Metrology
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Lecture – 32
Introduction To Comparators, Mechanical Comparators

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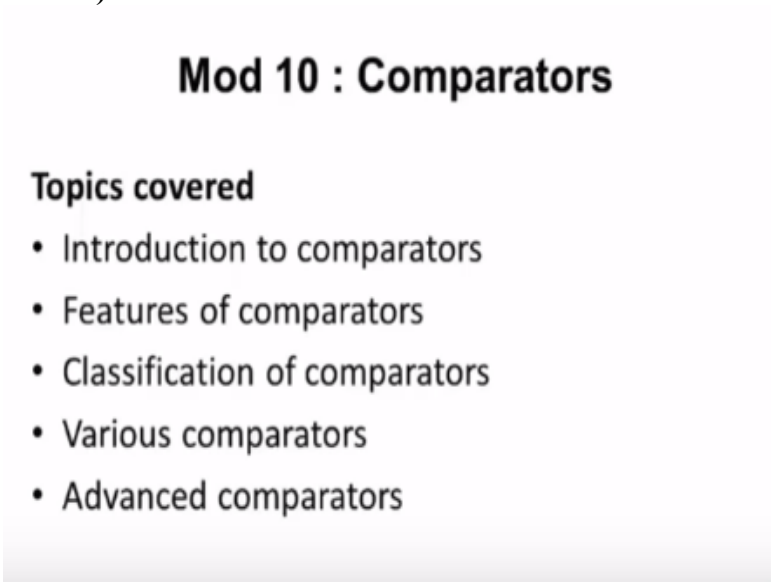

I welcome you all for the series of lecture on metrology so now we will start the lecture series on module 10 in which we will be discussing about the comparators topics covered in this module or introduction to the comparators various features of comparators and how the comparators are classified various types of comparators we will discussed and also advanced comparators we will discuss.

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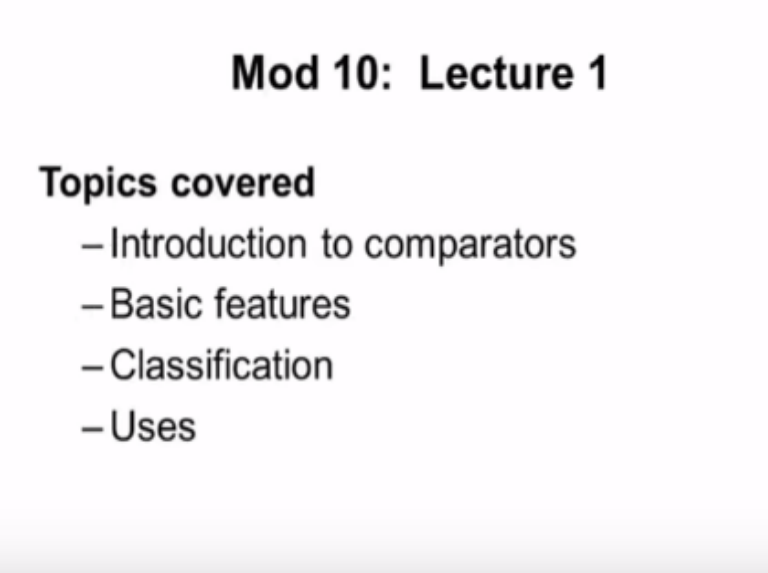

Now will start the first lecture in this module number 10 topics covered in this first lecture or introduction to the comparator and the various basic features of the comparator and how they are classified we will learn about the classification of comparators and also the uses of the comparators.

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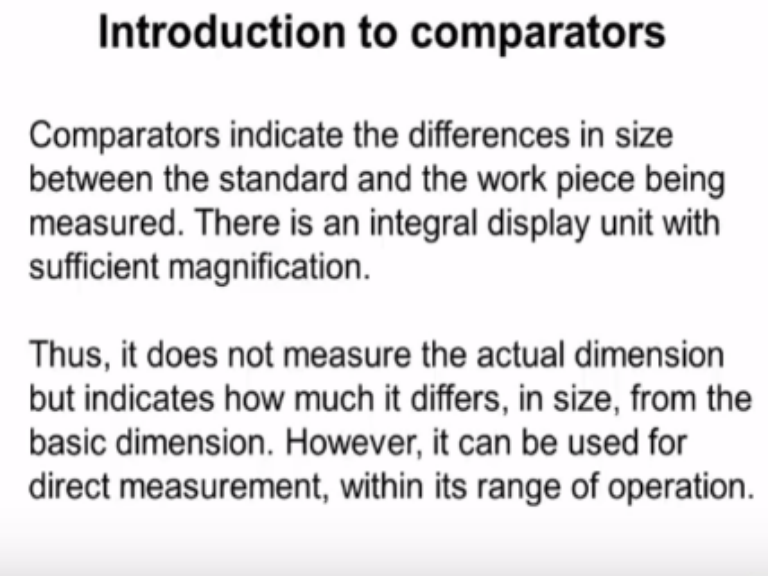

Let us start the introduction to the comparators. Now these comparators indicate the difference inside between the standard and the work piece being measured. There is an integral display unit with a sufficient magnification that means it does not indicate or it does not measure the actual dimension of a work piece but it indicates how much it differs in size from the basic design dimension.

However the comparators can be used for direct measurement within its range of operation for example if the range of the dial indicator is 0 to 10 millimeter within this range the comparator can be used for the measurement of the work piece.

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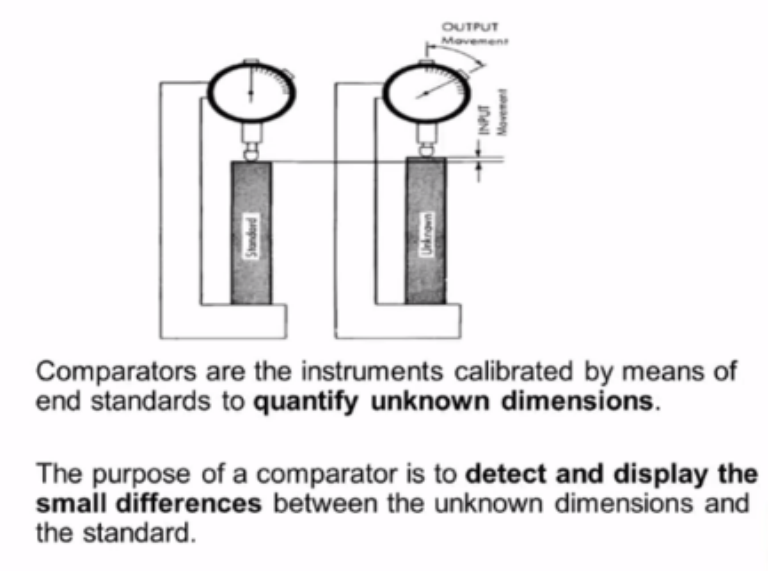

Now this picture shows the basic system of the mechanical indicator so they have a stage where in the standard and work pieces can be placed in an arrangement that is a column with comparator can be mounted and the differences initially they have to place the standard on the table and we should set the reading of the comparator to zero and then we have to remove the standard.

We have to place the work piece of unknown size between the table and the spindle and the dial indicator of the comparators shows reading which will be the difference from the basic size .These comparators are the instruments calibrated by means of end standards for example the gauges almost to quantify unknown dimensions. The purpose of a comparator is to detect and display the small differences between the unknown dimensions and the standard.

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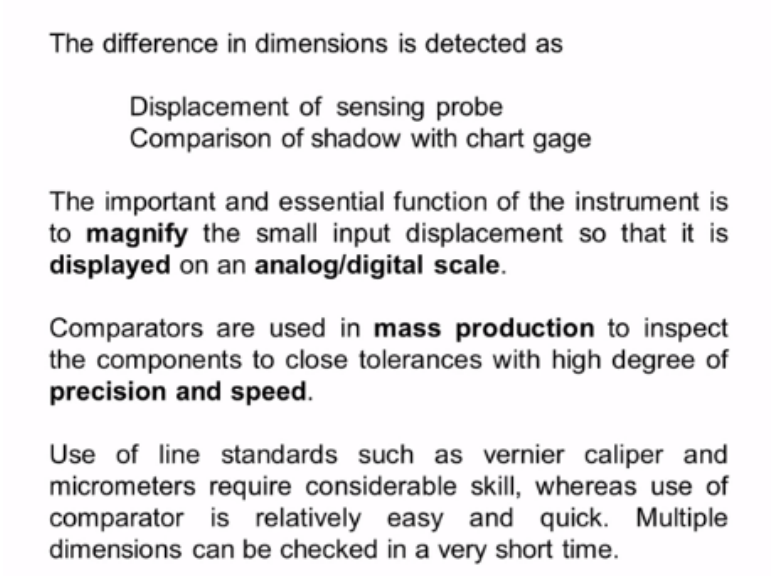

Difference the difference in dimensions is detected as displacement of sensing probe for example content pro in the dial indicator and the difference in dimensions are also deducted by comparison of shadow with chart gauge which we will be discussing after sometime. The important and essential function of the instrument used to magnify the small input displacement so that it is displayed on an analogue or digital scale.

Comparators are used in the mass production to inspect the components 2 very close tolerance with high degree of precision and speed quickly we can inspect the work pieces and we can segregate as acceptable work pieces and not acceptable work pieces use of line standards such as vernier caliper and micrometer require considerable skill in the use of the instruments various use of comparator is relatively easy and quick multiple dimensions can be checked in a very short time using comparator.

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Basic features

1. A **sensing device** which faithfully senses the input signal

2. A **magnifying system** to amplify the signal to suitable level
   - Mechanical method
   - Optical
   - Pneumatic
   - Hydraulic
   - Electronic

3. A **display system** (commonly a scale and a pointer)

Let us study the basic features of the comparator. In any comparator consists of a sensing device which faithfully sensors the input signal and there is a magnifying system to amplify the signal input signal to suitable level for this magnification different methods are used like mechanical methods come optical method pneumatic method hydraulic method or electronic method of magnification and any comparative will essentially consist of a display system commonly a scale and pointer is used.

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Desirable features of comparators

- Scale should be linear
- Wide range for comparison
- No backlash, no friction, less inertia
- Should be precise and accurate
- Clear indicator

Now what are the Desirable features of comparator. Now the scale of the comparator should be linear within the its operating range there should be wide range of comparison so that it can be used for within wide range of application there should not be any backlash or any friction should

be very less or inertia of the parts various parts should be less it should be precise and should have good measurement and accuracy and the indicator should be very much clear.

So that we can easily take the reading the indicator can be analogue type or from here so I can see the analogue indicator it is from 0,1,2,3,5 again counterclockwise in 1,2,3,4,5. this is the contact probe and we have the pointer and we can see the marking on the screen are very much clear so that we can very easily read and this shows digital indicator so that we can very easily take the reading also we can transfer the data via some communication system to the computer system.

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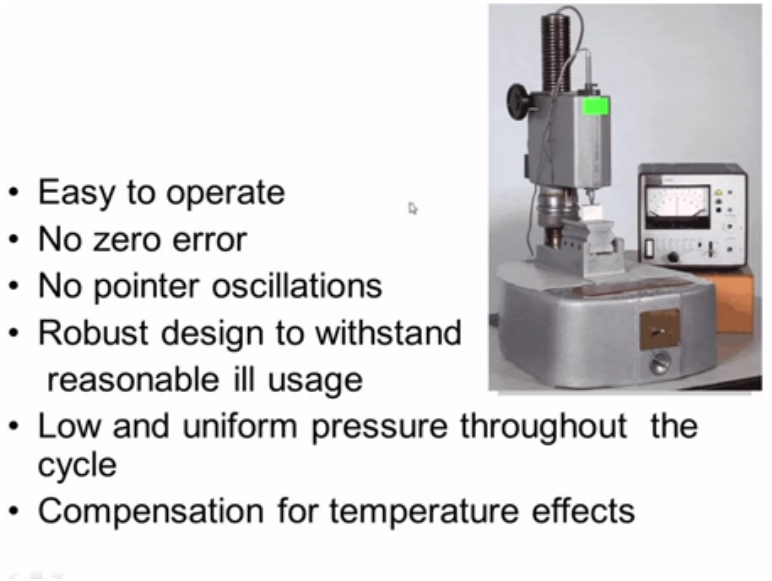

Now they are the desirable features are easy to operate it should not require much skill of operation and no zero error there should not be any oscillations it should smoothly move over its range and its robust in design to which stand the reasonable in usage and measuring the pressure it should be very low it can be uniform throughout the operation and it should be bill inbuilt compensation for temperature effects.

So you can see here a system which has comparator system with the base and there is a column we can see the threaded column so that this measuring head can be moved up and down this height between the table and the probe can be adjusted depending upon the work piece size and

also these tables are re generate table depending upon the applications and change the tables this is the sensing probe.

The output this is an example of an electronic comparator in led t and place the work piece between the table and the probe. The probe will move and the signal is sent to the indicator and the pointer will move on the scale rotary scale we can select the desired range and sensitivity of the operation.

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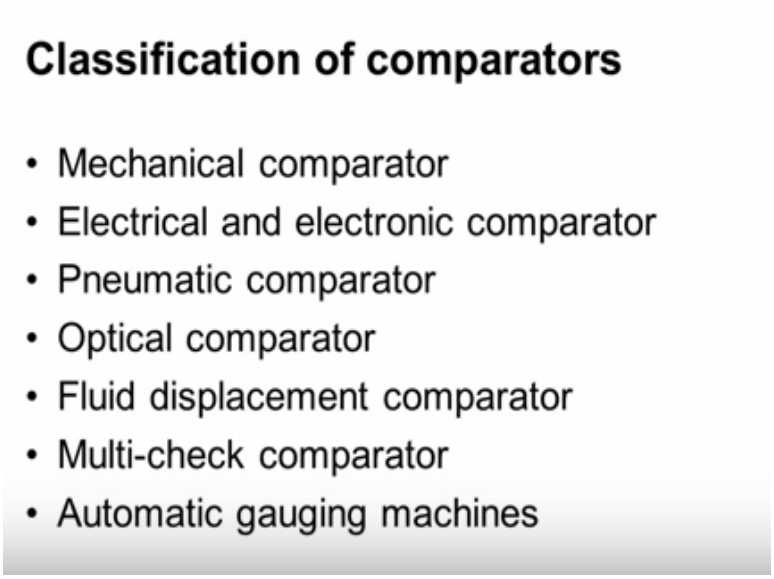

Now how these comparators are classified depending upon the design they are classified as the mechanical comparator electrical and electronic comparator pneumatic comparators, optical comparator which is the optical system fluid displacement comparator multi check comparators in which multiple dimensions can be checked at a time and an automatic gauging machines.

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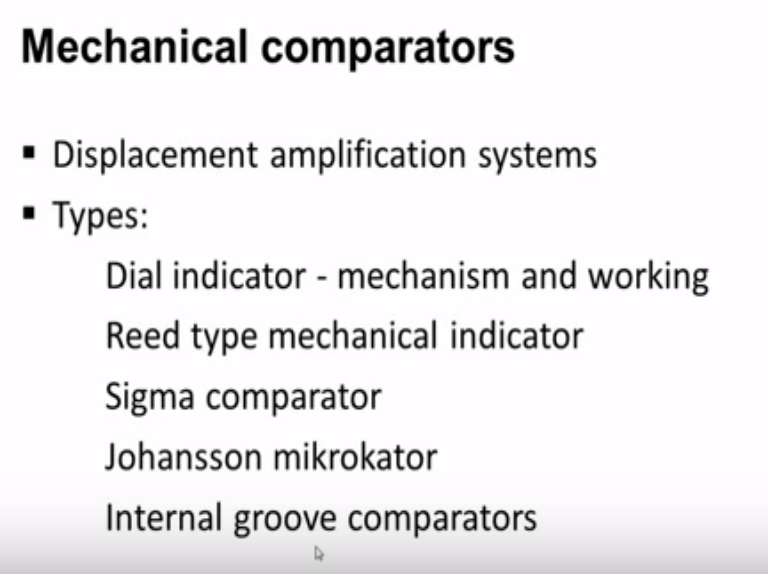

Now let us start the discussion on mechanical comparators. Now let us study the different displacement amplification systems what are the different types of application system used in the mechanical comparators and what are the various types of mechanical comparators different types are available like dial indicator reed type mechanical indicator sigma comparator Johansson mikrokator and internal groove comparators.

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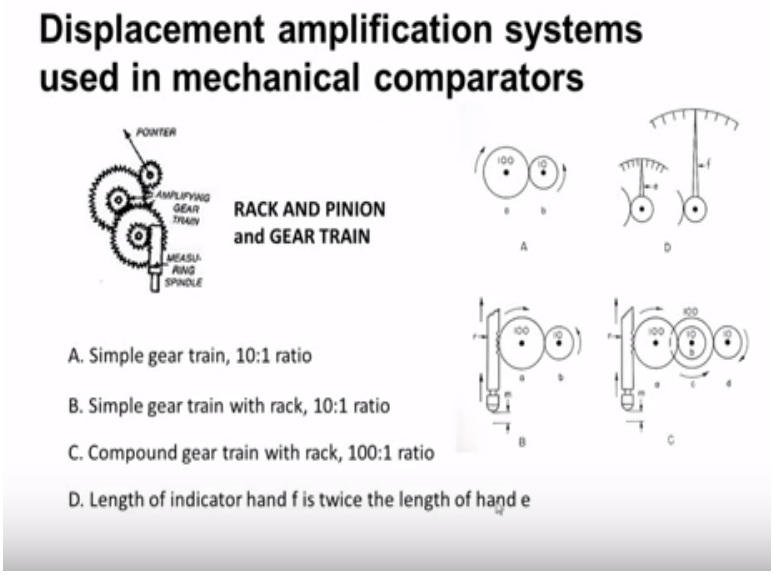

Now the displacement amplification systems used in mechanical comparators are illustrated here different amplifier systems are used in mechanical comparators like rack and pinion and gear train we can see this is the spindle contact spindle which is contact the work piece so when the

work piece is placed in between the table and the spindle the spindle will move in so spindle is connected to the rack.

We have the rack on this on the spindle we have the pinion here when the spindle moves that is the rock moves pinion will rotate so this rotational pinion amplified using the gear train finally the motion is transmitted to the point and then we can take the reading now this is a very simple gear train with 10:1 ratio and we have another simple gear train with rack, we can see the rock which contains the contact probe when the right moves up and down.

This get will rotated and amplification of 10 is to 1 ratio and then we have compound gear train with track so this is the right then we have the compound gear train which will give the 100 is to 1 amplification ratio and then we have the length of the indicator hand F, so this is the length of the indicator as the length of the indicator increases there also we get some amplification.

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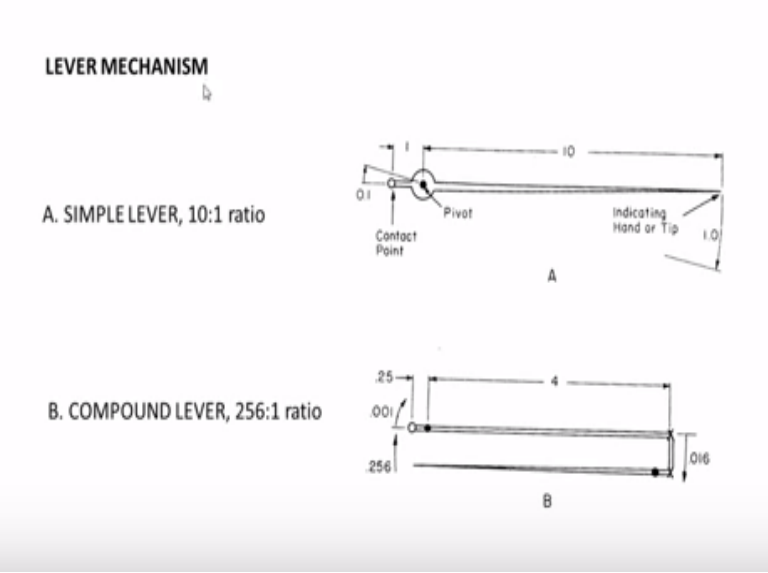

Now another amplification mechanism used is lever mechanism so this is simple lever with 10 is to 1 ratio we can see here this is the contact and this is the pivot the distance between the contact point and the pivot is 1 millimeter here, 1 unit and the distance between the pivot in tip of the pointer is 10 so that the signal displacement the signal amplified by 10 times.

Now this shows a compound lever wearing at an amplification of 256 time period, so this is the contact. and this is the pivot and this is the here we have another secondary lever so totally we get an amplification of 256 times.

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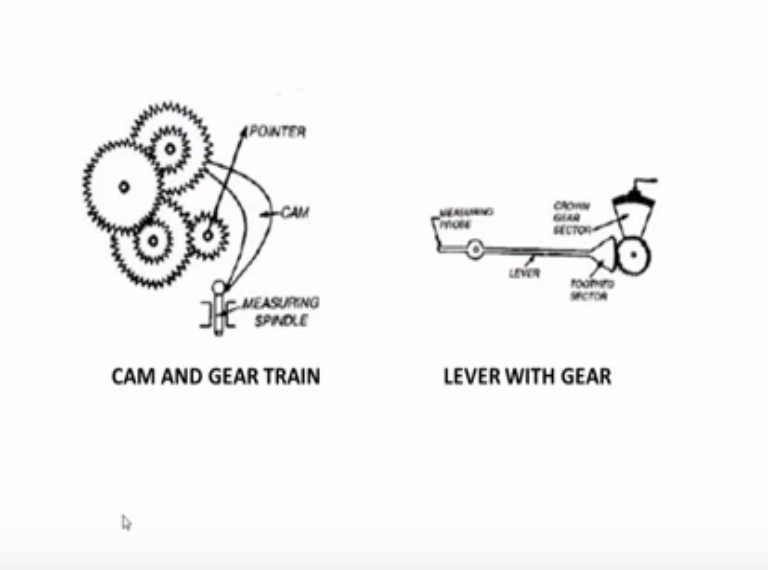

Another mechanism is cam and gear train this is the measuring spindle in the camp and we have the set of gears so using this weekend do the amplification of the signals and this is another system which uses lever with gear using lever system we get some amplification and using the gear train added amplification for the amplification signal.

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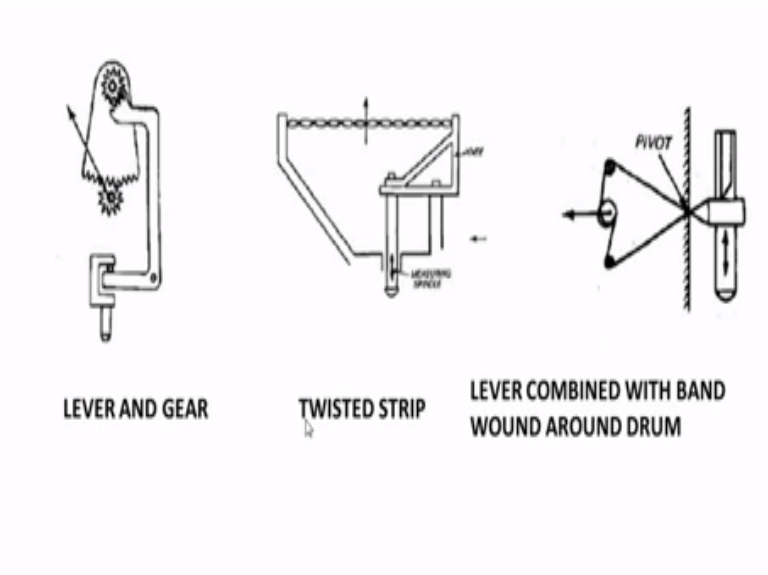

Now this or the other system to amplify the input signal lever and here, so this is lever and gear and twisted strip lever combined with band round around drum. We have a drum here and a band is bound around the drums so there also we get the amplification of the signal.

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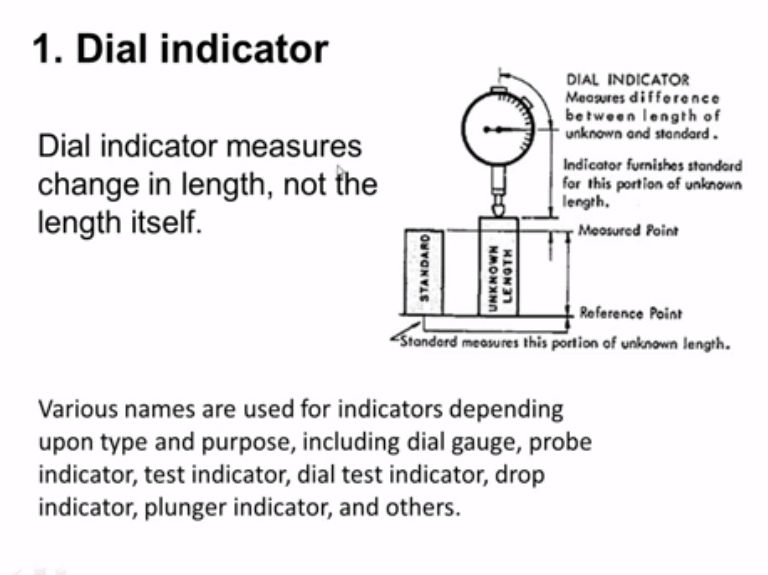

Now let us study a very common type of mechanical comparator that is a dial indicator so this dial indicator measures change in length and it does not measure the length itself other word within its range of operation it measures the actual length of the work pieces example if the range of the dial indicator is 02 to10 millimeter its range is 0 to 10 mm and if the work piece size is of 5 millimeter directly to measure the length of the work pieces.

So, various names are used for dial indicators depending upon the type and purpose including dial gauge probe indicator test indicator dial test indicator drop indicator plunger indicator extra. Now this picture shows the arrangement of the dial indicator this is the table on which the standard or the work pieces are placed.

So this is the reference point and this is the standard example slip gauge can be used as a standard in the desired distance between the plunger and the reference point. now we say we want a desired height of 10 millimeter this is the basic height dimension then the use the slip gauge of 10 millimeter dimension we keep it in between the plunger and the table it is the reference point. And we set the dial indicator to read 0 status.

When, we adjust the height of the dial indicator so that it read 0. Now we remove the standard and we place a piece whose height is to be checked that is play the work piece is placed between the plunger and the reference point. If the size of the work piece is greater than the standard size 10 millimeter then this is the error or the difference inside can be measured using this dial indicator arrangement.

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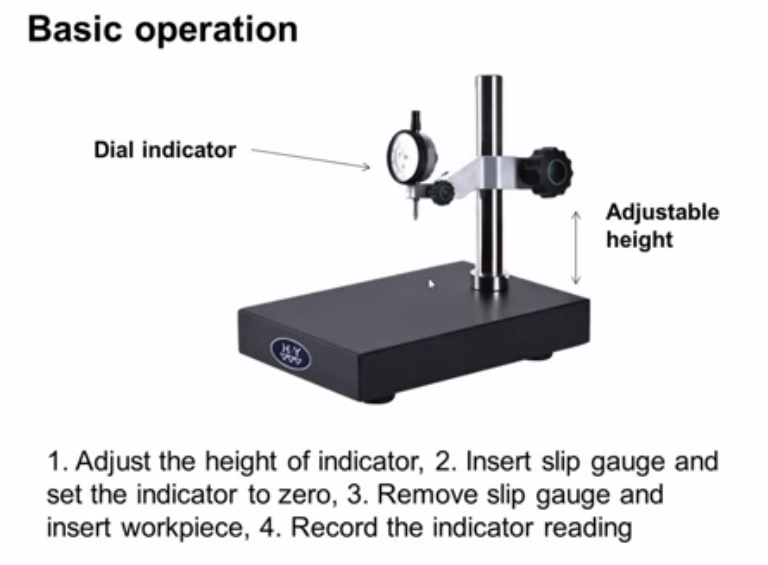

Now let us study the basic operation of the mechanical indicator the dial indicator and we have a granite table or cast iron table which is the reference point and we have a column on which we have a bracket for mounting the dial indicator. The dial indicator height can be adjusted by moving this bracket or the dial indicator itself can be put down and then it can be clamped using this knob this is the height can be adjusted on the work piece.

Now initially we have to adjust the height of the indicator to accommodate the work pieces of different heights and then we have to insert this slip gauge in between the spindle and the reference point that is surface top surface of the reference table and we should set the indicator to reach the road.

Now we should remove the slip gauge and standard should be removed the work piece whose height are to be inspected are inserted between the table and the gear and if the size is different

from the standard size the pointer will move and that will say the change in the difference so that is recorded.

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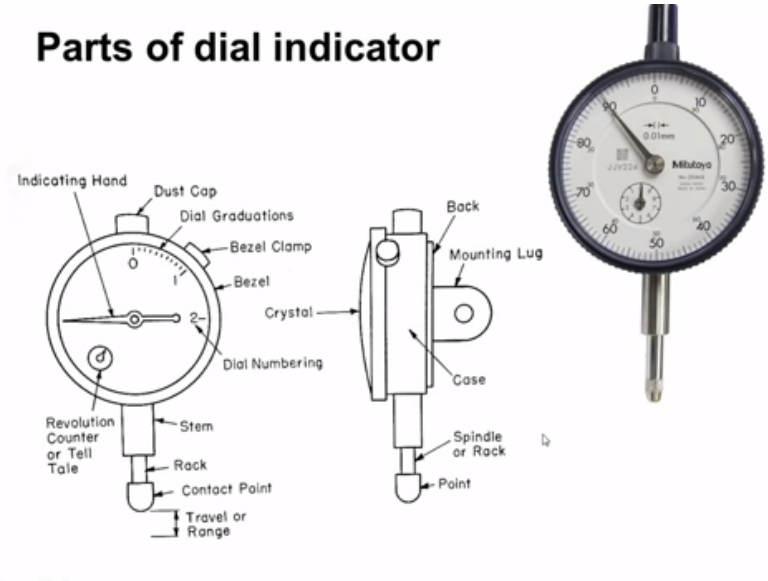

Now let us study the construction of the dial indicator there are many parts in dial indicator. There are indicating hand and they have the rotary scale with markings and this dust cap to protect the rack and we have a bezel to protect pointer and scale clamp and then we have the stem connected to the back connected to the body of the dial indicator and there is a rack or spindle and then the contact which is mounted on the rack now there is a mounting lug.

Now this is the mounting lug connected to the stand now this shows a dial indicator wherein we can see we have a pointer and then we have a revolution counter and this is the scale we can see this 0, and this is 10, so this 0 to 10. We have 10 marking each markings represents 0.01 millimeter. The pointer moves from zero to 10 so the displacement of the plunger will be 0.01 to 10 that is. 1 mm.

So like that if the pointer completes one revolution it will be 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and then 1mm. So if pointer completes one rotation the movement of the plunger will be 1 millimeter like that we can see the pointer can rotate time standard rotations. So we have 10 marking here 0 to 1, 2, 6, 7, 8, 9, 10. So the range of the dial indicator is 0 to 10 and least count is 0.01 millimeter.

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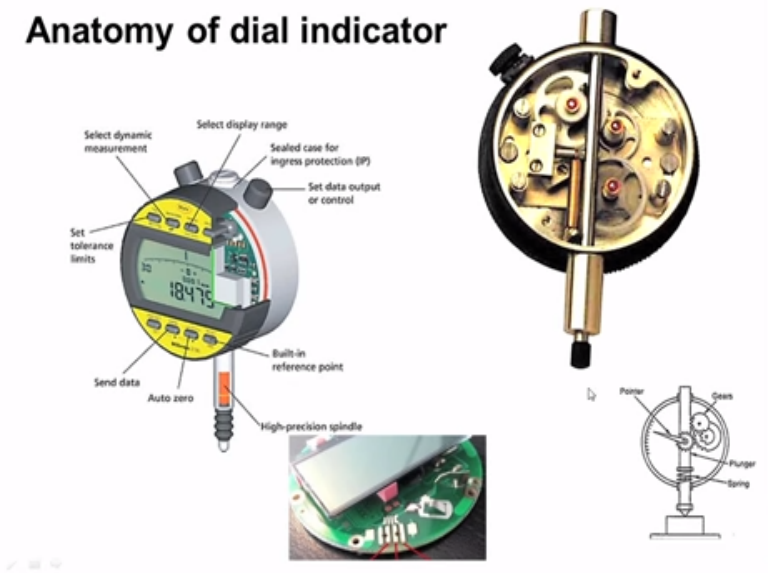

Now let us see the internal construction of the dial indicator .that is mechanical type dial indicator. You see the contact lenses the stem and the back cover is open. This is the spindle bearing the rack and the sack is cut the rack is connected is contact with the pinion. Then we have the set of gear train and there is a spring to bring back the spindle back in position.

When we move the work piece period this is the design of the dial indicator we can see the digital display and then the weekends set the tolerance limits and lower limit we can also set the select the display range is from 0 to 10 mm, 0 to 20 mm, 0 to 30 millimeter. So the range can be selected.

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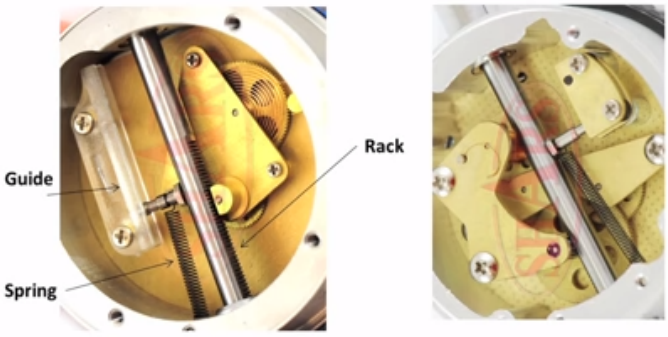

Gear train amplification is the most common method used to magnify dial indicator motion, because its accuracy meets the requirements of comparison measurement. In use, the **sensitive contact probe is part of a rack**, in which a series of three to five gears; magnifies and transmits the movement of the contact probe, to the pinion gear on which the indicator hand is mounted.

Now this is the magnified view of the internal structure we can see the spindle on which the rack is kept and the pinion is in contact with the rack and this is the spring to bring back the rack when the work piece is removed the guide are there ac under the spring and it is near the trains for amplification of the signal here train amplification most common method used to magnify the dial indicator motion.

That is the plunger motion because its accuracy meet the requirements of comparison measurements. In use the sensitive contact group is part of a rack in which a series of 3 to 5 gears magnifies and transmits the movement of the contact probe to the pinion gear on, which the indicator hand is mounted.

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Now we can see the dial indicator back cover is opened and pressing the plunger we can see the movement of a plunger. We have guide for the moment of the plunger and guide rod we can also see the rack on the pinion .we can also see a spring.

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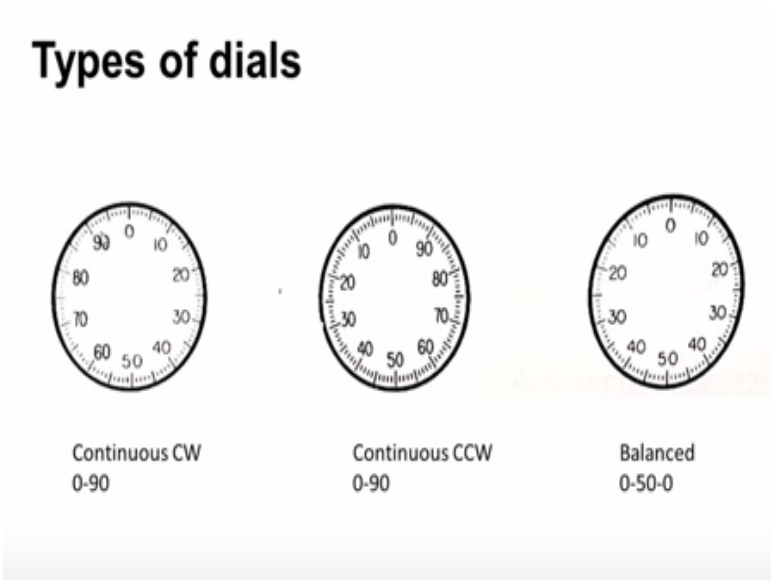

Now different types of dials are used. This is a dial with continuous clockwise marking 0 to 90 markings and this is continuous markings this continuous counter clockwise markings and this is balanced type that is in the clockwise it is zero to 50 marking and then in the counterclockwise we have 0 to 50 markings.

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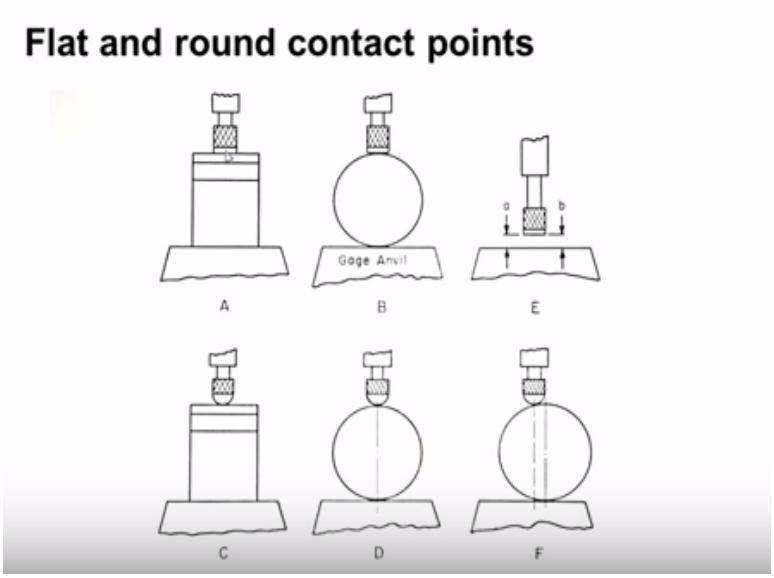

Here, we have flat and round contact points so we have the flat contact and this is the angle of the table which work piece is mounted here work piece with flat surface round work piece. okay. Now it is very essential that the surface of the flat contact should be parallel to the angle surface of this gear error and we can see here and we can see here round contact points.

Now, when we use round contact and checking the round part is essential that the contract the maximum size of the work piece, example the diameter of the work piece. If we cylindrical object like this then we get the error in the reading.

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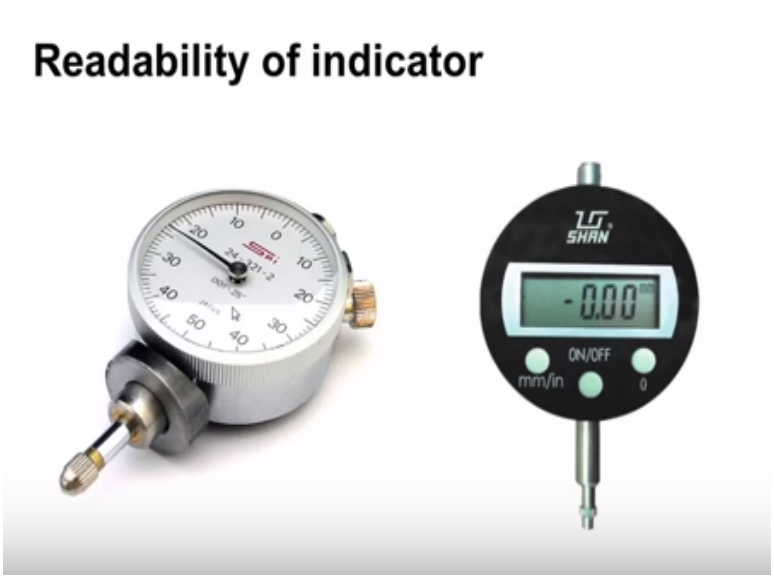

So the readability of the dial indicator is also an important thing. This is the commercial dial indicator where in the marking are there and they are very much clear so reading is very easy also we can work or digital indicator so where in we can select the systematic system or this system.

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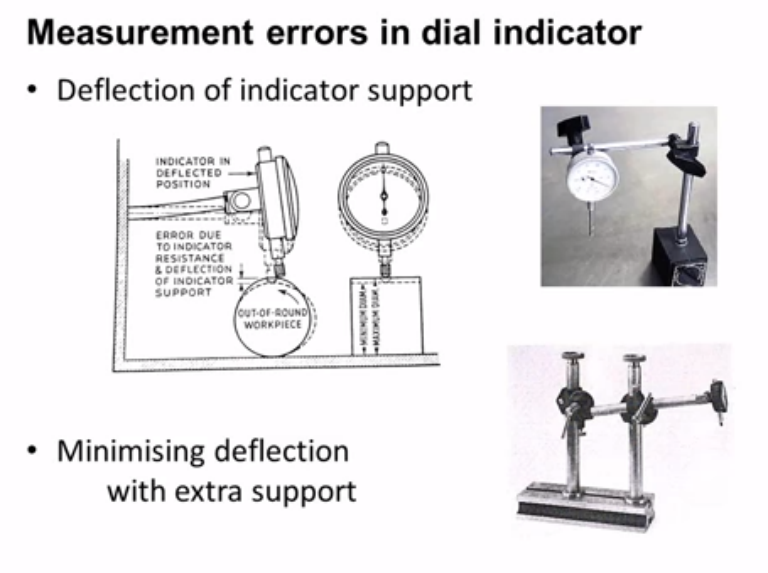

Now the measurement errors in the dial indicator now we can see here in this picture the table on which the work piece are placed. now they have this dial indicator mounted on this on. Now when we insert the work piece what happens if this arm is not rigid enough it will bend and then we get wrong reading so how do we eliminate this deflection of this support we should use a rigid a very strong arm or else we have to minimize the overhang this dial indicator.

It should be bolt as close to the arm as possible. Also we can minimize the deflection of this support using extra support as shown here.

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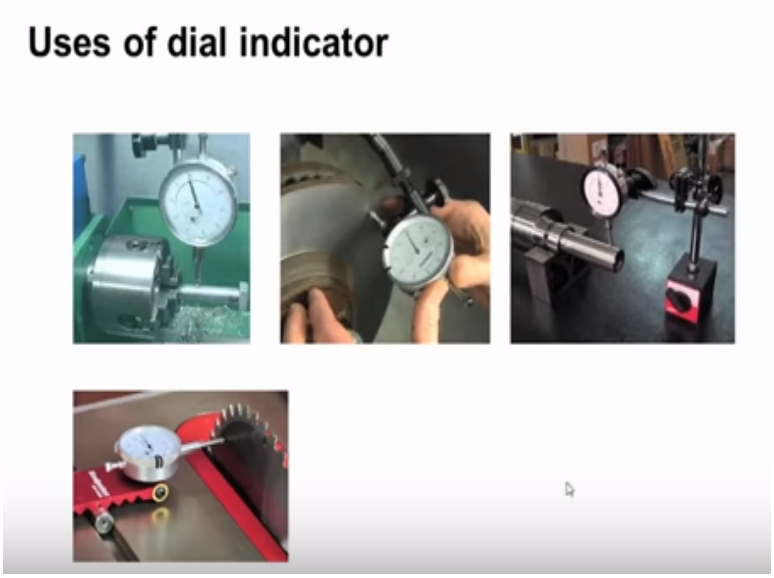

Now we will see the uses of the dial indicator. So it is used in the turning work to check whether we have the fit the proper size of the work piece. It is used to check the wobbling of the rotating surfaces we can also used to check the roundness of the work parts. This is the work piece mounted on a block and rotation is given to the work piece.

So it is rotated and then readings of the dial indicator are taken. If this is not wrong, this will indicate. What is the amount of the error also it is used to check the wobbling in the rotary rods.

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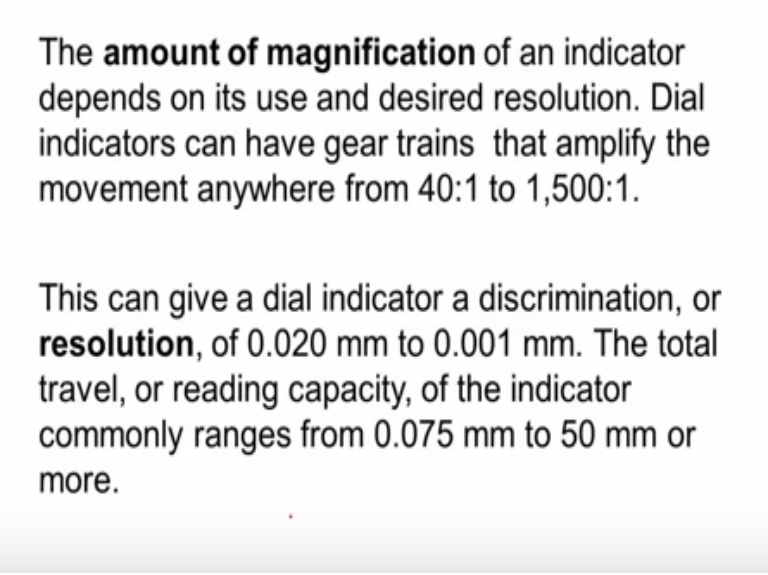

The amount of magnification of an indicator depends on its use and desired resolution dial indicators can have to train that amplify the movements anywhere from 40:1 to 1500:1. That

means the magnification of 1500 times is possible period this can give a dial indicator a discrimination or resolution of 0.020 mm to 0.001mm. The total travel or reading capacity of the indicator commonly ranges from 0.075mm to 50 mm or more.

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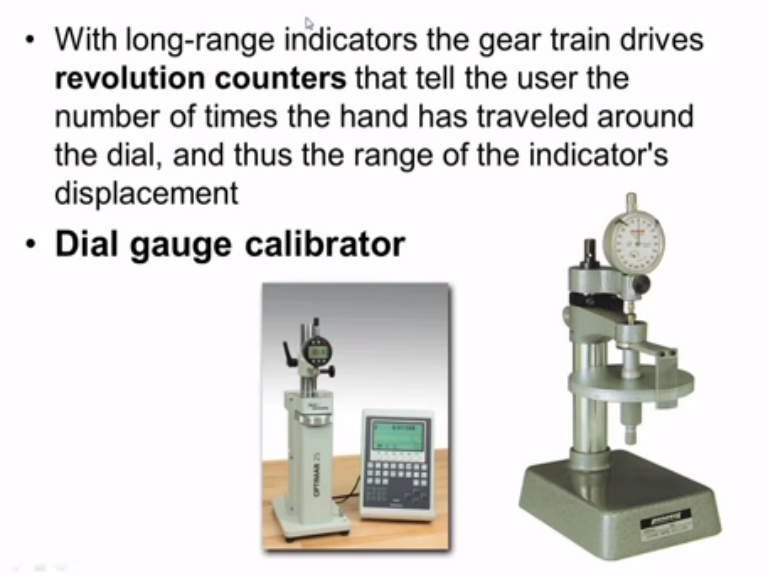

In the case of long range indicators, for example 0 to 100 millimeter, 0 to 50mm the gears drives and revolution counter us. We can see here we have this pointer in main scale and then the revolution counter. We can see here which tells how many revolution the hand has rotated. The revolution counters till the user the number of times the hand has travels around the dial.

Thus the range of the indicators displacement can be known these dial indicators are calibrated using slip gauges or using dial gauge calibrators. So we can see here the calibrating stand is used to calibrate the dial indicators the dial indicator which is to be calibrated is mounted and we can see there is a disc with markings and then we have to note down.

What is the reading given by which standard calibrator and what is the reading given by the dial indicator. We will come to know what will be the error of the dial indicator. So these are the calibrator, which is digital.

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Now latest study how we can use the dial indicator as comparator period. We can see how

Slip gauge box the slip gauges are used as the reference to set the basic size of the dial indicator we have the round work piece and a vernier calipers to measure the diameter of the work piece the close view of the work piece. Now we can observe the dial indicator fixed to the stand we can observe the replaceable table these replaceable tables can be changed depending upon the work piece

We can see the slot in the stand to accommodate the drill that dial indicator is fixed in the bracket period the least count of the dial indicator is 0.1 millimeter and range is 210 m. Now we can adjust the height of the dial indicator to accommodate the work pieces of different heights by rotating the this nut we can adjust the diameter of the bracket raised or lower it in the column.

Now I am measuring the diameter of the work piece using a vernier caliper the diameter of the work piece is 19 millimeter now I have to select the 19 millimeter slip gauge I am selecting to slip gauges one 9 millimeter thick and the other 10 mm thick. The surfaces of the slip gauges we have to bring them properly to build a pile of desired thickness now we can see the slip gauge repel 19 millimeter thickness.

After bringing we can use this file to set the basic size dial indicator we have to insert the slip gauge file navigate between the table surface and the dial indicator so this is the this is desired size 19 mm is the desired size. We have to set the dial indicator to read zero by rotating the bezel now the dial indicator is reading zero that means when the gap between the spindle and the table surface is equal to 19 m indicator shows 0 now we have to remove the slip gauge.

Now reading is zero. We have to remove the slip gauge and then we have to insert the work piece which is to be inspected so I am inserting the cylinder which is to be inspected and we have to rotate it slowly so that we get the maximum reading so I am trying to slowly rotate roll the work piece.

I can see the pointer is moving so we have to note down the maximum reading so the maximum reading is 3 divisions that means the least count is 0.01 millimeter. So it is giving 5 divisions. So

the work piece size, diameter size is greater than the size by 5 divisions that means o.05 that means the size of the cylinder is 19.05 mm.

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Another type of dial indicator known as the dial test indicator, we will see the photographic view of the dial test indicator we have the lever which moves in this fashion the pointer will move and it will indicate the movement of this stylus. So whenever we want to measure the displacement example we have a work piece like this placed on the surface plate now depending upon the height of the work piece stylus will move up and down.

So the movement of this stylus is amplified by using this lever so we have a pivot ball bearing we have the pivot here and we have a lever here so in the end of the liver we have the gear sector and which is in engagement with the engagement sector in engagement with a pinion, so the opinion will rotate.

So the rotation of the pinion will be transferred to the point by means of gear arrangement and the will move on the scale and then we can note down the reading period, so we can amplify the displacement of this stylus by means of this lever arrangements.

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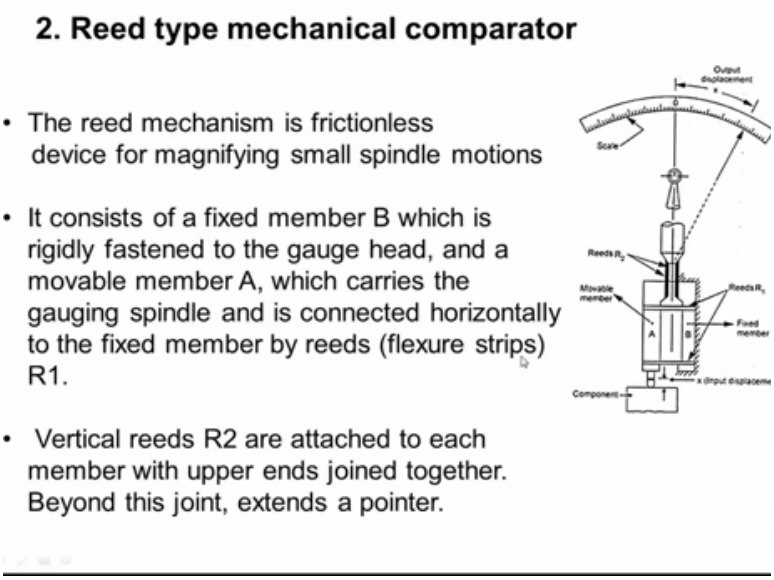

Now we will move to another type of mechanical comparator that is reed type mechanical comparator. This structure shows the arrangement of the reed type mechanical operator we have member 2 members member A, this is the movable member it will move up and down and there is fixed member. These 2 are connected by means of the horizontal reeds.

We have horizontal reed here and we have another horizontal reed here. So these are the 2 horizontal reed named r1 now we have a set of vertical reed R2 one vertical reed is connected to the movable member and another vertical reed is fixed to the fixed member. Now when the component is inserted between the surface plate and the plunger the plunger will move.

So this x will be equal to the displacement depending upon the components plunger will move up and down and then movable member A will also move up and down the 2 vertical reed are joined at the top and the pointer is fixed at this point. so since the 2 vertical reeds are joint the plunger moves up and down the reed will tilt in this fashion and hence the pointer will also move and then they can note down the reading displacement reading.

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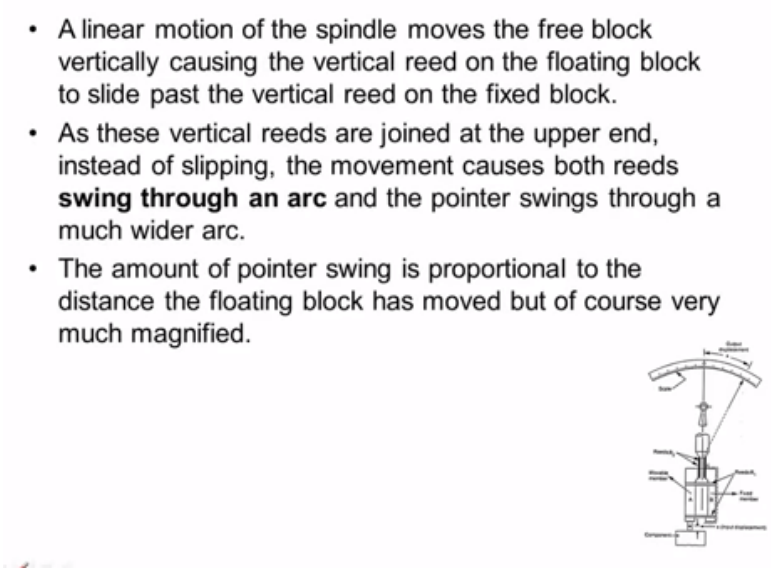

A linear motion of the spindle moves the free block vertically causing the vertical reed on the floating block to slide past the vertical read on the fixed block. Now as the vertical reed are joined at the upper end, the to reed or joint up the upper end instead of slipping the movement

causes both the reeds swing through an arc and the pointers swing through a much wider arc. wider distance.

The amount of swing is proportional to the distance the floating block has moved, but of course very much magnified.

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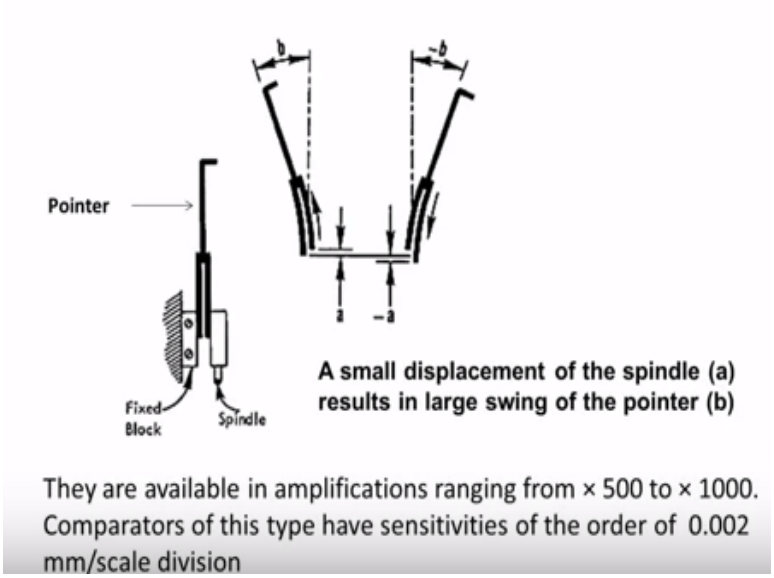

Now this shows the amplified view of the fixed block and then the vertical reeds then the spindle, which is fixed to the movable member and the 2 vertical reeds are joined together at the end. At the top end we have the pointer so now A is the displacement depending upon the height of the work piece.

The A can be positive or negative and then when the height of the work piece is greater than standard on the desired height, this spindle will move in this direction and the pointer will swing in this direction. if the height is smaller than the desired height then the swing will be in this direction and the pointer will be like this and then we can note down the reading.

There these comparators are available in the amplification ranging from 500 mm comparative of this type of sensitivities of the order 0.002 mm per scale division.

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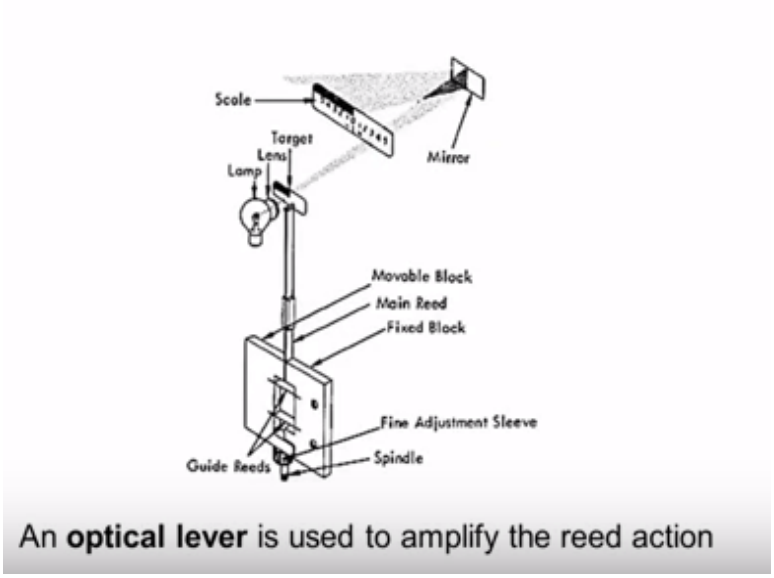

Now again we have a reed type comparators variant the mechanical pointer is replaced with an optical lever. so this is the top end of the reed, reeds a vertical reed and we have a lamp and the lens so that we have the light beam here light beam will go in this direction we have a mirror. So it is reflected in the mirror.

So when the top end of the read moves the swing in this fashion the reflected light will also move on this scale and hence we can know down the displacement of the spindle. so this case the magnification is obtained by the length of the vertical reed and also the magnification is for the magnification is obtained by this optical arrangement.

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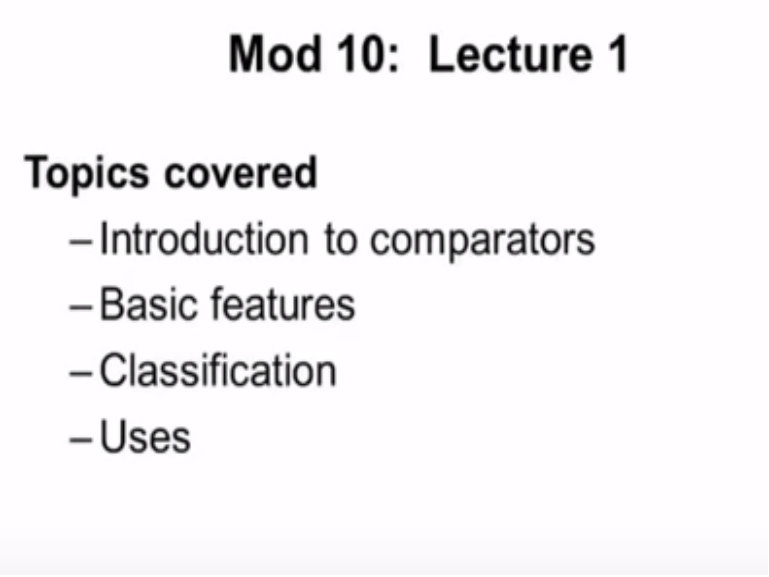

Now we are coming to the end of the lecture 1 in module 10. In this lecture we learnt about the basic features of the dial indicator or what are the features of the or characteristics of the comparators what are the purposes of the comparators, what are the uses of the comparators, what are the various types of the comparator and then we also learnt about the construction and we learnt about the mechanical type of dial indicator.

Now we will stop here and we will continue the discussion on other types of comparators in the next lecture. Thank you.