**Engineering Metrology**
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**Lecture – 12**
**Laboratory demonstration: Dial gauge and vernier, micrometer, feeler gauge, surface plate,**

Welcome back to the laboratory demonstration, the next instrument I have taken is dial gauge.

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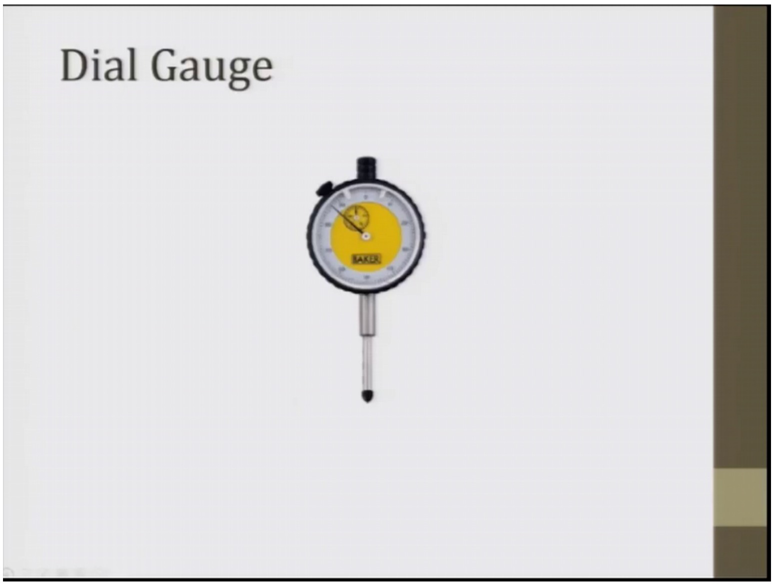


Dial gauge is an instrument that is used in which the principle is used at the reciprocating motion is converted in to a circular motion and that gives us some reading. I show you the principle plus first let us see the dial gauge, the components of this dial gauge, this is a dial gauge and its make is bigger. So, this dial gauge has various components; the first component is bezel. The bezel is the outer part which can be rotated to adjust this 0. So, this bezel can be used to adjust the 0, we see we can move it if there is arrow, so, if there is 0 error we can adjust it. Here we have the positive error, so, we can adjust this.

So, also we have the markers, we can see in the black colors, there are two markers. These two markers are used to mark the reference point and for the start of the measurements these markers are generally kept at the reference point or may be one of the markers could be kept at the 0 as well if required. Also we have two pointers, two pointers inside; one is the main pointer another the small pointer.

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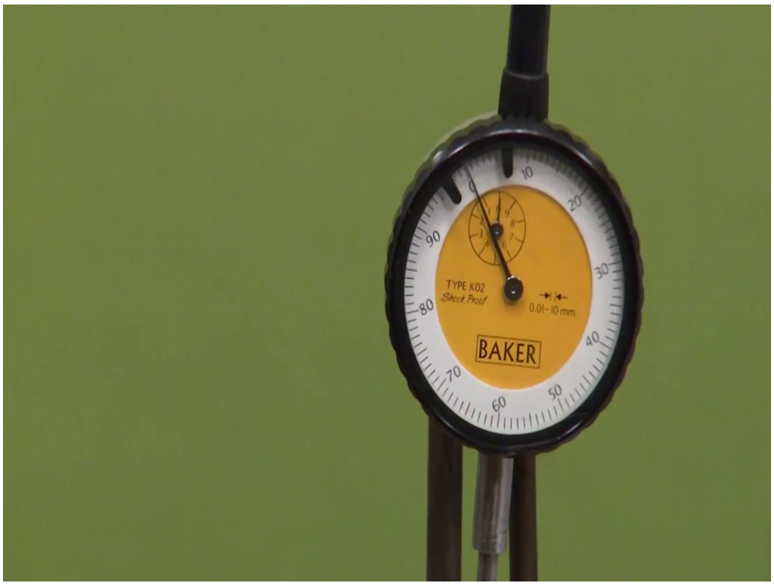


You can see we have the main point at the lower end which is at the plunger with the main point. If we put it up if we push it up the reciprocating motion, if we push it up slowly you can see the larger needle is moving very quickly, we can see the specifications here that it is written that 0.01 to 10 mm.

Now, 0.01 is if I move my plunger a little above you can see a little movement yeah, it has moved three readings forward ok; that means, it had moved 0.01 in to 3; 0.03 mm forward, the bigger needle I am talking about. So, when I push it a little more it makes one complete rotation from 0 to 0, you can see the larger needle is moving in the clockwise direction and the smaller needle is simultaneously moving in the anti clockwise direction, we will do it Again.

It is moving in a clockwise direction, the smaller needle is moving with the anti clockwise direction, I will explain the principle. You can see the larger needle has made one full rotation; that means, it has moved 0.01 in to 100; you can see that we are total 100 divisions on the larger scale, which just it has covered in one rotation and the smaller circle, the smaller needle, you can see which has moved anti clockwise, it has just moved 1 division ahead 1 division forward.

So that means, 0.01 to 10 mm is the range the minimum division the minimum reading that it can give is 0.01 and the maximum is 10 mm. If I push the plunger completely above you can see it has though it has gone more than 10 mm here, but the sensitive of the sensitivity of the instrument or the range of instrument is that can be read is 10 mm. So, we have plunger here, above the plunger we have stem in which the plunger is moving.

So, we can see the reciprocating motion of the plunger is giving the circular motion to the needle. The principle behind this is the (Refer Time: 03:57). If I pull or push the plunger above and leave it, what happens? The needle comes back to the original position; that means, thus it is some spring mechanism that is working in. So, it is an helical spring here. So, how it is working? I like to spin it in this way, this is actually my plunger.

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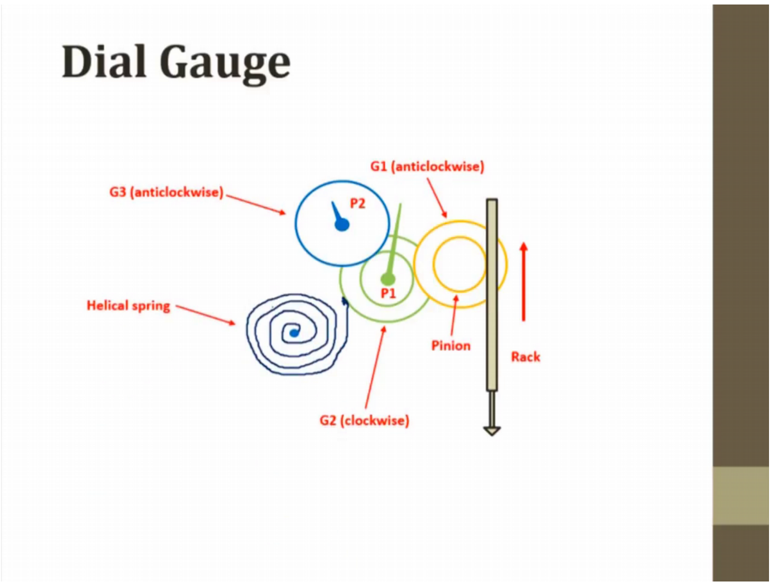


And it is actually a rack and pinion, I have a pinion here, when it moves up and upward down this pinion rotates this pinion rotates that means, there it is moving in upward direction this pinion will rotate, if it is to moving upward direction it is rotating this direction. And this pinion is attached to another gear here, which is this one and I have my pointer P 1 here.

Now, if you see if I move it in the upward direction you can see the dial gauge, if I move it in the upward directions slowly the pointer the main pointer is rotating in the clockwise direction, you can see it here. If I move it in a upward direction this gear, I will call it gear 1, this gear 1 is rotating in anti clockwise direction, I will put it anti clockwise, gear 2 which is rotating in clockwise direction this.

So, what happens? With a small movement of this plunger, there is a large movement because you know this is the small pinion and the gear ratio is there based on which the calibration is done, which is based on the gear 1 is the small movement of gear 1 is giving a big movement to the gear 2. So, here rack and pinion this is rack and pinion. So, this is the pointer P 1. So, this small pinion or the lets say the gear 2 is also connected to another gear, which is my gear 3. This small gear 2 is rotating gear 3, this is my gear 3 and also I have pin here sorry pointer here.

So, this is my point P 1 and this is my pointer P 2, you can see with rotation of the dial gauge with sorry reciprocating movement of the dial gauge the pointer one is making one full rotation and the pointer two is rotating the in the other direction. You can see if this is rotating in anti clockwise direction g 1, g 2 is rotating in clockwise direction and g 3 would; obviously, rotate in the anti clockwise. And also the velocity ratio or the gear ratio is such that one full rotation is only making one division in the smaller pointer; one full rotation of the bigger point is making one division in the smaller pointer. So, it is calibrated in this way. Also you can see that when we leave the dial we leave the plunger sorry or the pointer it comes to the original position by itself.

So, this spring mechanism is attached here; there is the spring that is the helical spring this helical spring stores energy, when the plunger is pushed up and when it is left because energy is stored it releases an energy and the plunger comes back to the original position, better, I would say the pointer point of contact comes back to the original position. This is the principle of the dial gauge. What is the application of the dial gauge? In case of rotating shafts, the dial gauge is put all the rotating shaft.

So, as to see whether there is in offset or play or eccentricity this can tell us whether defect to the what the eccentricity is, whatever the movement is we take the mid value. As you can see the dial gauge is attached to this stand here the dial gauge holder, in the dial gauge stand we can say that we have a kind of universal connection.

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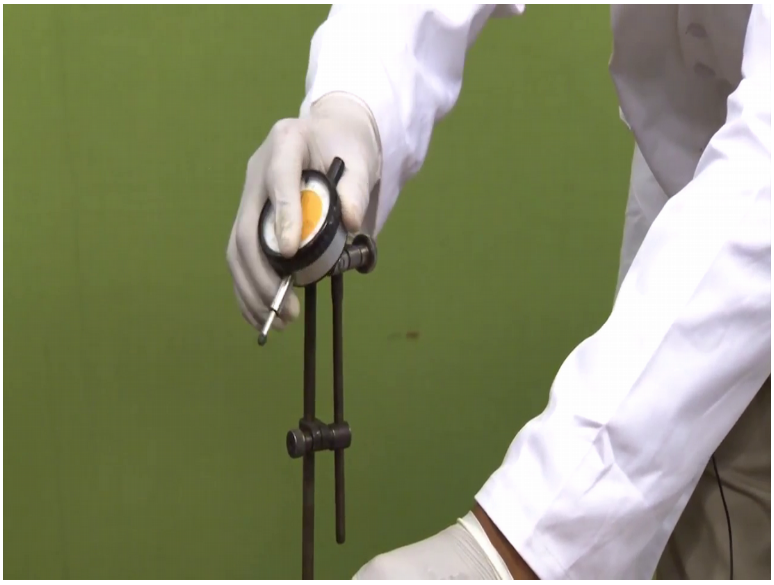

In which dial gauge dial gauge can have any kind of we can move in any direction, it will has actually the 6 degrees of freedom, it can you see it can move with this direction, it can move in this direction, it can also move in this direction yes ok, this is one more degrees of degree of freedom that is height can also be adjusted here. So, it can be fixed where ever it is required.

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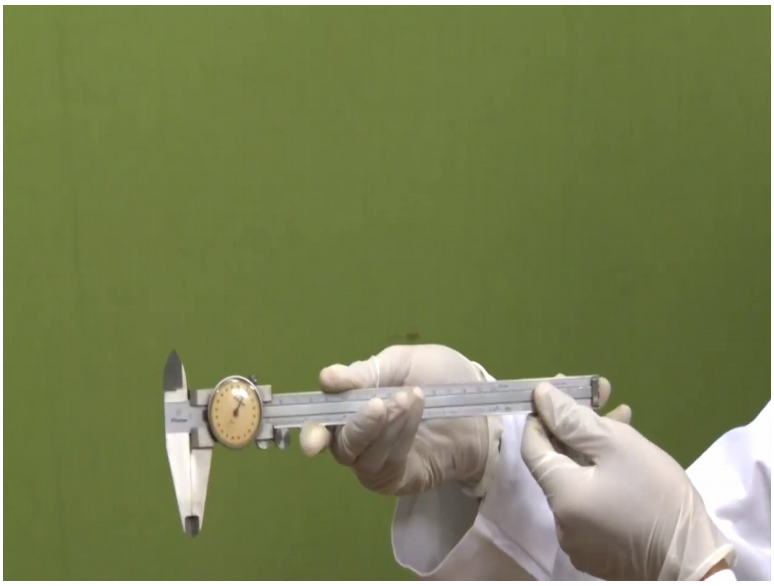

So, this is the use of dial gauge yes with dial gauge I can also talk about the dial vernier. So, this is a vernier caliper. Actually there is no principle or the movement like dial gauge, but it has a dial it has a rotary scale it is the circular scale here, you can see it has also the main scale reading which are calibrated in inches, and mm it has this vernier scale that use of this scale is that we can adjust this 0 at point whenever we like see you see wherever, wherever we need at this point also we can adjust it to be 0 at least of the vernier scale, you can see here that its least count is 0.001 inches.

So, this is another vernier caliper which is having this circular scale and it can be adjusted, this is the advantage; however, the other uses are same it has internal jaws, external jaws it has this depth gauge and this screw is the fine adjustment screw let us meet to the next part of the lab demonstration.

In this demonstration I will discuss what are micrometer, this is the laboratory demonstration for the course engineering metrology. In this course we are discussing about the measurements about the various instruments for linear measurements, angular measurements these two major equipments for linear angular measurements am discussing in this module. So, micrometer that we have selected here is a Mitutoyo micrometer.

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This micrometer is having range from 0 to 25 mm and the least count is 0.01 mm. So, you can see the specifications are given here, I will just discuss the components of the micrometer we can see that the maximum measurement that can be taken here is 25 mm and the least count is 0.01 mm, it is important to note here that the least count is half the least count of the vernier caliper the least count of vernier caliper was 0.02 mm.

So, this is 0.01 mm that is the reading that we had readings that we had in vernier calipers were like 44.448 12.28 here we also can have 12.27 or 12.29. So, it is more sensitive also the micrometer can or is used to measure the external dias only, it is not very much possible to measure the internal diameters internal lengths using the micrometer. So, the various components of micrometer you can see here. The first component is the anvil the anvil is a portion that is the fixed jaw, if I if I open it little if when I rotate it, when I rotate it you can see it is opening, you can see it is also known as screw gauge screw gauge why it is known as screw gauge, because it is it is working on the principal of the nut and screw it is just like loosening or tightening a screw ok.

So, when we are loosening the screw this component is anvil that fixed component is anvil and it is calibrated based upon this surface, this surface is very flat the anvil surface is flat the flatness is quite precised. So, we have thimble or spindle here which can be which we are using the screw which can move forward or backward, and we have the lock nut at any point we can lock the reading using this lock nut. So, this lock nut is used again for the convenience once we take the reading. And then we can lock the reading at this point and then note down it very easily conveniently.

So, we have two scales here the main scale, this is the main scale you can see and the micro scale the circular scale we call it. We can see on the main scale between 0 and 5 between 0 and 5 there are 10 divisions looks like that we have 5 divisions; however, on the upper side there are 5 divisions and there is a division at the lower side that well as well which are in between the divisions of the upper side. So, you can see the first division on the upper side that that is 1 mm, first we know the upper side is 1 mm, if we say the lower side this division is between 0 and 1 that is 0.5 mm.

So, if I close it completely you can see that when I close it completely, at the end you will see you will listen to a click noise see there click again I open, again I close click. This click is actually the ratchet mechanism it can move in one direction only if when I open it there is no click or there is no plate, but it can adjust when I rotate it clockwise further it will keep on giving the click noises clockwise, clockwise further it will keep on giving the click voice noises like click, but one click is enough to let us know that the pressure is enough that the work piece or the our moveable, that is our moveable spindles touch the work piece.

So; that means, enough one click this is natural attachment, other components here are we have adjusting at and the frame the lower frame is known as u frame or u state or u shaped steel frame, then we have thimble here, then we have sleeve here we have spindle I have already discussed the moveable part is known as spindle. So, these are the major components of the micrometer. The principle on which this micrometer work is the principle of screw, it is the principle of the screw gauge that is the screw pitch.

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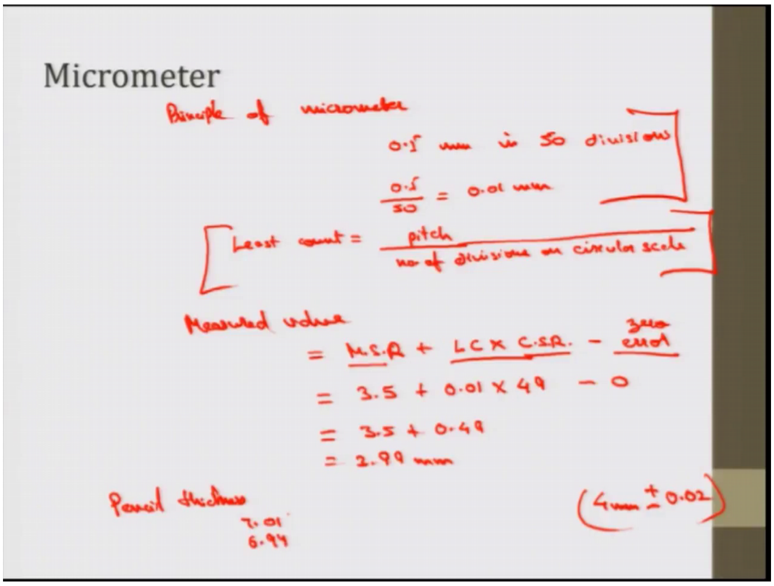


I can write the principle of micrometer. So, micrometer is based upon a principle of this screw to amplify the small distances that are two small to measure directly in to large rotations, you can see if I make one full rotation 0 is again coincided with this central line, it has moved 0.5 mm forward, we can see the line there is central line there is center line here. The line below the central line is 0.5 mm; that means, one rotation on the circular scale, we had actually 50 divisions you can see 0 from 5 we can I will rotate it to show it 0 5 10 15 20 so, on I have 50 divisions and one rotation will take it forward to 0.5 mm.

So, this large rotation large rotation of screw; only brings small movement in our spindle. So, this is the principle; one full rotation only 0.5 mm, another full rotation only 0.5 mm.

So, this is the principle on which is based upon also the least count of the micrometer can be calculated very easily, you can see that the 0.5 mm was seen 0.5 mm in 50 divisions.

So; that means, roughly we can say the least count would be 0.5 by 50 is equal to 0.01 mm however, the general relationship here is the least count is equal to pitch by number of divisions on circular scale. So, pitch is in one rotation it is the pitch of thread like we have discussed the thread system will already get the feed of that, one rotation how much forward or how much had our screw goes in one rotation. In one rotation that is pitch divided by number of divisions is a least count, they are simple relation here.

So, this is our least count. And the measurement value the measured value, the measured value is equal to main scale reading plus least count into circular scale reading. And if it is main scale reading and if there is some error, if in the beginning the 0 is not coinciding with the center of the line then error has to be adjusted this minus or plus minus error.

Actually if I put here 0 error 0 error as re have discussed it is always subtracted. So, this minus 0 error that three terms. So, let us try to find a few dimensions using micrometer, let us first pick a simple wire steel wire. So, the procedure is we will again loosen it to a length to a gap little more than the feature or the dimensions that had to be seen that is to be measured, then we will add the wire then I will put the wire end of anvil and close it. So, at the ratchet makes one clockwise one click sound yes.

Now, I locked the nut now I can take this out. So, you can see and the main scale the reading is more than 3.5; it is 3.5, you can see reading is more than 3.5; however, it looks like it has crossed 4, but if I see the central line, the central line is coinciding with the 49th division, one division before 0.

So, I am putting 3.5 plus 0.01 into 49; so, is there any 0 error? Let me close it to see is there any 0 error? So, can you see that the 0 is exactly coinciding with our central line or not? Yes it is. It is coinciding so, there is no 0 error. So, this error is 0. So, this reading this diameter of the wire is 3.5 plus 0.49 is equal to 3.99, well, this wire when it was purchased, it is purchased in the dimension 4 mm. So, we can see that reading that we are getting at some point is 3.9 m.

So, the sensitivity you can say if the wire is purchased 4 mm is the wire and plus minus 0.02 is the tolerance this is acceptable. So, 3.99 mm is data measure also we can see the reading at another point it might be HM, I think may be 3.98 3.97 may be because 0.01 mm is not it is cannot identified by naked eye or cannot be just felt by hand as well.

So, this can be done and I will do one experiment. The diameters that we calculated using vernier caliper, I will try to see those readings diameters of dimensions of components that we used we measured using vernier caliper that I will try to see the values or one or two of those values using the micrometers as well. So, let us try. So because the values that we had there were in 0.02 places ok. If the odd, the even places of decimal at the second place over there, now, I would like to see the single place; the odd places are also be there.

So, the sensitivity is 150 percent of that so, the sensitivity we saw is double of that and the reading would be 50 percent of that half of that. So, we have decided to conduct an experiment to measure the length of the pencil at various places. So, actually this is the pencil let us see not length sorry the thickness of the pencil what is the general thickness of the pencil here.

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If I do it using this, so, with one click and locking the nut this length comes this thickness comes to close to actually you can see this reading 0, first reading is coinciding this first reading is coinciding after this 5th 6th 7th 7.01. So, we can see the length of the thickness of the pencil at one point is 7.01, now let me unlock it and take the second reading at about point that is little deeper than the starting point, let us give the click I will lock the reading here is, you can see the reading here is now a little lesser you know 44th reading is coinciding here, if you see the 44th reading of the circular scale is coinciding with the main scale and it is after 6.5.

So, 44 plus 0.44 plus 6.5 69.4; so, we have got two readings here, so, for the pencil thickness it is 7.01, 6.94. Let me take another reading on the same surface here, with one click locking the nut taking this out in this we have 20s it is actually 5 6 7 7.5 and 25 yes this is a little way out.

So, it is 7.75; you know the pencil is an instrument it is a tool that will just use is to be used in a hand, and the general the measure of the pen or the pencil whatever we use is between 5 mm between 6 or 7 mm to 15 mm for the precision writing pencil is a kind of precision writing and for the white boards etcetera, it might be 20 mm might be whenever the larger it becomes the lesser is the sensitivity or the precision in writing.

So, in general the thickness of the pencil if you see is 7 mm but if I use it if I use the micrometer to calculate you can see this variation, 7.01 6.94 7.55. So, this is a little weird because this is just made to hold in the hand. So, the range might be between six point because you know there is a paint also the painted the paint is also there in the pencil, this is also having some thickness. And it is not very important to design it exactly close to 7 mm it can vary from 6 point I can say 6.5 mm to 8 mm to may so, on. So, this is actually one way to see that how the things are designed had it been a key, had it been a metal hexagonal key, which has to be inserted in something like may be go or no go gauge ok.

So, it has to be more accurate, but it has just to be whole held in a hand we need not to design it in a very precise accurate way. So, this was about the micrometer.

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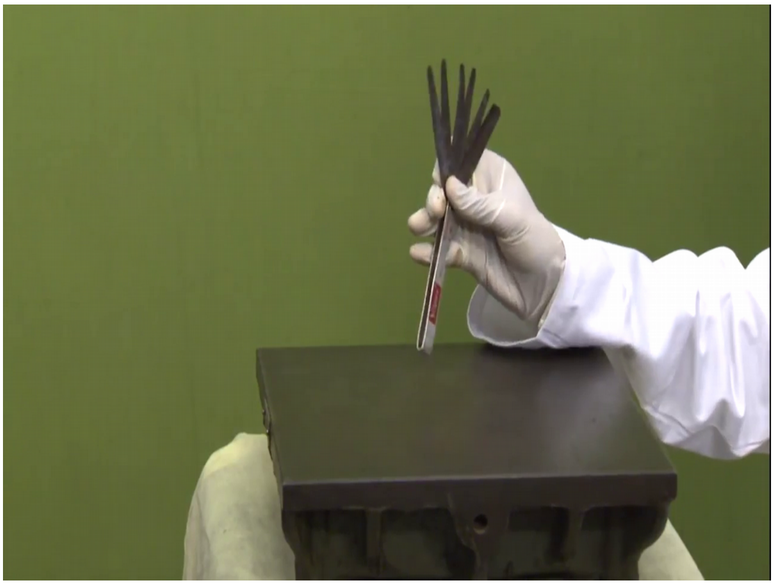

Next I will discuss about this surface plate. So, here we have a surface plate. Surface plate is actually the basic or fundamental, I can say tool that is kept in a metrology lab, because you know the foundation of all the geometric accuracy and all the dimensional measurement is a flat plane, which is actually provided in the work shop and inspection laboratories by the surface plate only.

So, this is a cast iron surface plate the surface plate can have high accuracy the accuracy can be 10 micrometer to 0.01 mm, but the 3000 mm of great. So, it its accuracies can be different these days actually this is an old surface plane, if it is first kept in a IIT Kanpur, I think this was purchased about 40 years back to these days which place which are available are of this stone like granite surface plate. The black granite surface plate is also there so, the sensitivity of the black granite surface plate is 1 by 10000 of a inch.

So, this is one surface plate it is n dimensions 15 inches into 15 inches the length and width and the thickness is 1 inch. You can see that it is a smooth surface we can using the spirit level, we will next move to a spirit level we can see that whether it is kept properly flat to the base or not ok. This is one thing, surface plate forms the foundation of a metrology lab, the most surface plates are rectangular which are there which are having 4 by 3 length aspect ratio is 4 by 3, they may be square they may be round or they are geometrically most correct for creating a flat plane by 3 plate method. The commonly used cast iron surface plates has special ribbing and structures formation in to the surface so, that this will be as like in the weight as possible, but you know it is not very solid surface phase it is having ribbings below it you can see.

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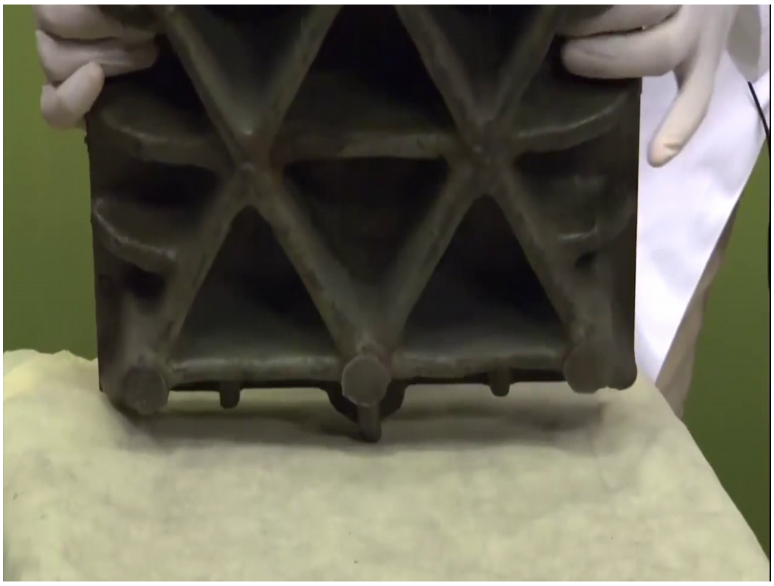

So, as because to reduce the weight, so it is not the whole solid, so, to reduce the weight this is there. Also the true plane of the surface of the surface plate is not machine or scrap until it has really gauge it and all the tender surfaces have subsided; actually the granite surface plate is a very good adjustments, it is very tremendous replacement of the cast iron surface of the placing plates, because granite surface plates can be grounded again and again and also the cost is that less weight is lesser this surface plate, the surface is hard.

There is a surface hardness there, whenever we need to machine it the surface is again has to be hardened. And there might be such 10 bumps etcetera actually the hands sensitive hand can see whether there are bumps or not ok, this is an old surface plane, you can see there is small wear and tear here ok, but this is again workable we will use height gauge, spirit level and other instrument on the surface plate ok.

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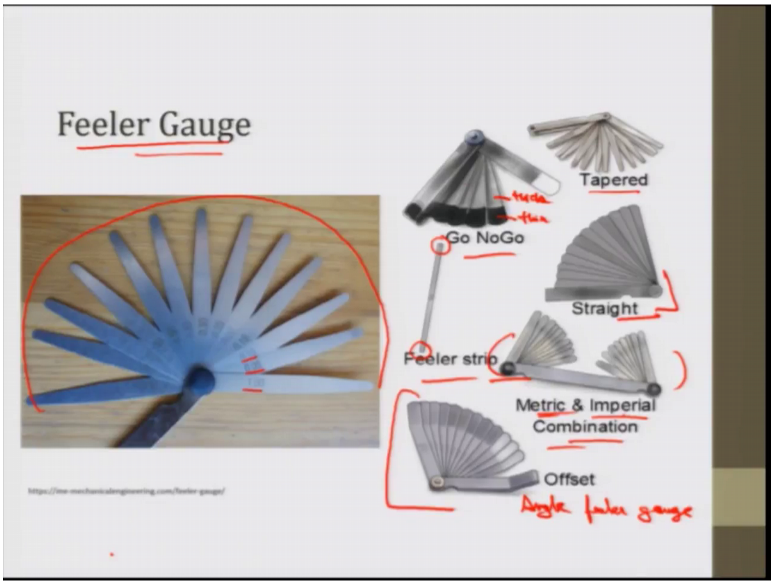


The next instrument is a feeler gauge; feeler gauge is a tool which has many strips in it. So, these actually different strips in here; the feeler gauge is used to measure the gap bits between two flat surfaces, where it is difficult to reach.

So, feeler gauge can reach it reach there and this widths this distance this is 1 mm, this is 0.05 mm, this is 0.01 mm. The various kinds of feeler gauge is you can see, we also having a feeler gauge which is width packs make width packs is there and it is having 10 blades in it, you can see the dimensions in it is having 10 blades from 5 by 100 to 80 by 100 mm.

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So, feeler gauge can be used for instance, there is a spark plug here, the gap between spark plug if you see the gap between the spark plug is 0.6 mm. This 0.6 mm is sparks, whenever the element deteriorates, when the spark plug gives the sparks continuously the inner element of the spark plug deteriorates and the gap increases.

So, what we see the mechanic put tap from the top of the spark plug to make bring the gap back to the desired value; desired value is 0.6 mm. So, feeler gauge; however, the scaled over the mechanic can just do it by itself, but the proper way is to use the feeler gauge of 0.6 mm, you can see this if this is a feeler gauge one of the leaf of the feeler gauge I am trying to put it in it is not coined properly.

So, I am trying to pick one leaf of the feeler gauge here the largest week leaf that is 80 by 100 that is 0.8 is not going in 8 by 100 is not going in properly. So, the second leaf which is exactly 60 by 100 it is 0.6 it is going it is telling us that the gap between the upper and the lower electrode in the spark plug is 0.6 mm and this can be adjusted. The feeler gauge is of are of various types we have go no go gauge tapered gauge go no go feeler gauge, it has thick base and thinner tip it has thick base and a thinner tip.

The thinner end of the gauge can go in to the gap and at a thicker body will not go. So, this is go no go this is thin this is thick then we have straight leaf feeler gauge like we have here.

Now, this is a straight leaf feeler gauge all the whole leaf is the thickness of the leaf is uniform throughout its length, then we have metric feeler gauge, or metric and imperial feeler gauge this are the two different feeler gauges combination metric feeler gauge is the one which gives Myers instruments in the 100s of a millimeter and imperial is the inch type, it gives the measurement in the 100 of an inch. So, which is a combination of metric and the imperial feeler gauges, then we have tapered feeler gauge a tapered, leaf feeler gauges has leaf that a thin towards the tip.

So, this feeler gauge actually is a taper tapered one, if you see the leaf that is tapered to (Refer Time: 33:28) tip. So, the tapered feeler gauge is this one then feeler strip is your it work identically, to feeler gauge blades exceptions is that they are not corrected in a set and either end can be used to Myers. So, this is feeler strip it is same here and here this is only one strip same width here. So, these are various kinds of feeler gauge also yeah this is an angle feeler gauge, angle feeler gauge or offset. In this case the feeler gauge bent towards a tip for the easy access to the intricate part of the motor, there are certain parts in which we cannot insert a straight path we need to have some bent do and search it properly.

So, this is a feeler gauge feeler gauge is also be used on the surface plate to see if there is a gap within the flatness or not, for instance when I will use the height gauge we will try to insert the thinnest of the feeler leaf between the base of the height cage and the top surface of our surface plate only. So, does it insert is the gap or not. So, we can see that. So, sometimes there can be warm space there can be bumps. So, at some point the feeler gauge would insert at some point it would not. So, this is the purpose the feeler gauge is used, the light feeler gauge the other gauge is like pitch gauge pitch gauge, or thread gauge that will discuss for the in the next part of our laboratory demonstration.

So, as of now thank you and we will meet again to discuss other instruments like pitch gauge, vernier height gauge, then sign bar combination gauge combination set actually. So, slip gauges and vernier or gear vernier yeah. So, these instruments will be discussed also we will also go to the in the laboratory to see the demonstration, how to note the coordinate using coordinate measurements machines. So, we will meet in the next session in the laboratory demonstration only as of now.

Thank you.