Engineering Metrology

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Lecture – 9
Linear Measurements (Part 1 of 2)

Welcome to the next topic of discussion which is Linear Measurements.

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In this lecture, we will have a small introduction followed by it we will try to have a design of linear measurement instruments, surface plates, V blocks, graduated scales, scaled instruments, Vernier instruments, micrometer instruments and finally, slip gauges. These are all used for measuring linear measurements.

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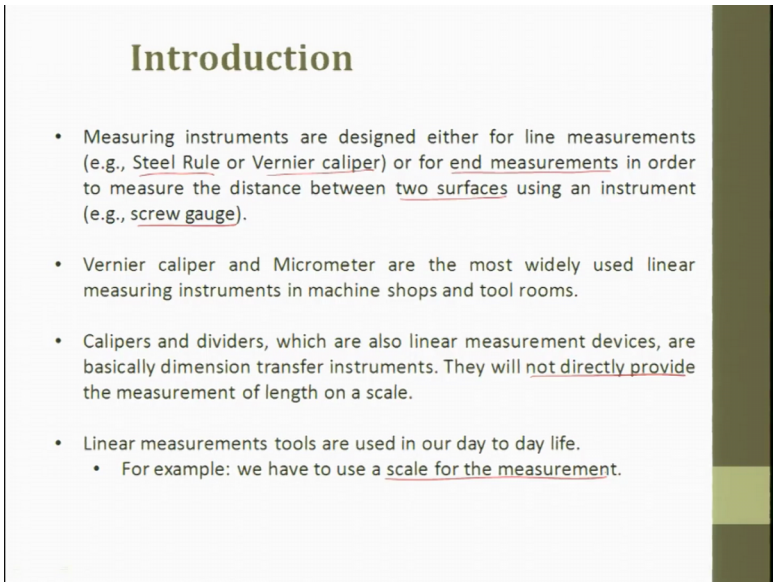

So, measuring instrument are designed either for line measurement or for end measurement. We saw earlier, how do we convert line to end an end to line we solve those things. So, when we talk about line measurement, the examples are nothing but steel ruler or Vernier caliper. In order to make sure the distance between the two surfaces using an instrument is flat.

So, this end measurement is always to make sure that the flat surfaces are in contact and then we try to measure the length, example is screw gauge. Vernier caliper and micrometer are the most widely used linear measuring instruments in machine shop and in tool room as well as in academics; calipers and dividers, which are also linear measurement devices.

Caliper, caliper is something like your gauges plug gauges. So, you try to have a caliper you try to set the diameter or you try to measure a component set the diameter pull it out and then keep it in front keep it in front of a line measurement and try to take the dimensions. Same with divider also, which are also linear measurement devices are basically dimension transfer instruments. They will not directly provide the measurement of length on a scale.

So, they will not directly provide, but what we do is we try to take it something like a comparator. Put a pen, try to measure the dimensions and then what when you do, when you measure it, it is just like a gauge. So, you just push it inside right, note down the

diameter pull it out, take it to a scale, measure it. The linear measurement tools are used in our day to day life are many. So, for example, we use a scale for measurement for drawing line, for and if you talk to a mason he always measures with respect to a measuring tape. So, all these things are linear measurement.

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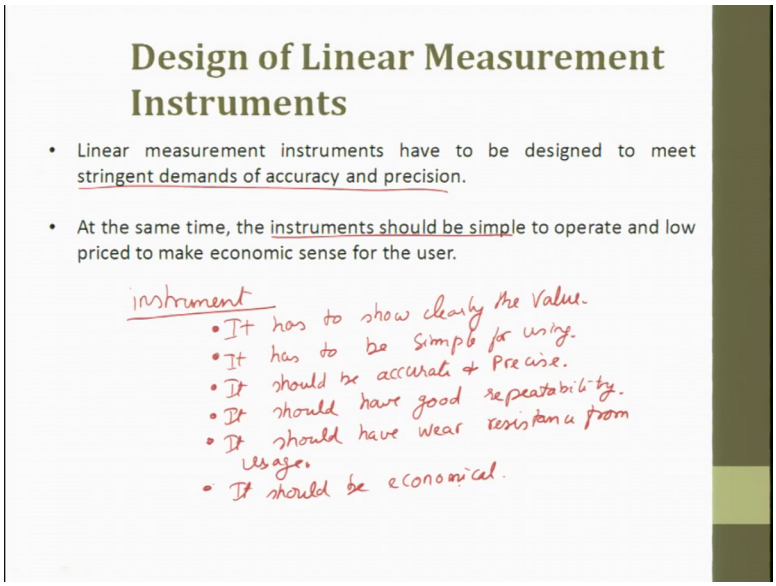

So, the design for linear measurement instrument is the linear measurement instrument have to be designed to meet stringent demands for accuracy and precision. Now, you will be able to distinguish what is accurate and precision right.

At the same time, the instrument should be as simple as possible to operate and allow price and low price to make it economical sense for the user. So, here the instrument must be as simple as possible. See when you try to have any instrument any instrument you have, so, what are the major things it has to be? First thing, it has to show clearly the values whatever you obtain or measure. Next, it has to be simple for using, so that means, to say it should not demand a skill the laborer to use this instrument.

The third thing is it should be accurate and precise in its measurement. It should have good repeatability in its data. It should have wear resistance from usage; you say this any environment ok. It should be it should be economical. So, that people can buy it. So, these are some of the characteristics should be there for any instrument ok. It should be clear, it should show or display clearly the measured values, it should be simple to use, it

should be accurate and it should be precise. So, when you put that repeatability gets into these two definitions.

So, it should have good repeatability, so that means, to say the mechanism whatever you use should not try to bring in any change erratically, it should have wear resistance good wear resistance. It should have good wear resistance to usage. It should be as economical as possible. So, these are some of the characteristics or features which you expect from any instrument linear, let it be angular, but in particular instrument.

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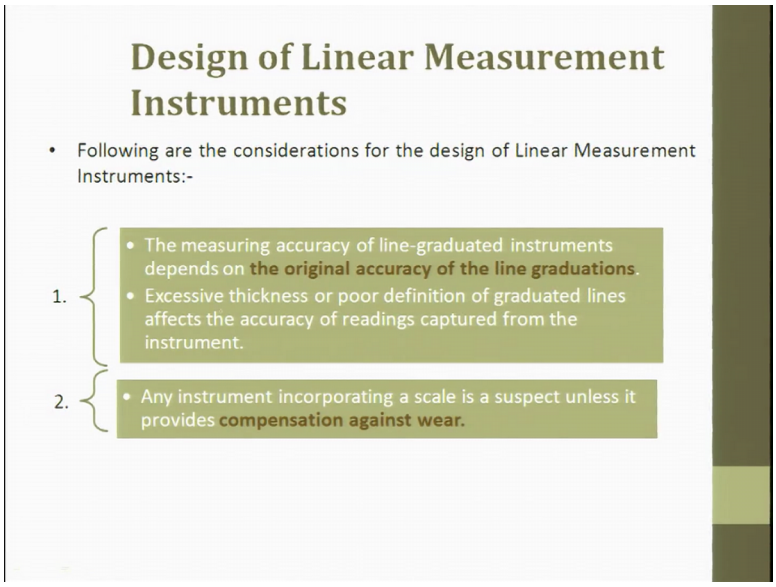

Following are the considerations for design of linear measurement instrument. The measuring accuracy of line graduated instrument depends on the original accuracy of the line graduation. Excessive thickness; so, excessive thickness or poor definition of graduating lines affects the accuracy of readings captured from the instruments, whatever I said earlier clarity. Any instrument, incorporating a scale is a suspect unless it provides compensation against wear.

So, I told you it has to have good wear assistance, the original accuracy of the line graduation.

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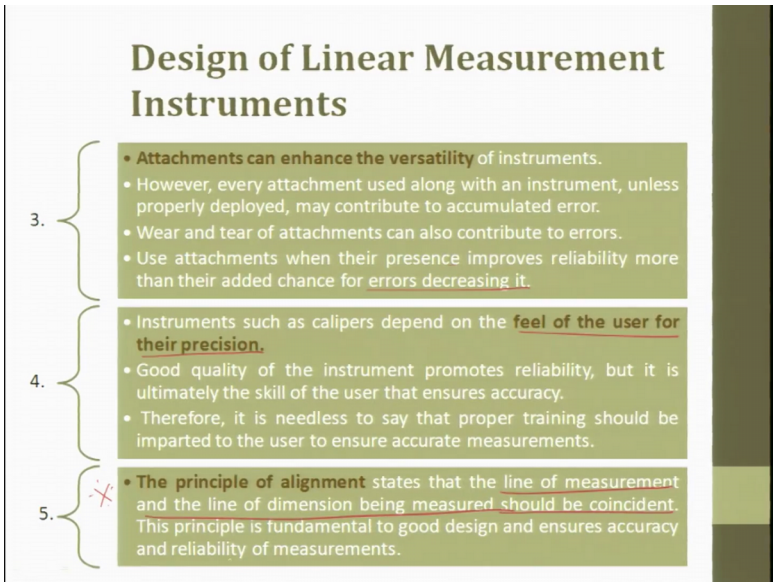

The attachment can enhance the versatility; that means, to say you try to have add on modules to it; so that you can try to do many more different different measurements. So, the attachment can be in, can enhance the versatility of the instrument; however, every attachment used along with an instrument unless properly deployed may contribute to accumulated error. That means to say, you are trying to fix one more attachment to your scale and if the attachment is not fixed properly, then there is going to be an error. So, this error is going to give you a value which is not original.

Use attachments when they are present presence improves reliability more than they are added chance of error decreases it. Then instruments such as caliper depends on the field of the user for their precision. So, when you put of shaft and then you put a caliper, you the looseness of the caliper or the tightness of the caliper is based on the field of the person who use.

So, the instrument such as caliper depends on the field of the user for their precision. Good quality of instruments promote reliability, but it is ultimately the skill of the user that ensures accuracy. Therefore, it is needless to say that proper training should be imparted to the user to ensure accurate measurements, when using these feeler calipers for linear measurement.

The principle of alignment which is very very important there is something called as a bias error, principle of alignment is very important. The principle of alignment states that

the line of measurement and the line of dimension being measured should be coincident. This is a very very valid point. If the lines do not coincides, then that is a small angle which gives you a different value. For example, if they are not coincident and if it is inclined at an angle, so, there will be a cos theta or a sin theta value added to the base when you get the result. The principles the principle is fundamental to good design and ensure accurate and reliability of measurement.

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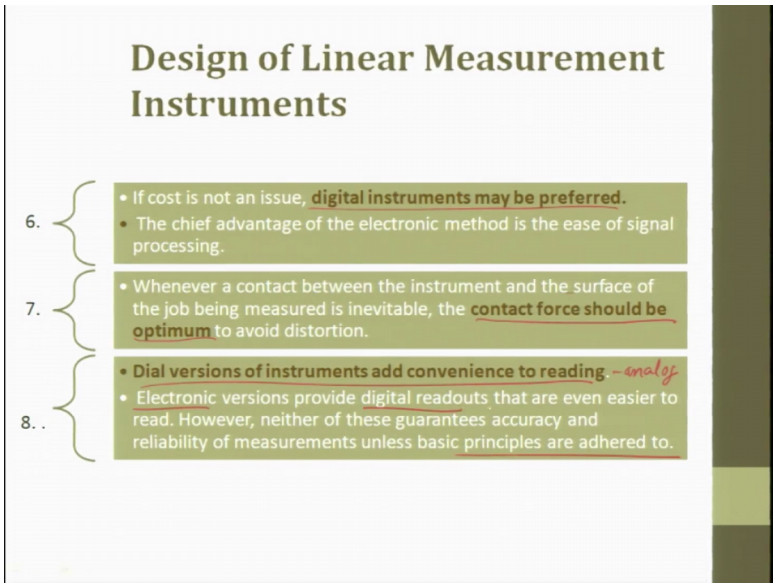

The cost is not an issue; digital display may be preferred because when you talk about second decimal and third decimal using mechanical and then screw gauge, it is always now becoming difficult. So, it is better to have a digital display and the digital display displays to the second and then third decimal to get good results and of course, today electronics are the stability of the electronics have improved a lot.

So, and the battery life, the portability of these electronics have also become very large. Whenever a contact between the instrument and the surface of the job being measured is inevitable, the contact force should be optimum to avoid distortion. So, this is what is the example I asked you to work after my first lecture. I give you a skin try to measure the surface roughness or measure the surface qua properties of the skin.

So, a skin is an elastic material. So, depending upon the contact forces, the force what you apply on the skin, there will be deflection and change in the values. Dial version of the instruments add convenience to reading. So, dial version means, so, we are talking

about analogous; analog. Electronic version versus digital readout provides digital readout that are even easier to read. However, neither of these graduates guarantees accuracy and reliability of measurement unless basic principle are harder to it. What is the basic principle? The coincident between the two accesses, so, this is very important. So, here if you want to go for electronic, it is digital otherwise, it is analogous output.

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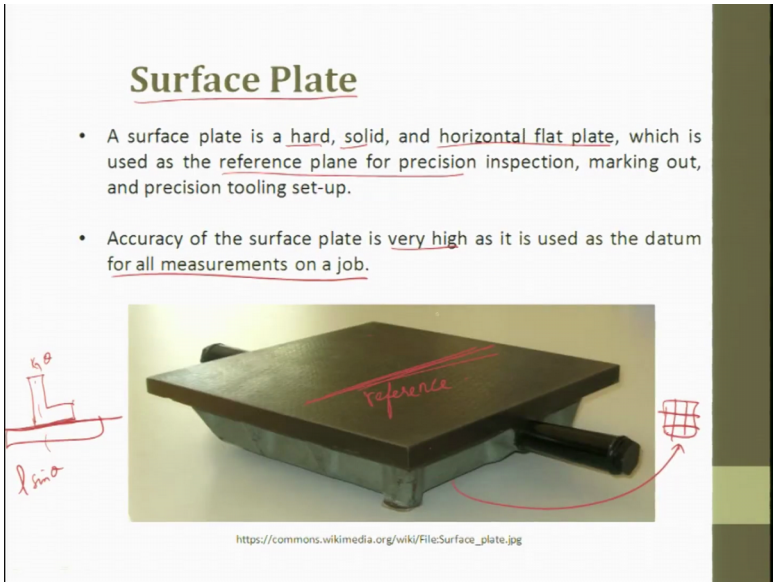

So, this is an instrument which is called surface plate. Surface plate are generally made out of hard is a hard solid horizontal flat plate, which is used as a reference plane for precision instrument. See what happens when you start the doing all these measurements. At least one datum one datum should be flat or one datum should be reference.

For example, I put a surface plate, I put a l square to read right and here this is a flat surface. If there is any angle, then the l square will have at an angle theta right and this theta will try to give me a value which is l length into sin theta. So, you will get a different value.

So, in order to make sure the measurement is correct, we always try to but the instrument as against a reference plane. So, this is a reference plane and surface plate is a reference plane, which is used for many instruments. For example, a height gauge is placed on a surface plate ok. The accuracy of a surface plate is very high and it and it is used as a datum for all measurements on your job. For example, if you want to put a shaft, if you want to put a flat plate, if you want to put any other objects and if you have a reference

surface that reference plane should but against the surface plate. Surface plate are done out of cast iron generally and the surface of the surface plate will be always hardened to so that it has very good wear resistance.

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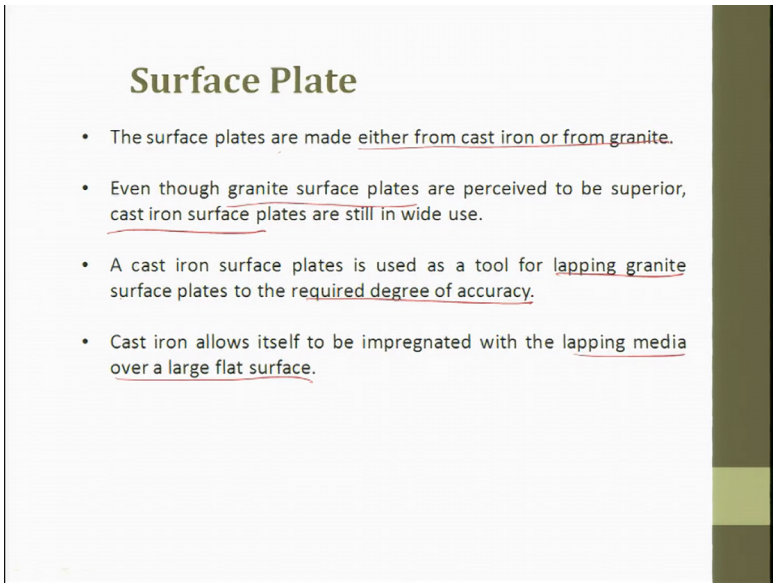

The surface plates are made either of cast iron or of granite. So, why cast iron and granite? Because the coefficient of thermal expansion is very less and we do something called as a scraping operation. So, here we try to make pits and then we try to make it flat ok. It will not be milled. Even though granite surface plates are received to be superior, cast iron and surface plates are still used widely. Because these granite what happens, it is though it the thermal expansion and all is very good but here it is brittle in nature.

So, if at all there is a shock or something happens then it will start cracking and it will break. The cast iron surface plate is used as a tool for lapping granite surface plates to the required degree of accuracy. Cast iron allows itself to be impregnated with the lapping media over a large surface plates. So, we always use this surface plates as a reference plane for measurements.

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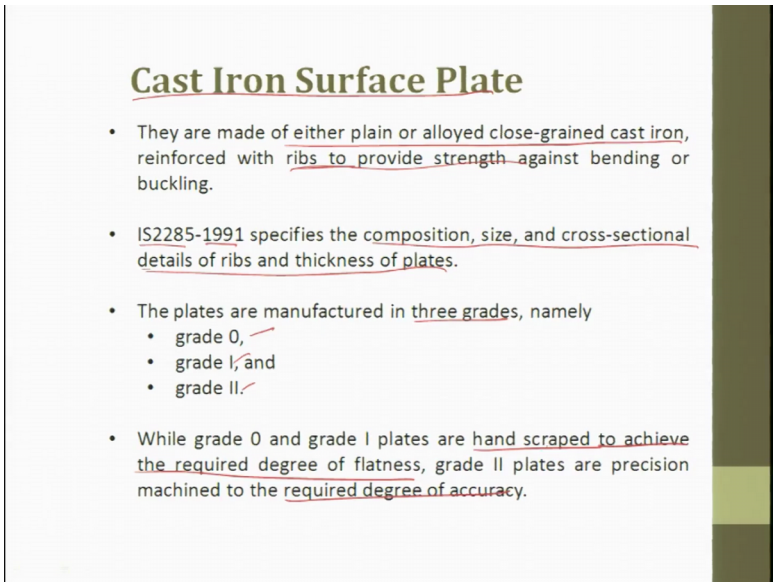

So, when we talk about cast iron surface plates, they are made of either plain or alloyed close grained cast iron, reinforced with ribs to provide strength. So, where are the ribs?

So, if you look at it, on the bottom side of this, this is a very heavy plate. So, on the bottom side of it you see this is cast iron you see here you on the bottom side you will see the ribs, on the bottom side; on the bottom side you will see ribs. So, these ribs and strength provide against bending and buckling may because this is a very small surface plate. You can have surface plate of meter by meter. So, when you have a meter by meter long large, so, then there is a possibility of bending and deflection ok.

IS 2285-1991, specifies the composition size and the cross sectional details of the rib and the thickness of the plate. There are three grades which are manufactured for surface plate; 0, 1 and double; 0 and 1 are hand scraped to achieve the required degree of flatness; grade II plates are precision machined to the required degree of accuracy. Scraping is an operation, where in which we try to make this surface flat.

So, scraping what we do is we try to make dents and remove material and then we apply Persian blue, try to figure out where the uniformity of the pits and with that we try to come out to the flatness of the surface. So, these two are done by scraping, the accuracy is very high when you go to grade II.

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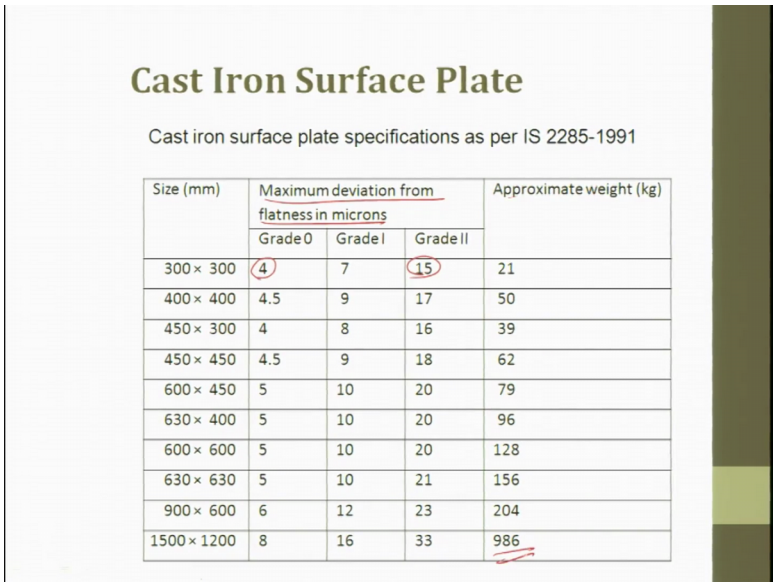

Size (mm)	Maximum deviation from flatness in microns			Approximate weight (kg)
	Grade 0	Grade I	Grade II	
300 × 300	4	7	15	21
400 × 400	4.5	9	17	50
450 × 300	4	8	16	39
450 × 450	4.5	9	18	62
600 × 450	5	10	20	79
630 × 400	5	10	20	96
600 × 600	5	10	20	128
630 × 630	5	10	21	156
900 × 600	6	12	23	204
1500 × 1200	8	16	33	986

So, these are the dimensions which are available, these are the grades. So, you can see maximum deviation flatness in microns; 4 microns, 15 microns ok. So, approximate weight you see it is very heavy. So, this is as per this standard.

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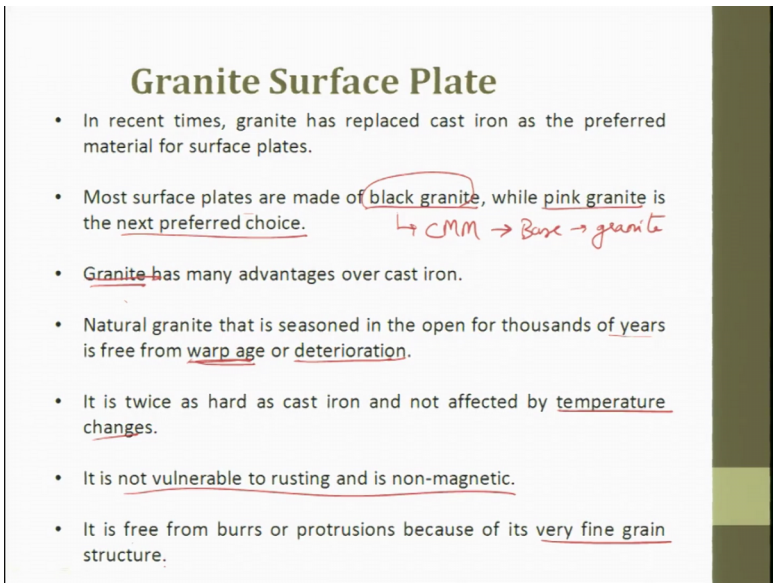

So, granite surface plate; granite surface plate I have started replacing cast iron surface plates. Most surface plates are made out of black, while pink granite is the next preferred choice. So, black is very common. So, that is why you see surface plates, when you buy a CMM machine; Coordinate Measuring Machine, the base of this coordinate measuring

machine is always a granite ok. Granite has many advantages of cast iron natural granite that is seasoned in the open for thousands of years is free from warp age or deterioration.

So, this is much better, warp age is less. Twice as hard as cast iron and not affected by temperature. So, granite has its own advantage as compared to cast iron and the cast iron will is sometimes vulnerable to rusting. So, here it is no rusting and no magnetic field influence and here it is free from bar or protrusion because very fine grain structures are there. So, this is very much used, this is very much popular and today; people have started using granite as compared to that of cast iron.

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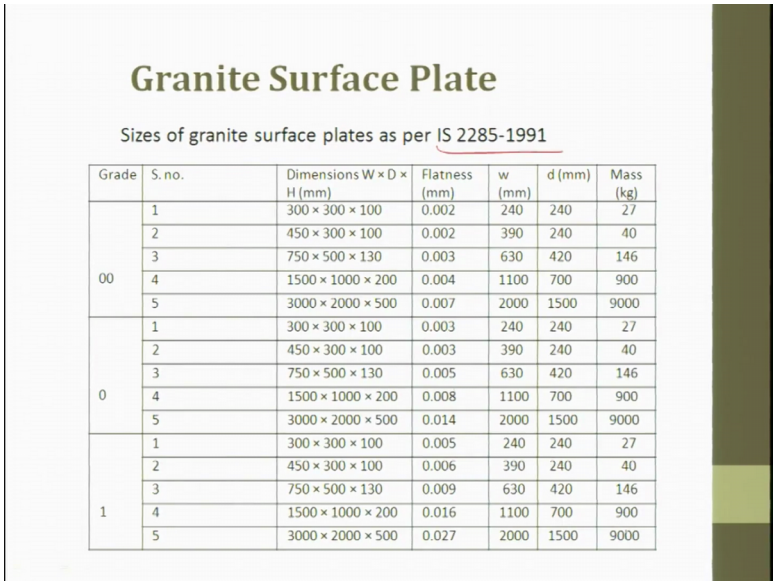

Grade	S. no.	Dimensions W × D × H (mm)	Flatness (mm)	w (mm)	d (mm)	Mass (kg)
00	1	300 × 300 × 100	0.002	240	240	27
	2	450 × 300 × 100	0.002	390	240	40
	3	750 × 500 × 130	0.003	630	420	146
	4	1500 × 1000 × 200	0.004	1100	700	900
	5	3000 × 2000 × 500	0.007	2000	1500	9000
0	1	300 × 300 × 100	0.003	240	240	27
	2	450 × 300 × 100	0.003	390	240	40
	3	750 × 500 × 130	0.005	630	420	146
	4	1500 × 1000 × 200	0.008	1100	700	900
	5	3000 × 2000 × 500	0.014	2000	1500	9000
1	1	300 × 300 × 100	0.005	240	240	27
	2	450 × 300 × 100	0.006	390	240	40
	3	750 × 500 × 130	0.009	630	420	146
	4	1500 × 1000 × 200	0.016	1100	700	900
	5	3000 × 2000 × 500	0.027	2000	1500	9000

So, to according to this standard you can see the grades; 00 0 1 and these are all in microns millimeter. So, you can convert into microns and these are all the weights which is there. So, for a just a distinct example, so, this is 1500 into 1200 which is around about 1000 kilos, which is here 900 kilos. So, it is slightly less ok, approximately it is less ok.

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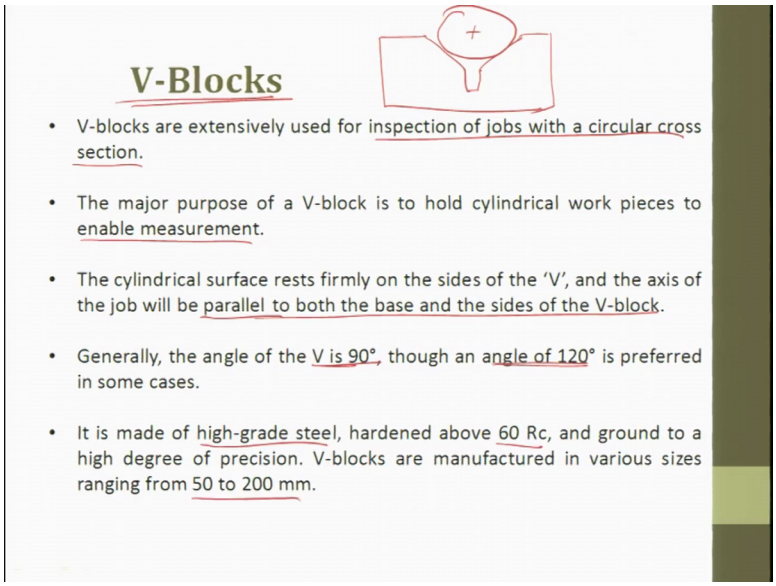

Next is V-Block, let me first show the V block.

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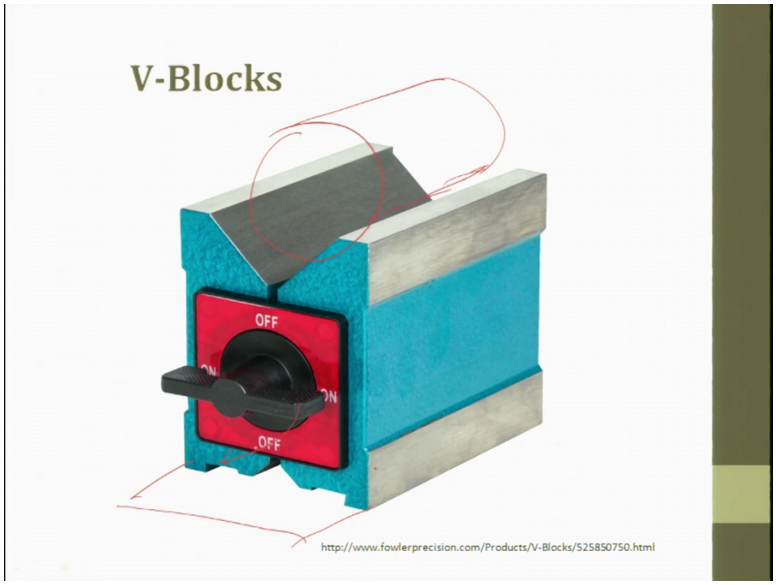

This is a V block. So, here in this V block, we always try to put a cylindrical piece, a cylindrical piece is put and then if you want to measure the height of it you can start measuring it. If it is a magnetic material, so all you have to do is you put a flat plate and then you try to rotate the knob and magnetize it such that this V block gets firmly fastened to the surface plate whatever you have, it is because of the magnet present. So,

V block are extensively used in inspection of jobs which are having circular cross sections, V block.

So, circular cross sections you can try to find out the height, you can try to find out other things also right, so, inspection of jobs. Major purpose of V block is to hold a cylindrical work piece to enable measurement. Otherwise, it is very difficult for you to hold. A cylindrical surface rests firmly on the sides of a V and the axis of the job will be will be parallel to both the base and to the sides of the V block. Generally, the V is 90 degrees, you also get 120 degrees in some cases. Here it is made out of steel which has a hardness of 60 Rc and then it is ground it varies from size 50 to 200 millimeter.

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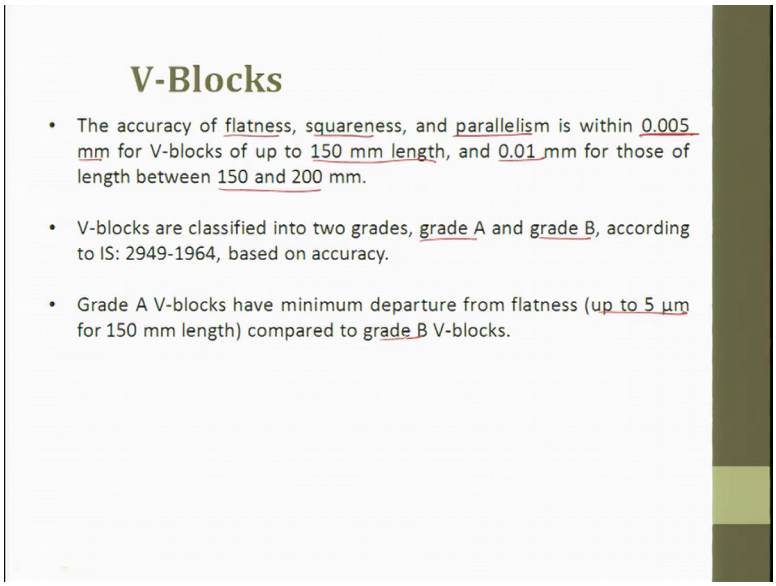

The accuracy of flatness, squareness, parallelism is all very very low; 5 microns. The V block up to 150 millimeter and it is 0.1 for anything more than that.

So, there are two grades; grade A and grade B. So, according based upon their accuracy great AB block has a flatness up to 5 for 150 millimeter as come that of B. So, A block grade is much better than B grade. So, I have already explained to you.

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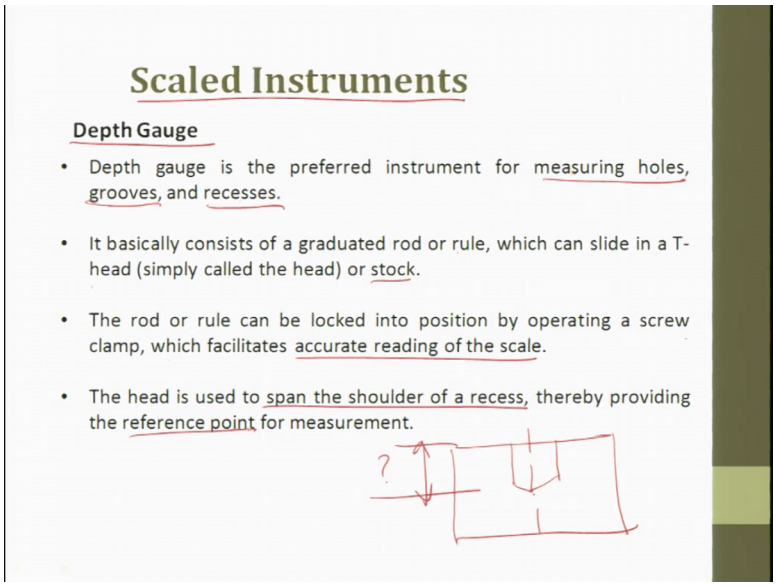

Next is scaled instruments. So, till now what we saw was we saw linear, now we are going to see scaled. First is depth gauge. Let me first to show you your depth gauge.

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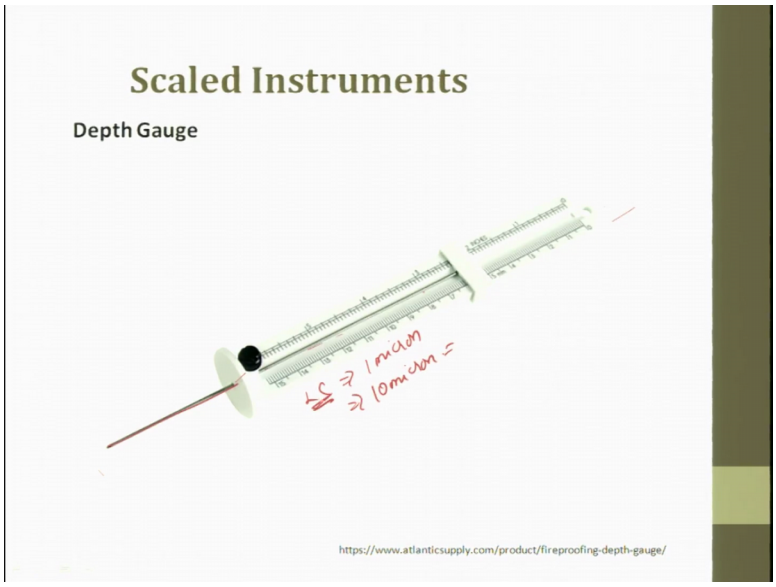

So, this is a depth gauge. So, you have several graduations, you have a pin or a plunger. So, this goes inside the hole, you try to go fit inside the hole and correspondingly this is adjusted height and then you can see the graduation; what is the depth which it has to undergo inside a hole and measure it. So, this is a depth gauge measurement.

So, the depth gauge is preferred instrument for measuring hole, grooves and recesses. Suppose, if you have a blind hole, you have a blind hole, if you want to measure the height of it depth gauge is the only possibility, which can be used to measure ok. So, you can also have holes, hole is through to who through you can have grooves you can also have recess. So, we use the depth gauge.

It basically consists of graduated rod or rules that can slide in your T-headed or a stock. The rod or rule can be locked into a position by operating a screw clamp which facilitates accurate reading of the scale. The head is used to span the shoulder of the recess, therefore, providing a reference for the measurement.

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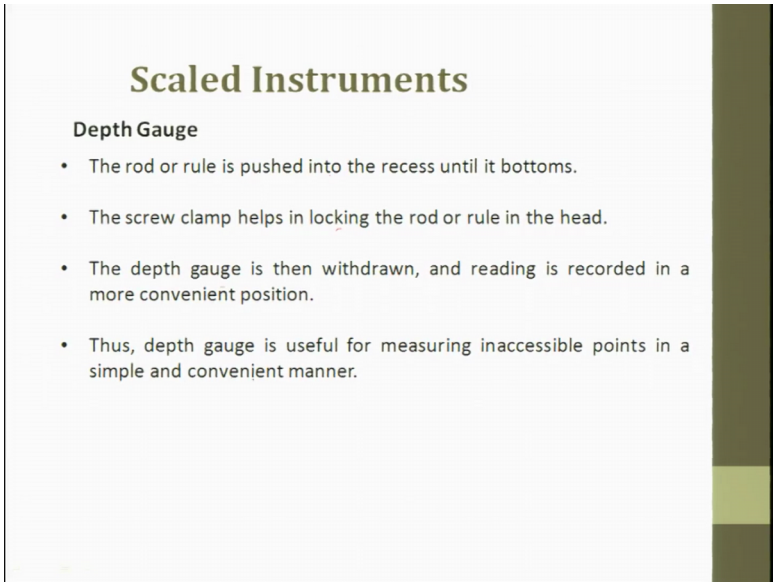

The rod or the rule is pushed into the recess until it hits the bottom. The screw clamp helps in locking the rod and the depth gauge is then withdrawn and you see read the readings accordingly the depth gauge is useful for measuring in accessible points in a simple in a convenient manner. So, this is a depth gauge. So, you can see here graduations and the least count can be up to 1 micron; generally it is 10 microns, it can go up to 1 microns. This is the least count. What does least count? Least count is the minimum distance between two graduations.

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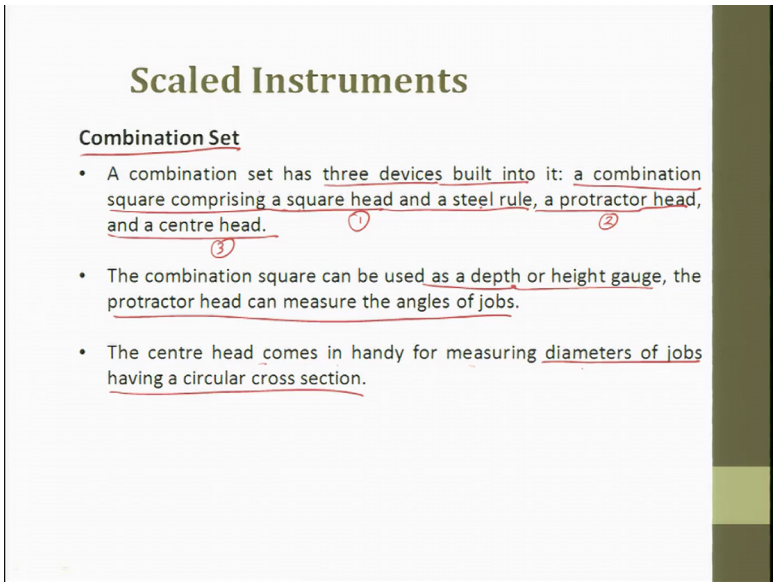

Next one is an interesting thing which is a combined set. A combined set has three devices built into it. So, till now what we saw was only a single instrument a V block right; a V block, a flat plate a depth gauge, maybe a Vernier or screw gauge.

So, all these things are individual equipments. Suppose if we wanted to find out several features, the dimensions of several features with respect to one flat plate or one reference plane then we would like to go for combined set combination come combined set or combination set. A combination set has three devices built into it; a combination of a square comprising a square head and a steel ruler, a protractor head and a center head. It has three. What are they?

A square head, a steel ruler, a square head and a steel ruler, a protractor head and a center head. The combination square can be used as a depth or a height gauge. The protractor head can be used as a angle gauge or angle to measure the angle of the job. The center head combines in handy for measuring diameter of the job having a circular cross section. So, is it clear? So, here is one square protractor and then center head ok.

The combination square can be used as a depth or a height gauge the protractor head can be used for measuring angle, the center head can be comes in handy for measuring diameter of the job having a circular cross section.

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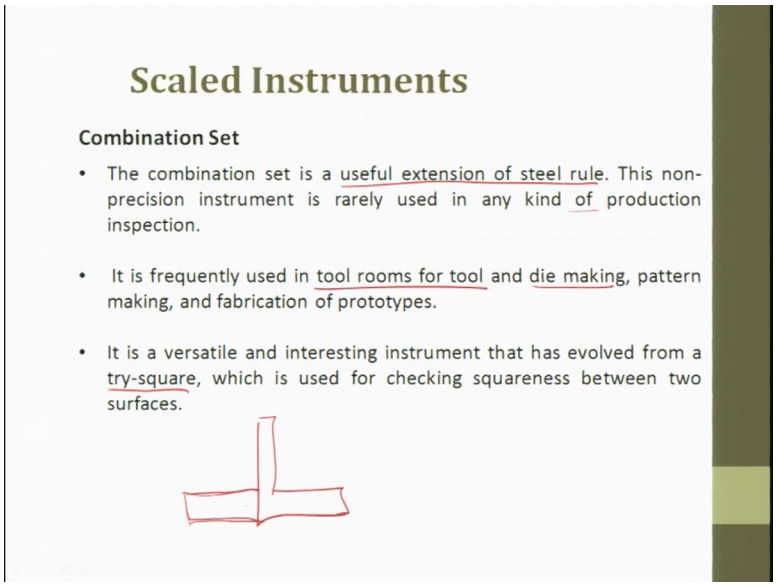

A combination set is very useful extension of a steel ruler. Steel ruler was basically to measure the length. This non precision instrument is rarely used in any kind of production inspection. It is frequently used in tool rooms for tools and dye making; reverse it is versatile an interesting instrument that has evolved from try square. What is try square? Try square is something like this ok. Try square it is try square which is used for checking the squareness between two flat surfaces; this is try square or a T square ok, people will call it as try square and T square.

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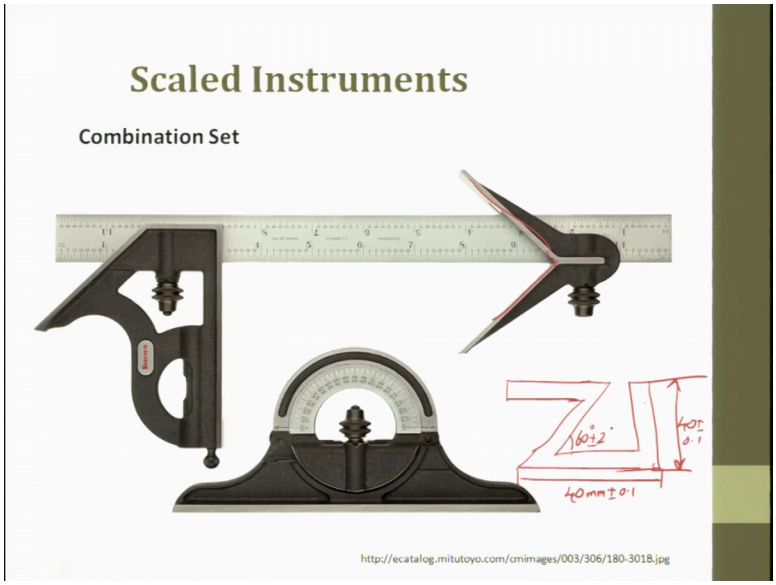

So, this is what it is. So, here is a V block combination set, here is a V block, here is an angle which you want to measure and you also can measure the depth of it by aligning it. There is a very wonderful equipment and really you need skill to use this. So, the advantage is if you have I would like to redraw if you remember I would like to redraw the same component which we discussed last time. Angle is 60 plus or minus 2 degrees, from here it is 40 millimeter plus or minus.1; it is maybe 40 plus or minus 0.1.

So, in this if you see there is an angle, there is a height to be measured, there is a depth also; there is a depth ok. So, this is up to here sorry this is up to this is up to here. So, you have a depth, you have a depth, you have an angle, you have a length to measure. So, then this in one shot can be measured using this combinational set. So, this slides on the scale, this also you can set a V block. So, that cylindrical component this is for at an angle. So, when you put a combination of this you try to get the result out of it.

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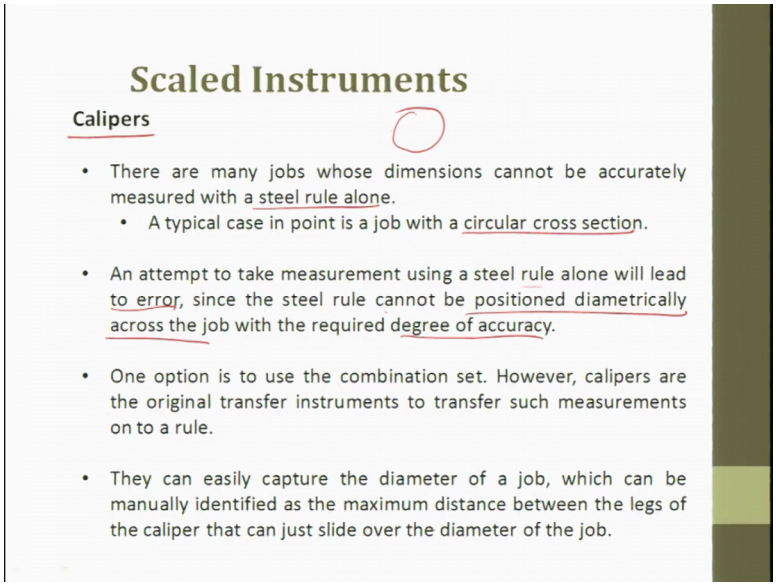

The next one is a caliper, a caliper is basically to take the dimensions but it will not give you the values. It is only to take the dimension, take the shape and then transfer it. So, there are many jobs whose dimensions cannot be accurately measured with steel ruler alone.

So, there we always try to for typically for a circular cross section or cross section jobs we cannot use as clear steel ruler. So, then we go for a caliper. The attempt of making measurement using a steel ruler alone will lead to an error. Since the steel roller cannot

be positioned diametrically across the job to the required degree of accuracy. One option is to use a combination set; however, calipers are the original transfer instruments to transfer such measurements onto a ruler. They can easily capture the diameter of the job which can be manually identified as a maximum distance between the legs of the caliper that can just slide over the diameter of the job. Calipers are like snap gauges, right.

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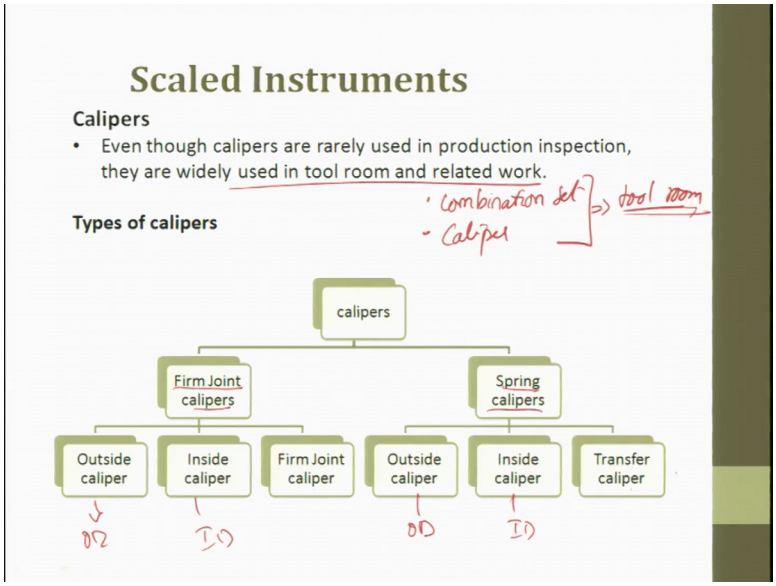

So, even though calipers are rarely used in the production inspection, they are very widely used in the tool room. So, combinational set combination set is also operation is very difficult combinational set then we talk about caliper, these are all used in tool rooms. Tool room basically tool rooms are rooms where in which is used for grinding or manufacturing a tool which can be used in the regular process line or they try to make tools.

For example, dye is a tool for metal for injection molding. So, they make tools and then they give to the regular production time or they try to take HSS tool or maybe try to take a HSS drill or they try to manufacture a lapping tool. So, all these things are done in a tool room. So, here they use this caliper very much.

So, caliper can be of two things; one is firm joint and another one is spring based. You can see even compasses or dividers are firm joints and spring joints. Again in firm it can be outside caliper, it can be inside caliper. This is for OD this is for ID ok; this is OD and ID. So, same way with spring also you can have four OD and ID and you also have firm

joint caliper and transfer caliper, these things are just to transfer the values where even which you will also have a scale to take care of this measurement.

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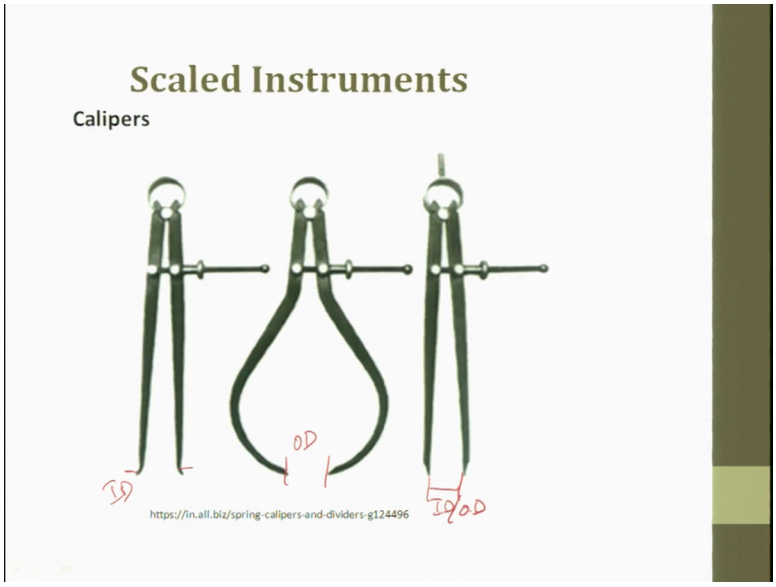

So, these are the different types. So, this is inward, this is outward and this is also you can try to put an attachment and make it inward or you can make it outward, outward dimensions.

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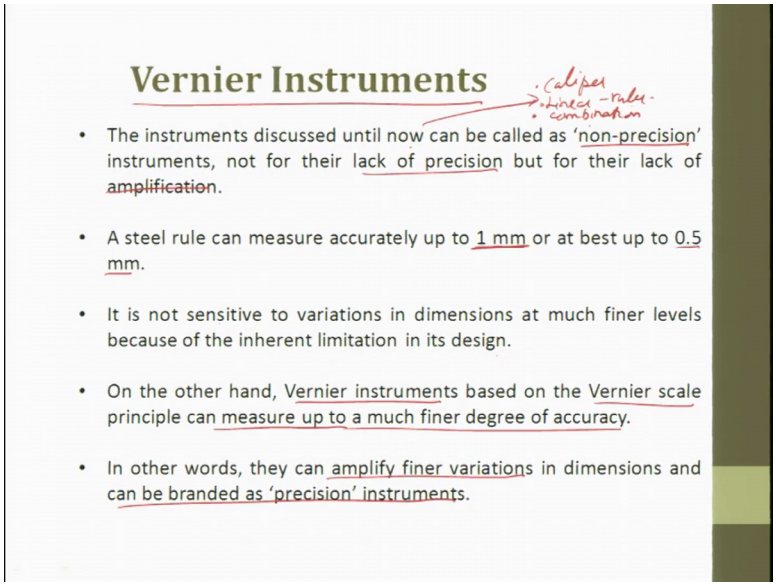

The next instrument for discussion is Vernier caliper. This instrument until now can be called as non precision instrument due to the lack of precision, but for their lack of

amplification. A steel ruler can measure accurate up to 1 millimeter, at the best it can go up to 0.5 millimeter.

If you want to go less than that then we have to use instruments like Vernier caliper and screw gauges. It is not sensitive to variation in dimensions at much finer levels because of the inherent limitation in that design. On the other hand, Vernier instruments, based on Vernier scale principle can measure up to a much finer degree of accuracy. In the other words, they can amplify finer variation in dimensions and can be branded as precision instruments.

So and discussed until now until now what did we discussed? We discussed about caliper right, we discussed about caliper, we discussed about linear measuring ruler, we were listening about combination ok. All these things were not highly positioned but moment when you come to this Vernier, we are having very high precision.

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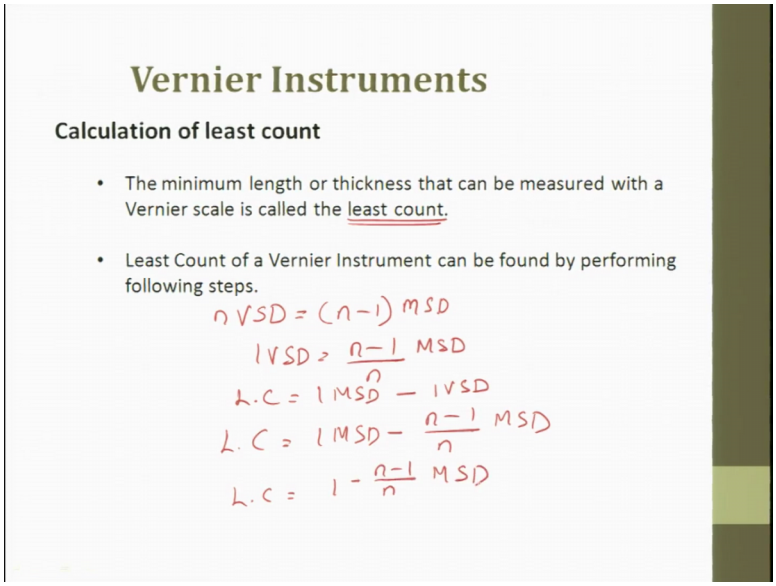

So, let us calculate, let us calculate the Vernier calipers least count. So, the minimum length or the thickness that can be measured with a Vernier is called as the least count, least count. What is the least count for a for a TFT monitor? There is 1 pixel ok. When you talk about rapid prototyping what is it? It is called as voxel ok. When you talk about a scale ordinary scale which you use for measuring, the that between two graduations that is least count. The least count for of a Vernier instrument can be found out by performing the following step. So, what we do is n VSD equal to n minus 1 MSD,

Vernier Scale Division and Main Scale Division. So, 1 VSD equal to n minus 1 by n MSD, main scale division. So, least count is nothing but 1 MSD minus 1 VSD, Vernier scale division.

So, the least count is 1 MSD minus n minus 1 by n MSD, correct and then this can the least count can be written as 1 minus n minus 1 by n MSD.

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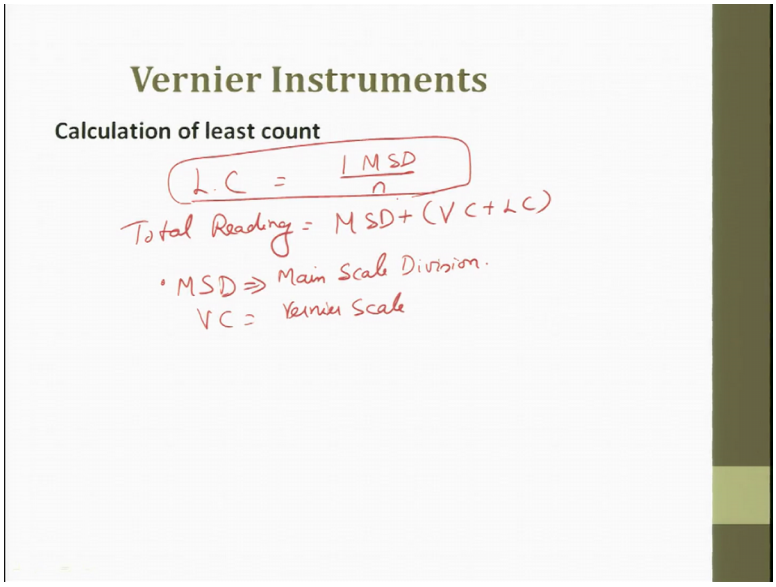

So, then least count is nothing but 1 MSD by n. So, the total reading whatever we do it is MSD plus Vernier scale least this thing. So, here let me explain the acronym; MSD is the main scale reading MSD or MSR, Main Scale Division ok, LC is the Least Count and VC is the Vernier Scale ok. If you want to call it as VCD, if you want to call it as I mean I call it as VSD VSD its Vernier scale division ok.

So, this is how we try to calculate the LC for a given Vernier. This is 1 MSD by n, n means number of divisions.

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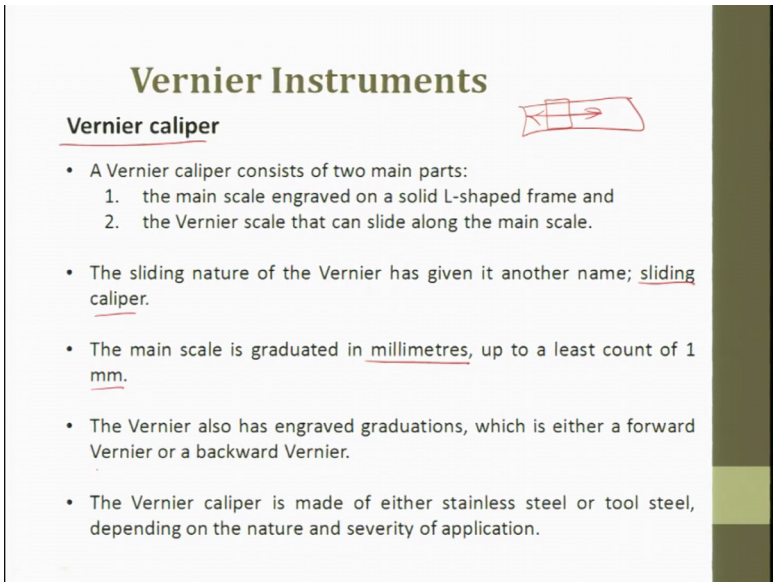

So, in a Vernier caliper, Vernier calliper consists of 2 parts. One is main scale engraved on a on a solid L shaped frame. Then you have a Vernier scale that is sliding on a main scale. So, this is the main scale, then assume that there is a block which slides on it, right; so, this is what is Vernier scale. The sliding nature of the Vernier has given it another name called as sliding caliper.

The main scale is graduated in millimeter up to a least count of 1 millimeter. The Vernier has engraved graduations which are either a forward Vernier or a backward Vernier. The Vernier caliper is made out of stainless steel or tool steel depending upon the sensitivity.

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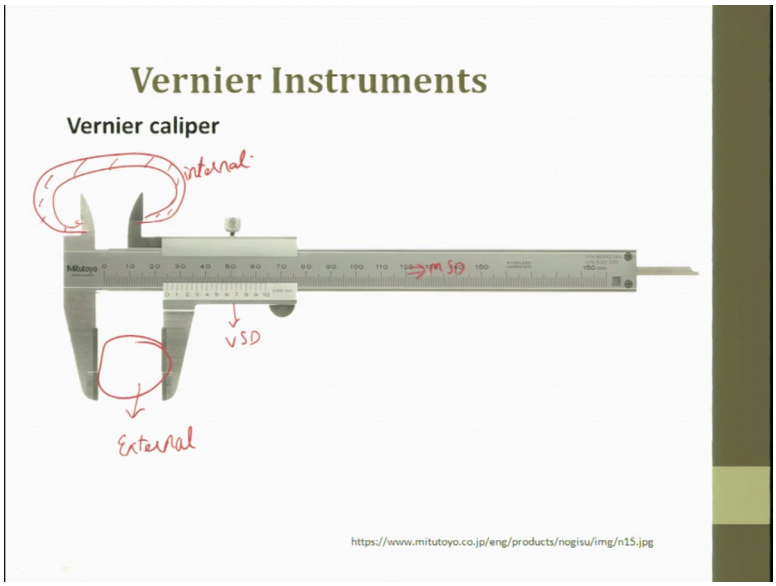

So, this is the main scale reading and this is the Vernier scale division ok. If you put a component here, so, first what we do is this can be used for external and this can be used for internal. For example, I can put a shaft, a component something like this. So, you can use it for this is for external, this is for external and this is for internal features.

First, we just slide this across the main scale division and then what we get is we try to see what is the value for 0? So, that we try to know what is a millimeter and then what we do is we try to match this graduation whatever is here with respect to the graduation which is there on the main scale division. Moment one of these graduations meet, so, then what we do is, we take this then we add this and then we try to take the Vernier scale division.

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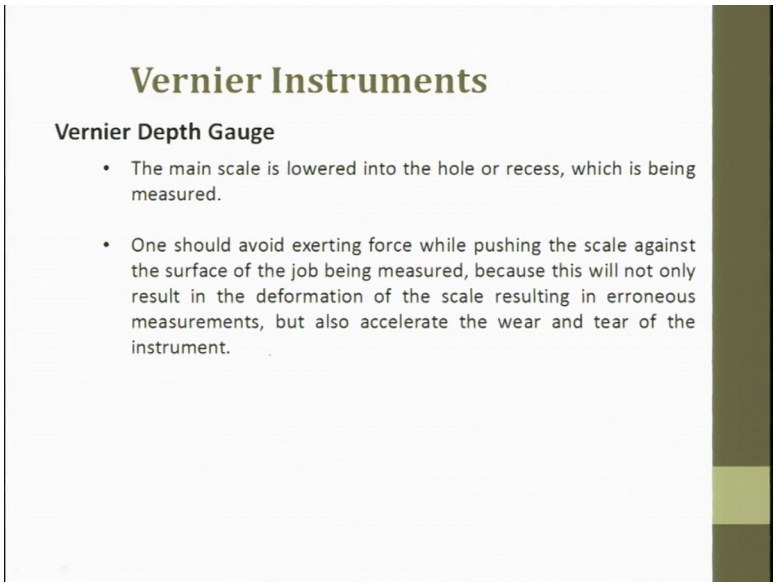

You also have Vernier depth gauge; Vernier depth gauge is a more versatile instrument which can be used for measuring up to this smaller. The lower surface of the base has a blunt form lay against the upper scale of the hole and recess. So, it we have already discussed. So, it has a nut to slide and then loosen it. The main scale is lower and then one should avoid excessive force to be applied. So, that it does not deflect.

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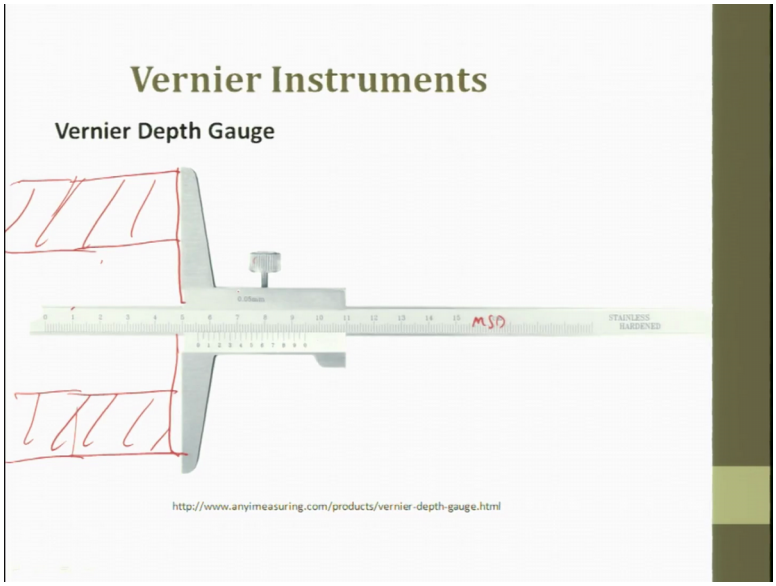

So, this is a depth gauge. So, here it rests against the maybe a component or whatever it is. So, this is a component, this is the depth and again this is a main scale division and

this is the Vernier scale division. First slide get the 0 value and then we see a matching value multiplied with some factor which is given here. So, with this 0.05 division we multiply and then we try to get whatever is the answer.

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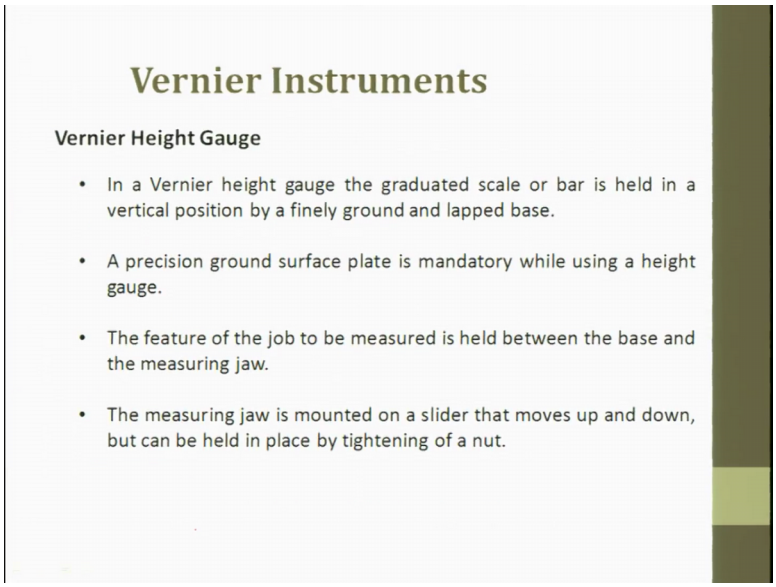

Vernier height gauge, we have already seen. So, I do not want to cover in depth much it is the same. So, here if you see here there is a screw which when you put it, when this book part hits against the reference plane then you tighten it and then remove the scale out and see what is the readings.

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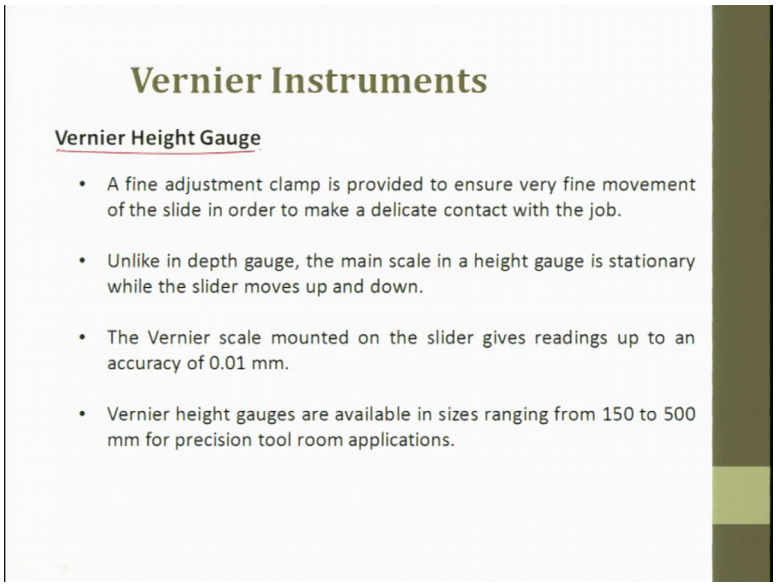

Vernier height gauge, it is the same. So, I need not go in depth on this.

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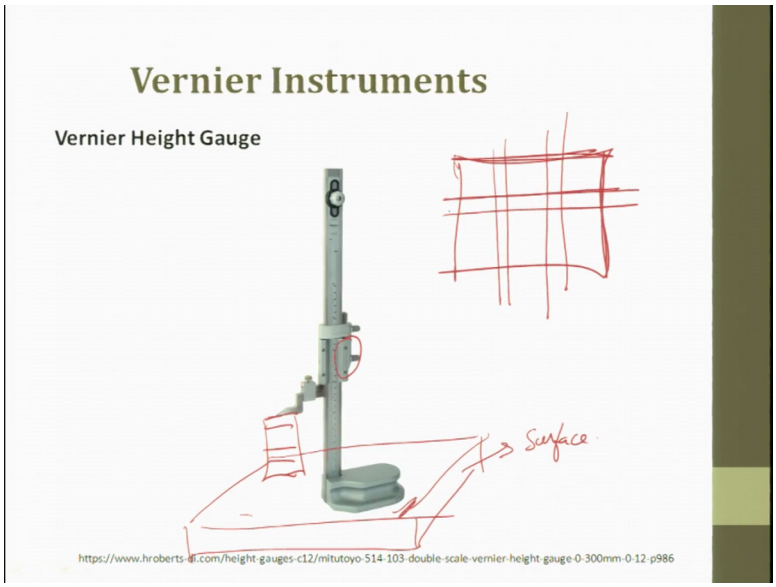

So, this is the, this is a Vernier Vernier depth gauge, this is Vernier depth gauge and in the very similar fashion you will also have Vernier height gauge ok, I have Vernier height gauge. So, here is a Vernier height gauge, this Vernier height gauge by the way can be put on a surface plate. This is a surface plate, where the reference on the surface and the flat on the base are buttered with each other, so that you do not get any angle theta value for this plane.

So, here is a height gauge, again the same concept of depth gauge, you have a Vernier here, you have a main scale division here and here you can try to put your end surfaces or you can try to make a small attachment and even put a cylindrical one and start measuring it.

For example, if you have a flat plate and if you want to measure and draw lines for some applications then what we do is we try to machine this work piece and make the surface flat and then keep it on a surface plate and then use the height gauge and then we try to scribe the line on top of the surface, so that we try to get the marking.

So, with this now either you can punch or you can do any operation of your choice for further machining.

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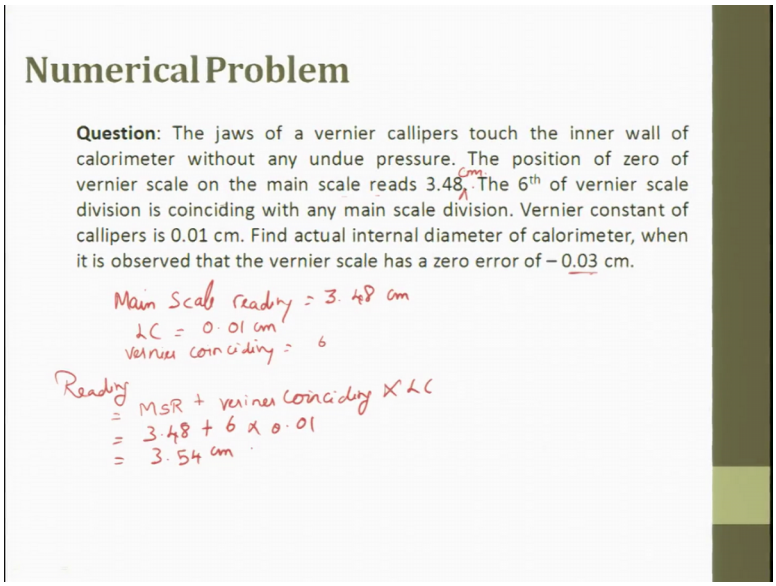

So, let us take a simple example here to solve the problem. So, a jaw of a Vernier caliper touches the inner wall of a calorimeter without any undue pressure and by the way when you use all these instruments makes sure that you do not apply tremendous pressure. That is why in screw gauge if you see after the shaft is put inside, we start rotating the screw and then later when we start rotating the Vernier screw head, we just wait for the click sound because the click sound will try to apply uniform pressure on top of on the cylindrical component.

The position of the zero of the Vernier scale or on the main scale reading is 3.48, the 6th of the Vernier scale division is coinciding with an with any main scale division. Vernier constant of the caliper is 0.01 centimeter.

Find actually internal diameter of the calorimeter when it is observed that the Vernier scale has a 0 error of minus 0.03 centimeter; that means, to say there is a instrumental error; over a period of time wear and tear has happened. So, they figure out there is a error of minus 0.3. So, now, let us try to solve the problem.

So, what is the main scale reading is equal to 3.48 centimeters, I will also take it here centimeters right. Then the least count is nothing but, 0.01 centimeter. So, Vernier coinciding which is nothing but 6. Now, the reading whatever is showing, reading is nothing but MSD reading, main scale D reading or if you want to say a main scale you can call it as main scale reading, I will change it into MSR, main scale reading plus

Vernier scale Vernier Vernier coincidence coincident coinciding into LC. So, this is nothing but 3.48 plus 6 into 0.01, so, which is nothing but 3.54 centimeter.

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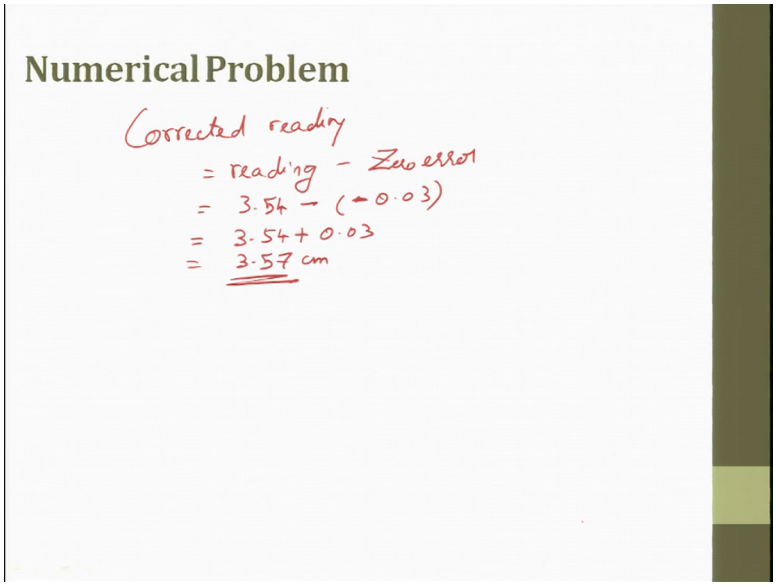

So, the corrected reading; the corrected reading which because we said there is an error. So, corrected reading is equal to Reading minus the Zero error, which is nothing but 3.54 minus 0.03; which is nothing but 3.54 plus 0.03 which is 3.57 centimeters.

So, the corrected reading will be this. So, for this problem, it is a very trivial problem, main scale reading plus Vernier coincidence into LC. So, we got this. So, now, what we say this is the minus value; so, reading minus 0 error. So, this minus minus gets compensated. So, it becomes plus and then the final answer is 3.57.

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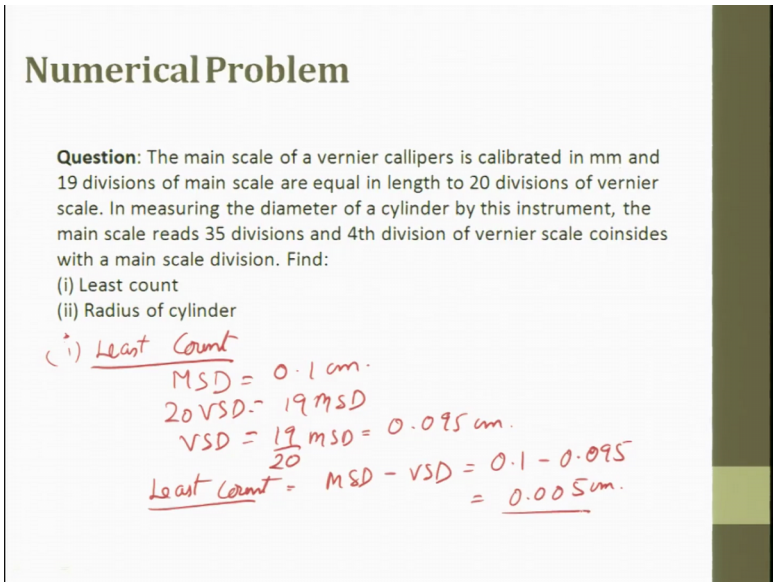

Let us take one more saw problem to solve. The main scale of a Vernier caliper is calibrated in millimeter and 19 divisions of the main scale are equal to 20 divisions of the Vernier scale. In measuring the diameter of the cylinder by this instrument by this instrument, the main scale division reads 35 divisions and the 4th division of the Vernier scale coincides with main scale division. Find LS, LC and find the radius of the cylinder. So, first let us take the least count to be figure it out, least count.

So, it is nothing but main scale division is nothing but 0.1 centimeter and if you want to have 20 Vernier scale division is equal to 19 MSD. So, VSD is nothing but 19 by 20 MSD, which is nothing but 0.095 centimeter ok, this is the least count. Is it right? No, no; this is the VSD, least count will be least count is nothing but MSD minus VSD which is nothing but 0.1 minus 0.095, which is nothing but 0.005 centimeter; this is the least count, least count. So, now, let us try to find out the radius of the cylinder.

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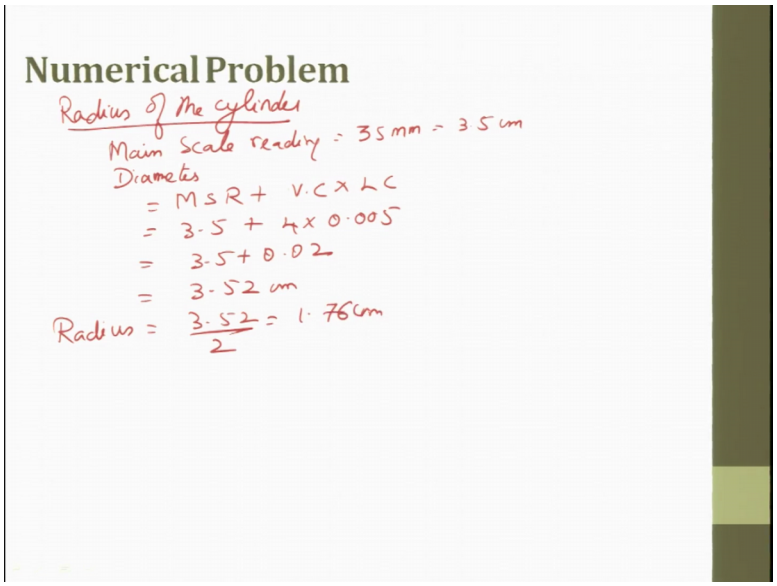

Now, radius of the cylinder; so, here main scale main scale reading is equal to 35 millimeter, which is nothing but 3.5 centimeter because I am trying to make it one uniform standard. So, the diameter is equal to main scale reading plus Vernier coincidence into least count.

So, this is nothing but 3.5 plus Vernier is 4 and the least count is 0.005. So, this is nothing but 3.5 plus 0.02. So, this is 3.52 centimeter. So, we are asking the radius and what you get here is diameter, so, 3.52 by 2, which is nothing but 1.76 centimeter ok. This is also a very simple problem. So, now, you see we have given some real time examples. So, you measure this, what is a division you get from that you are trying to find out the least count and you are also trying to find out the radius of the cylinder.

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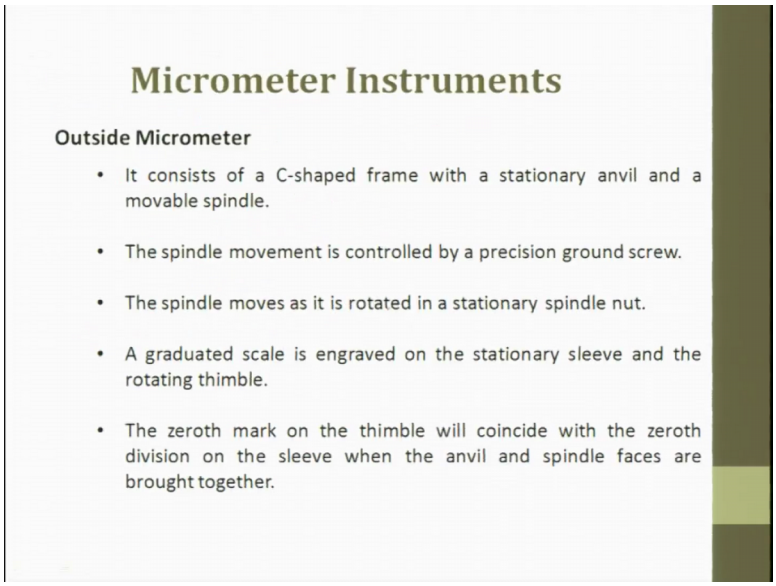

So, next we will move to outside micrometer. The outside micrometer consists of a C frame with stationary.

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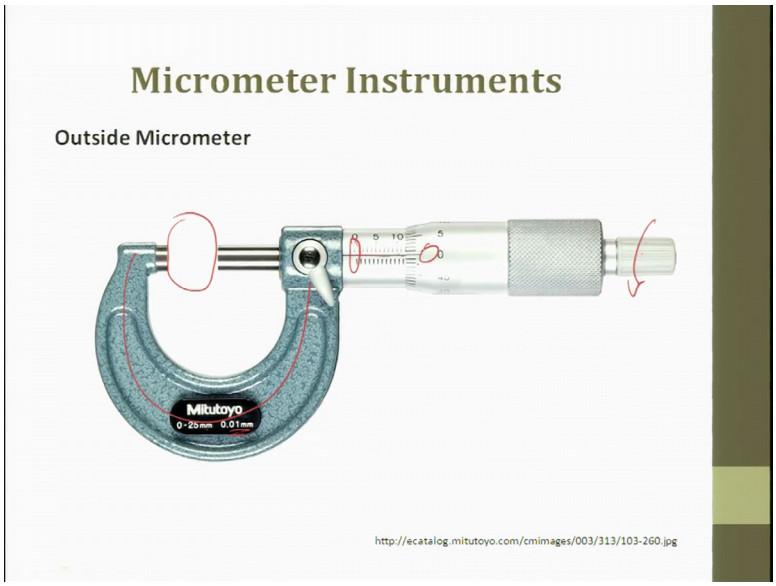

So, this is the outside micrometer. So, or people call it as screw gauge ok. So, here it is 0 to 25, this is the least count they have given. So, here ok. So, this is the main scale and this is the Vernier scale or here is that screw. So, what we do is we try to keep the component here and then we start rotating and then once it is very close and it is very tight then we start rotating this knob until we get a click sound. Moment we get a click

sound, the idea is uniform pressure is applied. So, that we stop and look at the readings of main scale and the Vernier scale to solve it.

So, it consists of a C frame with stationery anvil and a moving spindle. So, what this is a stationary anvil and this is a moving spindle. The spindle moves movement is controlled by a precision ground screw. The spindle moves as it rotates in a stationary spindle nut. The graduated scale is engaged on the stationary sleeve and rotating thimble. The 0th mark of the thimble will coincide with the zeroth division of the sleeve, when the annual and the spindle faces are brought together.

So, before you start measuring, you are supposed to bring this too close to each other, try to see whether this 0 and this 0, so, whether this 0 this 0 matches. So, that you try to get the 0 0, if not you try to note down the error and do the correction.

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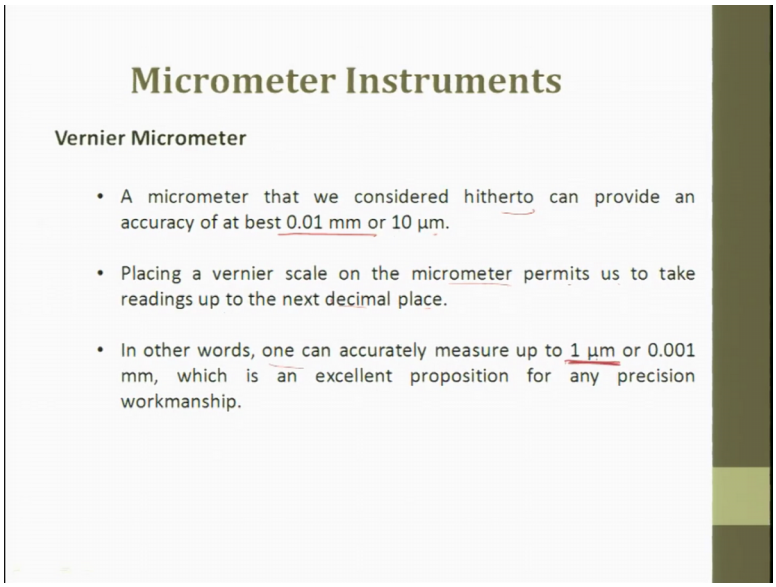

So, Vernier micrometer; so, this is outside micrometer. So, next is Vernier micrometer.

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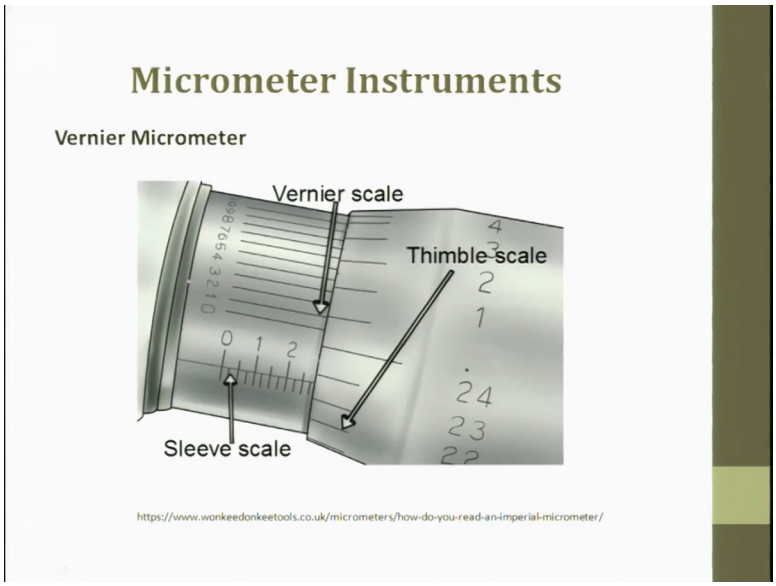

So, this is the Vernier micrometer, you see here were near scale and you see the thimble the thimble is a nut which is attached right and here is a sleeve scale which is there. So, this is the master main scale. So, the micrometer that we use can provide can provide an accurate to the best of 0.0 or 10 microns. Placing a Vernier scale on the micrometer permits us to take a reading to the next decimal place. So, here it goes to the next Vernier takes us to the next decimal place. So, you can accurately measure up to 1 micron using this Vernier micrometer. So, this is what is the thimble scale, scale and here are the graduations and here is the sleeve.

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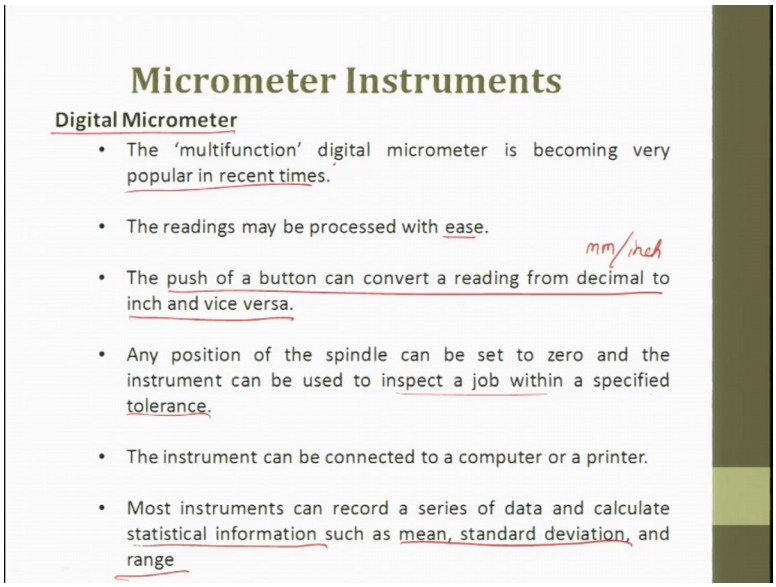

Digital micrometer is the latest which is there in order to get out of the ambiguity or measuring angle that if the principles are not followed, so, you might get to different values. So, in order to get out of it, we are nowadays using digital micrometer. A multifunctional digital micrometer is being is being very popular in the recent times. The readings are very easy to measure. The push of a button can be converted in can convert a reading from decimal to inches and vice versa.

Still today, people use decimal. So, people some people use millimeter, some people use inches for measurement. So, 1 quarter of an inch 3 by 4th of an inch. So, by push button, you can quickly swap the values, which is not possible for you in the in the normal manual display. Any position of the thimble can set can be set to 0 and the instrument can be used for inspecting a job without specifying the tolerance.

That means to say, you have a standard you have made that you have standard and then what you do is you reset the button of the digital and make it as 00 and hence for from that 25, you just try to check the variation alone. The instruments can be connected to a computer and this can also be used for the gives statistical information like mean standard deviation and range today. Mean is the average of data, standard deviation talks about the distribution of the data, range is the minimum and the maximum value which it can.

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So, you can see here it can see the decimals it can go up to three decimals. So, here these are something which are used to convert from inches to millimeter and other things.

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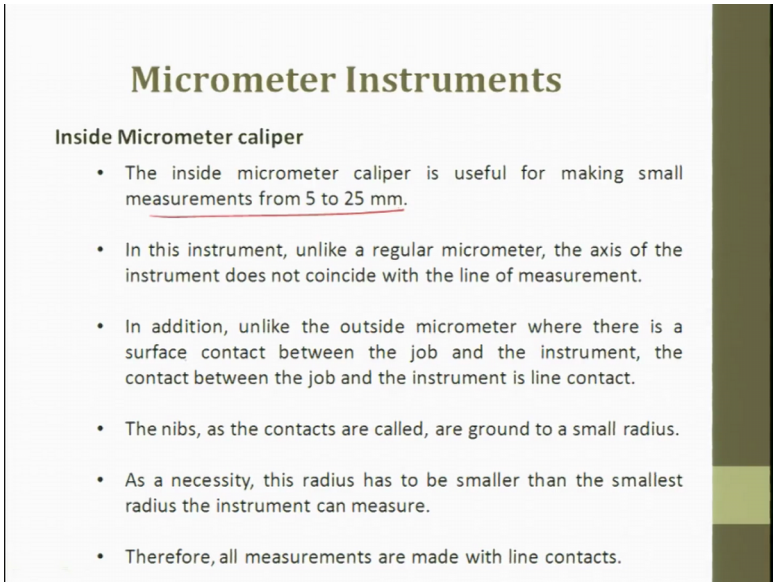

So, here is that lease count which is displayed which talks about 1 micrometer. Inside micrometer, so, inside micrometer the inside micrometer is used for making very small measurements from 5 to 25 millimeter.

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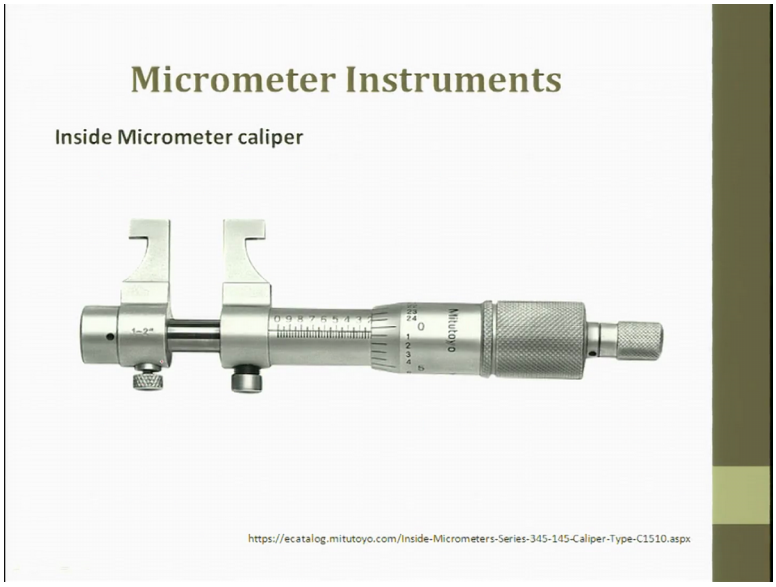

This is the inside micrometer. So, whatever we had here was outside. So, you can also have inside micrometer, rest all equipment follows the same. So, you will have a main

scale reading, you will have a thimble, thimble screw. So, these are the Vernier scale readings and then you will try to get the values.

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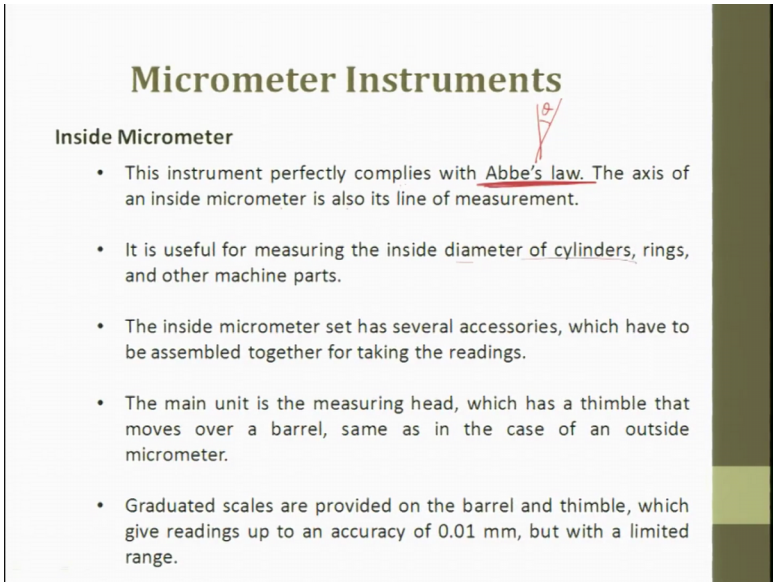

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So, this is another type of inside micrometer. So, this is a slightly higher end. So, this instrument is this instrument prefers complies with Abbe's law, the Abbe's law, the Abbe's error, we will see that little later; Abbe's law and the axis of an inside micrometer is also its line of measurement

So, Abbe's law is very much. So, Abbe's law is basically to make sure that there is no angle error in the measurement. It is useful for measuring inside diameter of a cylinder. This inside diameter set has a several accessories you can add to it.

The main unit is the measuring head which has a thimble that moves over a barrel, same as the case of an outside micrometer. So, here is the thimble. So, here is a movement which is happening, you can lock it and here you can see the accuracy the least count in terms of inches and in millimeter. So, several Add-ons can be added such that it can measure the values properly.

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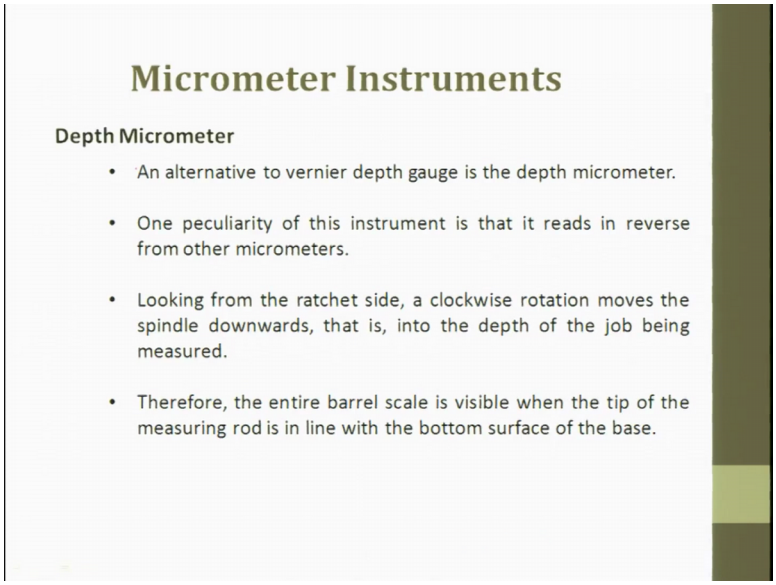

So, the depth micrometer we have already seen.

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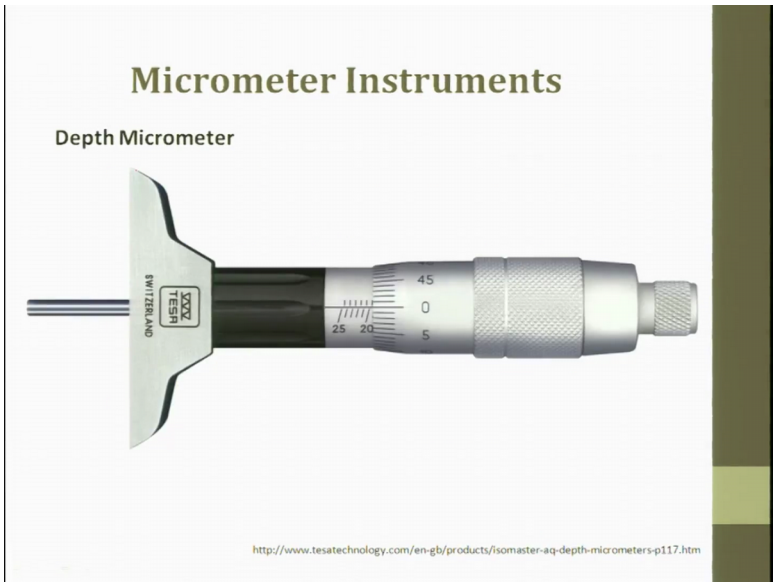

So, this is the depth micrometer. So, again same with a thimble, you have a main scale reading and you have a Vernier.

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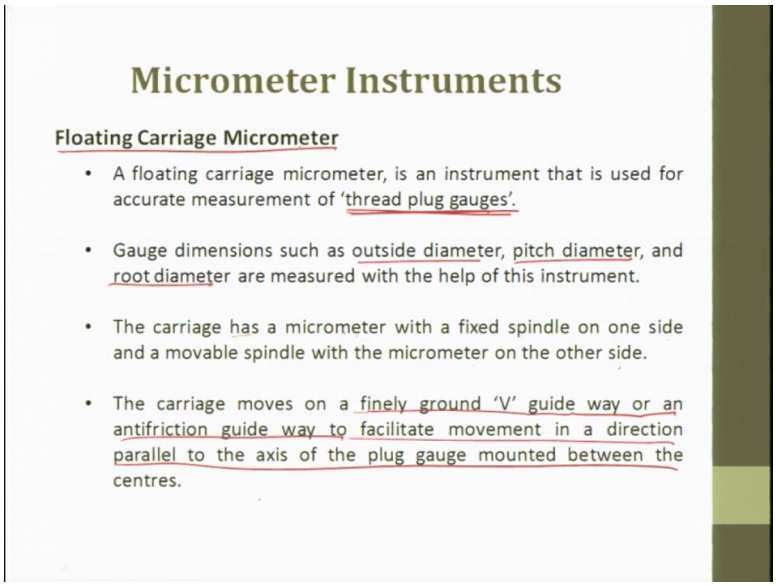

So, there is another thing which is called as floating carriage micrometer. A floating carriage micrometer is an instrument that is used for accurate measurement of thread plug gauges. So, measuring threads is also a very important parameter. So, this floating carriage micrometer is used to measure the thread plug gauge. The gauge dimensions

such as outside diameter, outside diameter, pitch diameter, root diameter are all measured with this equipment.

So, till now what we were measuring is only the length, depth, height, but now you see we are also trying to measure the thread. The carriage has a micrometer with fixed spindle on one side and a moving spindle of micrometer on the other side.

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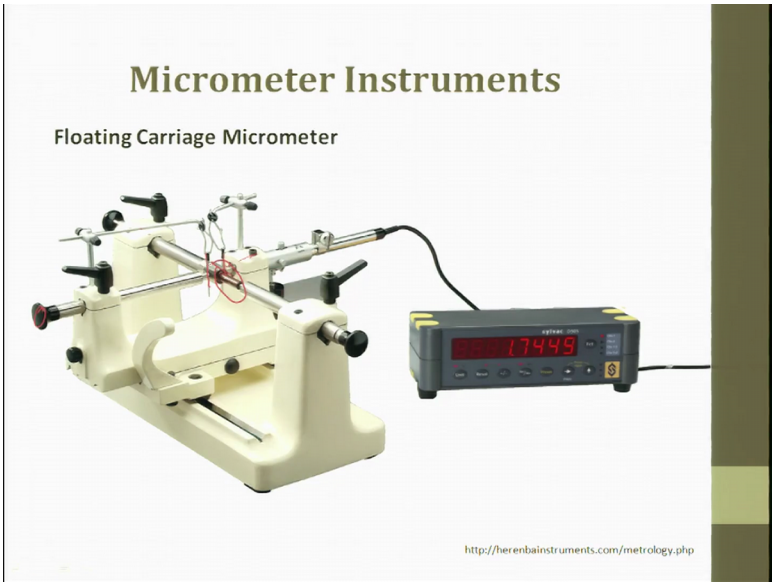

So, this is a floating carriage micrometer. So, it has a it has the carriage has a micro has a micrometer with a fixed spindle on one side, fixed spindle on one side and floating on the other. The carriage moves on a fine ground V guide ways or an antifriction guide ways to facilitate movement in the direction parallel to the axis of the plug gauge mounted between the centers.

So, the object is held between centers and then you try to measure the root diameter, the thread profile using this micrometer.

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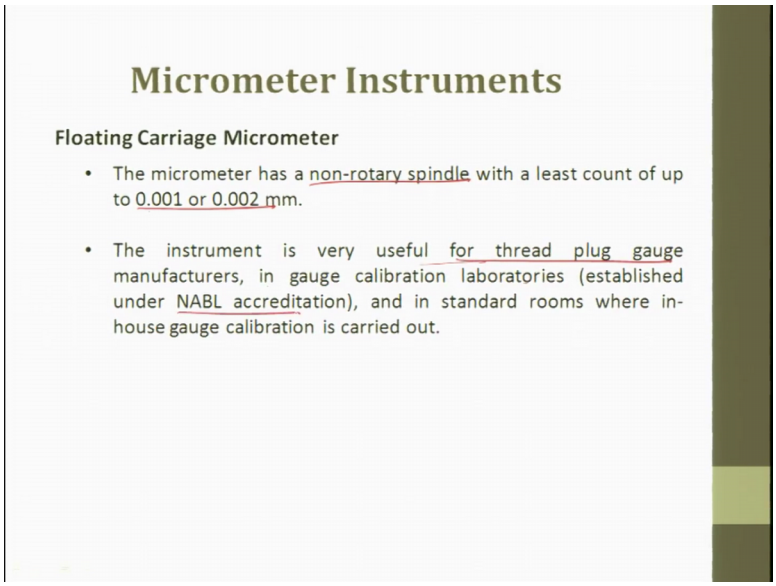

The micrometer has a non stationary spindle of a least count of 0.002; 0.2 that means, to say microns. The instrument is very useful for thread plug gauge measurement in gauge calibration laboratories which is there in NABL accreditations, which is there. So, this is a floating type. So, here you see here is a device. So, and then you can measure it. So, here you place it between the two centers and then we tight it, we lock these two and then we try to measure the deviations.

Thank you.