Metrology
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Lecture – 37
Universal Measuring Machine (UMM) and Coordinate Measuring Machine (CMM)

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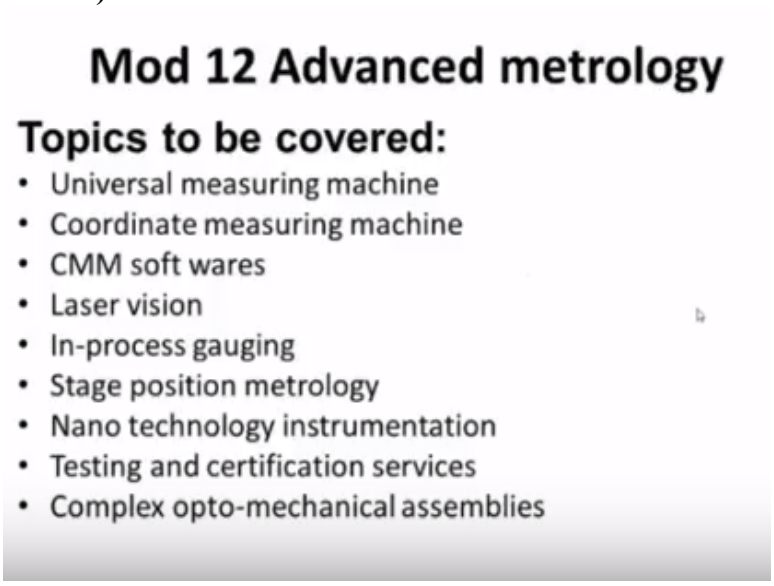

I welcome you all for the series of lecture on metrology, now we will start the module number 12. In this module, we will be discussing about advanced metrology. In this module, we will be discussing about the following topics and advanced metrology. We will be discussing about universal measuring machine, coordinate measuring machine, what are the softwares used in CMMs and then we will move on laser vision, in process gauging, stage position metrology.

Then, we will be discussing about the instrumentations used in nano technology and then we will discuss about testing and certification services. Finally, we will discuss about complex up to mechanical assemblies.

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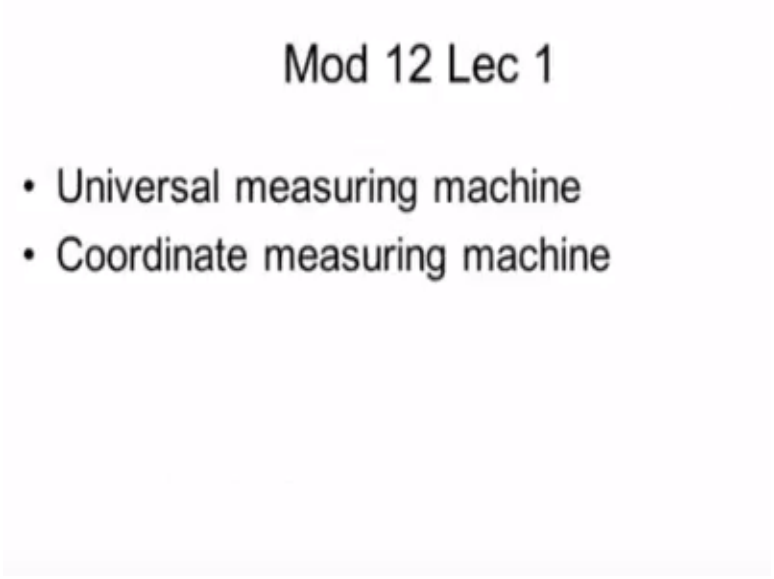

Now under module number 12, we will start lecture 1. In this lecture, we will be discussing about various aspects of universal measuring machine and coordinate measuring machine.

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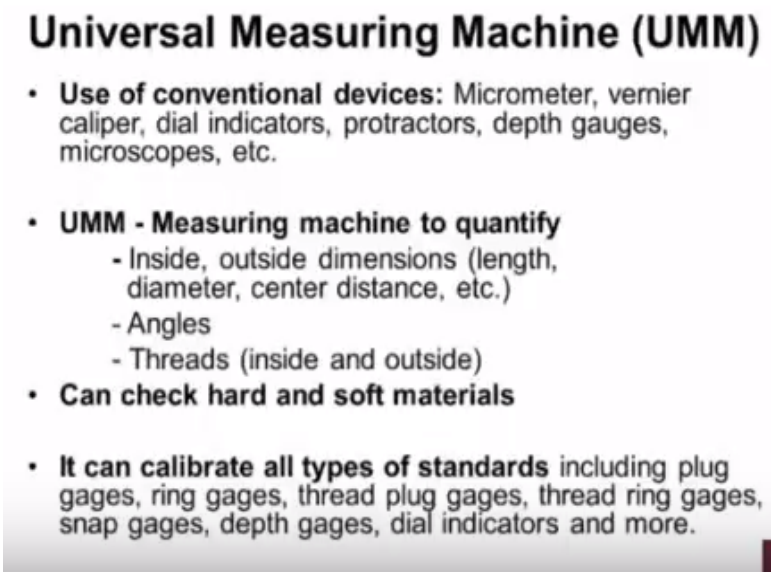

Now in the previous modules, we discussed about various metrological instrumentation like micrometer, vernier caliper, dial indicators, protractors, depth gauges, microscope, etc. these instruments are used mostly to check one feature of the work piece for example micrometer is used to measure the thickness of the work piece or the length of the work piece and then protractors are used to measure the angle between 2 surfaces, so depth gauges are used to measure the depth like this.

Now, measuring machine has been devised, which can be used to measure many features of the work piece in one setting so this device is known as universal measuring machine, so it is used to quantify inside and outside dimensions like length diameters and distance between poles and it can be used to measure angles between the 2 surfaces of the work piece, it can also be used to check the thread parameters of inside and outside threads.

It can be used to inspect hard work pieces made of hard materials or it can also be used to measure the features of soft materials. It is normally used to calibrate all types of standards, for example plug gauges, ring gauges, thread plug gauges, thread ring gauges, etc. can be calibrated using this universal measuring machine.

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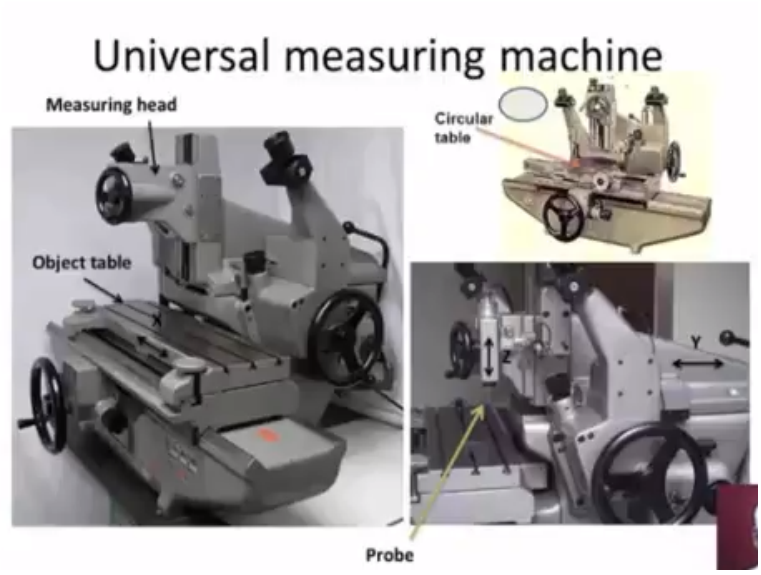

Now we can see the pictures of universal measuring machine, we have the base of the measuring machine, normally made of cast iron, these are the flat guide way and inverted guide way, on which the table moves. We can see when the table move in this particular direction if it is moving in the X direction that is longitudinal movement of the table and when the measuring head moves in this particular direction.

It is transverse direction or movement in the Y direction and this is the measuring head, which can be moved up and down, so this is the vertical travel of the measuring head. We can mount the different probes to the measuring head to carry out the inspection of the work pieces. We can

see the eye pieces through, which we can take the readings and a circular table can be mounted on this table for measurement of features like angles.

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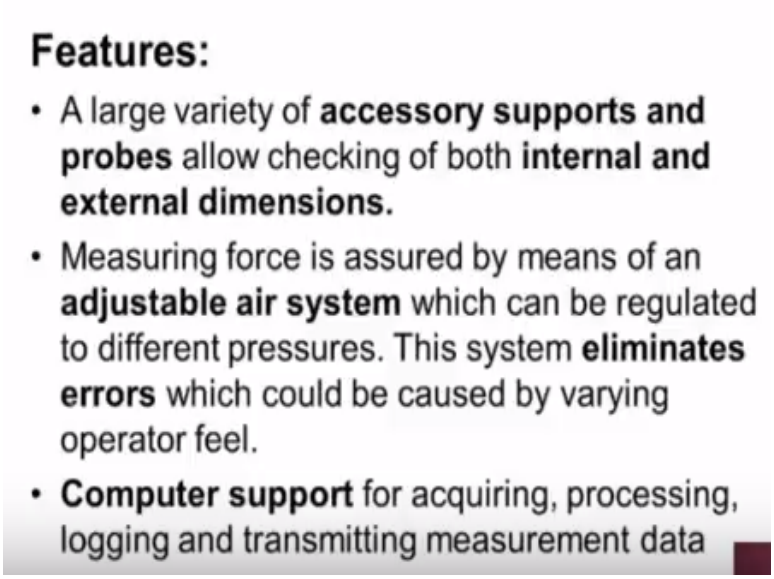

We can see the hand wheels to achieve the motions in XY and Z directions. Now let us study what are the features of universal measuring machine. Large variety of accessory supports and probes can be mounted on to the universal measuring machine to check both internal and external features of the work pieces. Measuring force is assured by means of an adjustable wheeled system, which can be regulated to different pressures, so by adjusting by maintaining different pressures, the measuring force can be maintained.

So this system eliminates errors, which could be caused by varying the operator feel. Because of use of this gear system the operator feel from the inspection process. Now computer support is available for acquiring processing, logging and transmitting measurement data. The measurement can be made using different kinds of probes and data is transmitted to the computer system, which has software, which will analyze the data and gives the required results.

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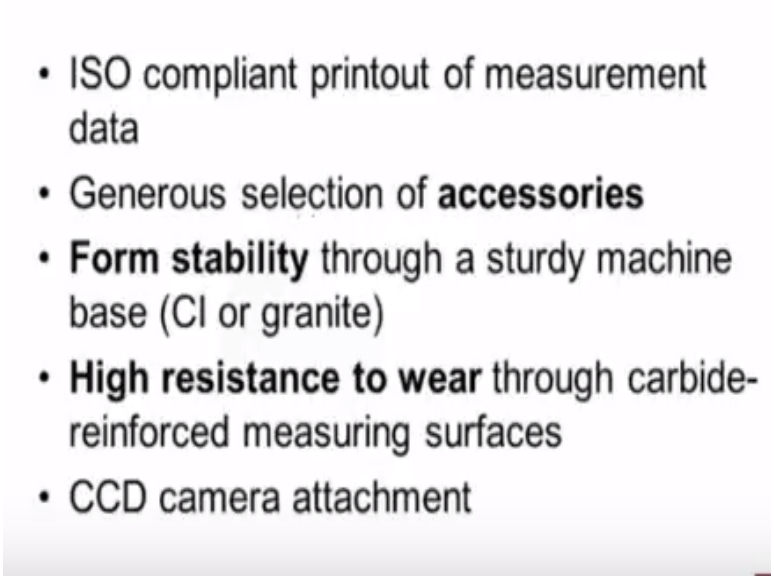

ISO compliant printout of measurement data is possible and the different kinds of accessories are available, which can be mounted onto the universal measuring machine to assist the inspection of very complex work pieces.

Form stability is achieved through a sturdy machine like this made of CI or granite and there is high resistance to wear through carbide reinforced measuring surfaces, all the surfaces, which are subjected to friction or the wear or covered by carbide reinforced measuring surfaces CCD camera attachment is also possible.

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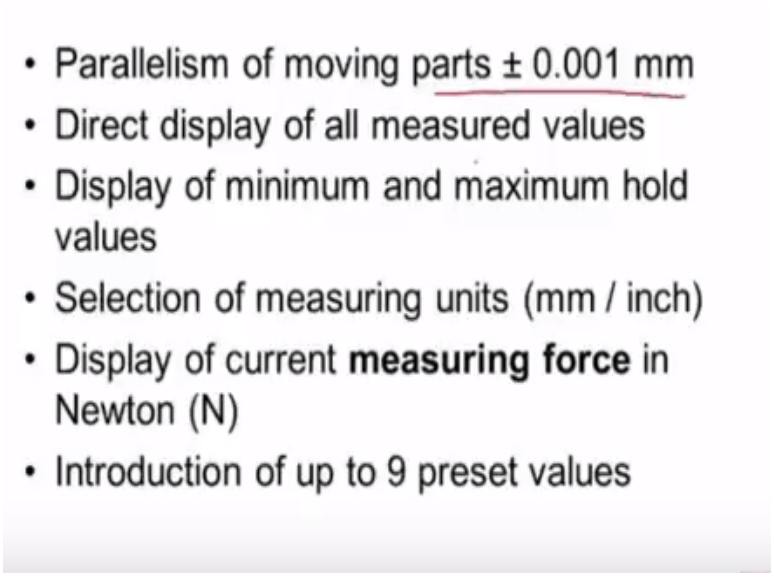

All the moving parts, they have very good parallelism within + or -1 micrometer and direct display of all measured valves is possible and we have display of minimum and maximum hold values, we can select the system depending up on our requirement and what is the measuring force currently used that also can be displayed because of this arrangement, operator feel is eliminated and it is possible to introduce up to 9 preset values in the universal measuring machine.

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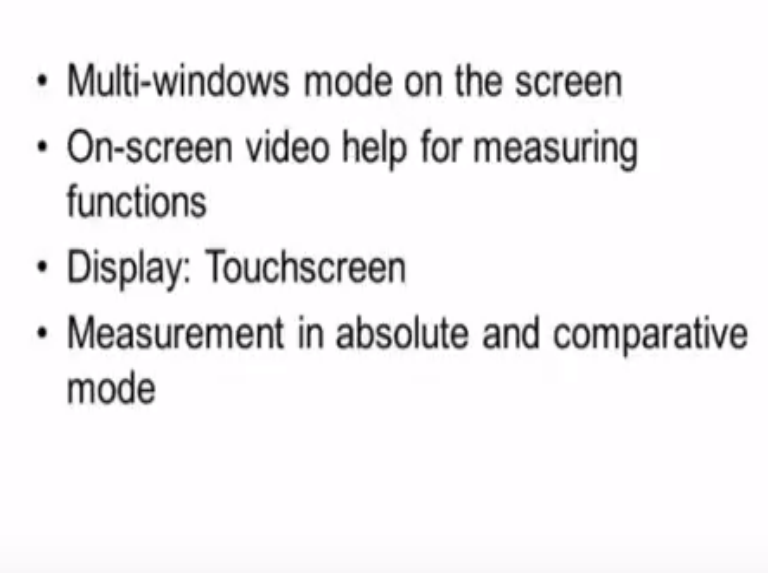

Now multi-window mode is available in the screen and then on the screen video help for measuring functions is possible, for example a particular function is selected, the on-screen help is available, so that the operator can use all the functions without much difficulty, touch screen display also possible and the measurement in absolute and comparative mode is possible.

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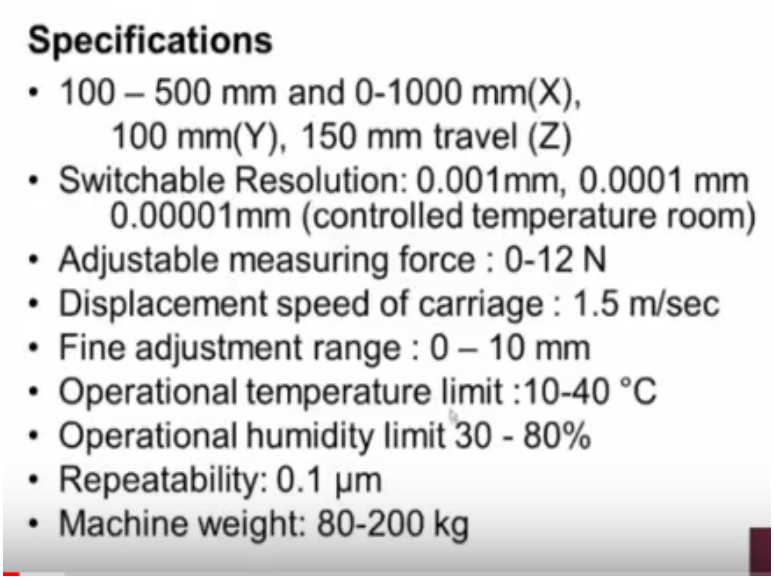

Now what are the specifications of this universal measuring machine so different size of different sizes of universal measuring machines are available in the range of 100-500 millimeter and 0-1000 millimeter is possible. In this is x direction moment and in the y direction moment millimeter and the z travels 150 millimeter.

So like this the universal measuring machines are different sizes are available and resolution can be switched depending upon the accuracy requirement we can select the appropriate dissolution micrometer on 0.01 micrometer or 100 micrometer like this resolutions can be switched and it naturally requires a controlled temperature room for the operation of Mu mm and the measuring force can be adjusted between 1-12 Newton depending upon the type of work piece.

Displacement speed of carriage of the table moment we can select up to 1.5 m per second such a high speed is possible and very fine adjustment ranges possible between 0-10 millimeter and then the operational temperature limit is from 10-40 degree celsius and operational humidity limit is 32-80% and repeatability can achieve up 0.1 micrometer mission weight will be 80-200 kg depending upon the size of the machine.

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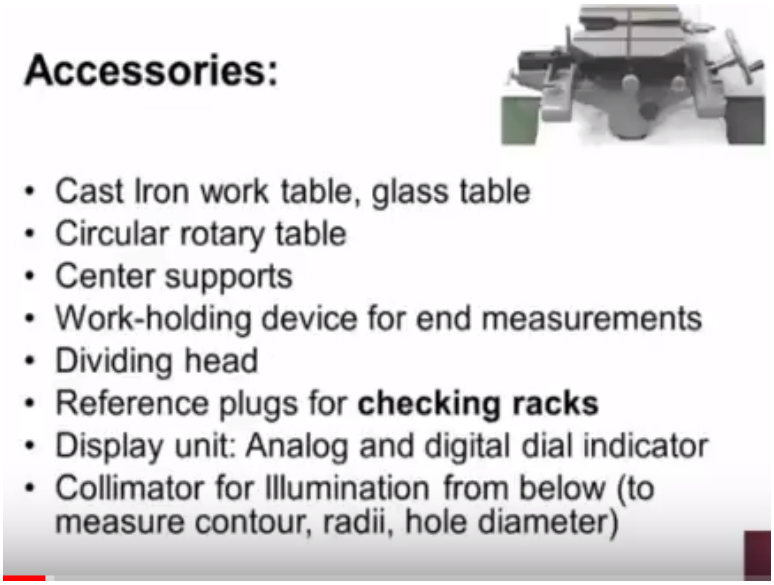

Now various accessories commercially available, which can be mounted into the universal measuring machine that is the work table of cast iron is possible, granite is possible and glass table is also available, which can be mounted on to the mission table circular rotary table can be mounted to assist the measurement of angles and centre supports are available to mount the cylindrical work piece and work holding device for and measurements or possible.

Dividing head, they can be mounted and reference plug for checking racks and display unit can be either analogue type or digital dial type and collimator for illumination from below measure contour radii hole diameter etc is possible 2 optical system can be attached to the universal measuring machine.

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- Locating microscope, goniometric microscope (to measure angles), probes
- Universal measuring head
- Single V-support, adjustable V-supports,
- Holder for knives
- Attachment for measurement between transversal anvils
- **Lapping** equipment
- User-friendly software to select testing procedure, resolution and probe type

And locating microscope goniometric microscope can be attached to the machine to measure angles different kinds of probes can be attached and universal measuring head are also available single be support address table we supports can be used and holders for checking the knives for holding the knives for inspection.

Then attachment for measurement between the transversal angles are possible and lapping equipment can also be used for wrapping papers and then user friendly software to select testing procedure resolution and probe type.

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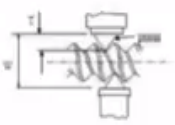
- Set of two prisms



- Calibrated **wires** for different **thread pitches**,
- Special tool holder
- Attachment for measuring the **pitch of internal threads**
- Microscope for measuring the **diameter of internal threads**
- **Thread profile** heads
- Taper measurement attachment

A set of 2 prisms can be mounted for the measurement of threads and calibrated wires can be used for measurement of thread pitches special tool holders can be used depending upon the requirement and attachment for measuring the pitch of internal threads, and microscope for measuring the diameter of internal threads can be attached and thread profile heads, taper measurement attachment all these are possible with universal measuring machine.

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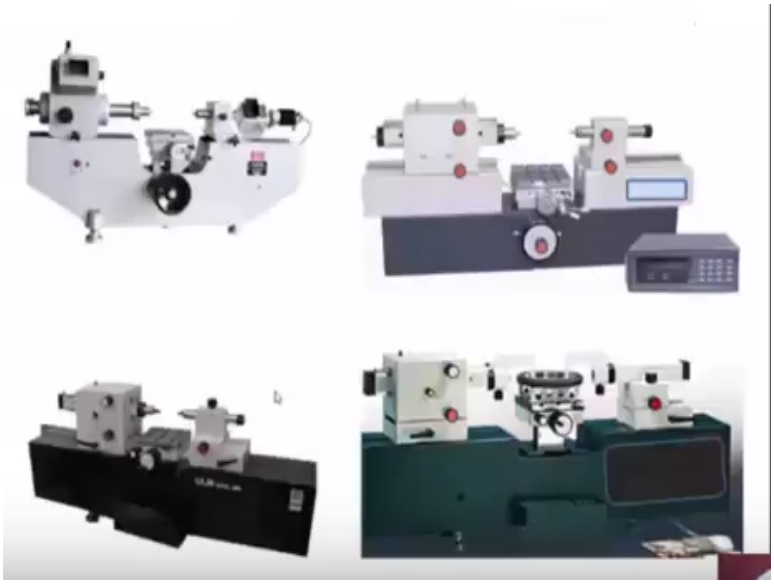

Now you can see some commercially available universal measuring machines you can see the base of which the other attachments are mounted this is the table on which the work piece or mounted and the table can be moved in the longitudinal and transfers direction and thus spindles are housed in the housing. This housings can be removed in this direction to accommodate the work pieces of different length and then and the wheels are provided to open the table.

Digital displays is also possible depending upon the movement of the spindle, so what is the moment can be read out from the digital displays and then we can see the digital display and the keyboard is also available for setting the preset values and proofs can be attached to the spindle for measurement of continual dimensions.

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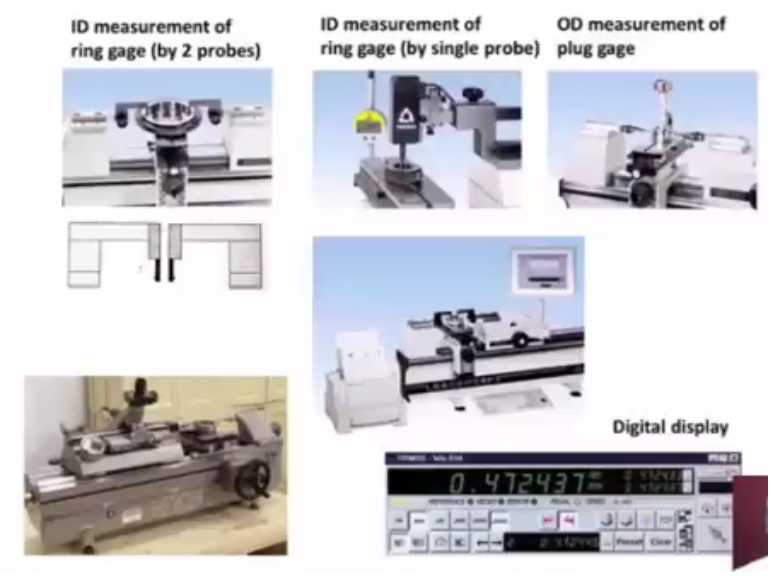

You can see here the ID measurement of ring gauge by 2 probes that means the ring gauge to be measured is placed on the table as shown here this is the ring gauge mounted on the table and probes are fixed to these 2 spindles by moving the probes we can check what is the internal diameter of the ring gauge as, similarly we can measure the outside diameter of the ring gauges and here ID measurement of ring gauges by single probe.

So that we can see and then display unit also can see just to see the display unit and OD measurement of plug gauge, so and here we can see digital display so when we move the probe what is the amount of moment and is displayed on the digital disc plate and finally we can take out the inspection report using the printers.

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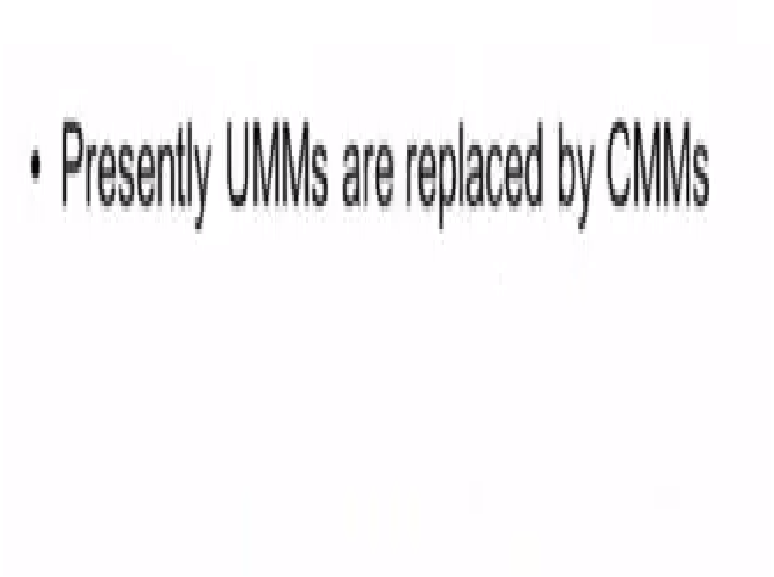

Now presently the universal measuring machines are replaced by co-ordinate measuring machines.

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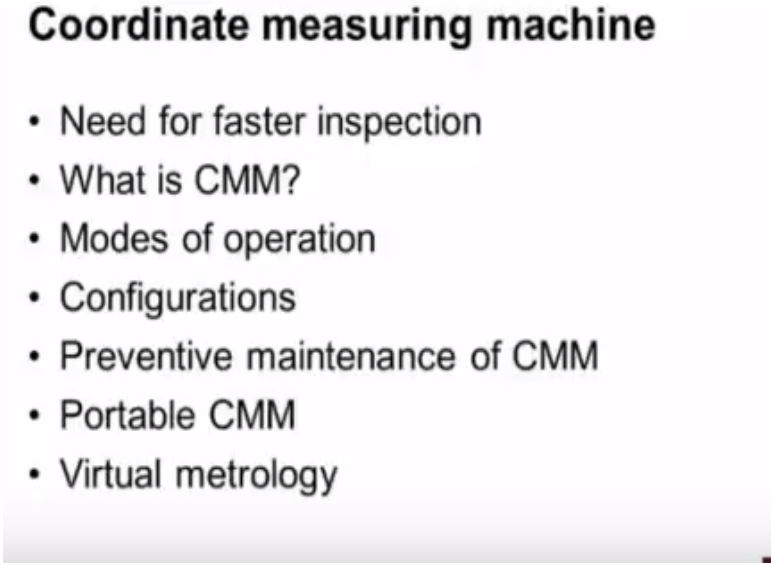

Now let us move to the discussion on co-ordinate measuring machine under this topic we will be discussing the following points what is the need for faster inspection and some basic about co-ordinate mission like what are the different modes of operation of CMM what are the different configuration available in CMM and how do we prevent how to conduct a preventive maintenance of CMM and then we will discuss about the recent advancement in CMM that is portable CMM and virtual metrology.

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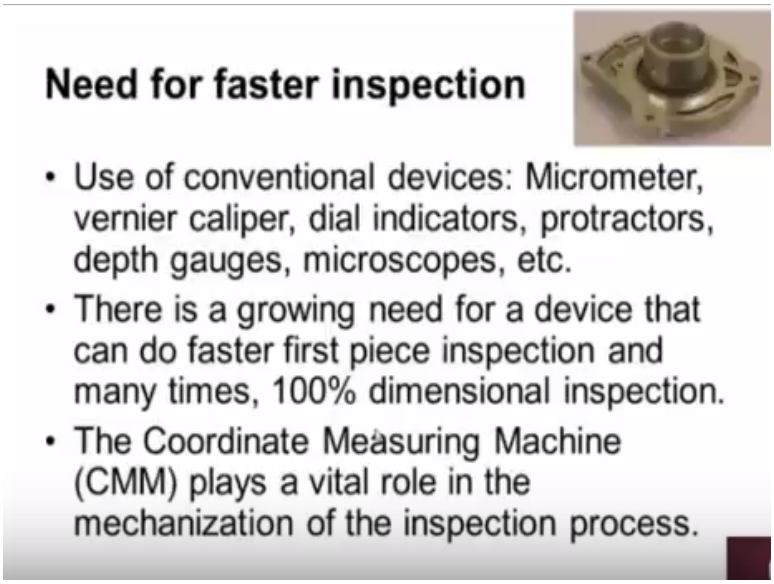

Now let us understand what is the need for faster inspection now we have discussed about micrometer, vernier calipers, dial indicators, protractor etc etc which are used to measure the various features of work pieces and these devices meteorological devices used to measure only the single feature of the work piece for example micrometer used to measure the length of the work piece of the thickness of the work piece.

So like that and for measuring the different features of the work piece we need to have large inventory of instruments meteorological instruments with different ranges with different accuracies etc, so the metrological instruments inventory too large and since we have to use different kinds of instruments to measure the various features of the work piece the time taken for the inspection of the work piece is too large.

Now there is a growing need for a device that can do faster the invention and many type of 100% dimensional inspection. Device is constructed which is known as co-ordinate measuring machine which is a sort of advancement in universal measuring machine, so this co-ordinate measuring machine plays a vital role in the mechanization of the inspection process.

We can mechanization in the sense the production like itself the CMM can be introduced and as soon as the work piece is made it is shifted to the table of CMM and inspection can be carried

out and feedback can be given to the software for making the necessary corrections in the program, if there is any deviation in the work piece.

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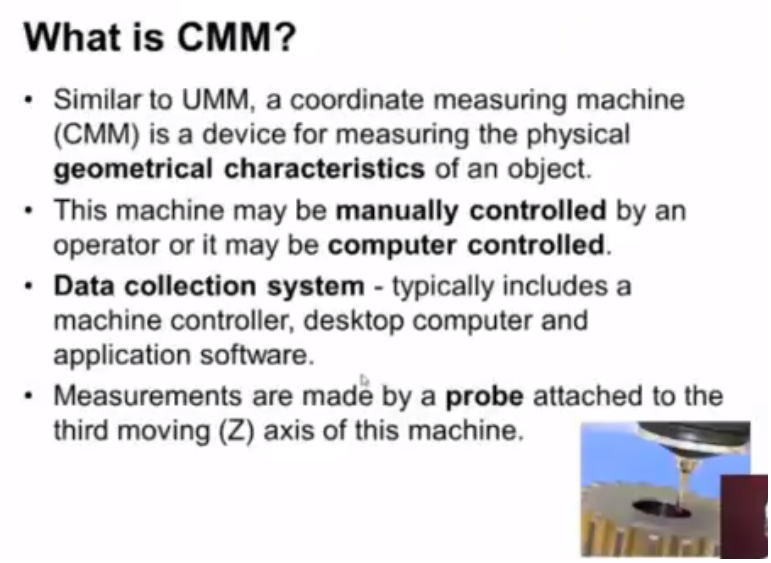

Now let us study some basics of CMM similar to universal measuring machine a co-ordinate measuring machine is a device used for measuring the physical geometrical characteristics of an object. This machine may be manually controlled by an operator or it may be computer controlled machine data collection system is used along the CMM and the data collecting system typically includes machine controller to control.

The movement of CMM and the desktop computer which has software to take the data points and to analyze the data points after analysis the data points will give the inspection report measurements are made by a probe attached to the 3rd axis of the machine which is known as Z axis of the machine.

Now we can see stylus attached to the probe head of CMM, so this stylus will move into the hole and it makes contact with the surface of the work piece and then again it is moved in the in this direction again the contact is made now when it make contact with the work piece at this point the X, Y, Z coordinates of this particular location is given to the computer.

Similarly X,Y,Z coordinates particular location is given to the computer and the software it calculates what is the distance between these 2 surfaces similarly diameter of the whole can be found out by making the contact with 3 points and using the data points of the coordinates of the 3 data points such way we calculate.

What is the location of the centre point and then calculate the diameter of the work piece like this by using the various sub routine the features of the work piece can be assist.

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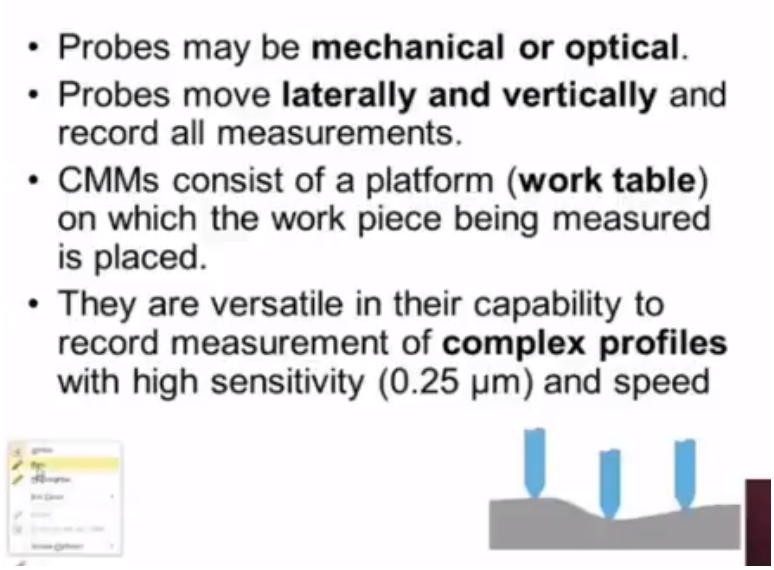

Now the probes attached to the CMM may be mechanical type or optical type by using the mechanical type of probes we can measure in the various features by making contact with the work piece surface in case of vertical probe. There is no contact with the optical probe and the work piece.

So it is non contact type of measurement and probes more laterally that is in the X and Y direction X direction and Y direction and probe also moves in vertical direction that is Z direction and the data points are recorded this co-ordinate measuring machine consist of a platform that is a work table or which the work piece is measured being measured is placed if depending upon the requirement maybe a picture is used to mount.

The work piece can be directly placed on the work table for the measurement purpose without using any fixture simple work piece they are versatile in their capability to record measurement of complex profiles with high sensitivity and speed whenever we need to measure the complex profile, we can use a scanning type of mechanical probe which will move along the surface and the data points recorded and then the profile can be evaluated.

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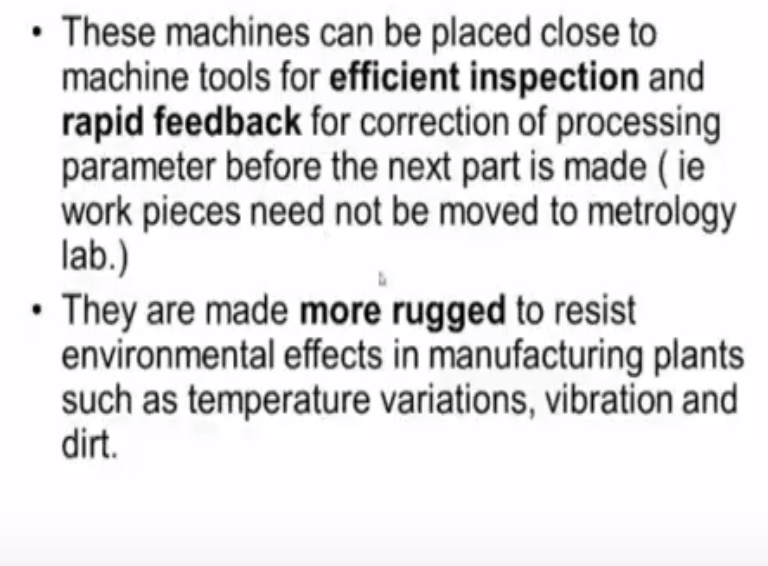

These CMM machines can be placed very close to the machine tool for efficient inspection and rapid feedback for correction of processing parameter before the next part is made that is work piece may not be moved to metrology lab CMM can be moved place where the machine enquiries is going on that is CMM can be start in the production line itself as soon as the path is produced it can be inspected.

They are made more runs to resist environmental effects in the manufacturing plants such as a temperature variations vibrations and dirt if temperature variations where or if vibration automatic compensation is made using necessary some pay.

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Now let us see how the CMM looks like I can see this is the table it can be a granite table cast iron table which has a flatness of fraction of a micrometer and on this table we can mount the work piece directly it can be placed on the work table surface or if necessary a fixture can be used to mount the work piece and then we have in this particular configuration.

We have 2 column this is column and this is column 2, these 2 columns move on the move along the Y axis by using ball screw appropriate guts you can see there is a dust covered to cover the ball screw, so that just cannot accumulate on the screw so at this place column number 1 will be moving on the granite surface.

So there will be below the column surface, so that it moves frictionless free between these 2 columns there will be a bridge and this bridge carries the probe head and we can mount the different kinds of probe to this pro head and this probe head can move vertically up and down to Z axis by using appropriate type system.

We can move the stylus X, Y and Z direction by operating the joystick you can see the joystick and you can various subroutines are available we can select the subroutines by using the keypad for example measurement of diameter of a hole or the angle between the 2 surface, so like this appropriate subroutine is selected and then the data points are collected we can observe the stylus stand here.

Directly mounted on the surface of the granite table and this stylus and holds the stylus of different sizes and different shape depending upon the inspection department the stylus is selected automatically it is fixed to the probe head and then measurement is carried out.

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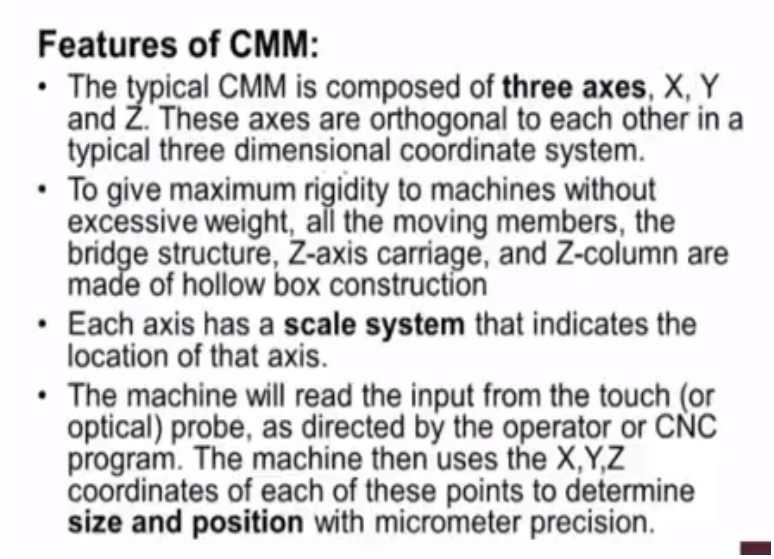

Now what are the features of co-ordinate measuring machine now we can observe that typical CMM is composed of 3 axes X axis, Y axis and Z axis these axis are orthogonal to each other in a typical 3 dimensional co-ordinate system. To give maximum rigidity to the machine without access wait all the moving members that is bridge structure Z axis carriage and Z column are made of hollow box construction.

Each axis has a scale system maybe linear scale or rotary to indicate the location of that particular axis the machine will read the input from the touch probe or mechanical probe or an optical probe as directed by the operator or CNC program the machine gun uses the X, Y, Z coordinates of each of these points to determine size and position with micrometer precision.

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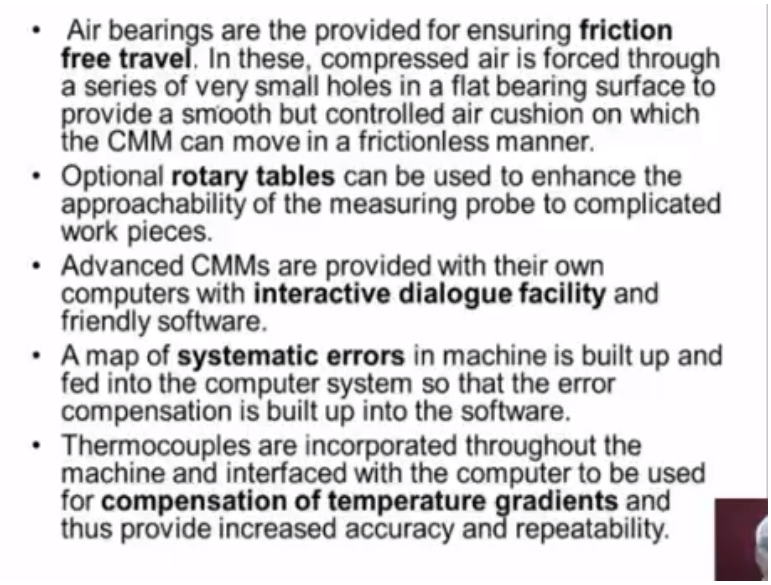

Air bearings are provided for ensuring friction free travel in this compressed air is passed through a series of very small holes for example we have a granite work table and then the column, so column in the case of moving column type column will be moving here. Air that will be there so I will just enlarge this portion to the table surface and this is the bottom of the column.

So here small holes are provided to which the compressed air allowed to pass the air will be escaping like this because of this arrangement the columns will move friction free. Optional rotary tables can be used to enhance the approachability of the measuring probe too complicated work pieces in the case of advanced CMM they have their own computers with interactive dialogue facility and friendly software.

So that the work pieces can be inspected with least effort and then a map of systematic errors in mission is build up and fed into the computer system so that the error compensation is built up into the software. Various thermocouples are incorporated throughout the machine and interfaced with the computer to be used for compensation of temperature gradients and the thermal compensation is provided with the software.

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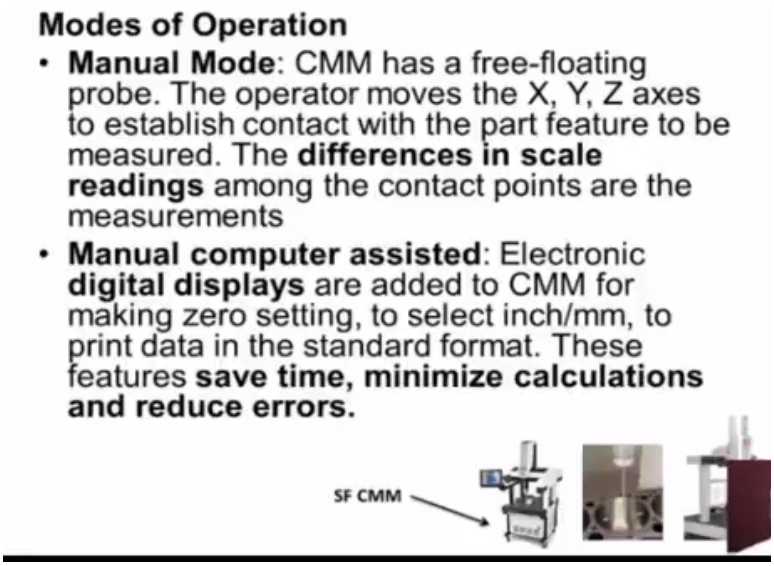

Now what are the different modes of operation now CMM are available which have manual mode and in this case it has free floating probe the operator moves the X,Y,Z axis manually move to establish contact with the path feature to be measured the differences in the scale reading among the contact points are the measurements.

Now you can see the particular picture the granite table and the work piece and then column, bridge etc. Now you can see the operator is holding the probe head and manipulate the that is manually moves the probe to make contact with the piece for example this is the probe and then we have work piece has stepped like this.

So the operator moves the probe and he makes contact with the particular surface and records what is the reading and then he lifts the probe and it is moved in this direction and again it is moved down and again the contact is made between the probe and the work piece surface. What is the reading is recorded then the difference between these 2 readings is calculated.

To give what is the depth of this stuff like this manually the probe is moved and contact is made with the work piece feature and readings are recorded and the required value is manually calculated, so this consumes lot of time and maybe operator make some mistake by calculating and the advancement over the manual mode manual computer assisted mode.

In this case electronic digital displays are provided to CMM we can observe here monitor is provided which indicates the data points so electronic distilled displays are added to CMM for making 0 setting to select required in system or metric system to print data in the standard format.

These features saves time minimises calculations and reduces errors now you can also see this is stop floor CMM. You can see the CMM is mounted on this table which has wheels so wherever measurement is required we can move this co-ordinate measuring machine with the help of this wheel and then measurements can be made.

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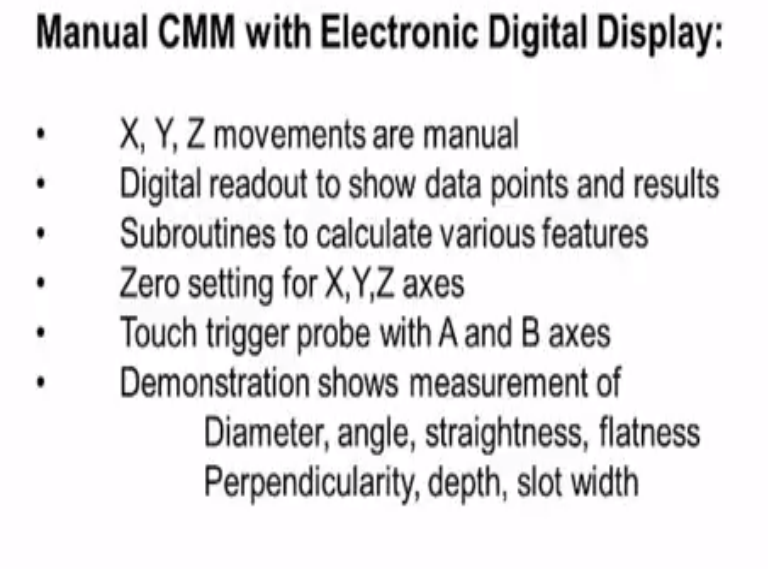

Let us watch a demonstration of a manual coordination measure machine which has a built in electronic digital display so in this demonstration we can see CMM that X,Y,Z. moments are manual that means the operator has to hold axis to move by applying force, manual force.

There is a digital readout interfaced with CMM this digital readout shows the selected coordinates data points and it also shows the results the software in the electronic system has many subroutines we can select appropriate subroutines to calculate various features like angle straightness etc manual zero setting for the 3 axes also be observed.

There is a touch trigger probe with A and B axis fix to the Z axis probe for this demonstration shows the measurement of diameter and straightness, flatness, perpendicular, depth and slot width.

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This is our free axis measuring machine, it is ideal for measuring some machine parts, laser part, water jacket part, those are the 2 things. It has got a moving gantry, so this moves back and forth, forcing away from the operator, up and down, a touch probe has number of articulating positions that you can lock into, so to do a measurement on a plate like this, first thing we are going to want to do is measure the flat surface of the plane to get aligned.

Now measure along the edge to get a straight, now set a point at the end and we will make that corner 0 location, so I am going to bring the probe in, take those, will stay down here, come along the edge, take those and stay there and we will take that and finish out. Now we will take our features, we can go to our display, so we can take that plane that we started with, go to the read out, align that, so now it is flat. We will make that our Z axis 0 location, we will go to that edge we measured, align that.

We will make that our Y axis 0 location. We will go to that point that we measured, make that our X axis 0, so now that corner of the part, with this edge, this edge and plane surface come out and then resect. Now all the features that we measure are going to be taking from that point, so we will go ahead and probe a circle here and stay there.

We can go and probe a circle here, just press and finish when I have done, taken my points and the read out is going to figure out based on the points I have taken what those features are, so we have got a few features in the read out. We can come up and we can construct a circle through the centers of those 2 holes and that arc that we just measured, so we will measure circle, we are going to our feature list and check each one of those, so we have got 3 features.

We have finished, now we get the circle that goes through those centers. We got an XY position for that and the diameter of that circle. Now on the part, if we want to see if that hole is concentric to this circle pattern, we can come and check this hole location, finish it up and then

up on the read out, we can go to a distance, we can select last hole we measured and the hole we constructed, if finished, now give us how far that XY position varies.

To measure an angle on the part, we can come down and we will probe one edge of the angle and come and probe the other edge of the angle and up on the read out, we will get a display as to what that angle and measurement is. We can also pull up a view and visually see what the angle is and we can change that to angle sets depending on which way of its dimension, varying angle measurements. When you are done with that, we can just hit the power button, hit the enter T a couple of times.

All those features disappear, we can check something else, so with this plasma cup part, we can do something very similar and say we have got an alignment to the center line of this part. We can probe a line here, we can probe a line over here then up on the read out, we can create a line, select those 2 lines and hit finish and that gives us a mid line in between the 2, since that is going to be the center of our part, then go to the read out view.

We are going to align it to that and we can 0 out of our X axis along the center line then we can check our feature measurements to that center line, so down the part, we can command and probe each of these hole locations and up in the read out, we have got XY centers, we have got our diameter for each of those holes.

We an create an arc feature or circle feature from those and find out what the overall radius is and what the center point of that is as well, so you can check arc shaped, laser cut or plasma cut, water jacket parts using something like this.

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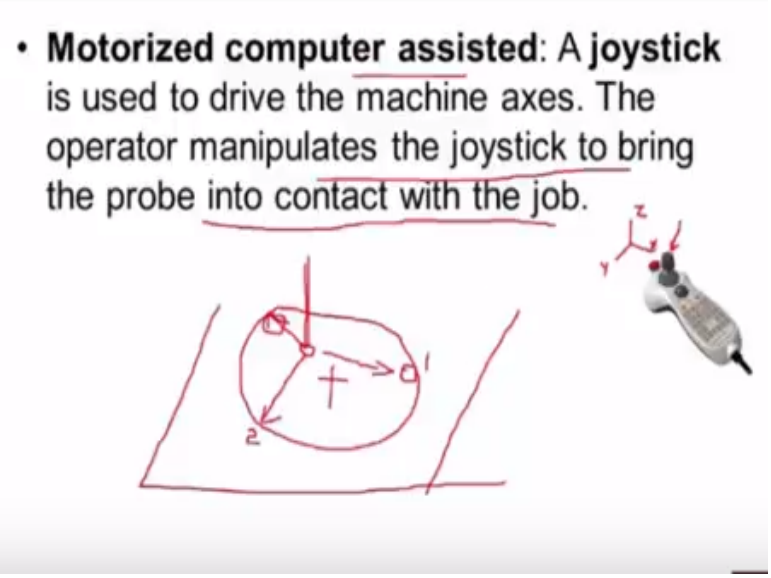

And next mode of operation is motorized computer assist CMM in this case joystick is used to drive the machine axes, you can see here we have a joystick this is moving the 3 axis X axis Y axis and Z axis Accordingly the probe move the operator manipulate the joystick to bring the probe into contact with the job for example we have a hole in the work piece surface then the operator will operate the joystick.

So that the probe moves in the Z axis it is inserted into the hole then it is moved in the X axis it makes contact here and coordinates of this point.1 are recorded and then it is moved to this point by operating the joystick, so the data points of this particular point are recorded and then again it is moved to this direction and contact is made and then the computer records the coordinates of this points and then it will calculate.

So what is the co-ordinate of centre point and the diameter of the hole, so like this using computer the manual calculations are eliminated and the error due to operated is also eliminated so this is faster compared to manual operated CMM.

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Now the another configuration is director computer controlled CMM so this is fully programmable CMM in this case the mission users thought location of CAD data to decide where the probe contacts the job and then collect measurement data that means the software itself will calculate what is the probe path.

From path is calculated by the software by using the card data that is provided that is how the probe should move so that path is automatically calculated the fully automated CMM allows the operator to place the job in a fixture or on the table run a stored program collect the data points and generate and output report I can see here fully programmable on direct computer controlled CMM.

We have the monitor and we have the computer system we have the keyboard and then joysticks are also available and this is a bridge type co-ordinate machine with granite table the complex work piece is directly mounted on the granite table and the probe will move depending upon the program inspection program.

The probe will move and collect the data points and necessary inspection report is generated by the software so here the operator error is completely eliminated since the path is calculated by the software and the path is also optimized what is calculated by the software, so that the inspection time is very much less and there are no chances of collision in the work piece.

Since the path is calculated by using the card data the chances of collision probe work piece are eliminated.

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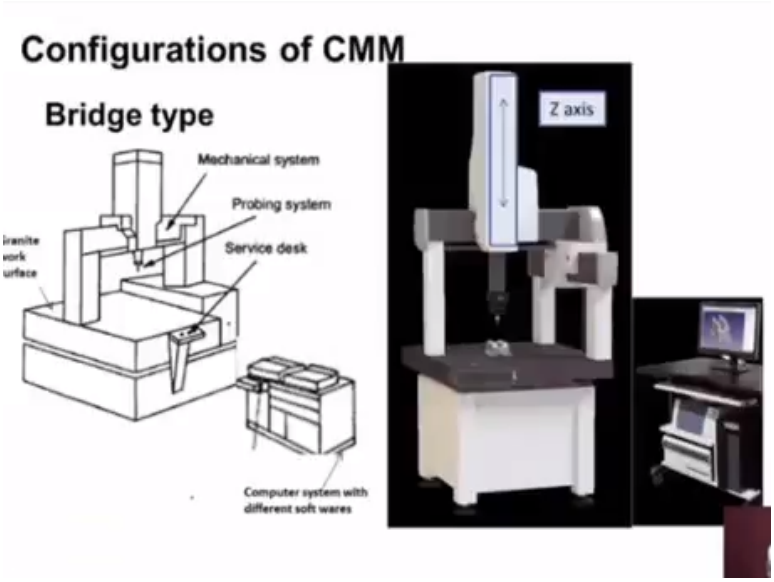

Now let us study what are the different configuration of co-ordinate measure machine very most common configuration is bridge type co-ordinate machine wherein we have 2 columns here, so you can see here there is a column here 2 columns here in this particular case and there is a bridge between these columns.

The bridge carries the probe head can go up and down, so depending upon the work piece hide the Z axis moment is calculated since the probe head is supported by 2 columns the deflection of the bridge is very less. So these bridge type CMM are more accurate and this is the dedicated computer system interfaced with both co-ordinate machines.

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Now here you can see a huge gigantic co-ordinate machine this is the granite table on which very huge large work pieces are mounted which is column one column to and then we have the bridge which houses the probe head and this is the probe and we can also see the operator to operate the co-ordinate machine.

So very tiny bridge type co-ordinate measuring machines are also available at the same time gigantic co-ordinate measuring machines are also available to accommodate large work pieces.

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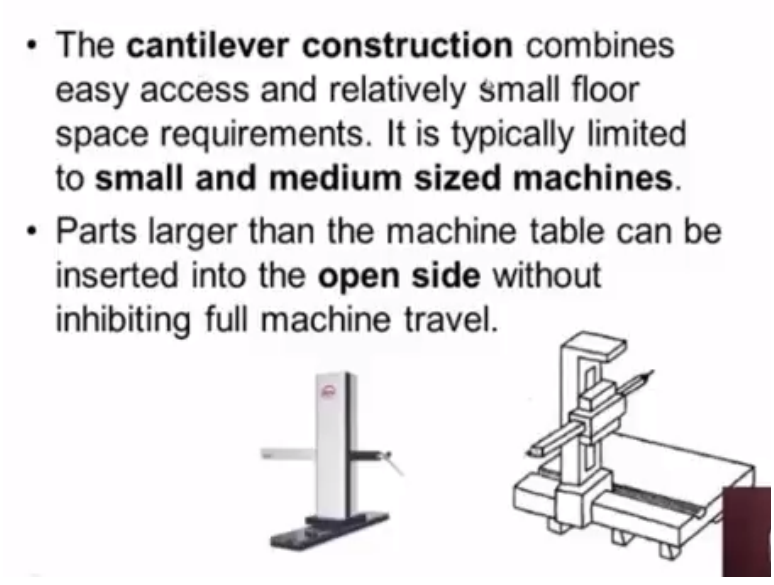

Another configuration is cantilever construction which combines easy access and relatively small floor space requirements. Typically limited to small and medium sized machines like we can see

here the unlike the bridge type. So here the one side is completely open so that we can easily load the work pieces on the table from this open and parts are larger than the machine table which can be inserted into the open side without inhabiting full mission travel.

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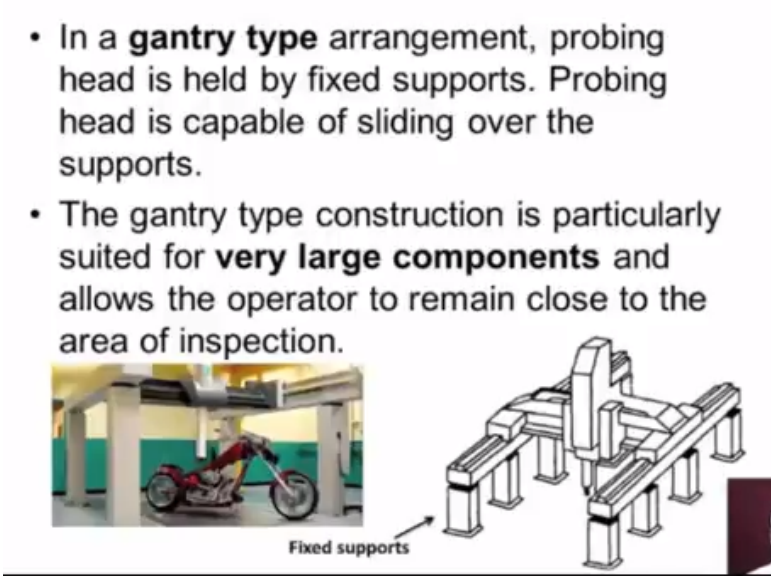

So we have another type of configuration known as gantry type configuration wherein the probing head is held by fixed support. Now you can see in the diagram we have fixed support which will support the bridge on this supports we have guide way, so this is one guide way and this is another guide way, so all these gateways bridge will move probing heads is capable of sliding over the supports.

The gantry type construction is particularly suited for very large components and allows the operator to remain close to the area of inspection you can see here motorbike is being expected by a gantry type co-ordinate measuring machines.

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Horizontal-arm coordinate measuring machine (CMM) which is designed for **large work pieces.** The open structure of this arrangement provides **optimum accessibility** for large objects such as **dies, models, and car bodies.**

So another type of configure configuration is horizontal arm co-ordinate measuring machine so where in we have 2 columns in this particular type of machine we have 2 columns and then there is a bridge and there is a overhanging arm it supports the probe head. In this case we have only one column and then which supports the probing ahead, so this has open end so we can insert large work pieces from this open and the open structure of this arrangement provides optimum accessibility for large object such as dies, models and car bodies.

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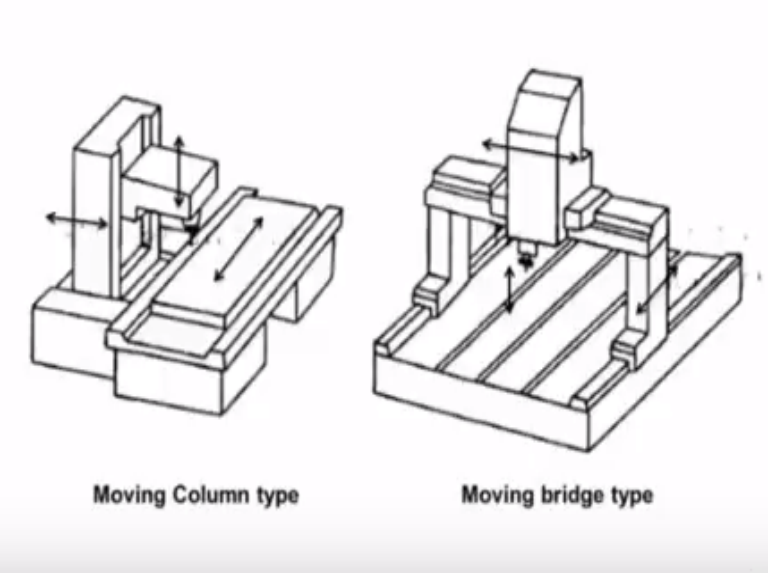

Now in this diagram you can see the moving column type this column can be moved in and out and then we have moving bridge type configuration so depending upon the type of work pieces we can select the appropriate configuration.

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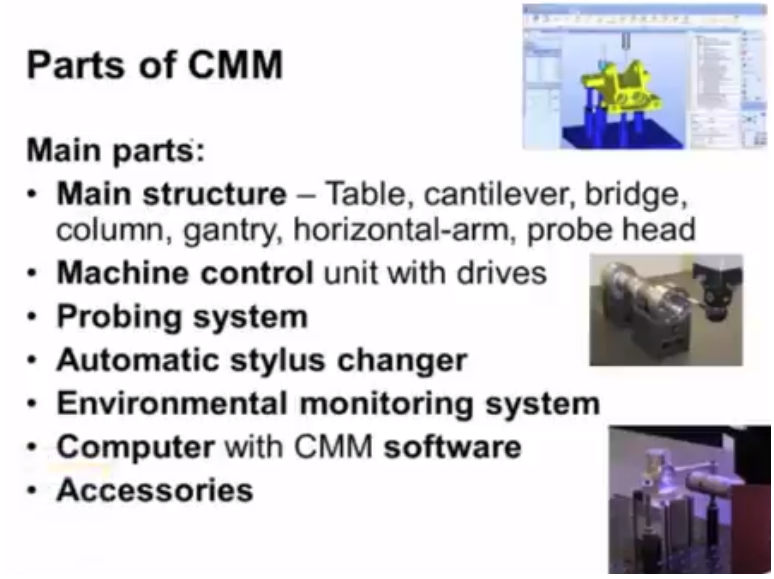

Now what are the various parts of co-ordinate measuring machine we have main structure of co-ordinate measuring machine consists of table, cantilever, bridge, column, gantry, horizontal arm, probe head and then we have mission control unit with driving systems.

There is a probing system and automatic stylus changer, environmental monitoring system which monitors the temperature using thermocouple and then there is computer with CMM software to assist the work pieces and then different kinds of accessories can be used during the inspection.

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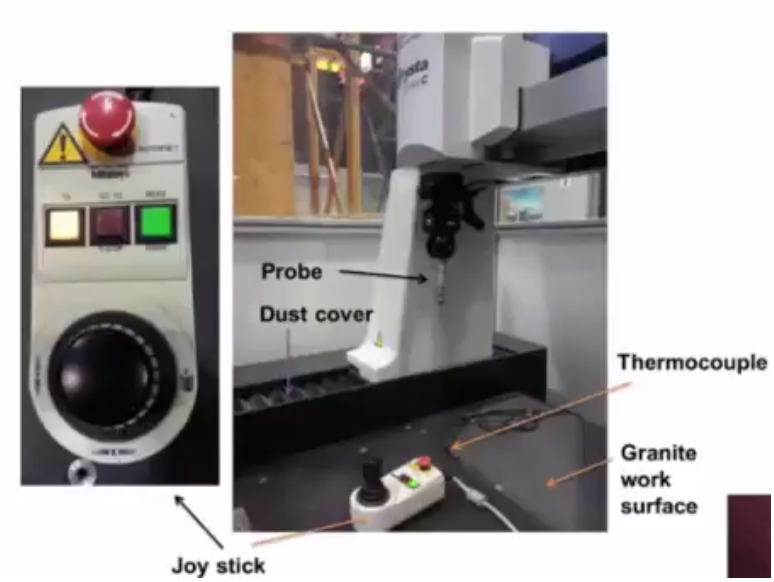

So we have joystick I can see the joystick by operating this we can see the 3 direction X,Y and Z in this direction you can move the probe by operating this joystick and there is an emergency button also to stop the moment in case of emergency and then they have prepared stylus driving system to move the column dusk covers granite table on which the work piece in the mounted thermocouple to set the interpreted variations ,so like this different type of parts are there in CMM.

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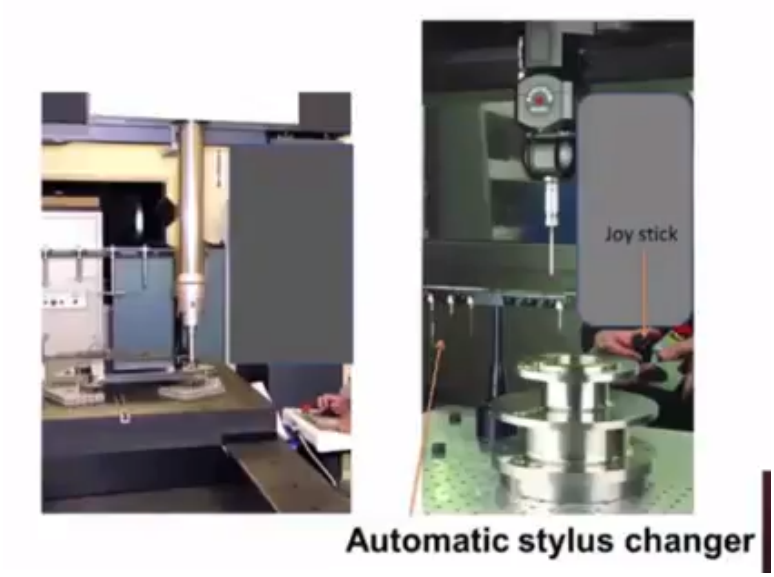

And then there is a joystick we can also see an automatic stylus changer which holds the stylus of different configuration depending upon the inspection these probes are automatically selected and fix into the probe head and by operating the joystick probe can be moved X,Y,Z direction.

You can see the joystick here and then granite table and we can also see the work piece fixture are placed on the granite table and the work piece which is to be inspected its head by these 4 fixtures.

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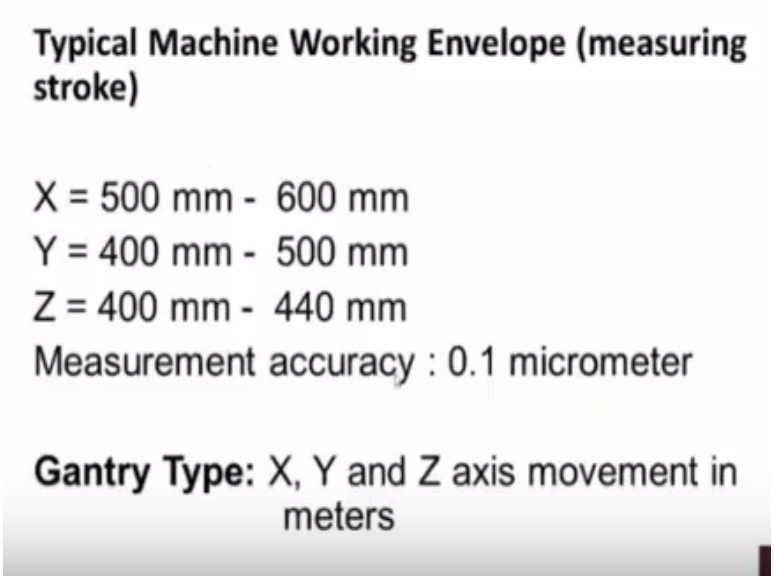

Typical machine working envelope that means the size of the CMM we have X direction movement 500 millimetre-600 millimetre in the Y direction the movement is from 400 millimetre-500 millimetre and in the Z axis 400 millimetre - 440 millimetre.

In an accuracy of 0.1 micrometre, so this is a tiny CMM and in the case of gantry type the X,Y and Z axis movement in metres with measurement accuracy of 1 micrometre.

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Now you can see the automatic stylus change system which is directly placed on to the work piece table this holds the probe different type configuration different length and you can also see non contact type that is optical probe or sometimes vision type probe and here you can see

motorized the probe system and probes of different lens that can be mounted on to the stylus changer here.

You can see a spherical type, a ball type stylus depending upon the inspection requirement and depending upon the program, these probes are selected automatically and inspection is carried out.

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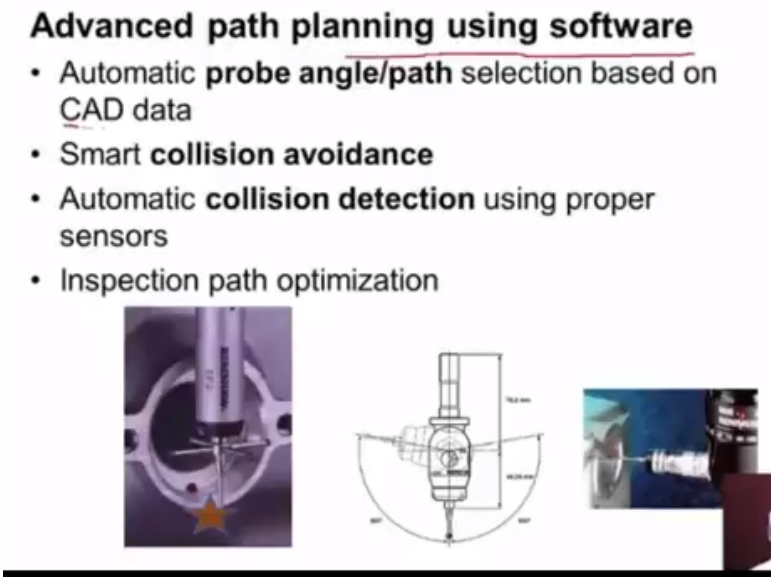

Advanced path planning using software, so depending upon the CAD data is provided automatic probe angle is selected and heart is selected you can see here depending upon the work piece we have work piece at some angle a hole at some angle. So depending upon the data provided the probe at times this particular angle this angle is automatically selected by the CMM software also.

What is the path of the stylus so depending upon the data provided the probe movement path will be automatically calculated and the collision in the work piece is avoided and then automatic collision detection is also possible using appropriate sensors and once the path is determined it is optimized depending upon the CAD data.

I can see here whenever they are using the multiple stylus type probe when the probe moves in this xyz direction this particular stylus should not touch the work piece, so that care is taken in CMM software.

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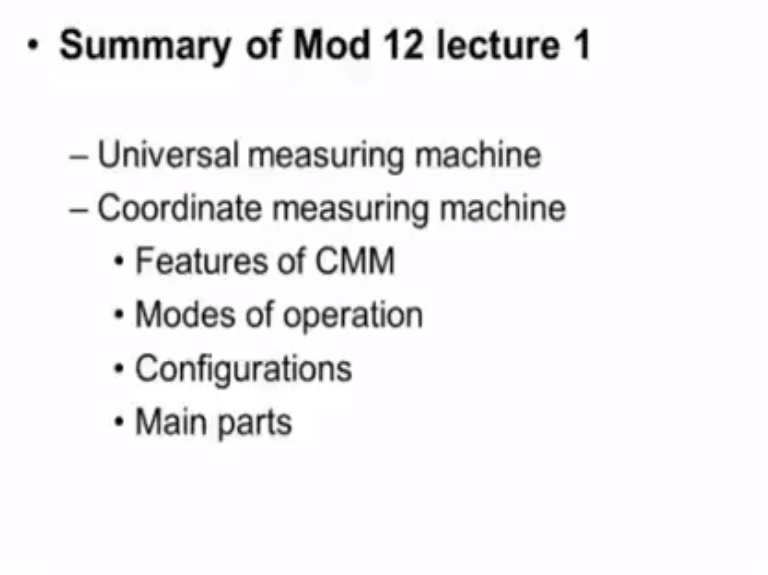

Now let us summarize the lecture number 1, in this lecture we discussed about the various aspects of universal measuring machine and we also discussed about the features of co-ordinate measuring machine, different modes of operation co-ordinate measuring machine and different configuration of CMM, parts of CMM with this, we will conclude this lecture we will continue the discussion on the different aspects of CMM in the next lecture. Thank you.