Engineering Metrology

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Lecture - 17
Laboratory demonstration: Combination set, slip gauges, sine bar

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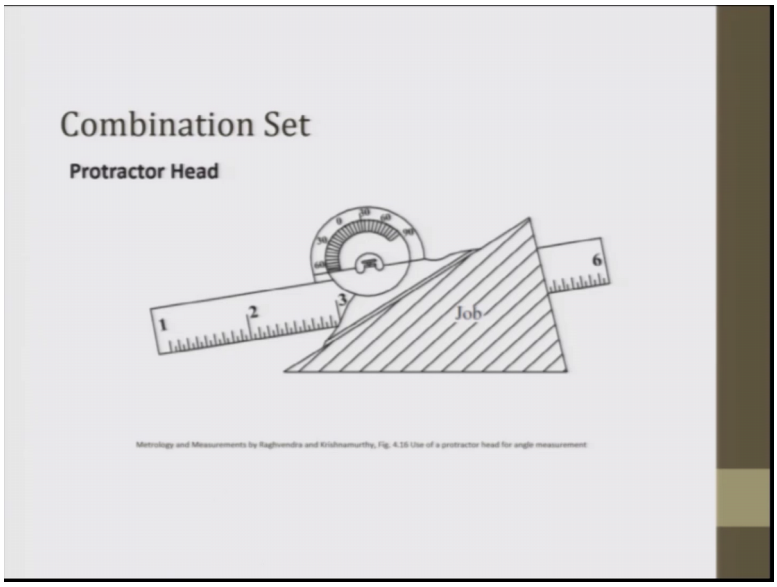

Welcome back to the course Engineering Metrology. We are in the Laboratory demonstration section here. So, next instrument I have picked here is the combination set. Combination set is the combination of three major instruments. Number 1 protractor head, number 2 center head, number 3 is square head. So, we have all the three heads here.

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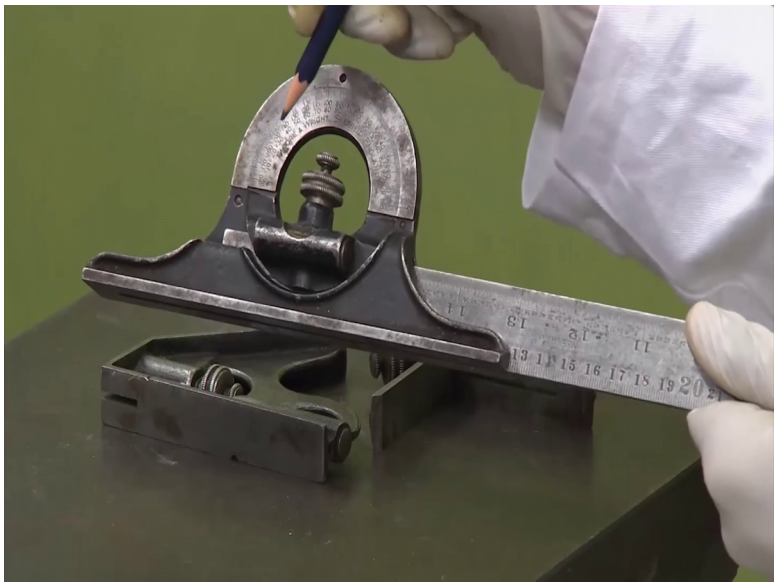

So, first we have attached the protractor head here. So, the combination set has three major devices. This protractor has comprises of a rotatable turret within a stock, this is a rotatable turret, which is held within a stock. And a turret has an angular scale, which is graduated in degrees. This is similar to the scale head, but the protractor head also can slide along the rule. It can slide, you can see here, so it can slide. Actually, it is rotating here, it can slide rule can also slide ok. The screw is tightened, I will loosen this screw, and it can slide here ok.

So, the blade of the protractor is held firmly against the job, and the angle can be directly read from the scale. The spirit level is provided with the combination sometimes, here the spirit level is actually not working, because we do not have spirit in it, but it is also some provided to see the level, whenever we need to see the leveling of the surface.

The protractor can also be used to determine the deviation of angle on the job from the desired one whatever it is required. But, the protractor is first set to correct angle, and then locked in the position. Now, then it is held to the surface of the job a with the angle is made. Any deviation from the desired angle can be checked by inserting the feeler gauge, so I will just ok. This is now locked here exactly at zero degree. This is the locking screw ok. And when I lock it here, I cannot move it properly, I cannot actually move it. It is not solid ok. So, this is kind of a rule now.

But, if I need to measure some angle, I will I will screw this. I can rotate this to the angle, whatever is desired. For instance I need to rotate it at 90 degree, here we have the graduation here we have the graduation here. If I fix it to 90 degree here ok, then I lock it. Now, this angle this angle is 90 degree. And it can work as a square head ok.

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But, the major use of this equipment is that we can measure the angle. For instance, I have this work piece here this is actually a duster the funter firm of the duster is removed here. And we have some angle I would like to measure the angle. So, what is this, if I align this to 0, this is 0, coinciding with 0. Let me see is there any zero error here locking. So, 0 is coinciding properly with the 0, and there is no zero error here. ok.

So, I will now put my job here. The angle for which I need to measure, I will rotate this I will rotate the combination or sorry the protractor of the combination head to align with the surface here, you know it is aligned properly with the surface. It is aligned properly here then I lock the screw. After aligning properly, the screw is locked in this position.

And I can see that, this angle is exactly 61 degree ok, 60 plus 1 degree, this angle is exactly 60. It is actually about 62 degrees ok, so that means, this angle is however, I think this is the wooden work piece. This might be manufactured based on the 60 degree angle, this angle might be 60 degree ok, this angle might be 60 degree, but because of the error in measurement or error in machining or error in manufacturing the angle as come

down to 62 degree. So, there is there might be two degree a deviation from the desired product that they need.

But this is not a significant, because this is need not to be fixed. And we not fixing, it is now fit any limits of it is we do not have to fit it at any place, it is not a key. It can work here, because we just have to hold it here ok. So, this is the use of the protractor head of the combination set ok. So, now I will remove it, and attach the other set. Before going to that I like to show you the steel rule of the combination set. You can see that, we have graduation here, we have the calibration in mm and in inches here in this big slot.

In this slot, we have a pin here. We have a pin here in this in which this key actually this is the key here, in which this in this the key is inserted ok, I will fix another head here. This is square head; I will see the direction of the pin. The pin is like this, the pin is like this like this, which is inserted here. And once the pin is inserted, it will move along the pin ok. The direction of pin is like this. So, I will insert it here to make sure that the pin is inserted in the slot of the screw head of the scale sorry it is a steel rule here. So, this is a spring here to adjust the length, to adjust the location of the pin here ok. The screw was locked, yeah and the tool is done, and it is fixed properly here.

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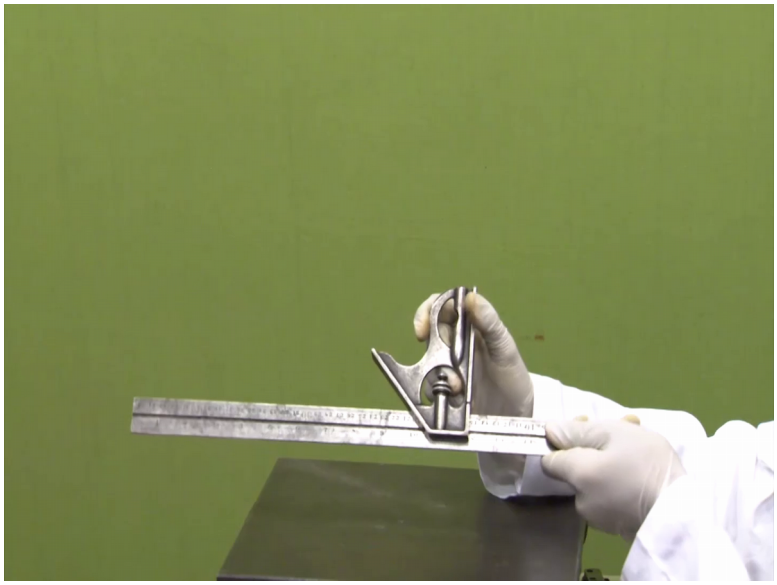

So, I have fixed the square head now, the square head is tightened here. So, this is our square head. The square head along with the graduated rule on the combination set provides an easy way of measuring heights and depths ok. While the square head

provides a right angle reference, so this angle is the right angle. And the rule provides the means of directly taking the readings. So, we can fix the square head at any position. For instance, it is fixed at the position 15 here close to 15 ok.

If this is my 0, I can even put fix it to 0. Then I can take the incremental readings. So, the primary requirement is that the square head can be used only against a flat reference surface. So, it is used to see the squareness, you know the definitions flatness, squareness, so it is used to see the squareness. And the surface has to be flat. The square head has to be firmly had against the flat surface of the job. And rule is lowered until it touches the reference point.

The rule can be locked in the position. Then, we can measure the measure the distance or the length, whatever you required. The range of the measure can also be extended by using attachments. We can use some instruments like square head (Refer Time: 08:17) is we can use some instruments like the scriber or something to mark the distance. For instance, if this is the length of the square head ok, I can mark I can mark something here, then I can start from here, where the marking is there, I can mark here, I can keep on continuing to mark the distance is (Refer Time: 08: 42) is are long.

However, this is used to check, those we know this is the surface plate. It has to be square. So, this is the requirement of the surface plate. So, we can see that is this square, if you see ok, this is no gap. We can use the feeler gauge to see, if the gap is here or not. However, I think also the optical method can also be used. If I pass the light from here or light from the bottom, if the light is not passing, that means there is no gap. And if the light is passing, that means there might be some gap.

If we need to find what is the value of the gap, I can put the feeler gauge in here. Also I can see this squareness of this surface is actually this plane, and this plane, this surface, this surface, and it is almost cure ok. So, these are the applications of the square head. This angle in the square head is 45 degree, this angle is 45 degree. This can be used to marked anything at 45 degree. I can keep the line here, and keep the component here. And mark the line at 45 degree. This line is 45 degree ok.

Now, if I keep it the other way round, try to mark another line ok, to make it look clear in the camera, this is again 45 degree. So, this angle is 90 degree. So, any markings like here what wherever we need, this square head is used for this purposes ok. Now, the next

component or the part of the combination set is this center head. This is the center head, it also has this screw, the spring here.

And we have the key inside, I will insert the graduated scale here ok. I can lock it at any point. This angle is also of 45 degree. If I need to mark this, this is actually not used to mark the angles. This is used to find the center of the circle. So, this center head attachment is used along with the stool rule.

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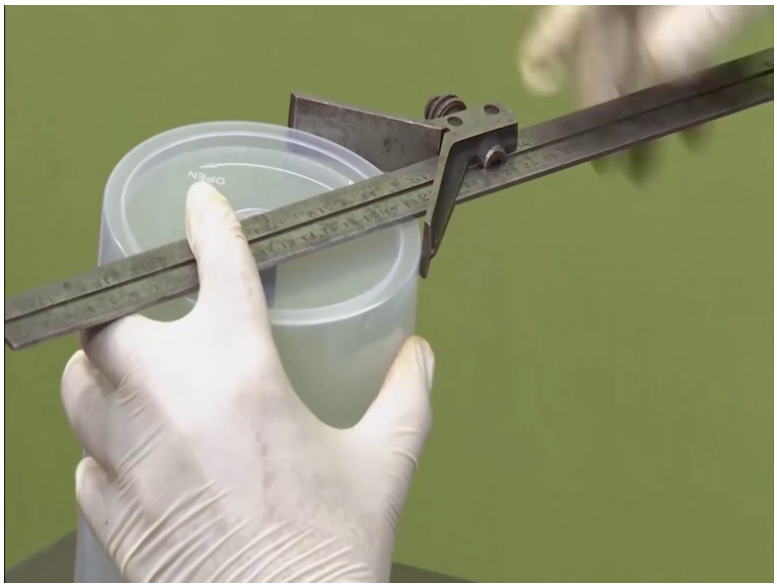

To mark this center of the bar stock or any circular job, I have this, I have do not actually the exact circular job; I have this circular box here. So, it can be used actually the diameter of job can be darkly red on the graduated scale, which is useful for marking the center of the job by using the scriber, so, the v between the two blades. This v between the blades of the center of the center had facilitate accurate positioning of the circular job. The circular job can be positioned here.

So, now this greatly improves the measurement accuracy, when compared to taking, reading, directly using a rule held against the job, this you know one way is to mark the center. I try to see this center like this, not to (Refer Time: 12:23) this center to see the diameter, I try to see the diameter like this ok. So, actually this is from see this is 45 from 0 ok. But, we are not sure that are we exactly at the center or not. So, this center is close this actually the diameter is I will, I mark from this side. The diameter is closed to 220

mm ok, but the use of center gauge or center square is that it can hold the circular job in between, and we can directly read while placing it like this.

This would always I when I lock it here. This is always at the center this is always at the center. And I can directly read the reading here ok, which is again actually 120 mm. So, also we can mark suppose the center is not there. This center point, however it is here in this box. If the center point is not here, I can use center square to mark the center. The way to do it is, I will just extend this scale here, mark a line here, I will mark a line here ok. Change the position, you can see I have marked a line here, this line if it is seen ok.

We change the position changes the not the position change the location here, change the location mark another line. Now, where these two lines coincide is the center. The line that is marked from this position, other line is marked from the other position. When these two lines, this line, and this line, this line, and this line, intersect that is the center of the circle. Actually, this is the work piece in which center was already there, because this is a plastic work piece in which this point is here ok, not work piece I will call it work piece, because I am measuring that is a plastic box. They are certain circular jobs in which we do not do not have the center.

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To mark this center, this is a very quick possess. This is very quick way to mark the center. So, this is the use of the combination set, we can also combine the center square with the protractor. Actually not the center square, the square head and the protractor

head can be used in the in the combinations. Like while we mark this square, we check the squareness of the surface, and also we can mark some angles whenever required. So, this is the application and the use of the combination set.

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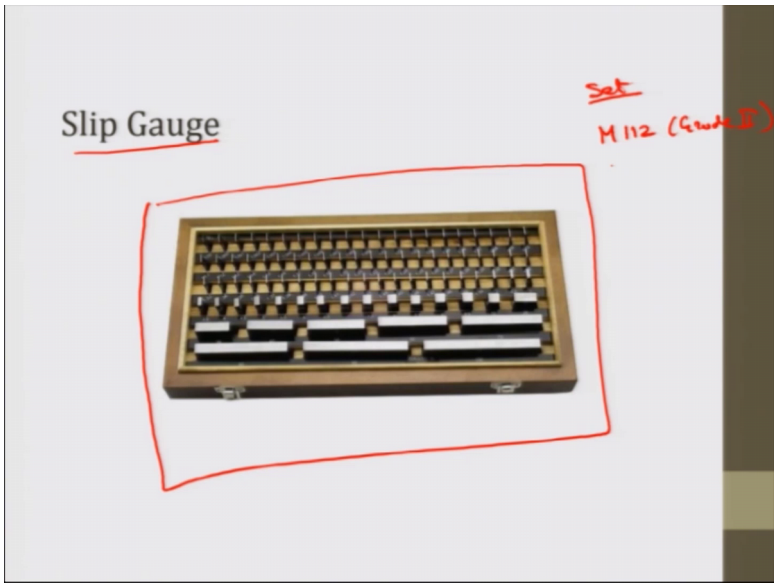

Next instrument, I will pick here is slip gauges. Slip gauge is a set of the rectangular work pieces, you can see we have a set of rectangular work pieces here.

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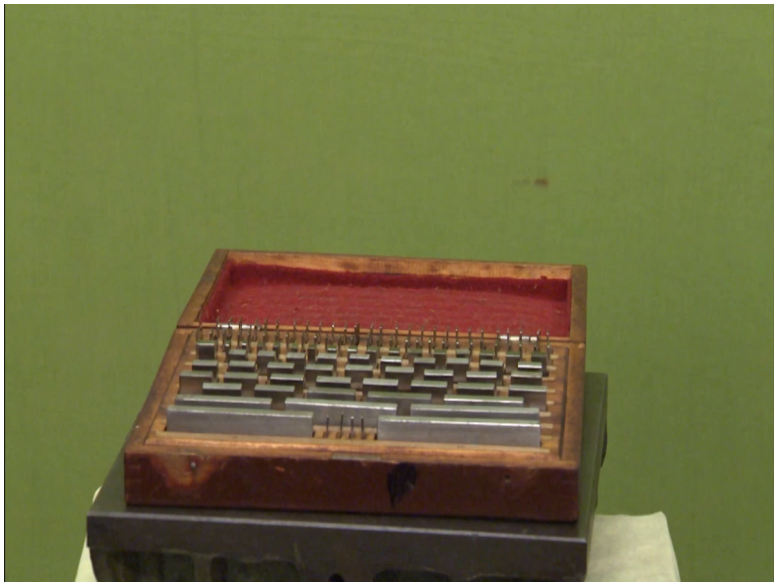

It is a set of rectangular work pieces. Rectangular pieces actually, which are made up of the hardened alloy. And the general cross section may vary from actually the thickness is

about 10 mm. And the cross section might be 40 into 10, 30 into 10, 50 into 10, in this cases we have different set of the cross sections.

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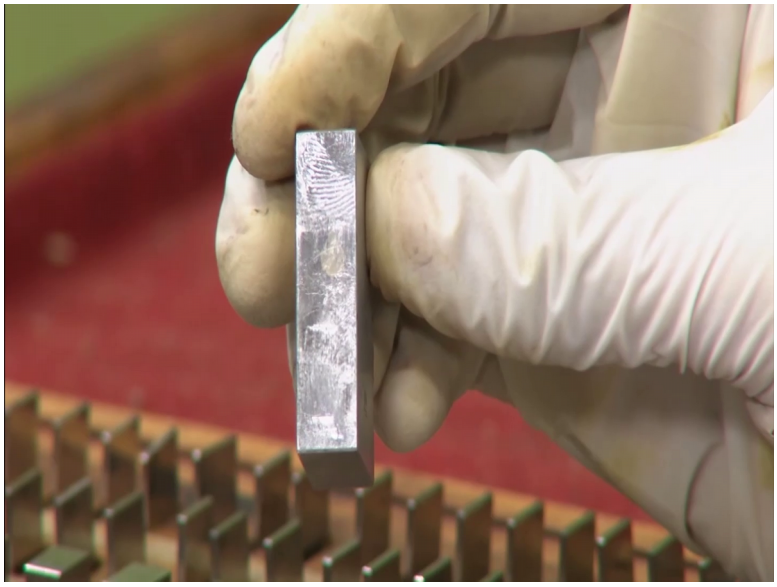

In general this slip gauge actually uses 10 into 40 mm ok. So, the name of the company that is manufactured this slip gauges is k n. So, it has 112 pieces, it is M 112, which is grade 2. M 112 this is the set ok, slip gauge are M 112 this is known as grade 2. It has 112 pieces of slip gauges here. Actually the steel is preferred material in the slip gauges, because it is economical. And it has some coefficient of thermal exponential as the majority of steel components used in the production. And hardening is required to make the slip gauges resistance to way us slip gauges has to have very high degree of accuracy, flatness, surface finish.

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If I pick any of this slip gauges, you can see the surface that has to be attached to the other surface is highly accurate, is highly flat, and the surface finish is also very good. The height is the slip gauge is engraved on one of the rectangular faces, you can see these specifications here. The height of the slip gauge is given here. The value of a this slip gauge is 1.1 mm.

So, this is the thickness, actually you can see the thickness, this thickness is 1.1 mm. And this surface is not the significant, the one the thickness surface, this is not the significant surface. The significant surface is the other one, it has to be highly finished. So, the length between the measuring surfaces, flatness. And surface condition of the measuring faces are most important requirements of slip gauges.

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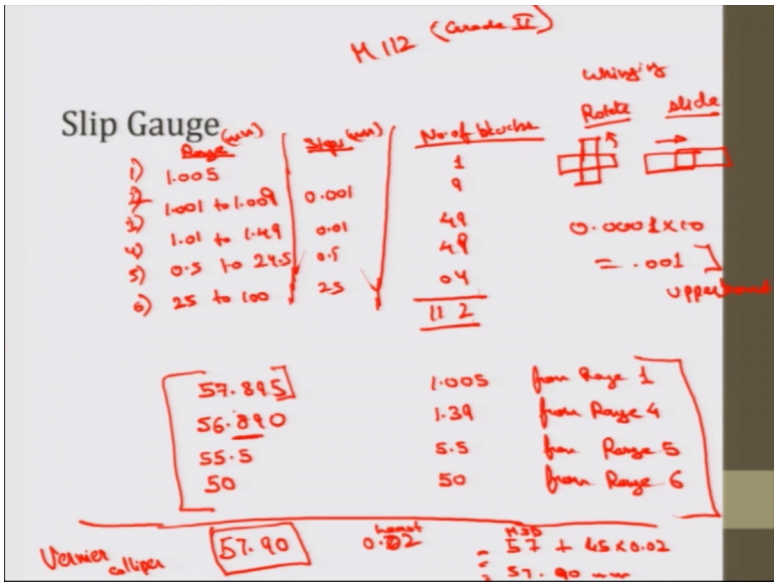

Now, carbide gauge blocks are also used for the superior wear resistance, and longer live wear also have low coefficient of thermal expansions, because the slip gauge is when they are attached. Actually this is known as ringing of the slip gauges, I will put it ringing. Ringing of the slip gauges are various ways we just put one slip gauge like this. Another on the perpendicular direction, then we rotate the one.

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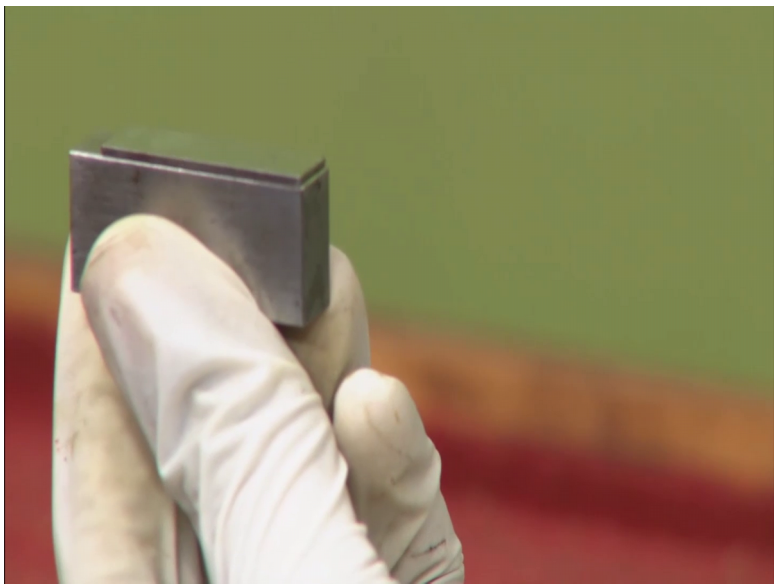

Actually, we put we hold this slip gauges, two slip gauges tight to each other, against each other. And then, we try to ring them. Ring them would mean, they would attach

with each other. And the thing is that the air between them is completely removed, air is removed. And this is the kind of a molecular adhesion that makes them stick together, you know this is not falling. So, there are various ways, I can just put one over there, and rotate, I can just put one slip gauge like I can pick one like this. Another one like this, then slide it ok. This is rotate ok, this is slide various matures to do this.

And several slip gauges are combined together temporarily to provide an end standard of a specific length. The major role of pick slip gauges is that sometimes the requirement at a specific length requirement is there, the standard has to be maintained. When stands, I need to check whether my Vernier caliper is reading exactly or not ok. I will find it or I need to find some specific length. Like I will use a sine bar after this, you will see the angle that has to be the measure. This specific length may be towards up to the three pluses of decimal that length has to be maintained.

So, we need to pick some specific combination of the slip gauges to attain the specific length ok. So, the ringing is done using rotate and slide node. And ringing actually is the phenomena of adhesion of two flat surfaces. The force of adhesion is such that a set of blocks will almost serve as a single block. The grip is solved that even sometimes when it falls, it does not get separate.

So, this surfaces are clean and flat then that thinner layer of film separating the blocks will also have negligible thickness, this means that stacking of multiple blocks of known dimensions will give the overall dimensions with minimum error ok. The gap between the slip gauge is between two slip gauge is of the order of the fourth place, after the decimal, this 0.0001, it is 1 by 10000th.

So, this much gap is between like it that means, even I use 5 or 6 slip gauges or 10 slip gauges. Then only the gap, the maximum gap that can would that can would be 0.0001 it could be 0.0001 into 10. If I use 10 slip gauges is equal to 0.0001, this I am taking the upper bound sorry I missed one 0 here 01 ok. This is upper bound or all the gap actually is quite lower than this value.

So, these slip gauges that we have here is having 112 pieces. The ranges are like that, if you see on the first row ok, so for the 112 set 112 grade we have one slip gauge of 1.005 size. We have only one gauge of this size, then we have from 1.001 to 1.009. And we have the gap between I will put range here range. Steps, this is in mm. This is in mm.

And this is number of blocks. This is 1.005, it is one block. From 1.001 to 1.009 with the gap or the step is equal to 0.001, I will get nine blocks. You can see there, we have nine blocks.

So, also we have the next range from 1.01 to 1.49 with the gap of 0.01 this makes 01 to 49, it makes 49 pieces. And 0.5 to 24.5 gap is 0.5, it also makes 49 pieces. So, then is 25 to 100 with the gap of 25. So, this makes 25, 50, 75, 100, four pieces. So, this total is 10 and 18, 4, 12, this total is 112 only, because it was M 112, which is grade 2 ok.

So, let me try to pick one dimension ok. Let me see, I will pick one dimension from the book that is the book by Shauni and Mahajan. Let me try to make this dimension 57.895. So, where to do is do this is that, we need to see, what kind of slip gauges, what kind of gauges are available with us. And can we make this thing number one thing. Second thing is if we can make this thing, if we cannot make this thing, what closest value, we can attain to the value that is given ok.

So, we have three pieces of decimal here. First we need to divide into number of parts. So, as we can make it the combination, so it is 57.895. So, I think it is 0.005. If I pick one of this slip gauges here, which is the first range 1, 2, 3, 4, 5 and 6. We have six range sets here. So, if I pick, 1.005 as one from range one from range one ok, I will pick this slip gauge 1.005 this is the slip gauge 1.005.

So, next I am left with the number 57.890. So, what else you know the number is 0.09, what can I do 0.09. I can pick 1.09 here or 1.29, 1.39 better way to do it is. If I pick 1.39, 89 minus 39 would be 50, I would be like 57.5. So, I will pick 1.39 from the range 4 from range 4, I will pick this second slip gauge 1.39 ok.

Let me try to ring them let me try to ring them, so 1.39 is there. So, then I am left with this reading 57.89 minus 1.39 it is actually fifty six point now, height is 56.5 before six point 6.5. Next I can pick 0.5 to 24.5. If I pick 5.5 ok, I think I made a little mistake here, so I was thinking why it is not getting made it is 56.89 here. So, this is it is will be 55. 5. So, 55.5, I can pick from the range 5 from range 5. I will pick slip gauge of size 5.5. So, I have picked another slip gauge of range 5.5 here ok.

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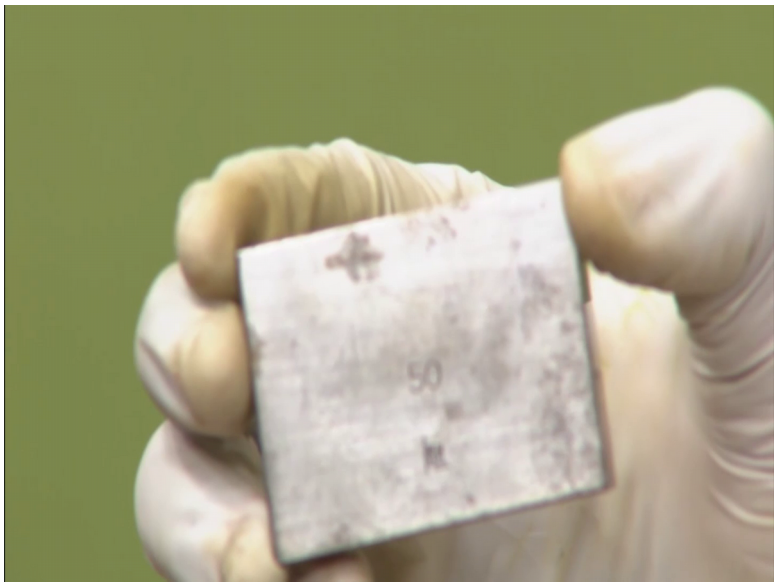

Next 55.5 minus 5.5 I am left with 50 means, I can pick just one this one the 50 exactly from range 6. I have only four slip gauges. And I can make this height 57.895 ok.

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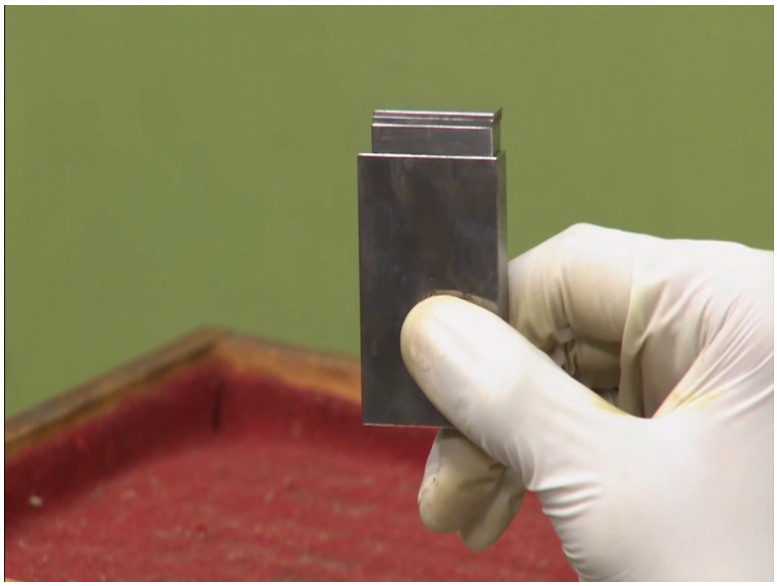

So, let us try to ring them. So, the first one thing is the basic requirement for ringing is that the surface has to be very clean, surface is almost flat. So, I am trying to rub it to my skin, because skin is dry here, then I am trying to ring them. This is 50 plus 5.5, I have picked 1.39, then I will pick 1.005 see I am rubbing it.

See, I have to hold it very tightly while ringing, otherwise it might yeah I know it is loosen. The reason for this might be that, it is not cleaned properly, I am trying to ring it. I am trying to rub between my skin, so that it is cleaned properly. I have to clean both the surface, then hold it very tightly against the main block. So, this is the height that we have achieved that is 57.895.

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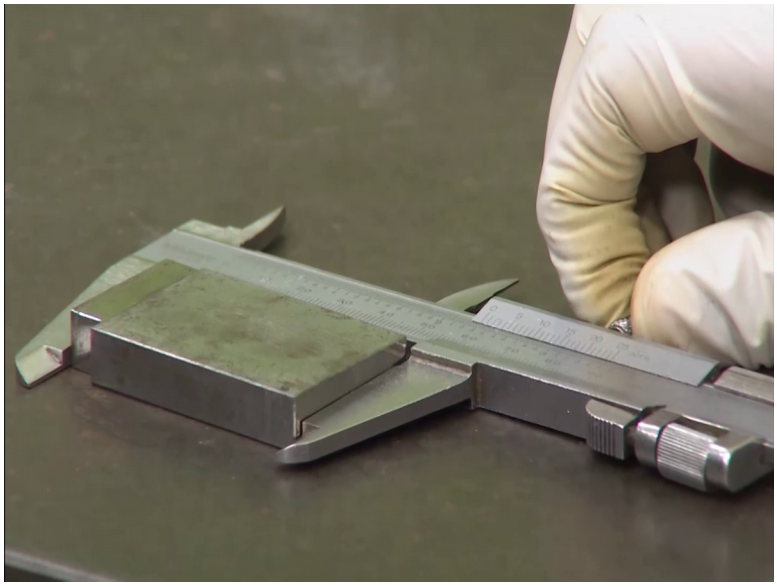

Next I have kept this slip gauges on a surface plate. I will try to measure the distance, which was 57.895. So, let me see the distance here ok, I will lock this screws. So, this distance is 57.895 with the Vernier caliper, we cannot get this value, however the value would be with the Vernier caliper. The value would be close to fifty seven point it should be close to 57.90, because the least count is 0.02 this is using Vernier caliper.

So, it cannot read 57.891. So, this is distance like even the Vernier calipers are available, which have the sensitivity or which have the least count up to point 0.001. But, this Vernier caliper that we have holding now is having just the least count is 0.02. So, it cannot do even it comes 57.90, we can assume that our reading is quite close. So, it is even, I think it is only 0.005 less than 57.90 it is quite close.

So, let me see the distance here in the Vernier caliper. We can see that it is exactly 57.90 that is the 57th reading in the main scale main scale division ok. And plus we have 45th reading coinciding into 0.02 this is equal 57.90 mm. So, this is the use of slip gauges. Slip gauges is the principle of the of the adhesion of the molecular forces, when the a gap

is completely removed. The adhesion forces, the force of adhesion holds the metal pieces together because of the very fine surface finish and flatness ok.

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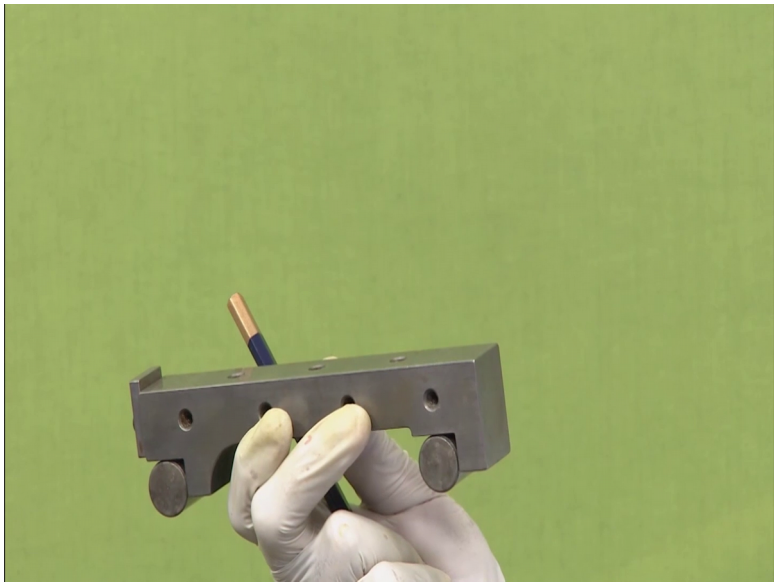

Now, this slip gauges can also be used in conjunction with the sine bar. Next, I will move to that step. So, next is sine bar. This is the sine bar, the sine bar uses the principle of the ratio of the length of two sides of the right angle deriving the given angle, it is known as sine bar, because we take the sine of the angle. How we do at do it, I will just show the calculations before that let me see the components of this tool here. So, these are two end phases of sine bar. And this is perfectly square ok, this has to be square. And there are two rollers here. The purpose of roller is that, if even if I move it at any angle, this length would always remain same, this length would always remain same that center to the base length would remain same ok.

So, they are relief holes. These relief holes are as we know they you can see that here (Refer Time: 32:16) some threading here, we can also put some screws and nuts, if we need to hold this one. However, for the bigger sine bar, there is big size sine bar as well this is only 6 inch sine bar. We can even have up to 24 inch sine bar in which the big relief holes are there to reduce the weight also. So, this is the low surface, this is upper surface. So, these are certain rollers, so it can have various dimensions.

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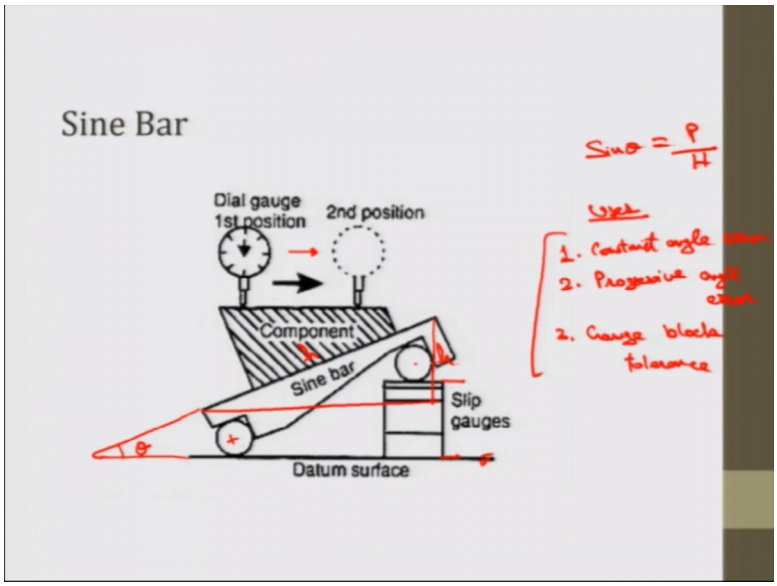

The use of the sine bars on the surface plate, you can see this set up here. We can adjust the slip gauges here, actually we know that this angle this angle, if it is theta. As we know that sin theta is equal to perpendicular upon high hypotenuse. So, this is the theta, and this is the height here, I take the height from the centre or I can oh sorry I will take this height ok.

So, this is perpendicular and hypotenuse is actually this value. This is height, I will better put the height here, and this is my hypotenuse ok. So, this can be calculated, this height can be calculated. So, while calculating this height, we can see that is the angle correct or not that can be used checked using the dial gauge here ok. I have made a set up here.

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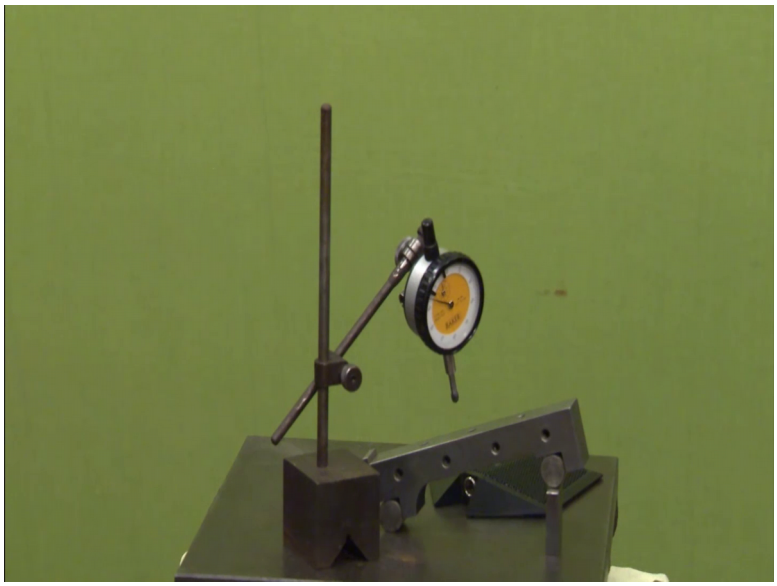

So, we need to measure the angle of this surface. We need to measure the angle of so this is I have just picked a speaker here. It has various flat surfaces a various surface at angles, I have picked this surface here. I have picked this surface based on this surface, I have calculated that the angle the angle was about 18 degree and height as come to close to 43 centimeters 43 mm.

So, this is of an idea, I am not doing the exact calculations, but I can try to find whether this setting is correct or not. So, I have fixed my dial gauge here. Now, I will retied this basil to bring it close to zero. So, let me think this angle is not correct, if I move it on this surface, there is the movement in the dial gauge that means, you know this is the big movement. It is keep on continuing 3 mm difference till the angle is not at all correct ok, this is not the flat surface. The thing is that the dial gauge should not be moving very much ok.

A small movement can be allowed like depending upon the accuracy that we required, but this is not the correct height. So, let me change the slip gauge set up here. So, let me try to reduce it by about 3 mm. We saw that the small gauge, the small pointer moved about 3 mm in this distance. So, I have to just reduce the height. So, I have made another set of the slip gauges here by reducing the height somewhat.

And then, I will again put my dial gauge here. And see if the movement is here, so the movement is less here. So, at some point, we can see that the dial gauge movement

should be 0 ok. This set up might take some time ok, we need to find the height, and we need to we can check the angle as well. So, this is the use of the sine bar. So, the sine bar is based upon the principle of the sined perpendicular to hypotenuse upon base. So, for checking the angle of small size components a sine bar is such to approximate nominal angle on the surface plate by suitable combination of slip gauges. And it is moved over the moved over the components throughout its length.

So, if there is a variation in parallelism in the upper surface, thus dial gauge would move and the reading would not be correct. So, the use of sine bar can be it can be used for checking the constant angle error, its uses constant angle error. Like this is caused by a the working surface and the cylinder axis. When the working surface and the cylinder axis are not parallel, this is the constant angle error. So, the sine bar can be used to identify, what is the value of this angle.

Now, another use here can be it can be used to find the progressive error progressive angle error. So, this is this angle is due to the cylinder center distance. So, it is if it is in progression that angle is the changing, it is progressing, this can also be evaluated. We can also find the gauge block tolerance. The gauge block tolerance is some gauge block tolerance accumulation is sometimes the also the source of the progressive error. So, these are certain uses of the sine bar.

With this, I like to close here the laboratory demonstration, also we will continue with the demonstration on the coordinate measuring machine. And we might pick some other instrument like surface roughness tester for to see the advance to see the this was actually just the linear and the basic measurement that happens in the metrological lab, that we have just studied.

And we can also see the, what are the CNC machines or what are the a various digital instruments that record the information even print the information, we will try to see them as well. So, please come up with the logical questions. And we are always happy to answer you. I will try my best to answer all your queries. And we will have the quiz in the end of this week, and there is some questions, some numerical questions of based upon the demonstrations or the other questions theoretical questions might also come in the final exam as well, so.

Thank you.