Computer Integrated Manufacturing
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Lecture 35
Computer Aided Quality Control
(Part 1 of 2)

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So, welcome to the next important topic which is on, quality control till now we were discussing about how to draw a part, then after drawing a part how do you manufacture then we were looking into the process plan. So, now it is getting into a new field which is called as quality control. Again here, if you want to establish a CIMS environment in a factory you are supposed to have a good quality control over your product and you should try to store the data using a computer.

So, earlier the quality control was talked about only in terms of product, product performance. Now, we are trying to talk about which day it was manufactured, who manufactured, how it was transported from one place to other. What is the, a service condition is expected to do, all these things are now getting tracked.

In fact, today there is a new team which is talked about in the auto industry, they are saying that you try to get my car on lease and we will try to maintain as well assess the quality of the car regularly. And then, try to do maintenance for your car. So, rather than owning, they are trying to give it on lease. With plane industry it is very common, now they are slowly started doing it for high-cost cars also. So, quality control is becoming very very important. What was done earlier manually now, it is going to be done by the use of a computer. And when it is computer used then, the data which is digitally stamped is stored in records. So, now this is the next topic of our discussion, computer-aided quality control.

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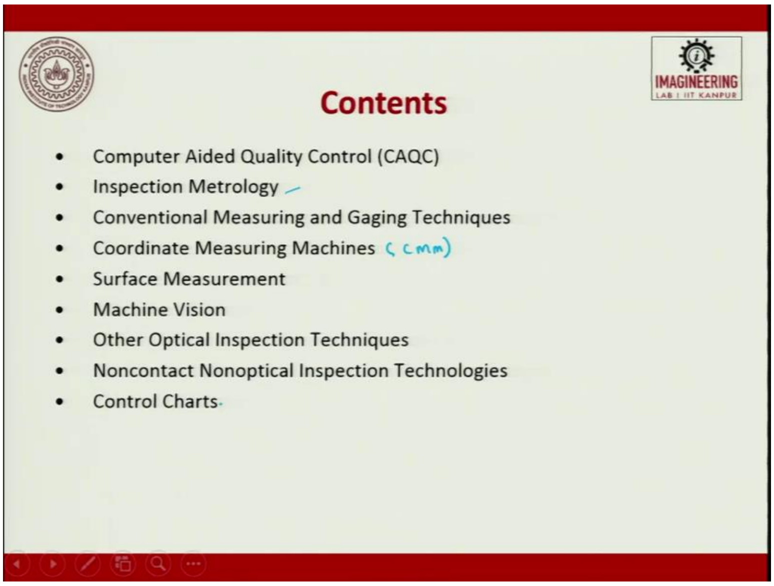

So, in this topic or in this lecture, we will see the following content. The first one is going to be computer-aided quality control we will see the definition then we will try to see inspection metrology. So, then we will see conventional measurement and gaging techniques. Then, we will discuss about coordinate measuring machine which is exhaustively used. Then we will try to look into surface measurement, machine vision, then optical inspection techniques, then noncontact no optical inspection techniques and finally we will see some amount of control chart in this lecture.

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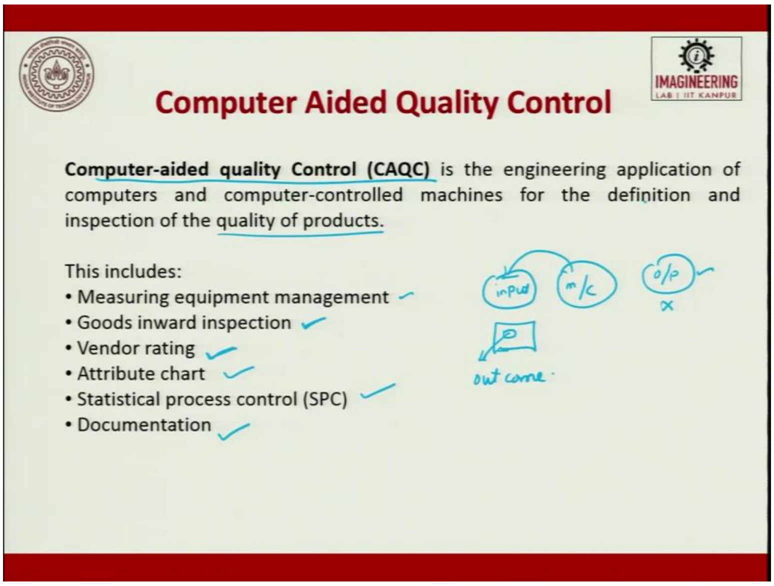

So, computer-aided quality control is the engineering application of computers and computer-controlled machines for the definition and inspection of the quality of the product. Which includes measuring equipment management, goods inward inspection, what came inside as input, see currently this pretty interesting you have a machine, you have an input, you have an output.

So, when the output is good everything is good when the output is bad so we just go back and then look in to the machine. If the machine is alright, many a times what we do is we will say that okay, there is nothing wrong it is, because of chance this has happened and we go. But, it is also worthwhile to check the input raw material which comes inside. What is its consistency of the product when it is given to the machine and then, what is the output. So goods inward inspection is also very very important, what is the batch size inspection you did, and what is their outcome?

So, this is also measured, goods inward inspection. Next is vendor rating which is very important I have supplied 10 items to you 10 same items to you over a period of last one year what is the performance of those parts which have given to you for machining and then to a supplier. So, that is called as vendor rating.

How perfect I am? What is the scrap which I produce? And how much are in the marginal good and bad? So, with that we give a vendor rating with then, attribute charts, then SPC statistical process control charts we look into, and finally documentation all these things are getting into the information of computer-aided quality control.

Because, of computer existence, all these data can be fitted inside and that can move along with the parts when it is moving from, factory to factory, from assembly station to the final station everywhere. So, this is a very important advancement which has happened and this makes the CIMS environment more successful. Earlier quality was thought of after making a part checking for quality. Now, it is thought of while making a part checking for the quality. So not even the first part will be scraped today.

So, this is the definition for quality, a computer-aided quality control, computer-aided quality control, is the engineering application of computers and computer-controlled machines for the definitions and inspection of the quality of the product.

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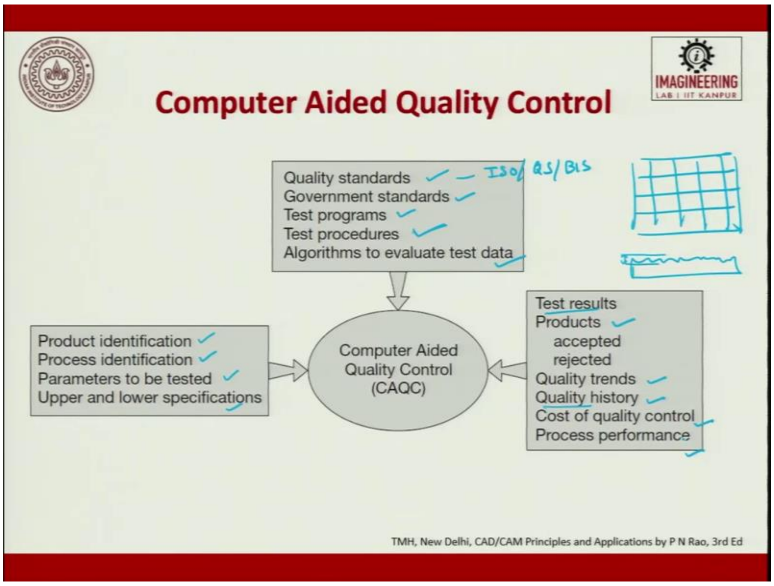

So, if you put it in a schematic diagram or a block diagram, it looks like computer-aided quality control, gets following information, product identification, process identification, parameters to be tested upper and lower specification for producing an attribute of a part then, what is the quality standards for example, ISO, QS all these things are BIS, these are some of the standards. Then, government standards, test programs, test procedures, so for example when you have to measure the thermal conductivity of a material, we should try to follow a certain procedure established to a normal temperature and then measure it.

So, test procedure is very important, when you are trying to measure the temperature-induced phenomena on the expansion, linear expansion, the test condition has to be at room atmosphere and they have put certain parameters so, that is called as a test procedure. How it has to be done, while using a measuring device Abbe’s principle has to be followed so, all these things are put in the test to the procedure.

Then, algorithms to evaluate the test data. For example, I have a flat plate if I want to measure the flatness of this plate so, naturally, I have to take all the discrete data points all across the flat surface. So, then I get the data now, what do I do is, I try to put the data and try to generate a surface.

Now, I am just drawing the 2D so, the variation in this if project it on a 3D, is called as a fastness so, the algorithm for getting an individual data, and constructing from point of data a surface that is called the algorithm to evaluate the test procedure. The test results and product acceptance-rejection levels, then quality trends, quality history, cost of quality control, and process performance. We have one interesting data which people have been telling is in Europe on Friday evening the quality of the cars produced and the Monday morning the quality of the cars produced are not up to their expectation.

That means to say there is always a human error happening because of weekend effect and weekend hangover. So, it is a data which is generated and now, what people are trying to is, they are trying to balance a people who go on a Friday who is working on car assembly and who come on Monday morning car assembly. They are trying to be more conscious about all the assemblies and the other option is the company has started doing it in two phases that means to say one part of the industry, people will come from Tuesday to Saturday and the other one will come from a Monday to a Friday.

So, they try to balance the load and do the operations this is all from the quality history. Then the cost of quality control so, cost of quality control is from the rejection, refurbishment what is the cost involved to generate a quality product. And process performance, all these things are inputs which are given to computer-aided quality control.

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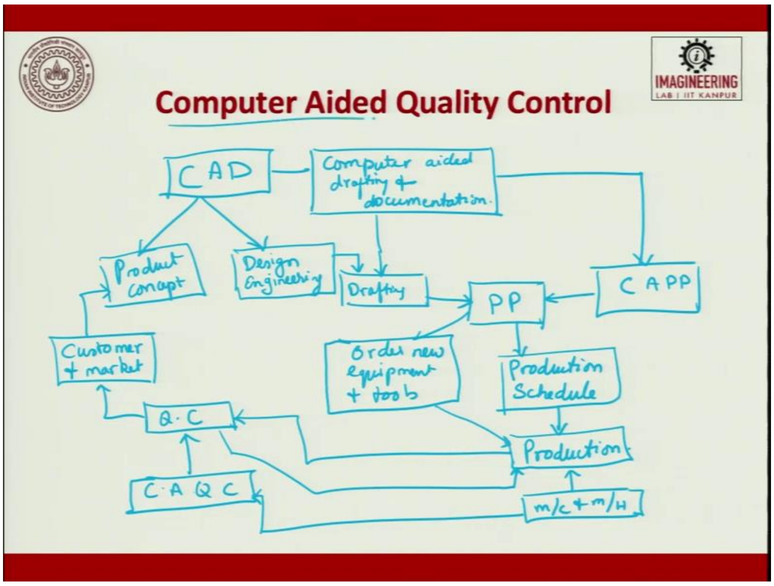

So, how does it happen is, first we will have a CAD, from a CAD it is attached to computer-aided drafting and documentation. From there the data goes to computer-aided process planning. From the process planning, it goes to a process planning. Then, from here, you have a drafting, this goes to process planning.

So, when I talk about CAD we talk about product concept and then design engineering. And from design engineering it goes to drafting so this product concept comes from customers and market, here we talk about the QC, quality control and here comes computer-aided quality control. Look at it how holistically it is all getting build, from the process plan what you get is, order new equipment and tools.

So, then it goes to a production schedule, and from production schedule, it gets to production. So, from the quality control, a production we try to have a computer control, so we will have material handling. Machines and the material handling we will have, okay, etc. So, this here so, the quality control from here to production it goes, and it also gets the information back and forth so, it goes between these two and this is data which flow from here to here. So, if you see this is an overall holistic view of the complete industry and you can see where it is CAQC come into action.

So, CAD can be split into a product concept and design engineering, design engineering leads to drafting, when drafting the information goes to PP, so PP is process planning and computer-aided process planning comes here and it helps it. So, from here we try to see whether there is a need for ordering new machines or old machines then a production schedule is done, production happens in production we will have machines and machine tools.

So, all these things try to give an input to computer-aided quality control. And this intern gives to quality control. The quality control intern gives the opinion to customer, it pretty goes to customer and the cycle gets completed. This is a very important a block diagram which you should understand which talks in totality everything which happens inside a CIMS environment.

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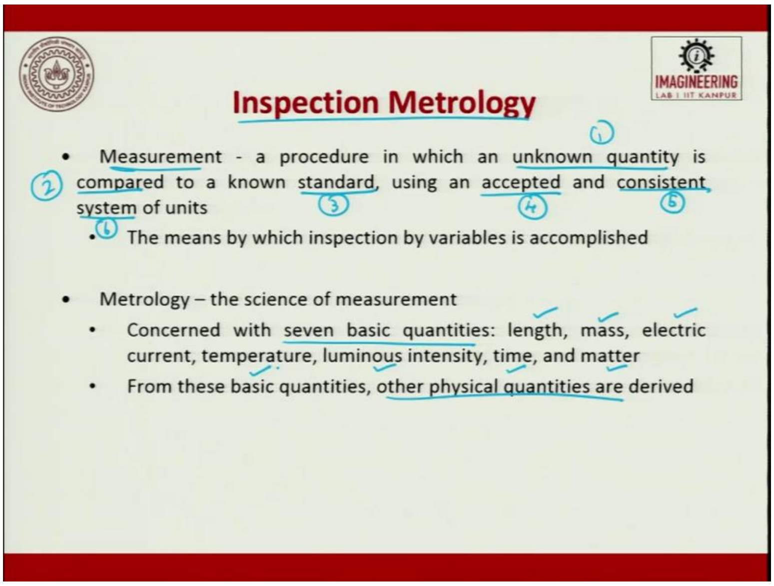

Now, let us see what is inspection metrology, which is very much talked about first we will try to understand what is measurement? , measurement is a procedure in which an unknown quantity is compared to a known standard using an accepted and consistent system of units. Very interesting you see here, unknown quantity has to be measured and how do you measure it? , you compare against the standard and then using an accepted and consistent system, how many keywords? , so unknown quantity compared with a standard accepted consistent system of units.

The means by which the inspection by variables is accomplished. Metrology is nothing but a science of measurement. Concern with seven basic quantities we measure length, mass, electric current, temperature, luminous intensity, time, and matter. These are the seven basic quantities which are measured, the science of measurement is nothing but metrology.

So, this metrology goes here, so that is inspection metrology from these basic quantities other physical quantities can be derived, these are the seven but, many things can be derived from these seven. So, the most interesting thing which we always do is, length measurement, mass measurement, and today exhaustively electric currents are measured, temperature, time, and the matter is measured.

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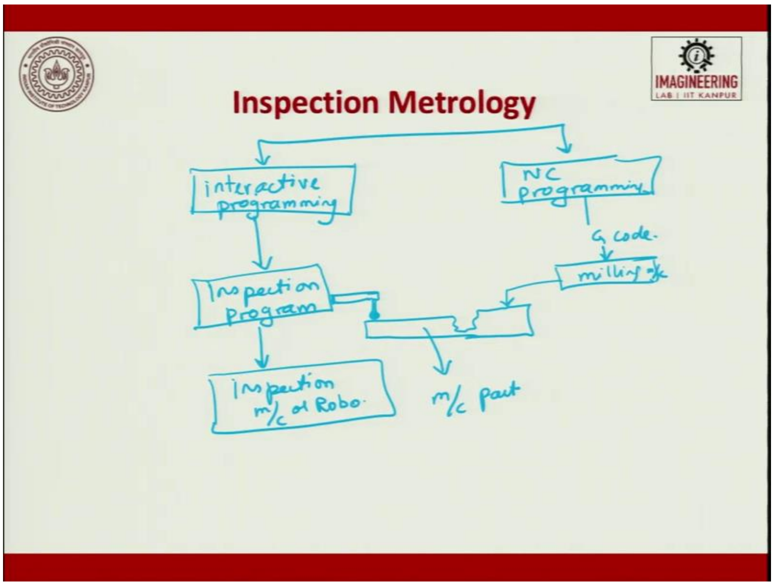

When we talk about inspection metrology, so inspection metrology we have an interactive program, and we have a NC programming. So here inspection program is given and here there is an inspection which is done by a robot or by a machine, machine or robot. So, this program, so we will have a machined part.

So, from NC program what you get is G codes and this goes to your milling machine and this is the, which is lead to the part. So, this is what a thing is. You will have an interactive programming from the interactive programming you get an NC program so when the same y also try to get a NC program as well as an inspection program. So, NC program is given to milling machine to produce a path. So, then the program tries to tell you what all these follow has machined, those points critical points to measured and the measurement will be done by a robot.

So, this is a separate vertical and this is a separate vertical, this clearly says that how is the interaction happening between the program and the NC program what you generate.

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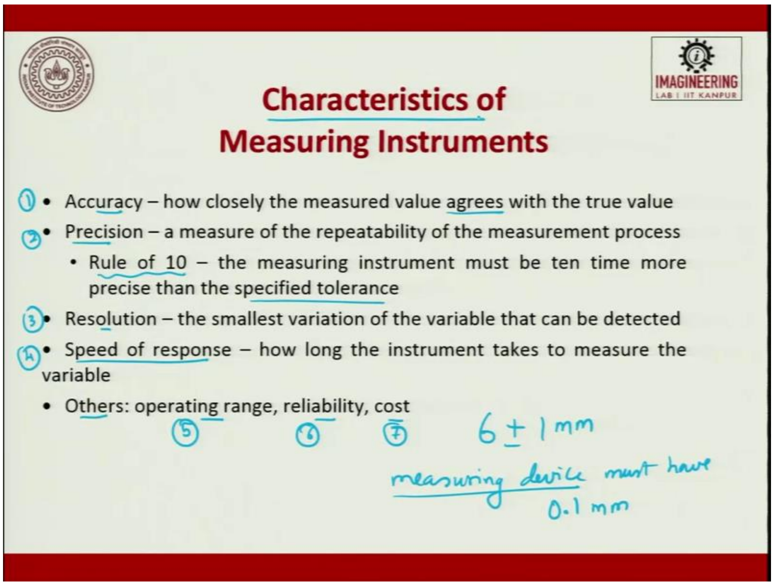

The characteristics of measuring instruments, first is accuracy. We have seen accuracy and resolution in robotics we have seen in CNC, a quick recap of the same accuracy. How closely the, they measured value agrees with the true value is called as accuracy. Then resolution, the smallest variation of the variable that can be detected is called resolution. Between these two you have one more terminology which is called as precision.

A measure of the repeatability of the measured process is called precision. Generally, a rule of 10 is used, the measuring instrument must be 10 times more precise than the specified tolerance. For example, you say 6 plus or minus 1 millimeter is the tolerance you are giving the measuring device must have, 0.1 millimeters as the precision should be there for the measuring device.

So, the speed of response of how long the instrument takes to measure the variable is called as the speed of response. You might have a data measured at what times it comes to a computer and does the data get transfer the time involved. The other thing is when we talk about others, the operating range reliability and cost or the other important characteristics which are there for measuring equipment. Accuracy, precision, resolution, speed, operating range, reliability, and cost, these are the seven most important characteristics of a measuring instrument.

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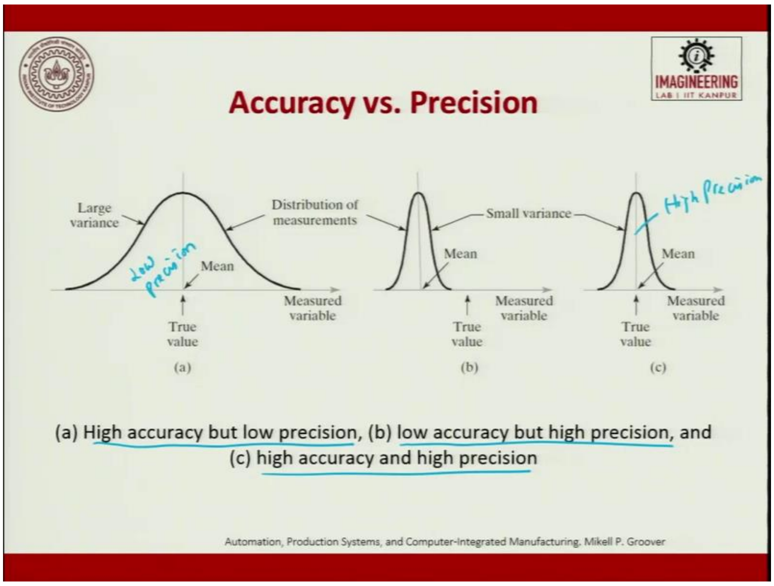

So, this is with a large variance the mean is here this is a true value this is the large variance you have and distribution of measurement you have it like this. And then here you have the same large variance is a small variance the mean still there. So the true value is here the mean is here. And the next one is the true value is here and the mean is around so, it is measured variable.

So, we can see so, this is of a high accuracy low precision, next one is low accuracy but, high precision because, it is all getting repeated at the same point. So here if you have a systemic error you can shift it and the last one is high accuracy and high precision the mean and the distribution variance are very close by. So, here it is of low precision, this is of high precision, low precision, and high precision.

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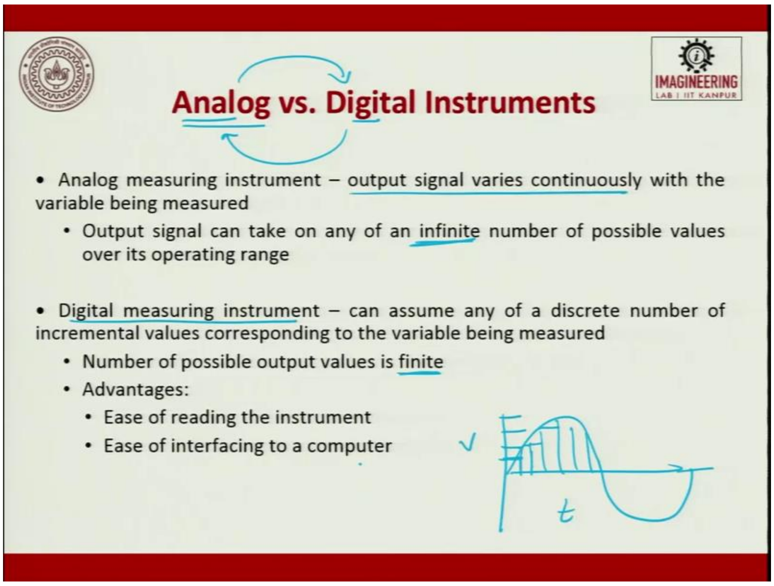

So, there are two types of instrument which are generally used for measurement one is called as analog the other one is called as digital. There is a mixed opinion people say all analog instruments should be converted in to digital and we start using the data but, now people say that digital puts a restriction on increasing the resolution more.

So, now it is better to have analogues data rather than to a digital instrument. Because there is a mixed opinion so, we can choose depending upon the requirements we can choose either analogues equipment or a digital instrument. Analogues measured instruments are output signal varies continuously with the variable being measured. So, for example, when we take a sinusoidal voltage, this is the time period this is the voltage so, you can see here, it varies with respect to time.

And now the same thing if it has to be digitized so, what we do is we try to digitize at this point. So here you see there it is all digitized so, you will have a voltage one shifts this time we will go to this so, next is high standard, next high standard, next high standard, it will go. So, can assume any of the discrete numbers of incremental values corresponding to the variable being measured is called as digital measured equipment. So, the advantage of analogues is output signal can take on any of an infinite number of possible values over its operating range.

If you want to split it to a smallest level you can keep splitting if you have a analogues data. Reconstructing from a digital data to an analog data will always have some error. So, that is why peoples say digital has a restriction. Earlier people use to convert from here to here, now peoples are going from here to here. So, here number of possible outputs is finite, here, it is infinite so, it is finite the advantages is, it is easy to read the equipment an easy to interface to a computer because it is a digital value.

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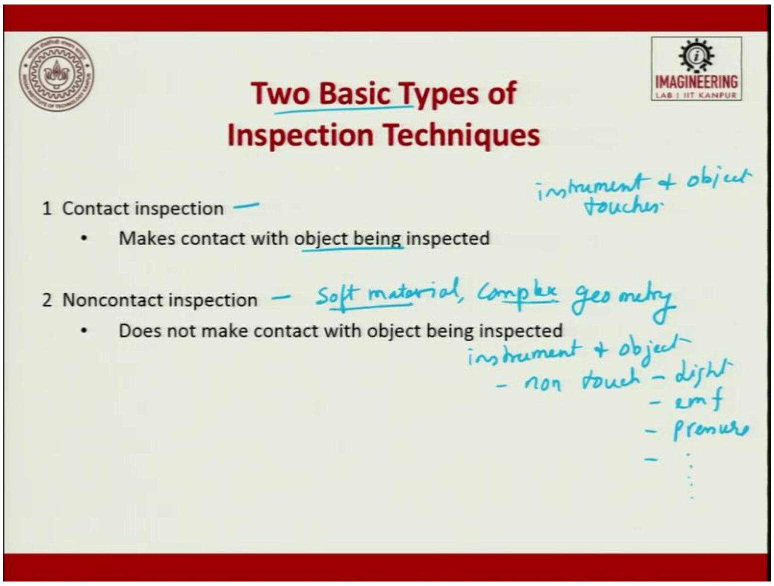

There are two basic types of inspection techniques one is contact, the other one is non-contact. Wherever there is a soft material and wherever there is a complex geometry, we try to go for non-contact inspection, contact inspection makes contact the measuring device with the object being inspected. The instrument and object touches here, instrument, and object no touch or it does not touch. So, what can we use? We can use light, electromagnetic field, proximity sensors can be used light can be used, we can use pressure, and so on.

So, a non-contact type does not make contact with the object being inspected. This is generally preferred for soft and complex geometries.

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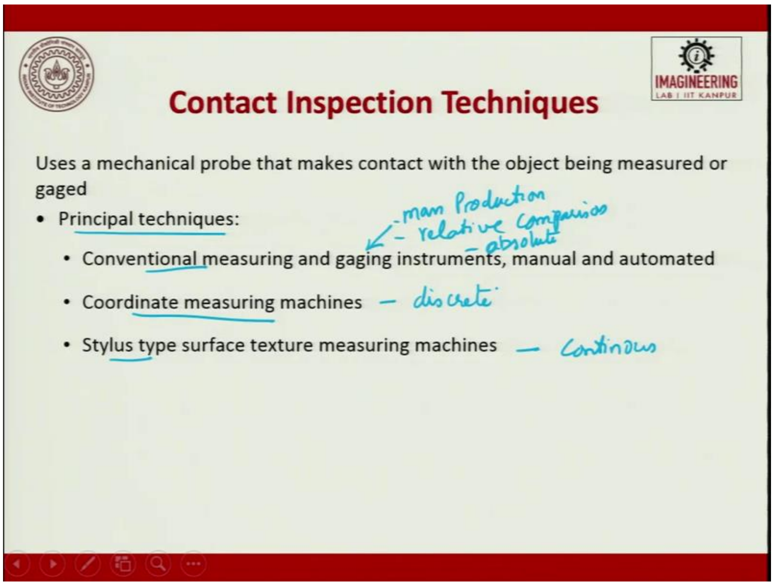

So, contact inspection techniques uses a mechanical probe that makes contact with the object being measured or gaged. The principal techniques are conventional measuring and gaging instruments, gages, gages are only used to for mass production and they are generally used to have a relative comparison. They will not give you the absolute value, absolute value cannot be there. If you just measure and say okay, that deviation, it falls within the deviation you are getting it.

So, conventional measuring and gaging instruments, manual and the automatic, all these things fall in this technique. The coordinate measuring machine is a part of a contact measuring machine. Today you have also non-contact type coordinate measuring machines where in which we use exhaustively optical.

Then, stylus type surface texturing machines are the other thing so, the three principal techniques are conventional measurements, coordinate measuring machines, and stylus measurement. So, the difference between coordinate measuring machines and stylus is here, it is continuous data we get. Here, it is discrete data we get by using the same contact probe we touch and then get it.

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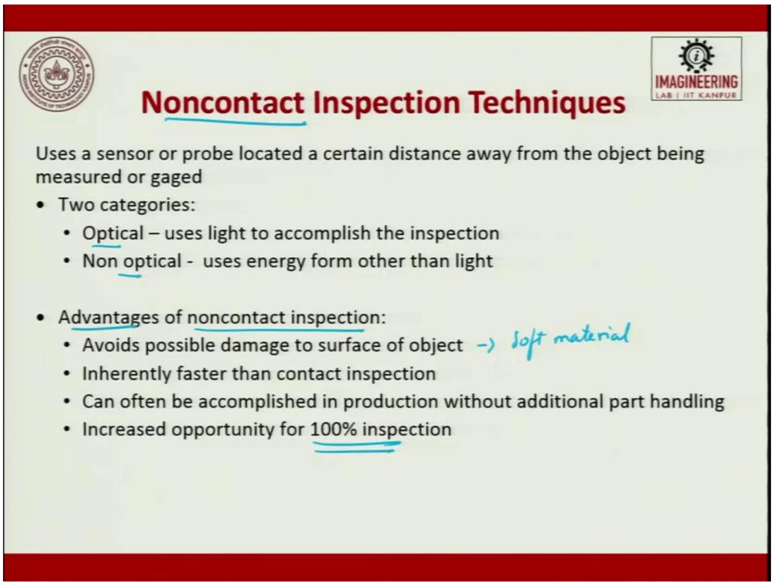

So, when we talk about non-contact inspection techniques use a sensor or a probe located a certain distance away from the object being measured or gaged. So, two categories, one is optical uses lights to accomplish the inspection, non-contact uses energy form other than light. So, the advantages of the non-contact inspection, is avoid possible damage of surface objects that is what I said, soft materials, it can be skin, it can be rubber, it can be PDMS whatever it is.

Inheritantly faster than contact, of course, yes, it is fast because it is going to scribe or and then go, it will not going to touch so, it will just move across it, can often be accomplished in production without additional path handling and then increase opportunity of 100 percent inspection. So, all these things are possible in non-contact today because of this advantage, non-contact inspection, is gaining more importance in a factory environment.

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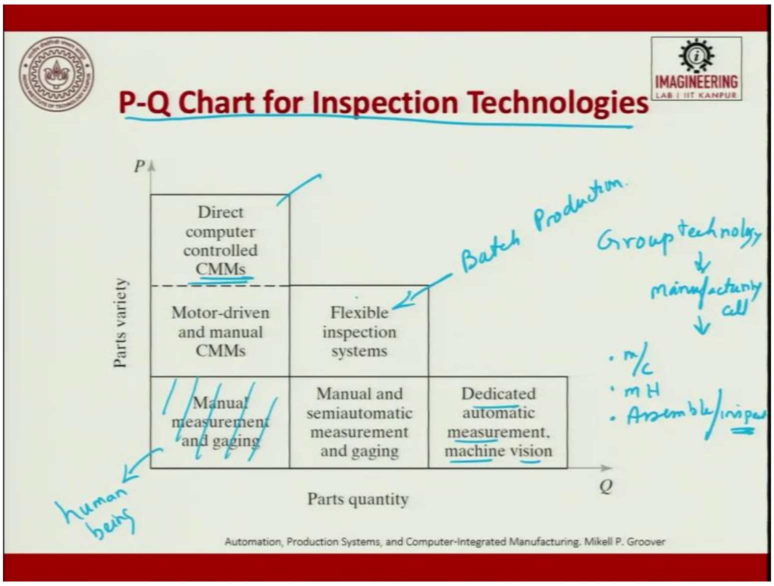

When we try to put PQ chart for inspection technique this is P and this is Q, this P is path variety and Q is path quantity. So, here if you see manually measuring and gages where and which we use human-oriented work is done here. So, here a human being is exhaustively used in measuring. Next, if you slowly move out the same thing if we could automate it is manual and semi-automatic can be done if it is more quantity lesser variety then we go for dedicated measuring machines.

And here, machine mission is also exhaustively used then, when we move to the large product variety, and quantities are very minimum, we use coordinate measuring machine. Coordinate measuring machine is assisted by a computer so, it is computer controlled coordinate measuring machine, wherein which flexibility is more quantity is less.

Then we have two more boxes so, one is for batch production, we will use flexible inspection system, we will see what is flexible inspection system later and here, it is motorized control it will not be computer control, but motorized control so, it is predominately by using a joystick.

So, this and this there will be a small overlap in the instrumentation part of it so, this is a PQ chart for inspection technology, this is very important for you to understand when we talk about CIMS environment which equipment to choose and what should be the level of automation in the factory.

When we talk about group technology leading to a cell, that means to say a manufacturing cell, we will have machines, we will have material handling devices, we will have assembly/inspection. So, inspection we have to think which machines to use and what should be the level of automation.

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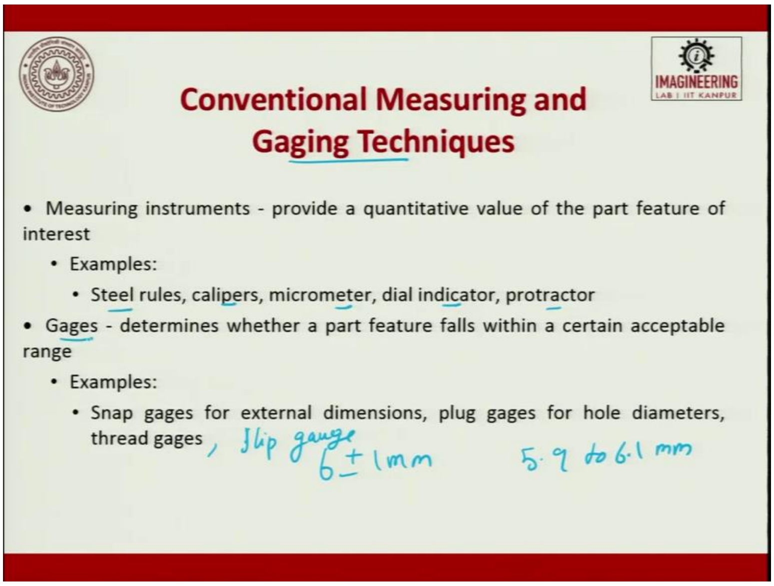

Where, the conventional measuring and gaging techniques, measuring instruments provide a quantitative value of path feature of interest. For example, steel roller, caliper, micrometer, dial indicator, protractor all these equipment provide a quantitative value of the part feature of interest. Next is gaging techniques, in gages what we determine, determines whether a path feature falls within a certain acceptable range. So, it will not absolute I told, you know, so suppose, if it is 6, plus or minus 1 millimeter you will try to have a gage which measures from 5.9 to 6.1 millimeter so, within that, it will only say yes, go no go, that is all.

So, gage is more of compare it and measurement so, determines whether a part feature falls within a certain acceptable range. Example, snap gages for external dimensions, plug gages for internal dimensions, thread gages, and then we also have slip gages. All these things are used for comparison and then we try to develop. So, these are the conventional measuring device and gaging techniques.

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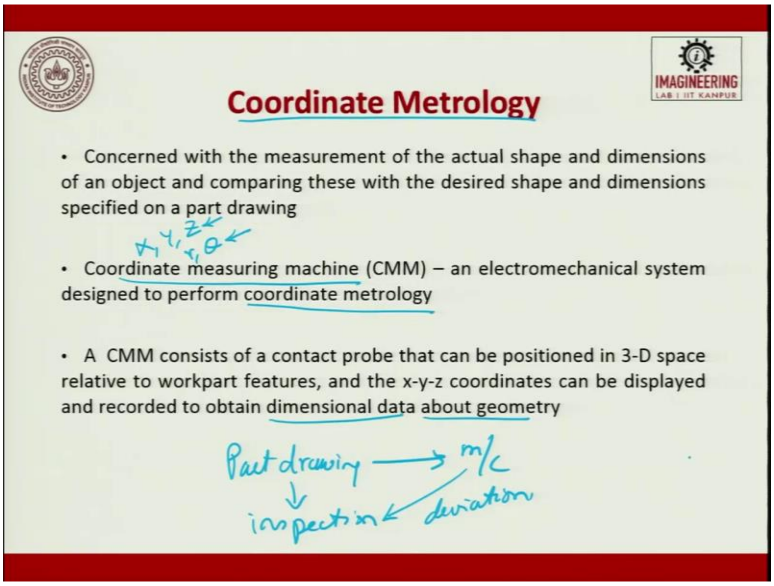

When we talk about coordinate measurement so, these two if we go to P to Q chart it is more of manual assisted measuring. When we talk about coordinate measurement concern with a measurement of the actual shape and dimensions of an object and comparing these with the desired shape and dimensions specified on a part drawing. So, what is that you have developed a part drawing you have used it for machining and now, same part drawing is used for inspection.

Now, in inspection what it does is, it compares with what is given in the part drawing and what is the deviation. To do this, we will use coordinate measuring machine, when I say coordinates, x coordinate, y coordinate, z coordinate, r coordinate, and theta coordinates are generally used. This is for partition and this is for polar so, you can use both or a combination of these two can be used for measuring.

Coordinate measuring machine, and electromechanical system design to perform, coordinate metrology. In a part drawing when you draw it in a three-dimensional view all you have is x, y, and z coordinates. So, while measuring we give the same x, y, z coordinates. A CMM consist of a contact probe that can be positioned in 3D space relative to work part feature and the x, y, z coordinates can be displayed and recorded to obtain dimensional data above the geometry. So dimensional data is nothing but the x, y, z data.

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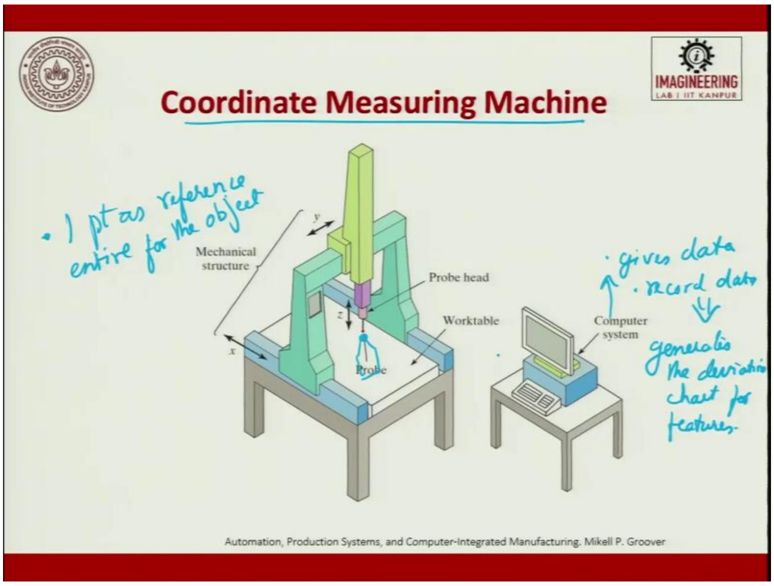

So, this is a typical coordinate measuring machine, the interesting part of this measurement is you can have 1 point as reference for the entire object. For example, if you try to use a Vernier caliper and dial gages and the other measurements it is very difficult for you to measure with respect to one reference and give the data. But, in CMM it has a 1 point reference you put a calibration dial you calibrated and then that you make it as one coordinate system 0, 0 then you transform the user coordinate system measure it on the part and then report it.

So, coordinate measuring machine is an instrument which is exhaustively used in a CIMS environment so, the data is attached to a computer the computer gives data, records data, and finally generates the deviation chart for features. All can be done by a computer.

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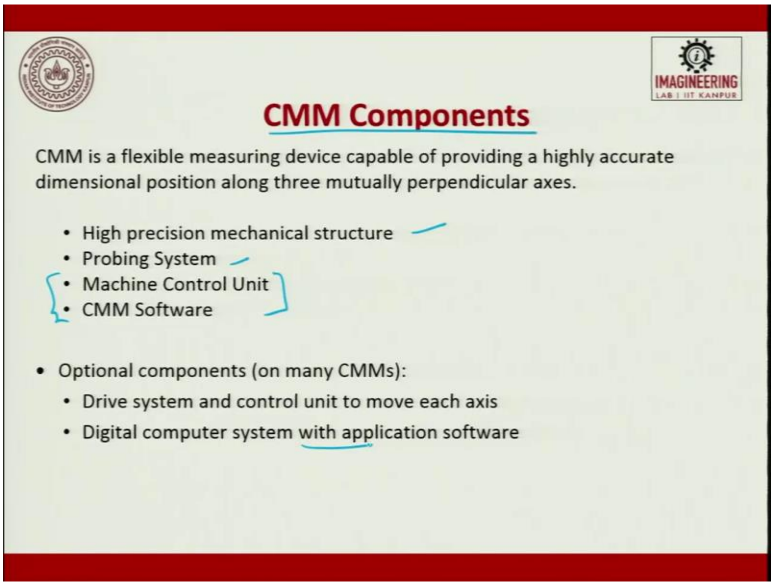

So what are all the components of a CMM? CMM is a flexible measuring device capable of providing a highly accurate dimensional position along three mutually perpendicular axis, highly precision mechanical structure, these are the components probing system, machine control unit, and the software. So, these two are very important, these two are of course more software-oriented. The optional components on many CMM are drive system and control units to move each axis like a pendent given, a digital computer system with application software.

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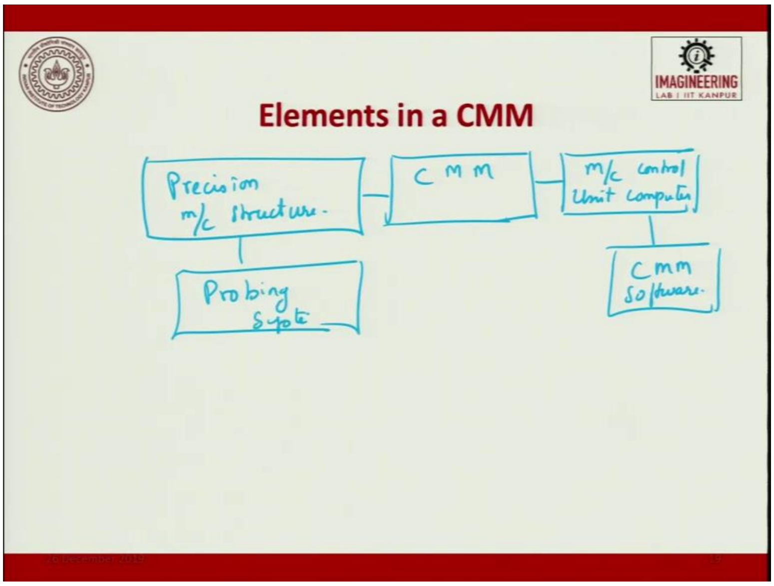

What are all the elements of a CMM? You will have a precision machine structure, this leads to a coordinate measuring machine, you will have machine control unit computer, then you have a CMM software, then you will have a probing system.

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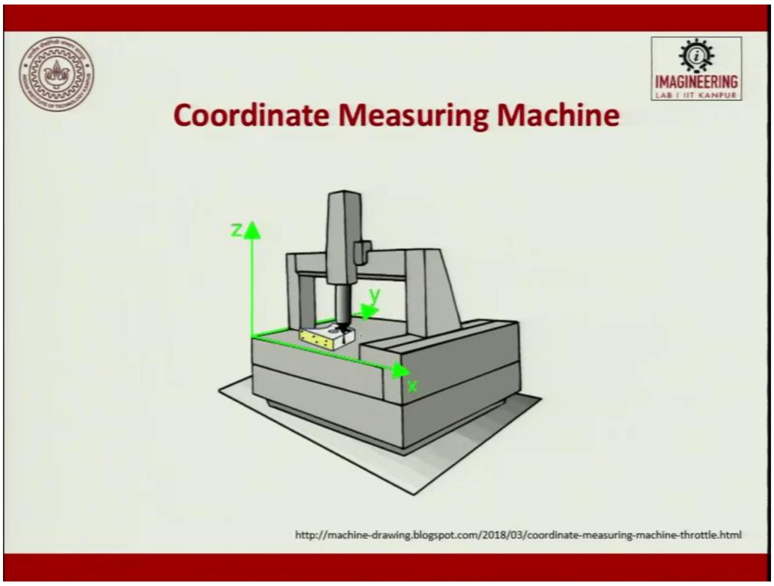

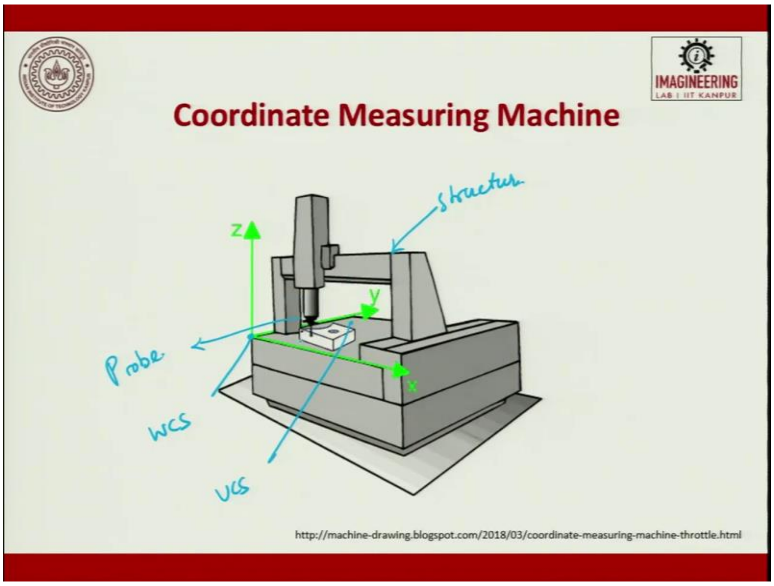

So this is how a CMM works so here is a part so, the this is a probe so, this is the structure what moves, this is the structure and you have this is the probe and then this is the well coordinate system and here, you will have a user coordinate system and here the probe touches the work peace and wherever you see a dot points these are all the points.

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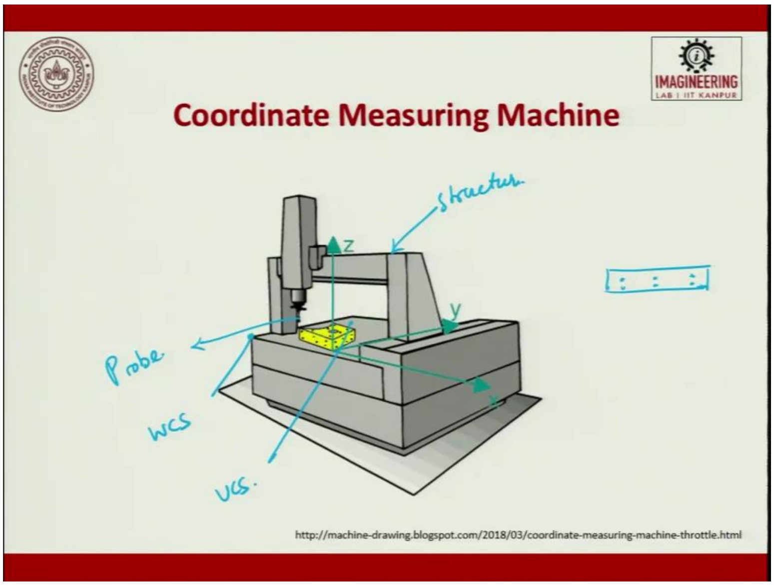

Suppose, you want take a plain so it touches 6 points and it tries to generate a plain surface. So these are the points the data points are taken and then, the data is now using a help of a computer and then we try to get the data.

You can say world coordinate system x, y, z, and then you see how does this coordinate system changes. So, they get all the data on the different types of surfaces. You see here, it is transformed, so it is rotated and then you try to get it. So, you can transform with respect to this probe or with respect to the workpiece. So, I would prefer that you can put it to the workpiece itself.

User coordinate system can be well coordinate system transform to user coordinate system and then you try to get the output.

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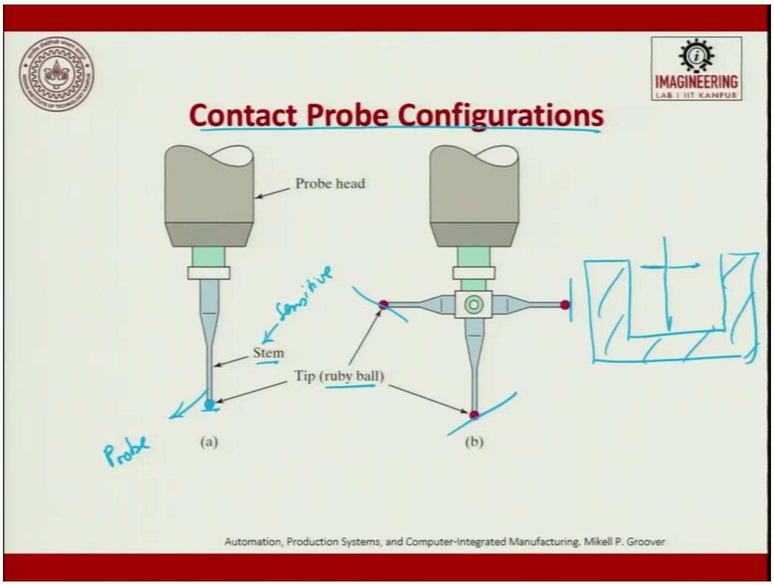

So, the most critical part is the structure wherein which the resolutions, all these resolutions repeatability, reliability, precision, all these things are taken care of. But, the heart of the CMM comes from the probe. So a probe has a spindle to hold the probe, this is the probe. This is the probe head and this is the probe.

So the tip of the probe is always circular in nature, why? Because, you can get a point contact or if you have a dot, then it might get worn and torn so it is always better to put a circular one, so you get a point data. So, circular is very useful when you have a perpendicular surface when you have an angled surface so, it can try to measure.

So, this round is a sapphire ball, alumina ball, or a ruby ball which is used it is spiny polished and it is placed at the tip. So, this is the stem, the stem is very sensitive, so any touch it can quickly deduct and do it, you can have a single probe you can have something like a star probe so, star probe if you have a hole to be measured, so now if you use a single probe it is going to take time.

So, what you do is, you try to do the depth and simultaneously move along the sides to get what is the width? or what is the diameter of the hole and the depth of the hole? So, for this, we use a star type probe. So, there are several configurations I have just put only two, for your understanding.

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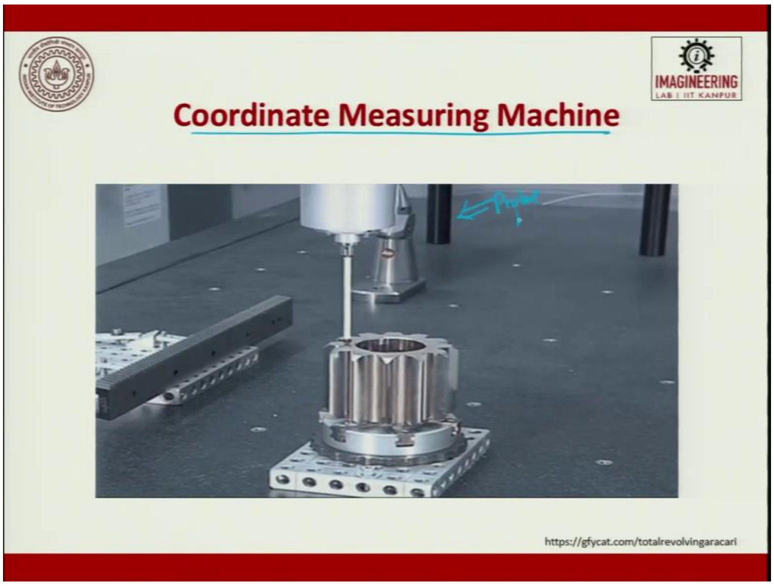

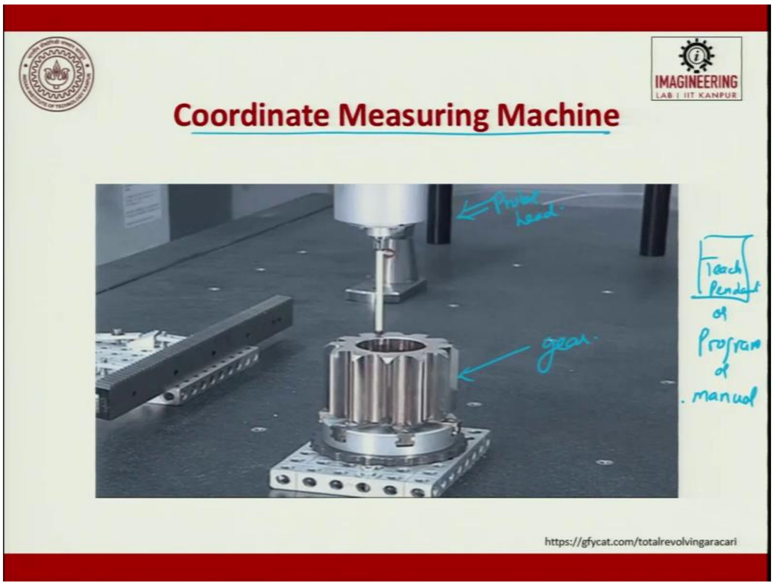

So this is a touches a single probe touch base, wherein which it touches the gear at several points. If we look at it, the points who decide at the points the points have been decided from the part drawing and not all the features will be measured only, critical features will be measured such that it will make sure the quality of the gear is good. So, this is the probe head.

This is a gear, very interesting, and it is all done automatically by the way. You can do it manually by a teach pendant, and what we studied in robot. We can also have teach pendant or we can write a program to do, or we can manually operate by a pendant which is there. So, this CMM works on programmable type. All the three options are open.

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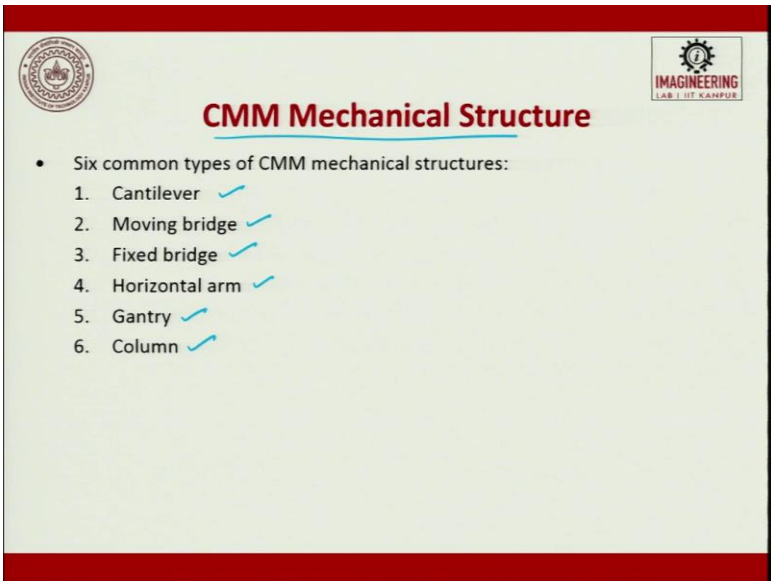

So, the mechanical systems, there are 6 common types of CMM mechanical structures there are 6 types. So, cantilever, moving bridge, why is this, this is like a robot what we studied body and the arms same say we have studied here. Structures, cantilever type, moving bridge type, fixed bridge type, horizontal arm, Gantry type, and columns type. You have to choose depending upon your size, shape of a component, you have to choose a structure because this structure is going, decide the resolution, repeatability, reliability, precision of your system.

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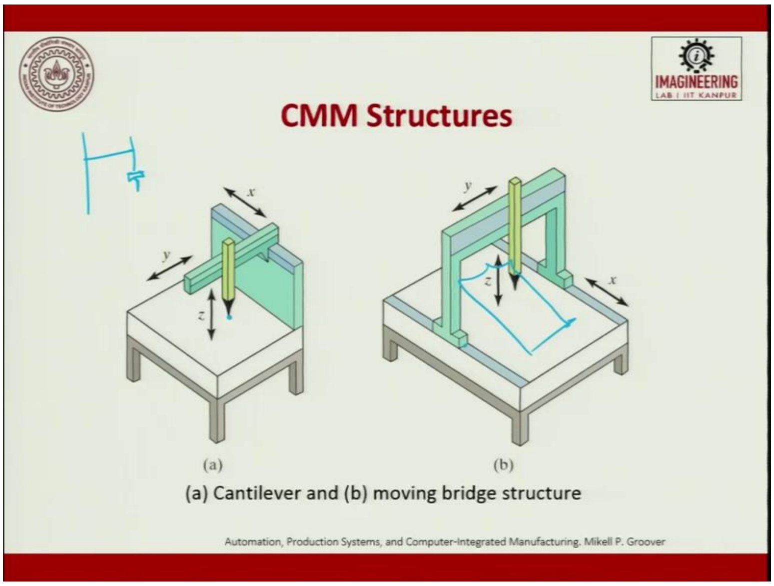

So, this is a typical cantilever type this is a cantilever type okay so, there is an overhand and there is one more overhand then you have a stylus which touches and then you try to get the output. So, if there is an error in this stylus, it is transfer to this and so, naturally, the error data whatever you measure is going to be tricky to handle.

So, first, we do calibration if it all there is sag we try to remove it and then get it done. So, the next one is going to be moving bridge so, this is moving along so, suppose you have a car here. Large component a car here or a rocket part which is a larger diameter you can place it here, and the gantry moves slides along the x-direction and then you try to get the data.

The advantage of this moving bridge as compare to that cantilever is if there is an error which is happening in the x-axis that will be carried to y-axis and z-axis while you here, what happens it will be removed to a large extent if there is an error in the x-axis, you can nullify after measuring with y and d z.

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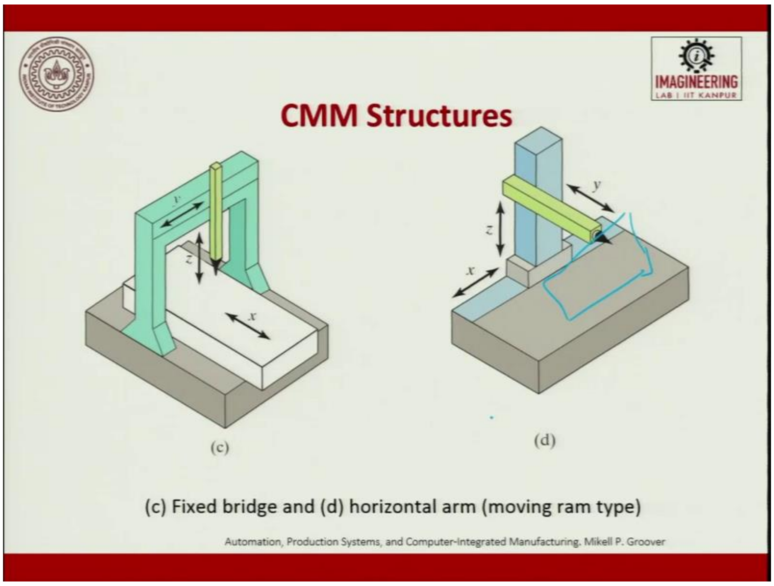

So, it will not be carried so, the third one you can have is fixed gantry but a moving table. The next one is horizontal arm so, the difference between the horizontal arm and the cantilever type is, there is a horizontal and then there is a vertical, here there is only horizontal so, if you have a large component and if it is along a plain and you want to measure it along the vertical axis then we use this horizontal arm.

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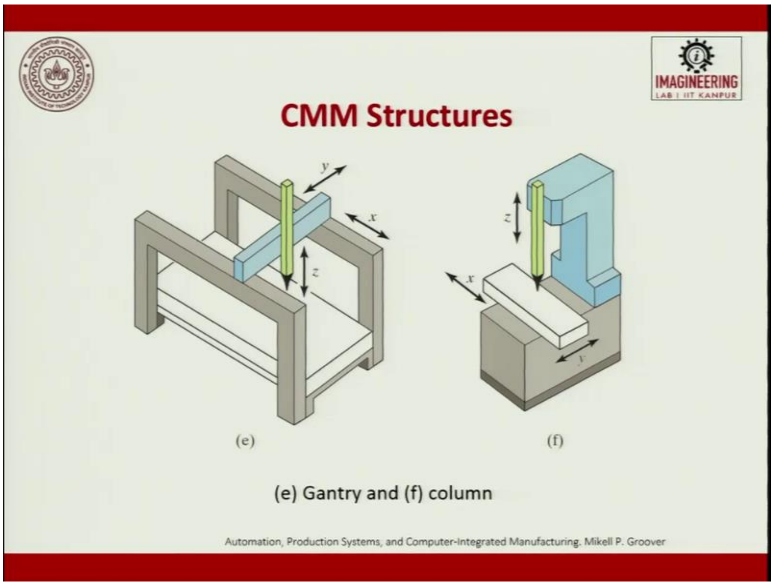

Then you have a gantry type which is used and then finally it is also a column type. These are the 6 common CMM structures which are exhaustively used in the factory environment. So, Thank You.