Rapid Manufacturing
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Lecture – 14
Laboratory Demonstration, Co-ordinate Measuring Machine (Part 1 of 2)

Good morning. Welcome back to the course.

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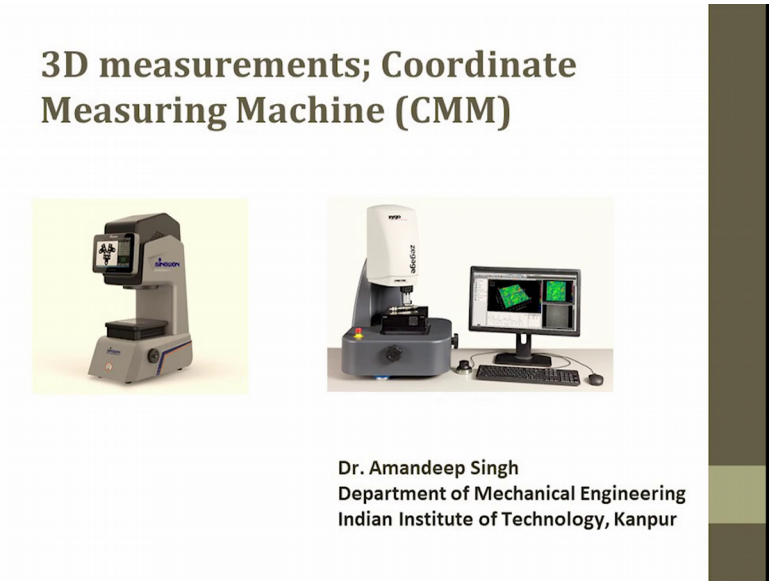

In this lecture, I will discuss 3D measurements and coordinate measuring machine. 3D measurements specifically I will discuss 3D scanning coordinate measuring machine, we will have a lab demonstration on the coordinate measuring machine. The coordinate measuring machine that we have here in IIT, Kanpur in machining science lab in mechanical engineering department is one that will work on.

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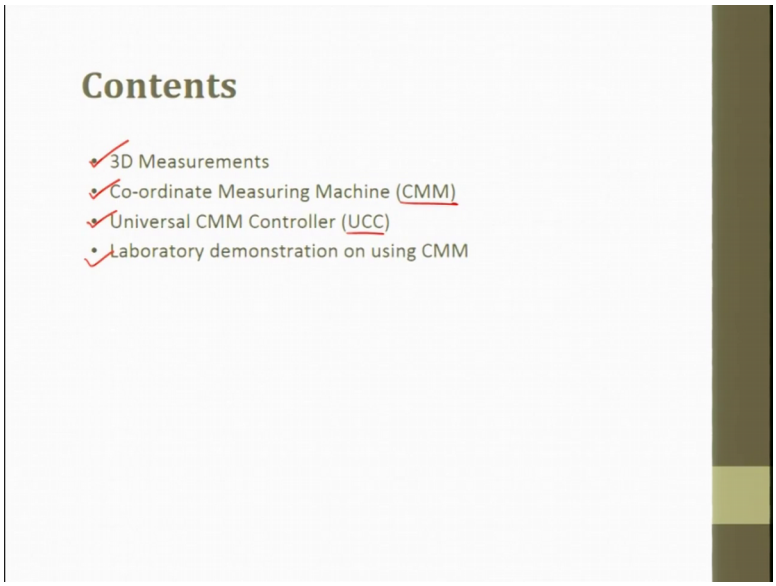

Before the start of the lecture I will just tell you what is 3D measurement,s we will just recall those. Then what is coordinate measuring machine and specification of this machine, the particular machine that we have in our lab that I will give you. Then we have UCCs, universal CMM controller that is kind of a inbuilt component I can say the if the if I think of the whole CMM machine the controller that controls the machine is known as UCC.

So, laboratory demonstration on using CMM, there will show you the parts the various heads all the axis, and we will see that what are the degrees of freedom all those things we will see. And also we will try to measure one component that would be a kind of a standard component.

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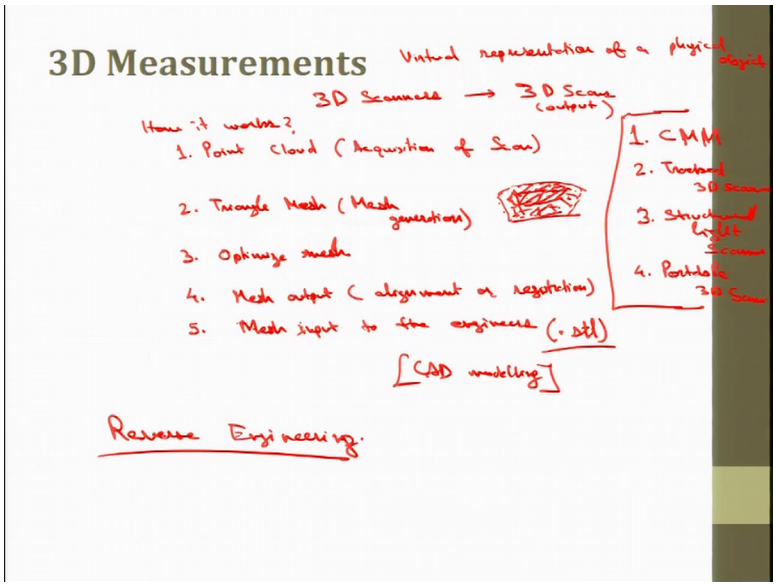

3D measurements, what are 3D measurements, 3D measurement is a process of creating measurement or virtual 3D representation of a physical object. This is virtual representation of a physical object ok. Now, 3D scanners are optical devices used to create 3D measurements or a 3D scanners, we have 3D scanners ok. 3D scans if I say 3D scanners, the outputs are known as 3D scans, 3D scan is the output ok.

There are certain kinds of 3D scanners we have measuring on 3D scanners, tract 3D scanners, area based 3D scanners, portable 3D scanner, portable 3D scanners could be held in hand. And for instance I will like to just scan this object.

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I can scan it form one view, side view, second view and third view ok, that is front view, side view, top view any view I can think this see. I just need to see that make sure that the angle on which I am scanning is also recorded in the software as well. So, I am putting the same a input in the software. So, they are kinds of scanners here. So, these outputs are known as 3D scans.

So, while the mainstream manufacturing continues its exception with 3D printing 3D scanning is act of capturing data from objects in the real world and bringing them into the digital pipe line. A recent study has reported that there would be about 15 percent increase in the production using 3D scanners annually. So, this is high rate 15 percent.

So, portable 3D scanning is actually (Refer Time: 03:25) the movement from laboratory to the front lines factory and field driven and followed by key factors, and because they are low cost. So, better accuracy is there, simplicity is there, convenience and flexibility is there. So, 3D scanners can scans the real object and produce a virtual image of that ok. It can a produce this object how, what are the steps for that I will just give a brief introduction to them as well.

So, before that therefore 3 or 4 types of 3D scanners, number one that I am going discuss here is CMM. This I will discuss in detail coordinate measuring machine. So, in these arms can be equipped either fixed probe or touch trigger probe heads. It is also possible to mount a 3D scanning head on the CMM. So, we will discuss this had many

advantages that many different tools can be mounted on a on the portable CMMs and making it possible to easily integrate scanning and probing.

So, limitations also there portable CMM, CMMs, you do not need to be fixed on the surface for use the physical link. So, we do not have a portable machine, we have a full fledged 3D scanner not a very big industrial size, but for research it is quite capable of producing the outputs that as required. So, also we are doing some industrial consultancy here as well.

So, second type of 3D scanner is tracked 3D scanner; tracked 3D scanner. Now, tracked 3D scanner here optical tracking devices can track various types of measurement tools including positioning of a 3D scanner. So, position method k v, external optical tracking device, this can use an external optical tracking device to establish positioning. So, they usually use markers such as passive or active targets that optically bind the tracking device to the scanner. So, another kind of a scanner is structured light scanner, structured light scanner.

So, by structured light I means that these scanners project a pattern of light on to a part or a process when it is happening, and how the pattern is started when the light hits the object. Either in LCD projector or scanned or defective laser beams projects the light pattern one or two or a sometimes more sensors record the projective pattern. So, it just put the light. And these structure light scanner the patterns in the change of a light tells us the various profiles or the curves of the object. So, this is another way.

So, one more type of scanner is portable 3D scanner, portable 3D scanner can be either CMM or they meant as a portable 3D scanner anything that can be held in hand and taken to the machine or the component that will lead like to measure is would be called as portable. So, these are the major kinds of scanners.

I am just introducing, I am not getting into details for details, we will share you the notes and you would read them. So, how does 3D scanning works? What happens, when it scans when it try to scan when we use CMM machine, it will try to touch the points ok. The first step it produced is the point cloud ok. I will write it, how it works. The first step is the point cloud. So, point cloud like an even better put as this is actually acquisition of the data, the data or the shape whatever we like to we are trying to just, this is the first input I am getting from my softwares. So, this is this is I can say acquisition of scan ok.

So, if I need to produce this surface the points would be produced first, this kind of curve the points would be produced first. So, this kind of points would be produced ok, the curve, it means this is the one surface ok. The points are produced, these are the points, this is point cloud. So, this scanning results are representing using free form. Now, this is seems to free form or unstructured form sometimes the structure components are like we have a circle, a cone, a plane, a rectangle or when these things are known the known shapes are there, those are known as structured forms. This is a kind of a free form ok.

However, if we know about; if we know about the curves, Bezier curve, these line curves, those are also there, but nowadays those are also not very significant even the three forms any curvature that we need is quite possible to be scanned using the 3D scanners. So, first point is the point cloud.

Using the point cloud we create a triangle mesh ok. What is triangle mesh? Now, this is the point cloud, we will make triangle out of this joining a point with other point we are make the triangles ok. Similarly, the whole surface would be in the form of the triangles, this is known as triangle mesh. So, this is actually I was just call it mesh generation ok

The third step could be when the mesh is generated, we need to optimize the mesh. Optimize mesh means their number of triangles you know when we conduct the analysis or when we conduct the strength analysis or heat analysis, this is the mesh. The number of triangles makes the more the number of triangles are more would be the computational part. So, it depends upon what type of computation we need to do. So, optimization of mesh to reduce the time of computation and to get the optimum shape as well, it is also important.

For instance, if the steep angles here, if the steep angles here, if the triangle mesh can be the smaller triangles, here it is the kind of plane surface. If it is a kind of a plane surface here, so either triangles can be of bigger size. So, we need to optimize the mesh to obtain the near possible shape here ok. So, optimization of mesh is required then.

After that fourth point here could be the output of the mesh. So, images and scans are brought into common reference system, where data is merged into a complete model ok. Complete model, data is merged and the complete model is from this process is called alignment or registration or we can call as mesh output. This is alignment or registration.

So, we have scan from front views, when we are aligning those surfaces to get this specific shape, the solid shape, this is known as complete mesh output.

So, after that so mesh input to the engineers, mesh input is the engineer workflow. So, this output goes, I will put the mesh input to the engineers. So, this mesh input goes to the engineers, they can create a surface if they like out of that. So, they can create a solid model if they like. So, these things can be created using this. So, this is the next step. So, this mesh input goes to the engineers how does it go to them, it is generally produced in the stl format; dot stl format ok.

So, the computer software can be used to clean up this scanned data filling holes, correcting errors, then data improving the quality. So, the resultant triangle mesh is typically spotted in this format stl format, and we can brought it into the known forms. Like we can convert it into the Bezier curves if it is possible if not then also the things are things can go ok. So, cad modeling can be produced out of this ok. So, this was the brief introduction about 3D scanning. Next where does 3D scanning apply the major application is in reverse engineering.

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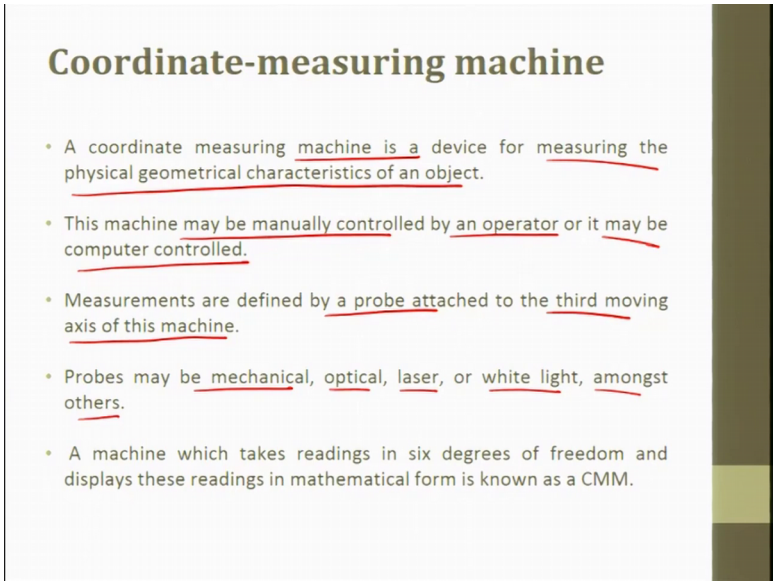

Now, I will like to move to the coordinate measuring machine. A coordinate measuring machine is a device for measuring the physical geometrical characteristics of an object this I have just explained ok. This machine maybe manually controlled by an operator or it may be computer control. So, we will show you the both operations, the manual

control using a joystick and CNC mode as well. CNC mode is computer with numerical controlled, we just give the initial point over this is a starting point.

Now, after each mm or after each 2 mms, we can just give that distance, it will just recording the points on a specific plane or on a specific curve or we can then change the direction of our probe those things can happen. This is CNC control. Manual manually also luck we just using a joystick, we can keep touching the probe to control the data.

So, measurements are defined by a probe attached to the third moving axis of this machine a three axis, x-axis, y-axis and z-axis. In z-axis, z-axis, third moving robe will attach, so that helps us to record the data. So, probes may be mechanical, optical, laser, white light and many such. Mechanical optical is like you know laser, white light all these examples, but probe we have here in our machine is the mechanical probe ok. It will physically touch the component that we were trying to measure it will touch, and it will produce a beep sound and also an indicator would blink.

So, whenever it touches here. So, this probe will use here. The machine which take readings in 6 degrees of freedom, and this place these reading in mathematical form is known as coordinate measuring machine. This is a freedom that is all the dimensions all the taken into account, and display the reading is in mathematical form.

When mathematical form that readings can be obtained like the distance between the two objects and the shape of the object if it is a free form it will create a free form. If we know that if there is a structured form we can selected before and only this is a circle that we are going to measure; for a circle, 3 points are minimum are required to measure; for a plane, 3 points are required to define a plane; for a cylinder 8 points required; for a cone 8 points are required. So, I will come to them when I will actually show you the lab demonstration.

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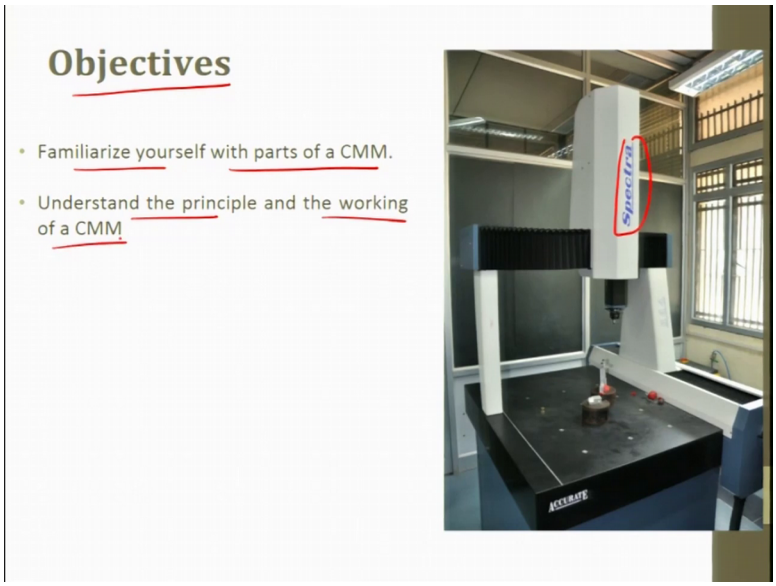

So, objectives I have just put the objectives of this lecture is to familiarize yourself with the parts of CMM, this specific CMM we have spectrum CMM in a laboratory, and understand the principle and working of a CMM ok.

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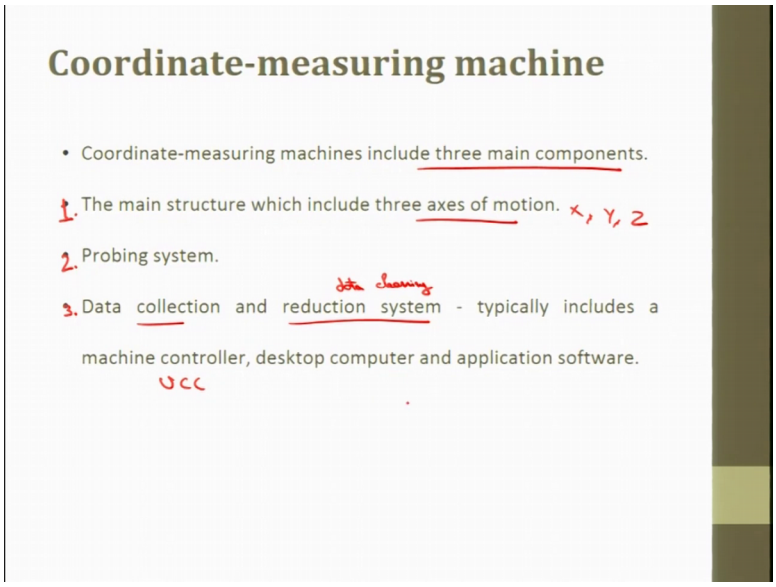

So, coordinate measuring machine include three major components. Number 1 is the main structure with include three axis of motion X, Y and Z-axis. Number 2 is the probing system as I said we have a mechanical probing system here. Number 3 is the data collection and reduction system. Data collection data reduction means we clean the

data; data cleaning ok. So, this typically includes a machine controller, machine controller is a UCC, desktop computer and application software.

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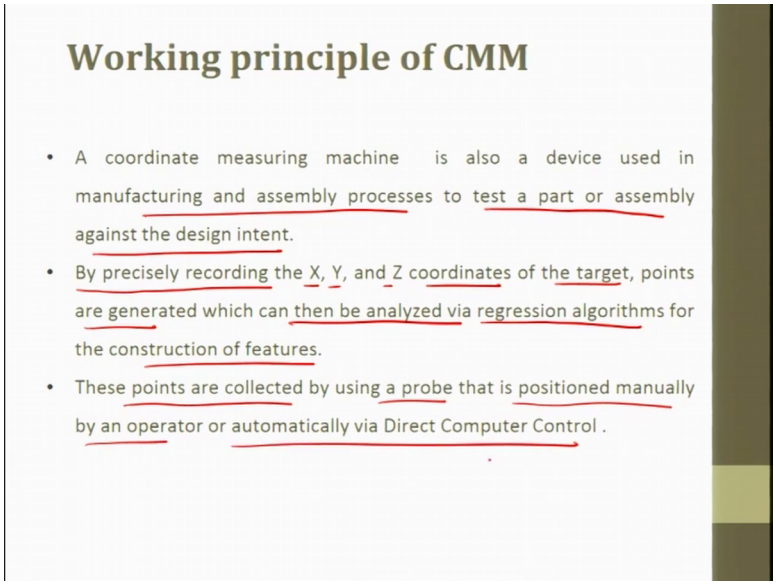

Now, working principle of CMM; a coordinate measuring process is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. What is our intent for design against that with test whether our part or assembly is trying to meet that or not. So, by precisely recording the X, Y and Z coordinates of the target points are generated which can then be analyzed via regression algorithms because we might we can have the mathematically relations mathematical equations which are regression algorithms as well. So, these via regression course algorithms, the points can be analyzed for construction of the features that we finally, need in above product. Now, these points are collect by using a probe that is position manually by an operator or automatically by direct computer control.

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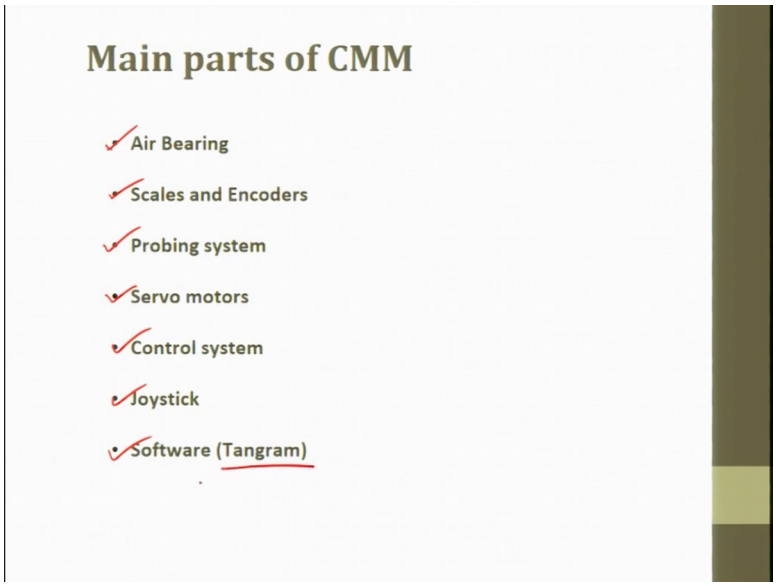

So, main parts of CMM are air bearing, I will show this parts do there. So, we have pneumatic bearings here; so, then scales and encoders, probing system, servo motors, which are just making the parts to move. So, control system is here, joystick is here, software is here, software that we use that is Tangram software.

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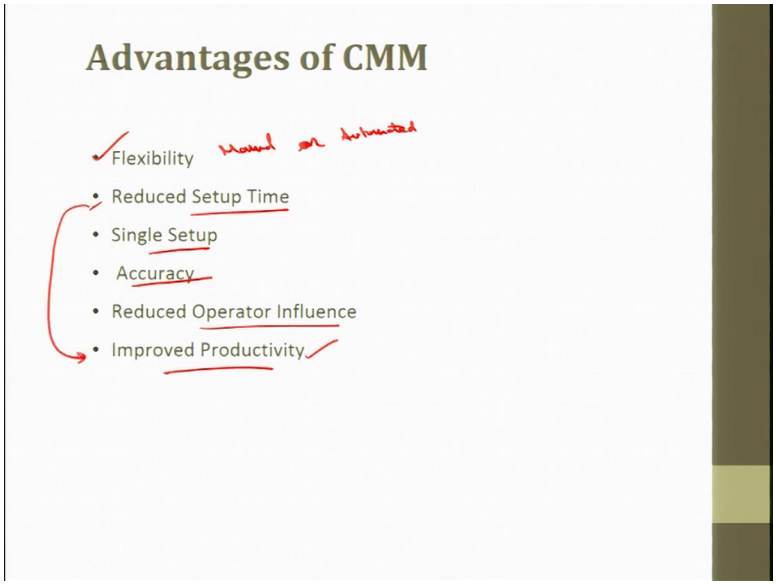

So, advantages of CMM, this I should have told you after completion of the whole lecture ok, but advantages here are the flexibility. Flexibility means we can use it manual or automated ok. So, in manual system, this is a big flexibility that whatever we need to

measure if we know the some initial information basic information we can use it accordingly according to our requirement. Reduced setup time is there, there just because the only work piece it will be set on the work table. The single set up is here, accuracy is high.

So, reduced operator influence is there, because operator is not actually touching or just making the work piece or probe to move. It is moving by itself is just trying to control the joystick. Once he defines the coordinate, he defines the origin, he defines the plane once the plane is defined by our probe; so, it has fix that plane ok. This is a reference plane, that means, every based on this f x plane if we do not change anything in the in the setup it will measure all the things accurately. So, operator influence is very less. So, improved productivity because we have reduced set up time ok; these are interrelated.

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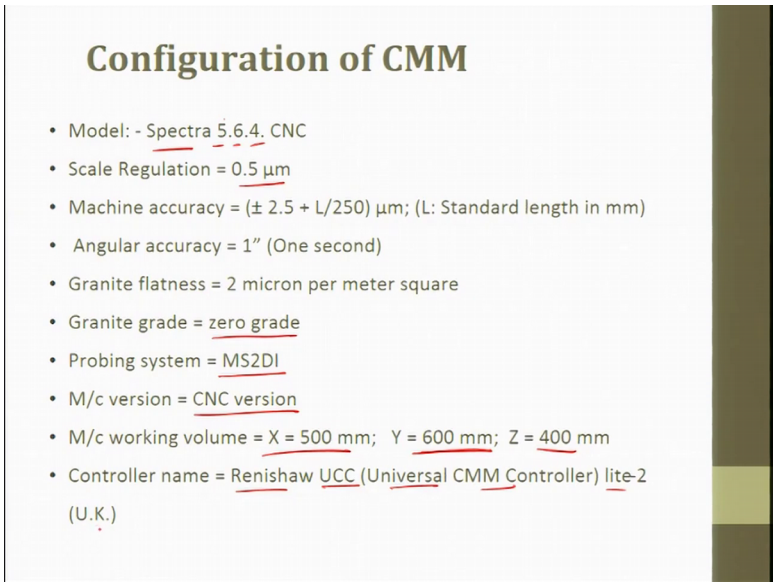

So, the CMM machine that we have here I will the configuration of that is it is spectra 5, 6, 4. What is 5, 6, 4? 5 is 500, 600 and 400 is the work area or the workspace that is available in the 3 axis; 500 mm, 600 mm, 400 mm ok. In scale regulation is 0.5 micro meter; machine accuracy is plus minus 2.5 plus alba 250 micrometer. So, this L is standard length in mm.

So, angular accuracy is by 1 second of the angle. So, granite flatness granite is the work table that we have it is the flatness it is the zero grade granite. So, the 2 micron per meter square is the flatness. So, it is quite smooth to keep our measuring instruments on over it.

So, it is zero grade that is thermal expansion is also 0. So, probing system this is the name of the probing system here machine version is CNC version. Machine volume is as I said 5,6, 4, 5, 6, 4 is X in X direction we can move 500 mm, in Y direction we can move 600 mm, in Z direction we can move 400 mm. So, controller name is Renishaw UCC, universal CMM controller lite-2 from UK.

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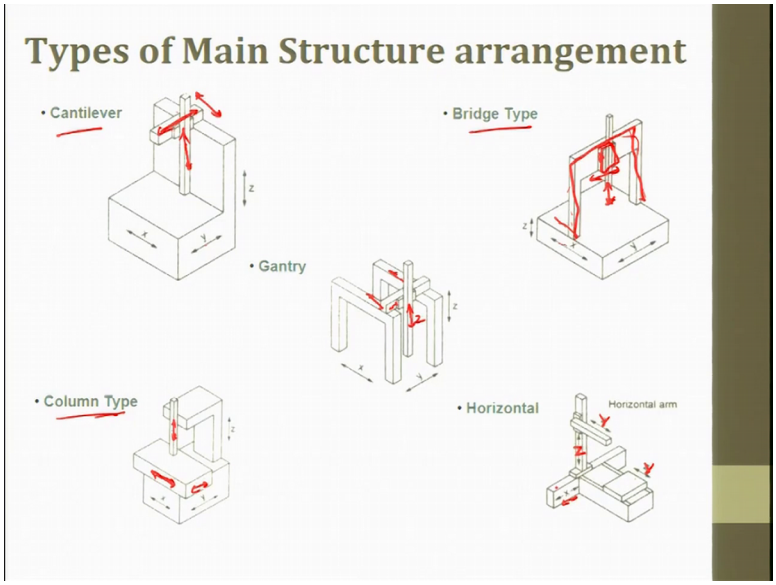

Types of main structure arrangement in the CMM machine are cantilever, you know this is the cantilever beam ok. The cantilever moving beam is moving in X direction. Cantilever beam can move in X direction and all these cantilever beam we have this arm that can move in Z direction. So, second one is column type in column type, we have the table that can move here. This table can move in X and Y direction; in Z direction this arm can move ok. So, this is the column that is attached here.

So, similarly we have gantry. So, in this you can see that this can move in X direction here. So, this can move in Y direction. So, this can move in Z direction ok. Next is bridge type is the machine that we have in our laboratory. In this, we have X direction. This whole bridge can move in X direction this whole bridge can move in X direction. This column can move in Y direction, and this arm can move in Z direction. Horizontal machines in horizontal how machines this is for X moment on this direction, y this is actually this should be Z, this should be Z, and this should be Y ok, Z in a top and on direction, so y in this direction.

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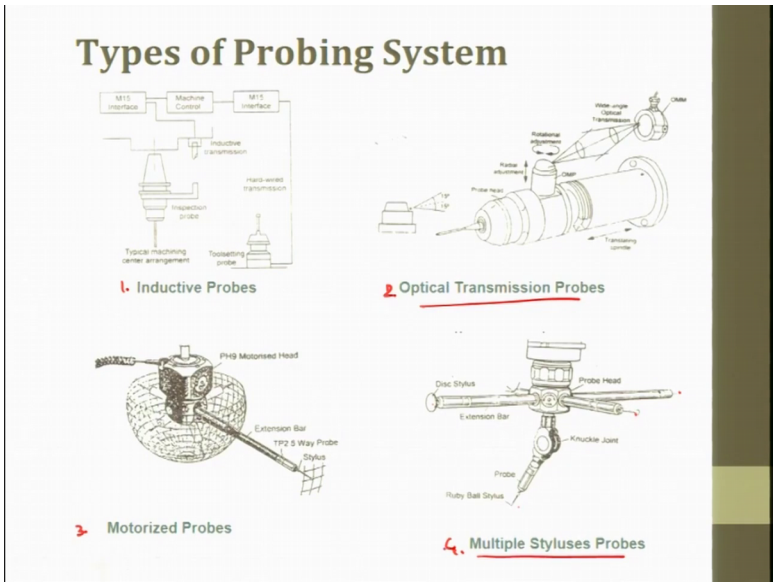

So, different types of probing systems are there, we have inductive probing system like we have induct inductive probing system, we have machining center arrangements. So, inductive or inductive transmission is the principle in using this probe. Then optical transmission probes are there. When optical transmission is the principal, similarly we have motorized probes motorized probes in which this is just we have the motors and motors can just rotate the probe or move the probe.

So, multiple stylus probes are also there. So, in the first three probes 1, 2 and 3, we had only one stylus. So, in the fourth one multiple styluses probe, this system can be motorized system can be inductive, but we have multiple styluses once on this like ruby stylus, then different stylus, and disc stylus different styluses are there. This is the probing system.

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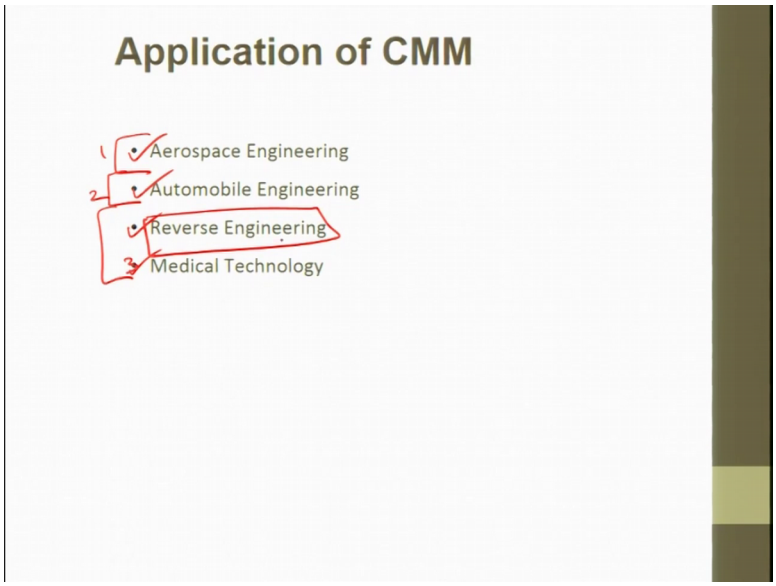

Now, application of the CMM is in aerospace, automobile engineering, reverse engineering, medical technology, we can this actually applied in all these things. Reverse engineering is reproducing the products. So, these three are the industrial domains 1, 2 and 3, three are the industrial domains. So, reverse engineering is the general application. So, with this I will just like to take a break here. And we will meet in the machining science lab in mechanical engineering department in the laboratory, and we will see how coordinate measuring machine works.

Thank you.