction, the magnet will come near to the Hall sensor and then the Hall sensor will generate Hall voltage.

As we get a pulse of Hall voltage, then we can say that there is sufficient fuel stored inside the container. Now we have to switch off the pump, which is pouring the fuel inside the container. The same thing happens in a vice versa case, when the fluid or when

the fuel is consumed the level of the fuel will decrease, then the magnet will move away from the Hall sensor.

And then we are getting no voltage at the output. That triggers or gives another message that we have to start the pump and we have to pour the fuel inside the container.

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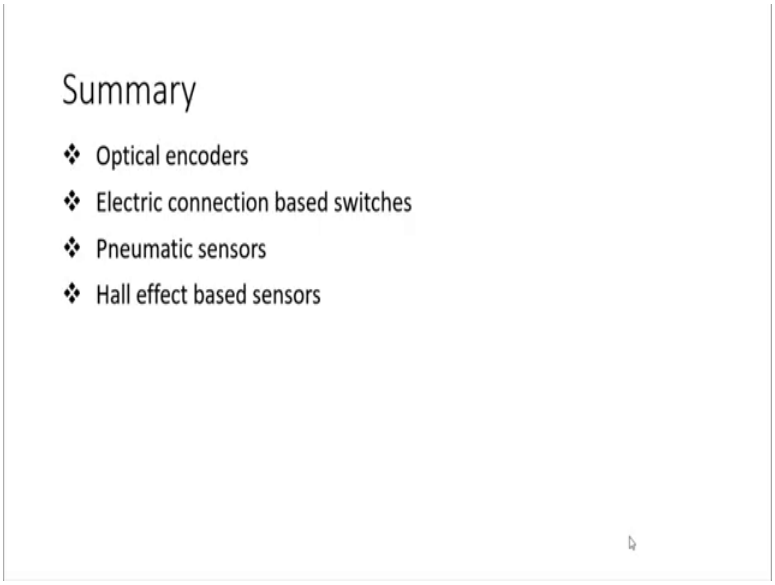

Well, let us summarize lecture 3 of week 4. We have seen very important sensors such as optical encoders, electric connection based switches, pneumatic sensors and Hall effect based sensor. We have seen their principle of operation construction details and their important applications in automation industry.

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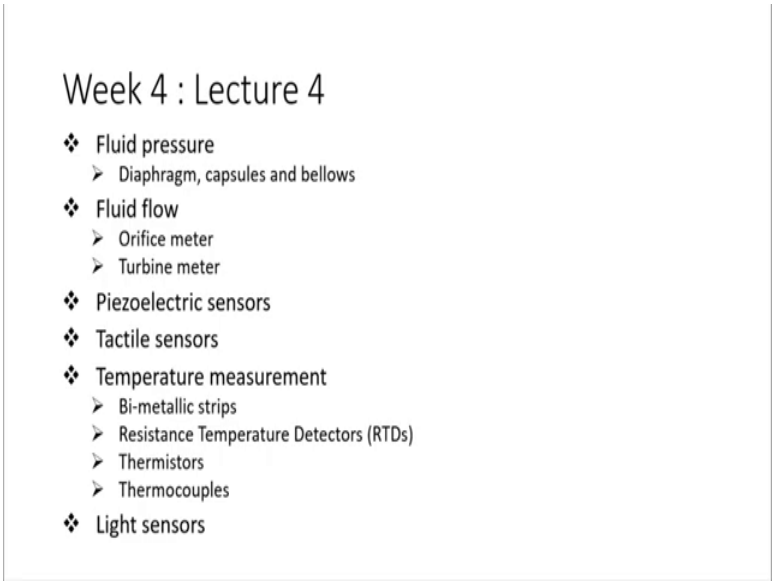

In the next lecture that is lecture 4 of week 4, we will study the sensors for fluid pressure measurement, these are diaphragm, capsules and bellows. We will also learn how to measure fluid flow using orifice meter and turbine meter.

Then some important sensors such as piezoelectric sensor and tactile sensor will be studied. After that, sensors associated to measurement of temperature will be studied. These are bi metallic strips, resistance temperature detectors, thermistors and thermocouples. At the end of the lecture we will see what are the various light sensors, which are used in automation industry.

Thank you.