Inspection and Quality Control In Manufacturing
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Lecture – 20
Miscellaneous Measurements

Hello my friends now we have come to the last chapter of this particular lecture topic that is called the miscellaneous measurements. Till now we have seen that we are we have already discussed about different types of some particular testing techniques like the leak tests like the different types of cavity taste like different types of flow detection tests like detection of different types of pores and cracks.

Now in this particular lecture we are going to discuss that whatever we have not yet covered till now.

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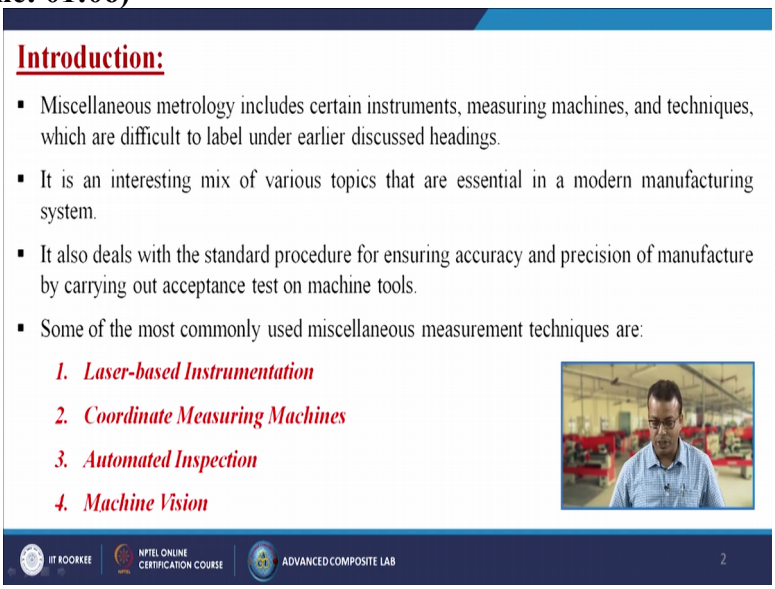

So, first what is the introductions? So, generally the miscellaneous metrology includes certain instruments measuring machines and techniques which are different to label under earlier discussed headings. It is an interesting mix of various topics that are essential in a modern manufacturing system because nowadays whatever the product whatever the equipment generally we are using that is becoming more complex.

So, that time it is not possible only by a single test equipment or maybe only by a single characters and techniques to detect about that particular defects. Now we need to mix up some different kinds of techniques or maybe we have to employ some kind of new advanced techniques to detect those kinds of defects or maybe the cracks or maybe the pores for that

particular material. It also deals with the standard procedure for ensuring the accuracy and precision of manufacturing by carrying out acceptance tests on machine tools.

Some of the most commonly used miscellaneous measurement techniques are laser based instruments coordinate measurement or maybe the measuring machines, automated inspections and the machine vision. So, now first let us discuss with the laser based instrumentation.

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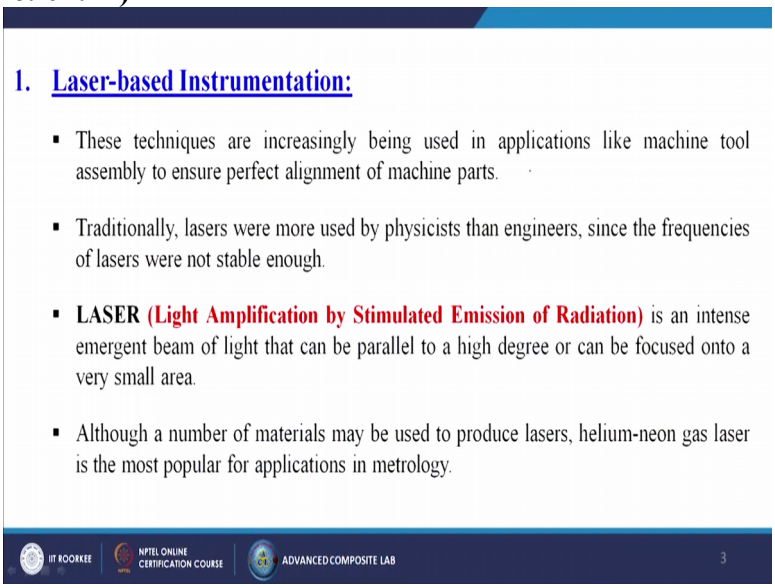

So, generally these techniques are increasingly being used in applications like machine tool assembly to ensure the perfect alignment of machine parts. Traditionally lasers were more used by physicists than engineers since the frequencies of lasers not stable enough. So, what is the full form of the laser that is nothing but the light amplification by stimulated emission of radiation is an intense emergent beam of light that can be parallel to a high degree or can we focused on to a very small area.

Although a number of materials may be used to produce lasers like helium neon gas lasers is the most popular for applications in metrology system.

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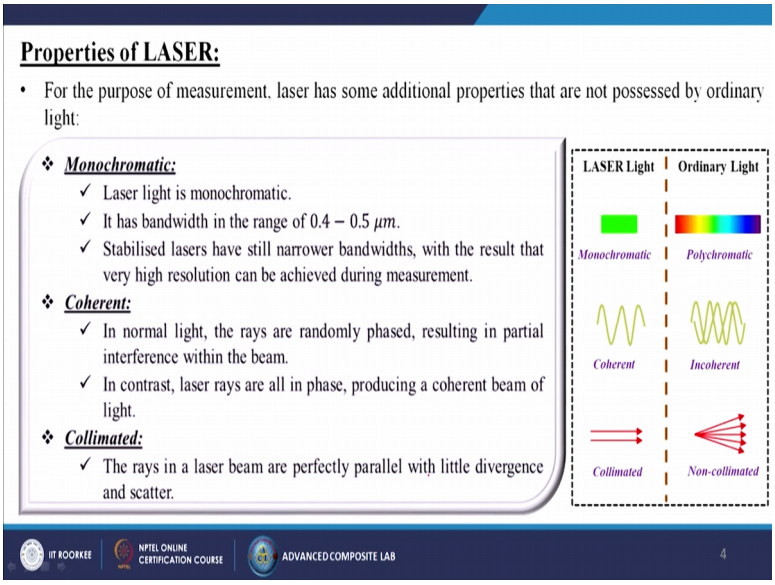

Now what are the properties of laser for the purpose of measurement laser has some additional properties that are not possessed by ordinary light. What is that first one it is monochromatic laser light is monochromatic it has bandwidth in the range of 0.4 to 0.5 micrometer. Stabilized lasers have still narrower bandwidths with the result that very high resolution can be achieved during measurement.

So, laser light as I told already it is monochromatic in nature where ordinary light is the polychromatic. Next come to the coherent, in normal light the Rays are randomly faced resulting in partial interference with the beam itself. In contrast laser rays are all in phase producing a coherent beam of light itself. So, this is coherent also and for normal light on with the ordinary light it is incoherent.

Then the last one is the collimated so sometimes you may heard about the collimated lasers right. So, the rays in a laser beam are perfectly parallel with little divergence and scatter so this is collimated and our normal light is the non collimated one.

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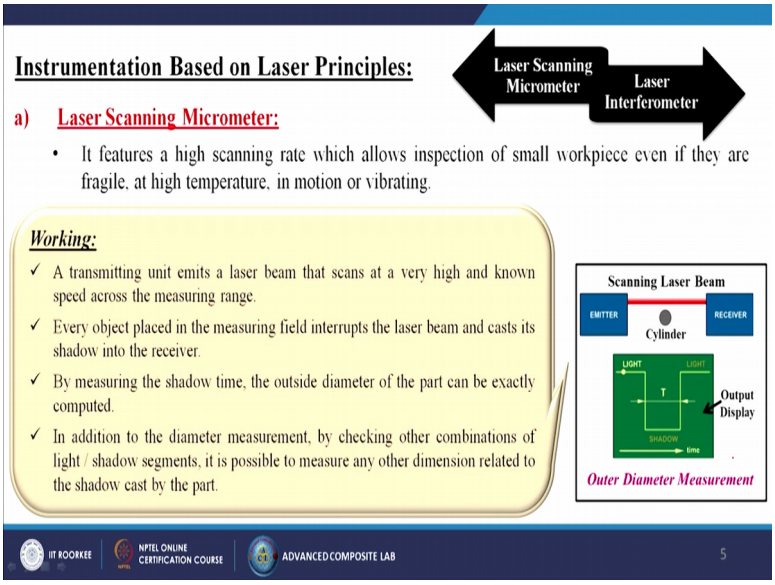

So, now what are the instruments based on laser principles like laser scanning micrometer and the laser inferometer. So, if we talk about the laser scanning micrometer so it features a high scanning rate which allows inspection of small workpiece even if they are fragile at high temperature in motion or vibrating. So, what is the working principle a transmitting unit emits a laser be that scans at a very high and known speed across that measuring range.

Every object placed in the measuring field interrupts the laser beam and casts its shadow into the receiver itself. By measuring the shadowed time the outside diameter of the part can be exactly computed. In addition to the diameter measurement by checking other combinations of light shadow segments it is possible to measure any other dimensions related to the shadow cast by the part itself.

So, simple I am having the cylinder I am having that emitter which is generating the laser and then the laser is passing through that particular cylinder and it is coming into the receiver end. So, light and how much time it is taking to pass through that particular materials if the material is having some pores or cracks automatically the laser will go fast if there is certain obstacle automatically it needs time so by the calculating that time easily we can detect that is there in any cracks or maybe any kind of pores are present or not or maybe the wall is the solid one.

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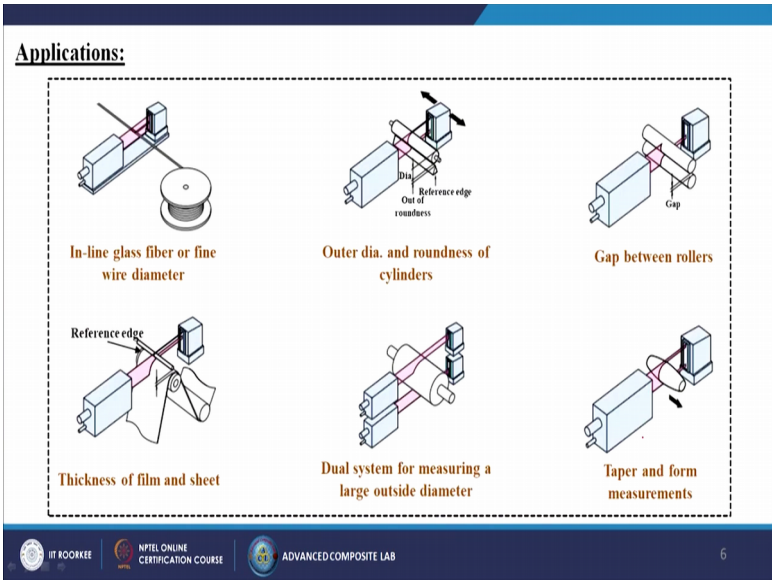

What are the applications generally inline gas fiber or maybe the fine wire diameter we can measure through it outer diameter and roundness of the cylinders gap between the rollers thickness of flame and seat dual system for measuring enlarge outside diameters paper and form measurements. So, in these all cases generally we are using these techniques.

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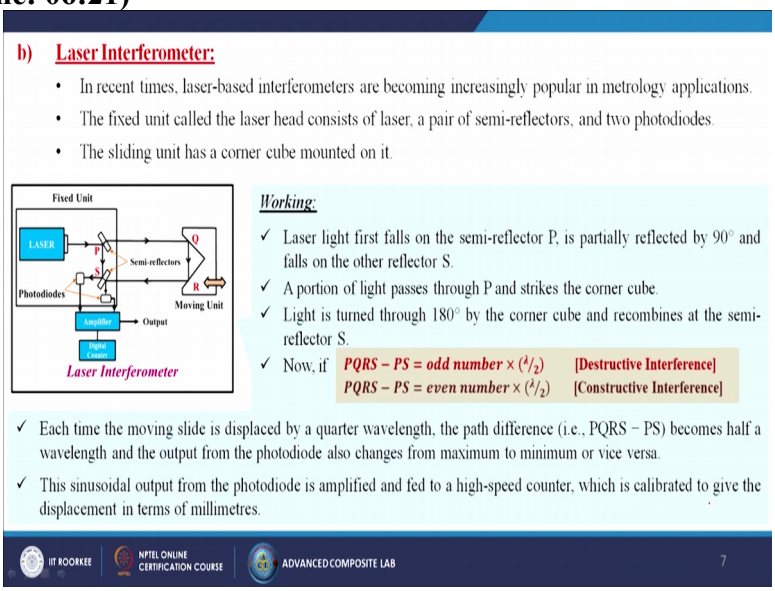

Next second one is called the laser inferometer. In recent times laser based inferometers are becoming increasingly popular in metrology applications. The fixed unit called the laser head consists of laser a pair of semi reflectors and two photo diodes. The sliding unit has a corner cube mounted on it so this is the schematic view of our laser inferometer. So, how its works generally the laser light first falls on the semi deflected P so here the laser is coming this is the first reflector and then S is the second reflector over there.

So, now P is partially inflected by 90 degree and falls on the other reflector S so directly it is coming to the S. A portion of light passes through P and strikes the corner tube here it is the

corner cube. Next light is turned through 180 degree by the corner cube and recombines at the semi reflector S so here in this particular case it is coming and exactly 180 degree it is rotating and it is falling on the S.

Now if PQRS -PS = odd number into lambda / 2 that is called the destructive interference and if PQRS - PS = even number into lambda / 2 that is the constructive interference. Each time the moving slide is displaced by a quarter wavelength the path difference that is PQRS - PS becomes half a wavelength and the output from the photodiode also changes from maximum to minimum or may be the vice versa.

This sinusoidal output from the photodiode is amplified and fed to a high speed counter which is calibrated to give the displacement in terms of the millimeters. So, here is the output generally we are getting through this particular amplifier and now we are having the digital counter.

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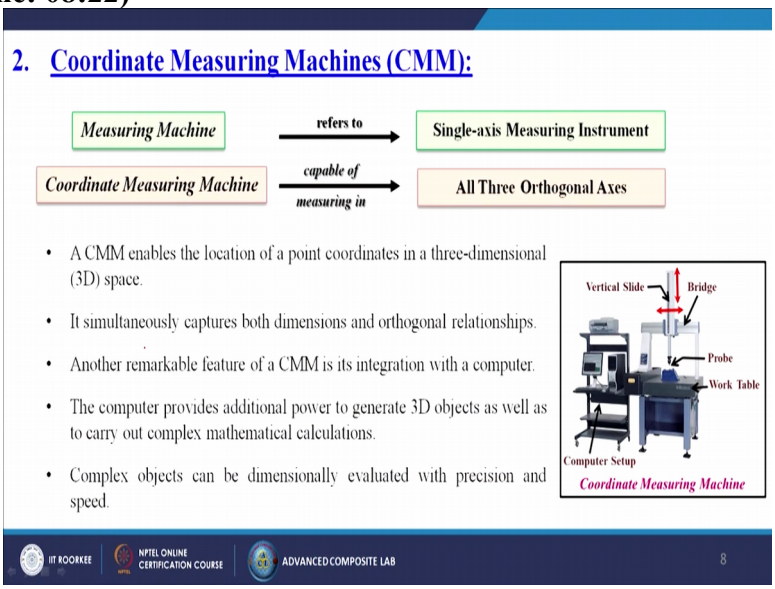

Now next one is come to the coordinate measurement or maybe the measuring machines in short generally it is known as the CMM this is widely used techniques. So, generally how it is working so we are having that measuring machines refers to the single axis measuring instrument and we are having that coordinate measuring machines that is capable of measuring in all three orthogonal axis over there so that is the difference.

So, a CMM enables the location of a point coordinates in a 3 dimensional space it simultaneously captures both dimensions and orthogonal relationships another remarkable feature of CMM is its integrations with the computer. So, directly we are getting the results into the computer itself. The computer provides additional power to generate 3d objects as well as to carry out complex mathematical calculations.

Complex objects can be dimensionally evaluated with precision and speed over there. So, now we are having that breech we are having that vertical slide. So, that means it can move into the vertical directions also it can move into the bridge also that means it can move into the x directions and y directions together and this is our probe and this is the work table on that we are putting our workpiece materials and this is the computer set up directly where we are getting our results.

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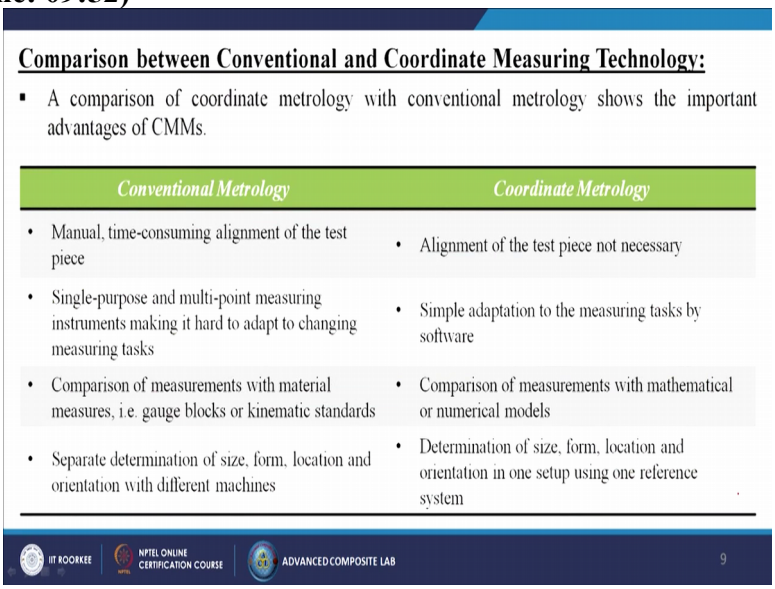

So, this is the coordinate measuring machine comparison between the conventional and coordinate measuring technology say comparison of coordinate metrology with conventional metrology shows the important advantage of the CMMs. So, conventional metrology manual time-consuming alignment of the test piece for the coordinate metrology alignment of the test piece not necessary and here in this particular case single purpose and multi point measuring instruments making it hard to adapt to changing measuring tasks.

For coordinate simple adaptation to the measuring tasks by the software itself now software is doing everything. Next for the conventional case comparison of measurements with material measures like gauge blocks or maybe the kinematic standards but whereas for the coordinate system comparison of measurements with mathematical or maybe the numerical models for conventional metrology separate determination of size form location and orientation with different machines. It is not a combination but whether CMM it can measure the size form locations and orientation in one set up using one reference system. So we can get all the results from a particular equipment.

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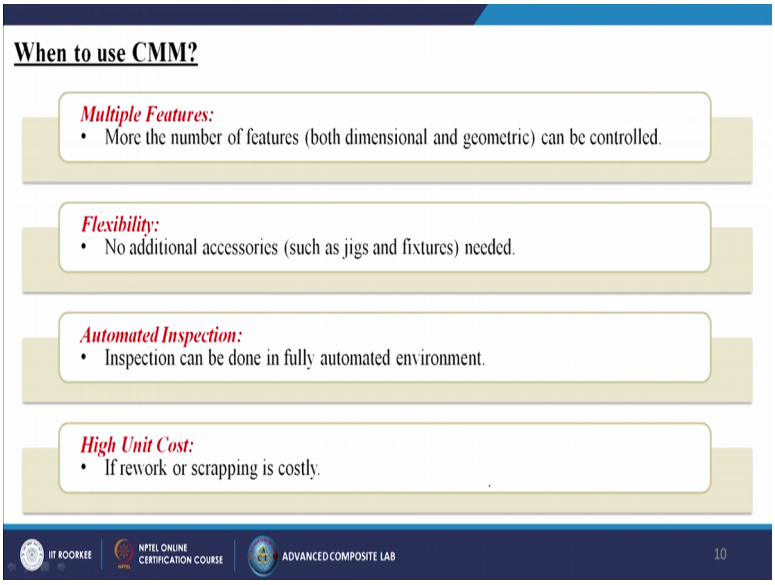

Then when to use the CMM so multiple features more the number of features both dimensional and geometry can be controlled. Flexibility no additional accessories such as jigs and fixtures needed. Automated inspection; inspection can be done in fully automated environment and the high unit cost if rework or scrapping is costly.

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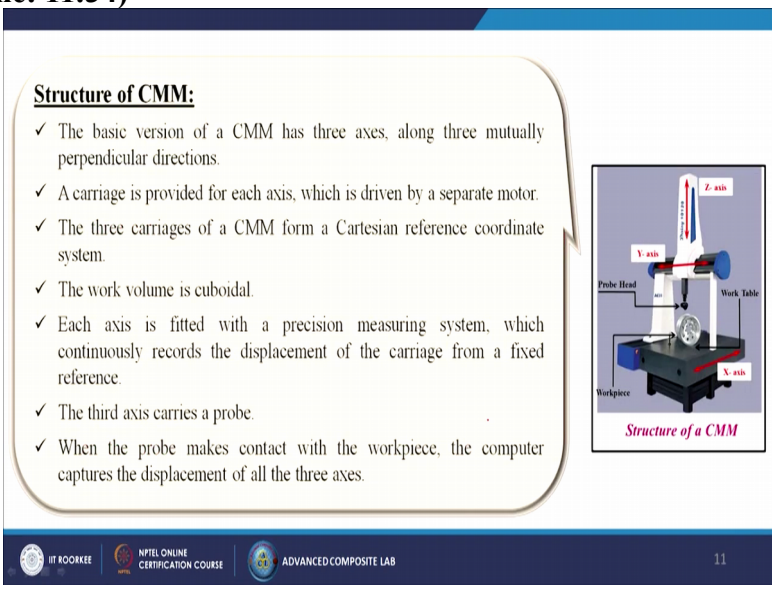

Then structure of the CMM the basic version of a CMM has three axis along three mutually perpendicular directions. So, in this particular case you can see it can move into the x-axis it can move into the y-axis and it can move into the z axis itself. So, if I am having one object from all the three sides it can measure the exact dimensions shape size or maybe the defects a carriage is provided for each axis which is driven by a separate motor.

The three carriages of a CMM from a cartesian reference coordinate system the work volume is cuboidal. Each axis is fitted with a precision measuring systems which continuously records the displacement of the carriage from a fixed reference. The third axis carries a probe

when the probe makes contact with the work piece the computer captures the displacement of all the three axis.

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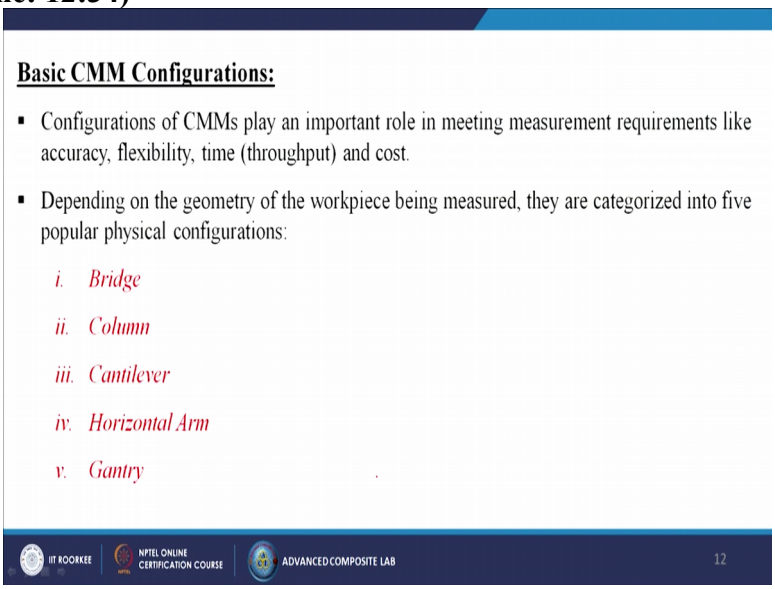

Basic CMM's configurations so configurations of CMM's play an important role in meeting measurement requirements like accuracy, flexibility, time that means throughput and of course the cost. Depending on the geometry of the workpiece being measured they are categorized into 5 popular physical configurations what are those? First one is called the Bridge, second one is called the column, third one is called the cantilever, fourth one is called the horizontal arm and the last one is called the gantry.

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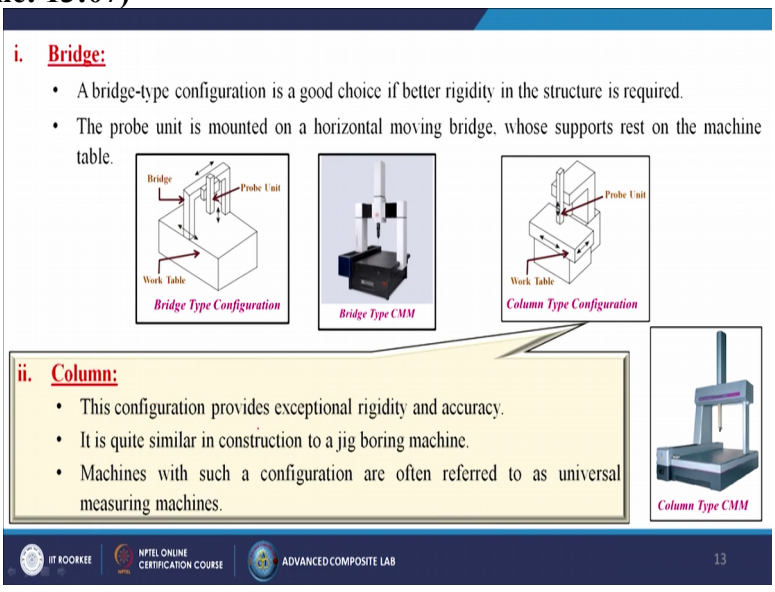

So first what is bridge, so bridge type configurations is a good choice if better rigidity in the structure is required. The probing unit is mounted on a horizontal moving bridge who supports rest on the machine table. So, in this particular case you see this is the bridge and

this is the probe unit so on the bridge itself the probe unit is going in these directions or maybe in these vertical directions and the bridge can move into these directions also.

So, this is called the bridge type configurations the machine seems to be like this and this is known as the column type configurations over there. So, in this case this is moving into these directions and the table is moving into these directions and the these directions. When you are talking about the column this configuration provides exceptional rigidity and accuracy. It is quite similar in construction to a jig boring machine.

Machines with such a configuration are often referred to as universal measuring machines and this is the column type CMM.

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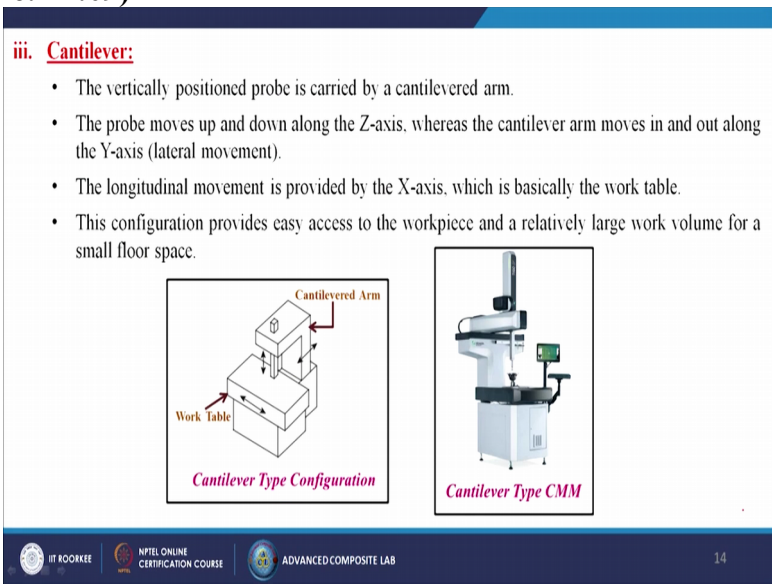

Now we come to the cantilever the vertically position probe is carried by a cantilevered beam the probe moves here you can see it is the cantilever arm over there. There is no support into this sight the probe moves up and down along the z axis where the cantilever arm moves in and out along the y axis. So, this is moving and the probe is moving into the z directions and the table is moving into the x directions itself.

So, the longitudinal movement is provided by the x axis which is basically the work table the configuration provides easy access to the workpiece and a relatively large work volume for a small floor space. So, this is the image of the cantilever type CMM.

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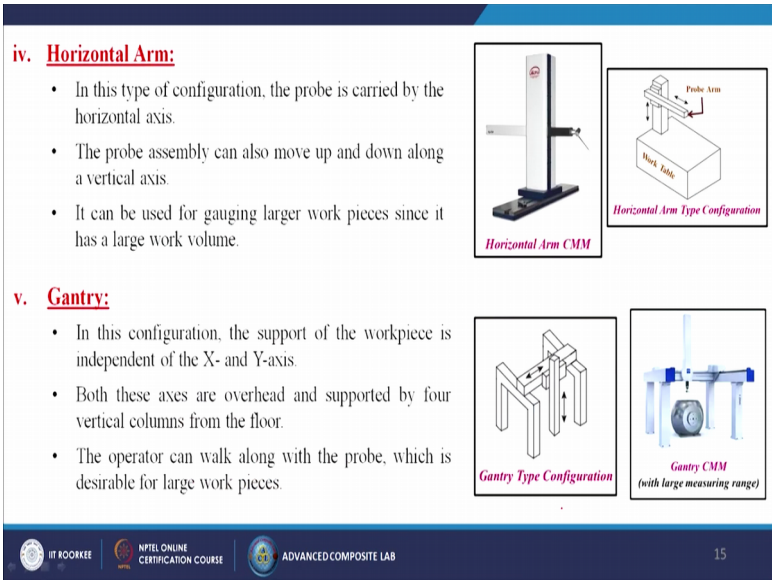

Now we are coming to the horizontal arm so in this type of configuration the probe is carried by the horizontal axis the probe assembly can also move up and down along a vertical axis it can be used for gauging larger workpiece since it has a large work volume. So, in this particular case the probe arm is varying into these directions and the arm also it is coming up and down so into these directions. Now come to the gantry the last one in this configuration the support of the workpiece is independent of the x and y axis. Both these axes are overhead and supported by four vertical columns from the floor itself.

So, you can see so this is also it can move into these directions this is moving into these directions this arm and this can go up and down also. So, the operator can work along with the probe which is desirable for large work pieces. Now this is the image of the gantry CMM now one question may come into your mind that which is the best or maybe which we are going to use or maybe which will give you the best results.

See the basic thing is that how your material is? What is the shape of your materials? So now based on your shape and size of your materials you can choose any other options because you need the results. So, at least you have to give the flexibility of these measuring machines so that probe can reach to all the corners. So, based on your shape and size you can choose any other operation which is suitable for your material shape.

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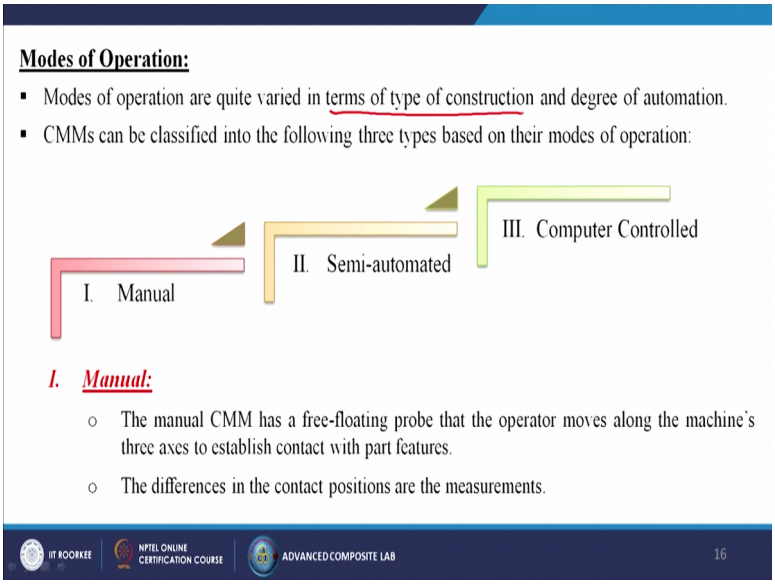

Now what are the modes of operations so generally the modes of operations are quite varied in terms of type of constructions and degree of automations CMM's can be classified into the following three types based on their modes of operations what are those first one is called a manual, second one is called the semi automated and third one is the computer controlled. So, when we are talking about the manual so the manual CMM has a free-floating probe that the operator moves along the machines three axis to establish contact with part features. The difference is the contact positions are the measurements.

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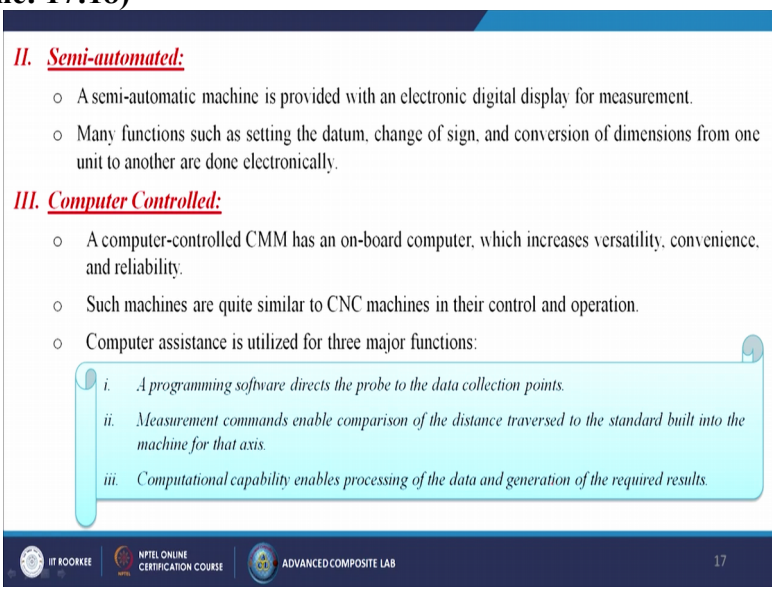

Now we are talking about the second one that is the semi automated one. A semi automatic machine is provided with an electronic digital display for measurement. Many functions such as setting that datum change of sign and conversion of dimensions from one image to another are done electronically. And the last one is the computer controlled a computer control CMM has an on-board computer which increase versatility, convenience and reliability.

Such machines are quite similar to CNC machines in their control and operation. Computer assistance is utilized for three major functions what are those programming software directs a probe to the data collection. Point number two measurement comments enable comparison of the distance transfer to the standard built into the machine for that particular axis. Point number three computational capability enables processing of the data and generation of the required results.

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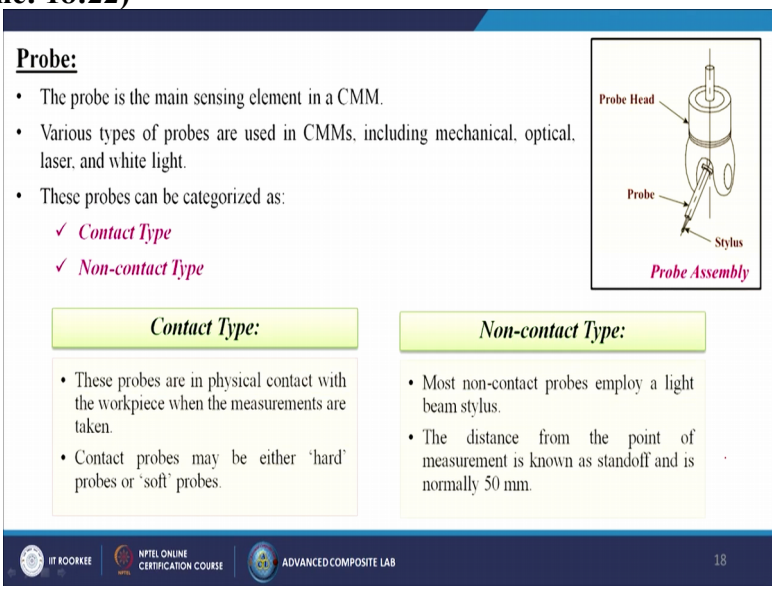

Now come to the probe, the probe is the main sensing element in a CMM. So, various types of probes are used in CMM's including mechanical probe, optical probe, laser probe, white light probe these probes can be categorized as contact type and non-contact type. So, from the name itself we can understand contact type means that probe will touch your sample and non-contact means that probe will not touch your sample.

So, if we talk about the contact type these probes are in physical contact with the workpiece when the measurements are taken. For non-contact type most non-contact probes employ a light beam stylus then when you are talking about the contact probes it may be either hard probes or may be the soft probes either it will just touch your materials or maybe it will very soft that it can take certain kind of area and it can rub onto your surface itself.

But when you are talking about the non-contact probe the distance from the point of measurement is known as the standoff and is normally the 50 millimeter. So, always there will be a gap in between your probe and in between your surface and that is the normal is that 50y millimeter that is standard one.

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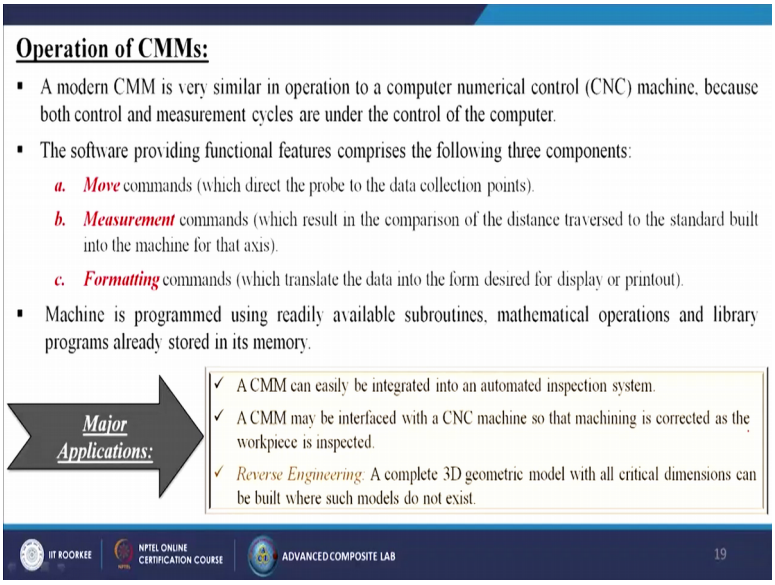

Now operations of the CMM's how it is working so a modern CMM is very similar in operations to a computer numerical control machine because both control and measurement cycles are under the control of the computer itself. The software providing functional features comprising the following three components like move comments which direct the probe to the data collection point first it will go at that place which one you are locating.

Second one is the measurement comments which results in the comparison of the distance transverse to the standard built into the machine for that particular axis and the third one is called the formatting comments which translate the data into the form desired for display or maybe the printout. Machine is programmed using readily available subroutines mathematical operations and library programs already stored in its memory.

So, now what are the major applications of these kinds of techniques first one is that it can be easily integrated into automated inspection systems, a CMM may be interfaced with a CNC machine so that machining is corrected as the workpiece is inspected. So, it is a online process while the machining is going on simultaneously we are checking its shape and dimensions. So, if there is any error form so automatically we are changing our input parameters so that we can get the exact shape and size.

Then reverse engineering a complete 3d geometric model with all critical dimensions can be built where such models do not exist.

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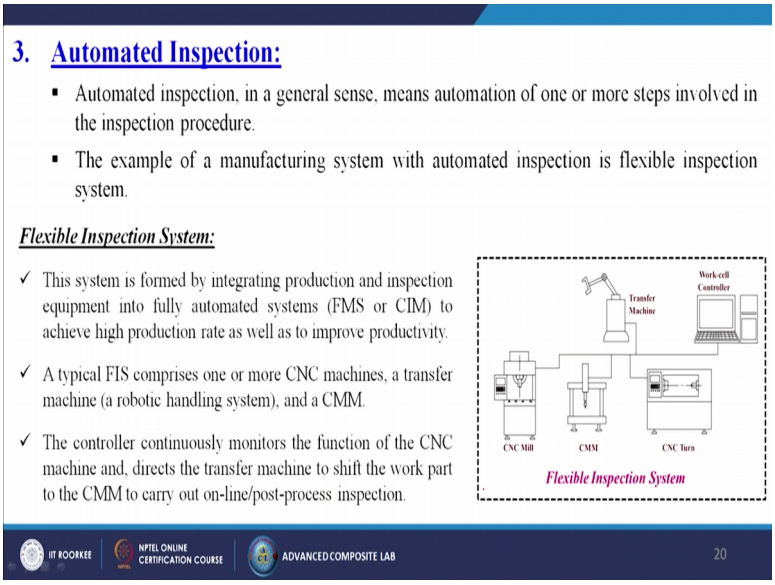

Now come to the third one that is called the automated inspections. So, automated inspections in a general sense means automation of one or more steps involved in the inspection procedure. The example of a manufacturing systems with automated inspections is flexible inspection system. Flexible inspection systems these systems is formed by integrating production and inspection equipment into fully automated systems like FMS or maybe the CIM to achieve high production rate as well as to improve the productivity.

In flexible FIS comprises one or more CNC machines a transfer machines a robotic handling systems and a CMM. The controller continuously monitors the function of the CNC machines and directs the transformation to shift the work part to the CMM to carry out online or maybe the post process inspection so that is the complex kind of inspections. So, we are having that CNC Mills we are having the CMM we are having the CNC turning machines and then all these going to the transformations and then from that it is going to the work cell controller.

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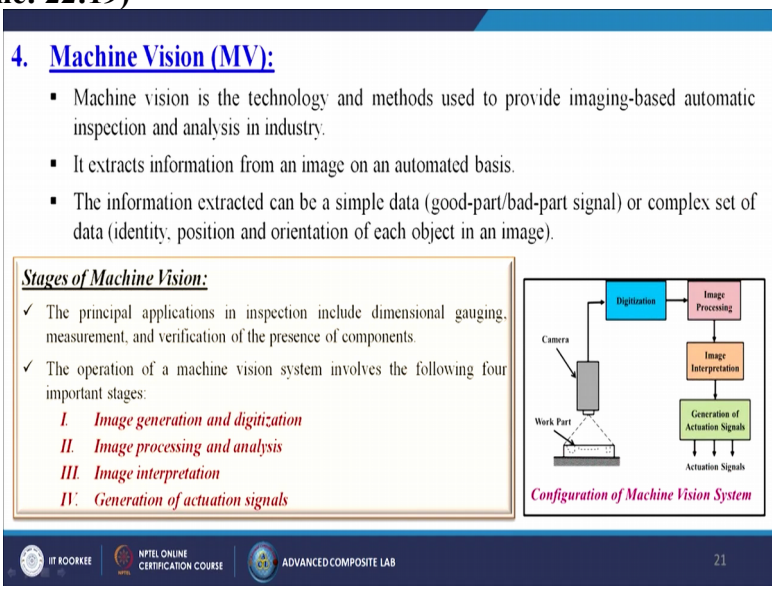

Now last one is called the Machine vision. So, generally the machine vision is the technology and the methods used to provide imaging based automatic inspections and analysis in industry. It extracts information from an image on an automated basis the information extracted can a simple data like good part or maybe the bad part signal or maybe the complex set of data like identity positions and orientation of each object in an image.

Now stages of the machine visions the principal applications in inspection include dimensional gauging, measurement and verification of the presence of the components itself. The operation of a machine vision systems involves the following four important stages like image generation and digitization, image processing and analysis, image interpretation and the last one is the generation of actuations signal.

So, in this particular case you can see we are having that work part through that we are having that camera we are taking the image over there so digitization is taking place after that we are processing the image. Then image interpretations what does it mean from the image we are gathering the information's and then the generation of the actuation signals and we are receiving the actuation signals from that particular image.

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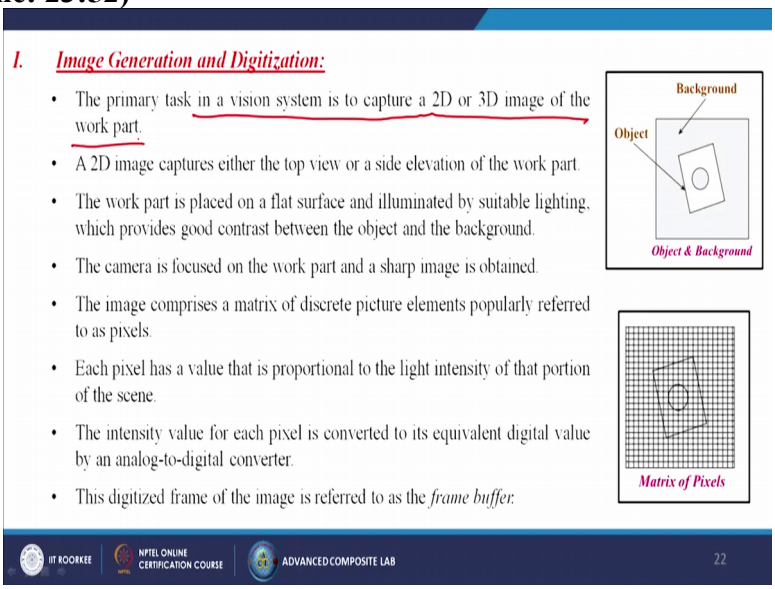

Then first is called the image generation and digitization so the primary task in a vision system is to capture a 2d or 3d image of the work part a 2d image captures either the top view or a side elevations of the work part. The work part is placed on a flat surface and illuminated by suitable lighting which provides good contrast between the object and the background. The camera is focused on the work part and a sharp image is obtained.

The image comprises a matrix of discrete picture elements popularly referred to as pixels. Each pixels has a value that is proportional to the light intensity of that portions of the scene.

The intensity or value for each pixel is converted to its equivalent digital value by an analog to digital converter. The digitized frame of the image is referred to as the frame buffer. So, now pixel and all these things nowadays we are well versed with these things because we are modifying some image or maybe we are taking some kind of characterization techniques and then we are well-versed at how we are taking the image into some signals.

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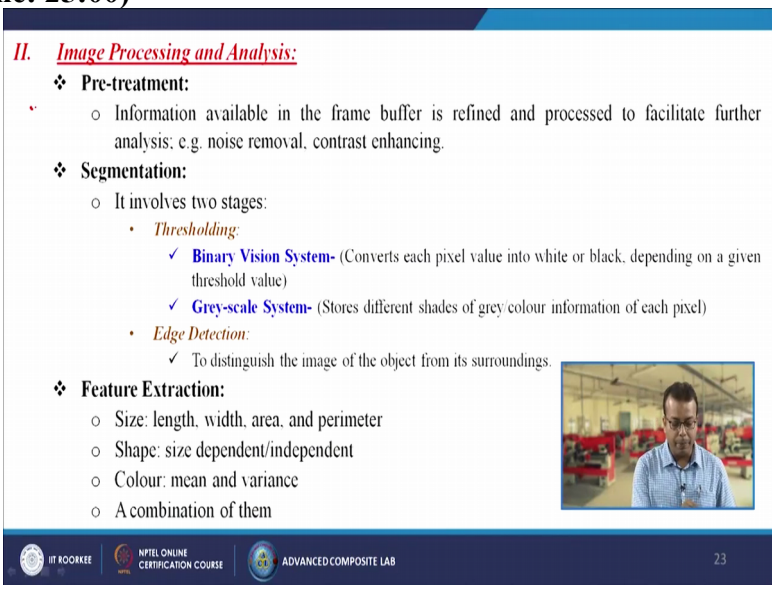

Next is called the image processing and analysis like pretreatment information available in the frame buffer is refined and processed to facilitate further analysis like noise removal and the contrast enhancing. Next segmentations it involves two stages like thresholding binary vision system converts each pixels value into white or black depending on a given threshold value and the grayscale system's stores different sets of gray colour or maybe the color information of each pixels.

Then edge detections to distinguish the image of the object from its surroundings. Now feature extractions like size we can check the length width area and the perimeter shape size dependent or maybe the independent one color mean and variance and last one is the combination of dim.

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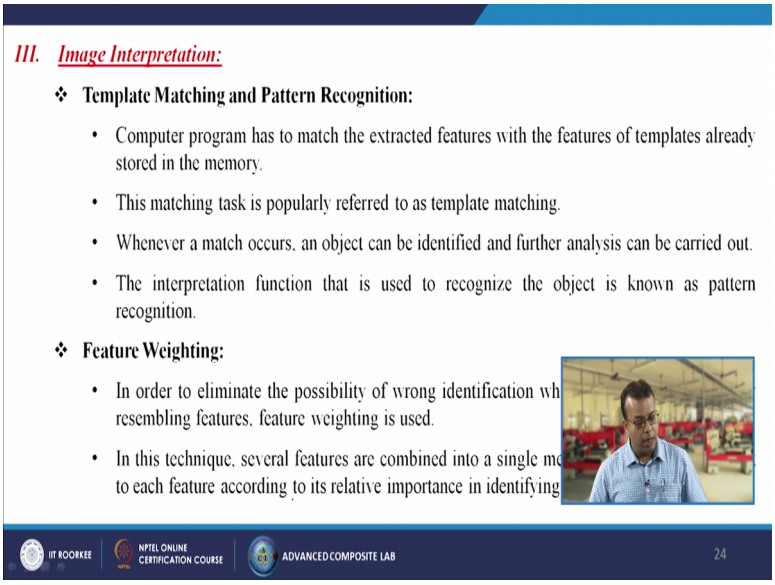

Third one is the image interpretations now we have got the image from that how we can interpret the results. First one is called the template matching and the pattern recognition computer program has to match the extracted features with the features of templates already stored in the memory itself. These matching tasks is properly referred to as template matching simple we are having the database with the database results we are matching our results.

Whenever a match occurs an object can be identified and further analysis can be carried out. The interpretation function that is used to recognize the object is known as pattern recognition. Next one is called the feature weighting. So, in order to eliminate the possibility of wrong identification when two objects have closely resembling features feature weighting is used. If from the both sides I am getting the same results then how to distinguish the results.

In this technique several features are combined into single measures by assigning a weight to each feature according to its relative importance in identifying the object itself.

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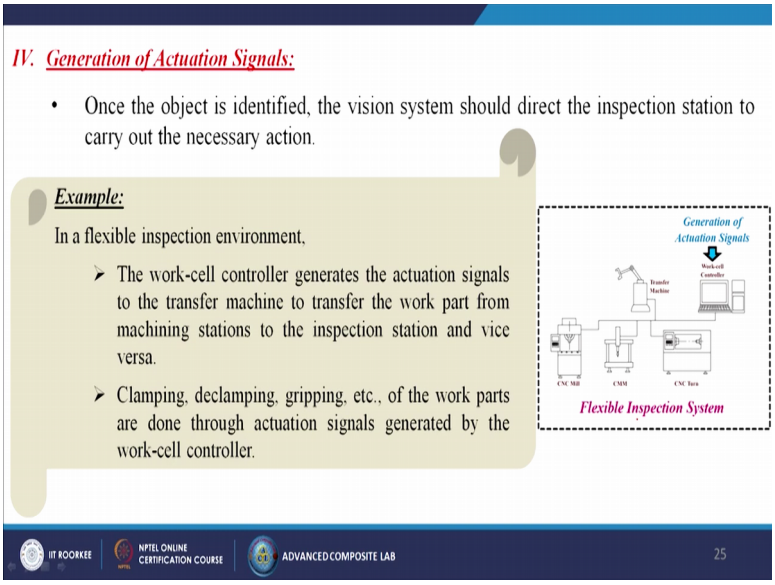

Then fourth one is the generation of actuation signals once the object is identified the vision systems should direct the inspection stations to carry out that necessary actions examples in a flexible inspection environment the work shell controller generates the actuation signals to the transformations to transfer the work part from machining stations to the inspection stations and vice versa clamping declamping gripping etcetera of the work parts are done through actuation signals generated by the work cell controller.

So, simple it is telling that your operation has been done now you send that particular part for checking so like this way we are doing this kind of testing.

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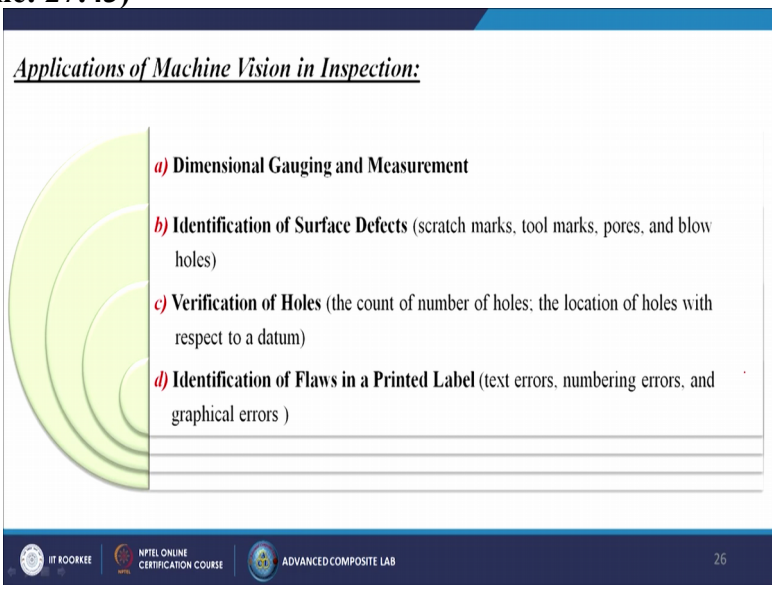

Now what are the applications of machine vision in inspections like dimensional gauging and measurements identification of surface defects like scratch marks tool marks pores and the blow holes verification of holes the count of number of holes the location of holes with

respect to a datum line datum means nothing but the reference line identification of flaws in a printed level like text errors numbering errors and the graphical errors.

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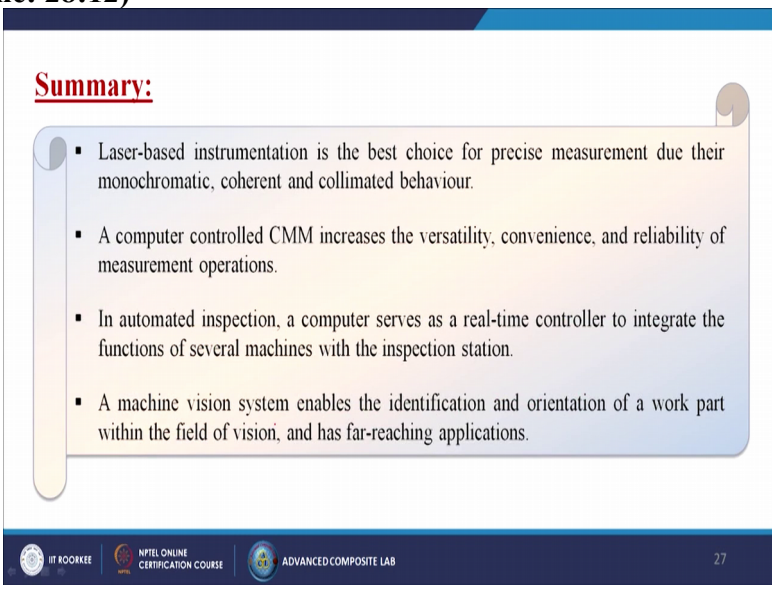

So, we have come to the last part of this particular lecture so in summary we can tell that laser based instrumentations is the best choice for precise measurement due to their monochromatic coherent and collimated behavior. A computer control CMM increases the versatility convenience and the reliability of measurement techniques. In automated inspection a computer serves as a real-time controller to integrate the functions of several machines with the inspection stations.

A machine vision system enables the identification and orientation of a work part within the field of vision and has far-reaching applications. Now as I told already because this is the last lecture of this particular subject topic that is the non-destructive testing of materials. So, we have already gone through total 20 numbers of lectures. So, now in last generally we are trying to give a brief outline that what we have discussed for this particular lecture.

So generally in manufacturing Quality Control is a process that ensures the customers receive products free from defects and meet their requirements? Yes of course when we are going to purchase certain kind of materials we are trying to purchase the best materials it should not have any defects it should not have any scratch it should not have any kind of material loss or maybe the property loss.

So for this what we need we need the proper inspections and the proper measurements so that we can get the accurate shape size and dimension product.

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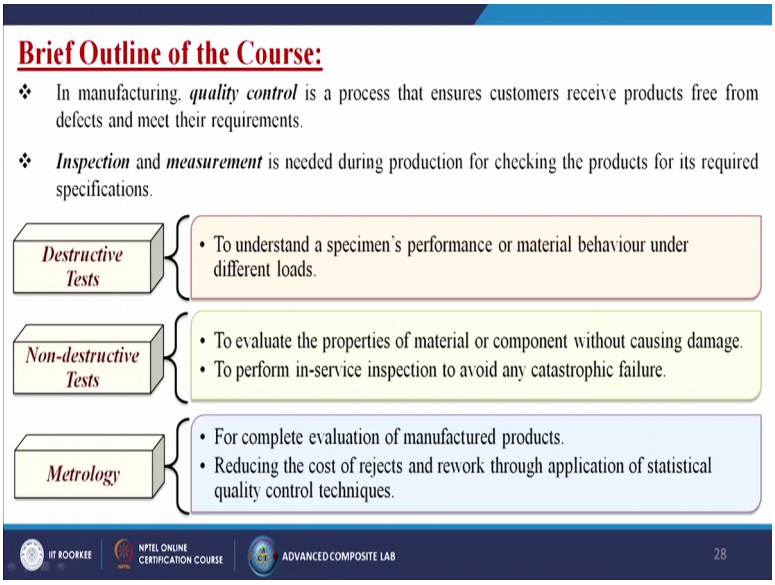

So, inspection and measurement is needed during production for checking the products for its required specifications. So, in these particular lectures series we have discussed about the destructive testing's to understand a specimen performance and material behavior under different loads. We have also discussed about the non-destructive testing where we are not harming the materials we are not giving any kind of load pressure or maybe you are not breaking the samples or specimens and we are simply measuring its outputs or maybe the dimensions or maybe the defects.

So to evaluate the properties of material or component without causing the damage to perform in service inspection to avoid any catastrophic failure and last we have discussed about the metrology that means how we can measure which kind of techniques generally we are employing for different defects measuring. So, for complete evaluation of manufactured products reducing the cost of rejects and rework through applications of statistical quality control techniques, thank you.