

Metrology
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Lecture – 33
Electrical and Electronic Comparators, Optical comparators

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Module 10 lecture 2

Topics covered :

Mechanical comparators

- Sigma comparator
- Johansson mikrokator
- Advantages and disadvantages

Electrical and electronic comparators

- Electrolimit gauge
- Visual gauging head
- Electronic comparator
- Advantages and disadvantages

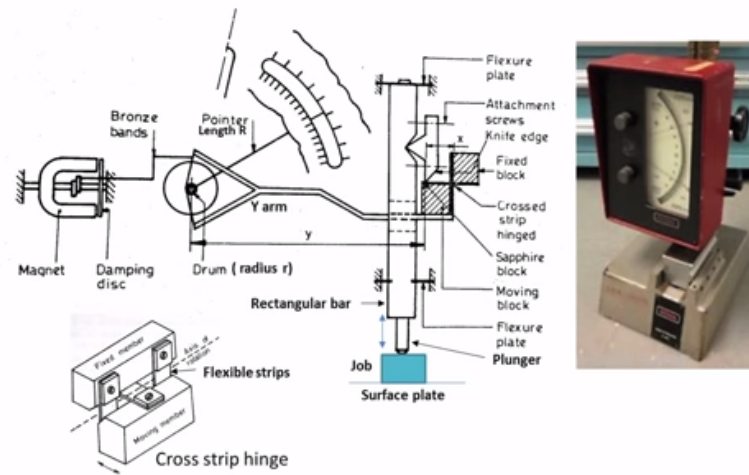
Optical comparators

I welcome you all for the series of lecture on metrology module number 10 and lecture number 2 in a previous lecture number 1 they started discussion on comparators and we discussed a few mechanical comparators in this lecture we will continue the discussion on mechanical comparators.

We will discuss about Sigma comparator, Johansson mikrokator and will also discuss the advantages and disadvantages of mechanical comparators and then we will move to the discussion on electrical and electronic comparator in which we will be discussing about the electro limit gauge, visual gauging head, electronic comparator and their advantage and disadvantages. Then we will move on to the discussion on optical competitors.

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3. Sigma comparator



Now let us discuss about the Sigma comparator, now you can see this photograph shows the Sigma comparator this is the study base and then have a column here on which the measuring head of Sigma operator is mounted we can adjust the height of this measuring unit by moving the it up and down and by clamping it at the desired height so this vertical moment of the measuring unit is needed to adjust the work pieces of different heights.

Now we can observe here a replaceable table depending upon the work pieces we can replace these tables and then they have to insert the word pieces between the surface of the table and the plunger so this shows the schematic diagram of the Sigma comparator I can give you the surface of the table and then we have a job which is to be inspected the work piece to be inspected is placed between the plunger surface plate.

When the desired work piece size is equal to the desired size then the pointer shows 0 initially the slip gauges we should adjust the gap between the plunger and the surface plate equal to the desired height, so in that case the pointer will show the pointer will show the 0 reading and then what is the upper limit and what is the lower limit of the work piece.

So accordingly we have to insert slip gauges = the upper limit of the work piece and then we can mark the upper limit of the work piece and then we should insert the slip gauge equal to the

lower limit of the work piece and then we can adjust the lower limit of the work piece so this limiting pointers we can adjust by operating the knobs.

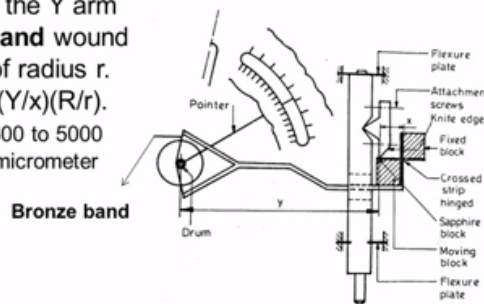
Now the construction of the sigma comparator is like this we have plunger which is connected to a rectangular block so this rectangular block is supported by flexure plates 2 horizontal flexure plates 1 plate is here and other plate is here and then we have a knife edge which is supported on the crossed strip inch the details of the crossed strip inch are shown here it consist of a fixed member.

Then a moving member with these members are connected by flexible strips as shown here and then we have a Y arm which is 1 end of this connected to the crossed hinge, crossed hinge movable part of the cross strip hinge the other part is bombed over a drum of radius r A pointer of length capital are mounted on the drum and then there is a bronze band wound over the drum.

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Mechanism

- The plunger is attached to a **rectangular bar** which is supported at its upper and lower ends by **flexure plates**.
- A **knife edge** is fixed to the bar which bears on a sapphire block attached to the moving members of a **crossed strip hinge**.
- A **forked arm** (Y arm of length y) is attached to the moving member of the crossed strip hinge.
- The other end of the Y arm carries **bronze band** wound around a **drum** of radius r .
- **Magnification** : $(Y/x)(R/r)$.
Magnification from 300 to 5000 possible, LC of 0.1 micrometer



Now having studied the construction now let us study how the comparators works the plunger is attached to the rectangular bar at we can observe here and knife edge is fixed to the bar which base on sapphire block attached to the moving member of a crossed strip hinge. We have this Y arm forked arm of length y and can see here the distance between the knife edge and this vertical cross strip is x .

Then when the piece is mounted or inserted between the table and the plunger the depending upon the height of work piece this plunger along with this bar rectangular bar will move up and down and this part chained up the forked arm will also move up and down then the other end of the forked arm will also move and hence the pointer will also move in this fashion.

Hence we can take the reading using this scale in the magnification can be calculated using this $(Y/x)(R/r)$ Y is the length of the fore form and x is the distance times r upon R were r is length of the pointer and small r is the drum of radius the magnification possible with such a comparative varies from 300 to 5000 and a least count of 0.1 micrometer is possible.

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- Range : +/- 0.07 mm
- Scale graduation : 0.002 mm
- Magnification : 1000 x
- Interchangeable work table and contact tips (flat/rounded)
- Work piece height : 150 to 600 mm (measuring head adjustable)
- **Tolerance indicators** (upper and lower limits)

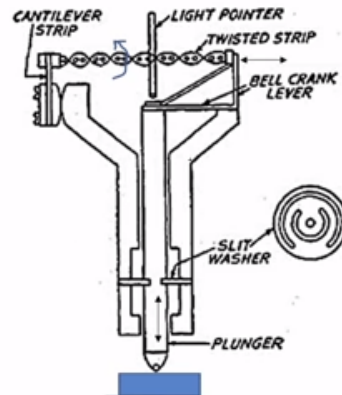
Now the specification commercially available sigma comparator are as follows range varies from -0.07 to +0.07 and scale graduation is 0.002 millimeter magnification of 1000 and up to 5000 is possible and then we have interchangeable work table depending upon the work piece these tables can be changed and they contact tips they plunger end which makes contact with the work piece they are replaceable.

We can have flat end contact tip or round end contact tip like this that depend upon the type of work piece to be inspected the work piece height that is that can be inspected between the plunger and the table surface varies from 150 millimeter to 600 millimeter by adjusting the

height of this measuring unit and then we can also have the tolerance indicators which will indicate the upper and lower limit of the work piece.

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4. Johansson mikrokator



Now we will move on to the discussion of Johansson mikrokator the construction of the Johansson mikrokator is shown here we have the 2 S shaped parts these 2 parts are assembled by using this flexible slit washer now in the middle we have the plunger which moves up and down depending upon the work piece height and then there is a bell crank lever.

This bell crank lever one end of the bell crank lever is connected to this S shaped body and the other end is connected to the top end of the plunger and there is a metallic twisted strip so here we have a cantilever strip between the cantilever strip and the bell crank lever we have this twisted strip and at the center we have light point.

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A **metallic strip** is twisted and fixed between two ends.
Any longitudinal movement (in either direction) will cause the central portion of the strip to rotate.
One end of the strip is fixed to an **adjustable cantilever** and the other end is fixed to the **bell crank lever**. The bell crank lever, in turn, is connected to a **plunger**, which moves upwards or downwards.



Now let us see how this comparator works the any when insert the work piece between the table surface and the plunger the plunger moves up and down depending upon the height of the work piece any longitudinal movement in either direction upward direction or lower direction will cause the central portion of the strip to rotate.

So when the plunger moves up and down this bell crank lever will move in this fashion because of this the length of this length of the strip changes and hence this pointed the strip will route along with the pointer Now we can see one end of the strip fixed to an adjustable cantilever and other end is fixed to the bell crank lever. The bell crank lever in turn is connected to the plunger at this portion so moves up and down when we insert the work piece.

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The bell crank lever, causes the twisted strip to change length whenever there is a **movement in the plunger**. This change in length will result in a proportional amount of twist of the metallic strip. The magnification can be varied by changing the length of the bell crank lever.



Now the bell crank lever causes the twisted strip to change length when there is a movement in the plunger this change in length will result in a proportional amount of twist of the metallic strip the magnification can be varied by changing the length of the bell crank lever.

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Advantages of mechanical comparators

- These are usually **inexpensive** in comparison to other devices of amplifying.
- These **do not require** any **external supply** such as electricity or air.
- Usually the mechanical comparators **have linear scale** which is easily understood.
- These are usually **robust and compact** and easy to handle.
- For ordinary workshop conditions, these are suitable and are **portable**.

Now what are the advantages of mechanical comparators these are usually inexpensive when compared to other devices other types comparators these do not require any external supply such as electrical supply or compressed air supply usually the mechanical comparators have linear scale which is easily readable these mechanical comparators are very robust and very compact and hence they are easy to handle for ordinary workshop conditions these are suitable and are portable.

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Disadvantages of mechanical comparators

- They have **more moving parts** than other types. Due to this, the **friction is more** and ultimately the **accuracy is less**.



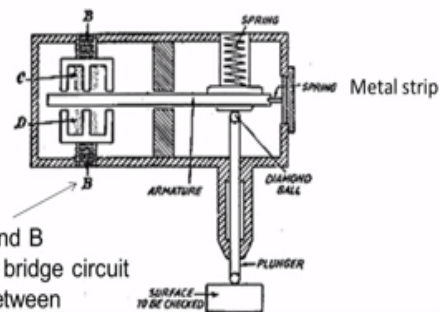
- Any **slackness in moving parts** reduces the accuracy considerably.
- The mechanism has **more inertia** and this may cause the instruments to be **sensitive to vibration**.
- The **range of the instrument is limited** as the pointer moves over a fixed scale.

Now what are the disadvantage of mechanical comparators they have many moving parts than the other types, due to this the friction is more and ultimately the accuracy is less. So this diagram this photograph shows the various parts the disassemble parts of dial indicator. Any slackness in moving parts reduces the accuracy considerably. The mechanism has more inertia and this may cause the instruments to be sensitive to vibration. The range of the instrument is very much limited as the pointer moves over a fixed scale.

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Electrical comparator – electro limit gauge

- Construction of measuring unit
- Working principle



Electromagnetic coils A and B
These form 2 arms of AC bridge circuit
Movement of armature between
coils sets up out-of-balance, which is
indicated by display unit.

Now let us start the discussion on electrical comparator particular comparator named electro limit gauge so in this we will study the construction of the unit of electro limit gauge and

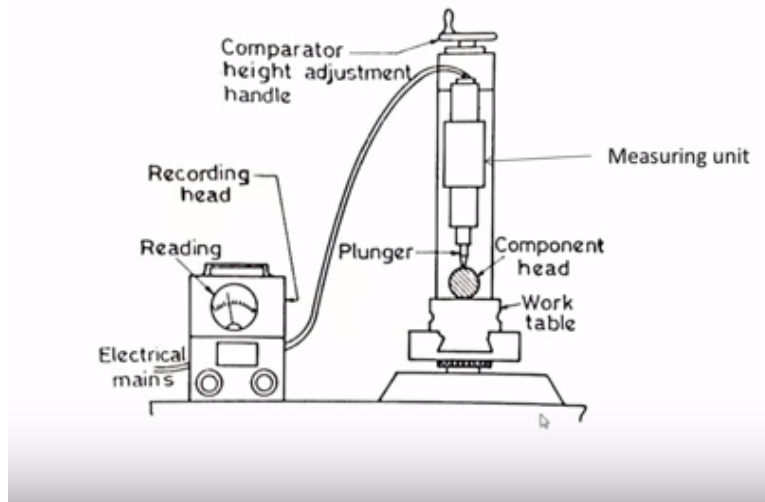
working principle of electro limit gauge. I can see here the schematic diagram of the measuring head of electro limit gauge the construction is shown here this is the surface plate or table on which we have to place the work piece.

We have to insert the work piece between the plunger and the table surface now the plunger depending upon the height of the work piece the plunger will move up and down if the height of the work piece is $>$ the desired height the plunger will move up if the height of the work piece is lower than the desired height the plunger will move down and then we have a armature which is supported by metal strip springs here.

So the other end is free to move up and down but the plunger moves up and down this armature will also move up and down like this it will tilt like this. This being the hinge point, now while the work piece the work piece is removed plunger will move back because of this spring force now we can see here we have 2 electromagnetic coils A and B host in this enclosure now these 2 coils A and B they form 2 arms of AC bridge unit.

When the plunger moves up and down this armature will also move the movement of the armature between the coil so the armature will move in this fashion so this part of armature will move up and down in the gap between these coils because of the movement of armature the coils sets up out of balance which is indicated by display unit so display unit will directly show the amount of movement of the plunger which will indicate the deviation in size from the desired size.

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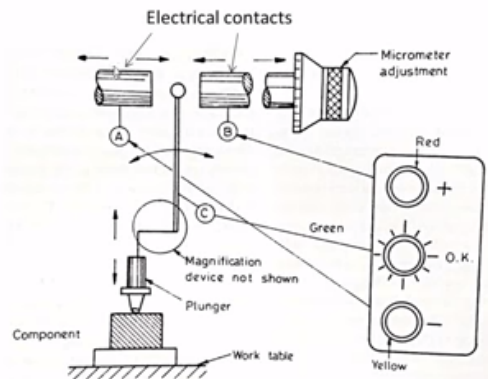


Now this view shows a complete arrangement of electrical comparator we have table surface plate surface and then this is the work table on which we have to place the components work piece to be inspected and this is the plunger of the electro limit gauge so this hosting contains the 2 coils armature, etc.

So this is the unit the height of the by guiding unit can be adjusted by operating this wheel to accommodate the work piece of different size Now the plunger movement sets the out-of-balance which is supplied to the recording head so there is out of balance because of the movement of the armature now this pointer will move over the scale and that movement of the pointer indicates the deviation the size from the desired size.

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Visual gauging head



Rod © in central position, Green light glows, the size of workpiece is OK
 If size is more rod © moves to right and makes contact with B, Red light glows
 If workpiece is undersize, Rod © moves to left and makes contact with A, yellow light glows

Now this is the schematic diagram of visual gauging head now this is the work table on which we have to place the components this is the plunger of this visual gauging head which is connected to rod C so in between the plunger and the rod C we have the magnification device which can be mechanical lever arrangement.

Now we have 2 electrical contacts A and B so in between there is a gap between A and B in between A and B there is a gap in which the rod C will swing now the electrical contacts position can be adjusted by operating the micrometers so depending upon the upper limit and the lower limit the position of these little contacts is adjusted by operating the micrometers Now when the rod C in central position that is not in contact with either A or B.

That it indicates that the work piece size is between upper limit and lower limit and the green light will glow, which indicates that work piece can be accepted. Now if the work piece size is > the that size or if crosses the upper limit then rod C moves to the right and makes contact with B when the work piece is height is > the upper limit the plunger will move up.

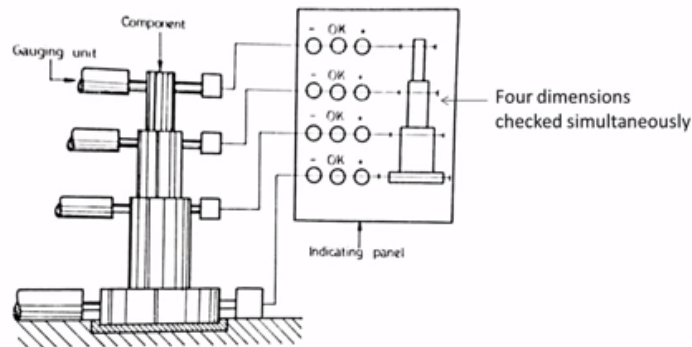
Then the rod C will swing and it make contact with this contact B and then red light will glow indicating that the work piece is above the upper limit and it should be rejected. Now the work piece is undersize that means it is lower than the lower limit then the rod C moves to left and

makes contact with the contact A and then the yellow light will glow will indicating that the work piece size is lower than the lower limit and it should be rejected.

So we can see that in this type of comparator the actual size of the work piece is not indicated it will only indicate whether the work piece is acceptable or to be rejected.

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Multi gauging device



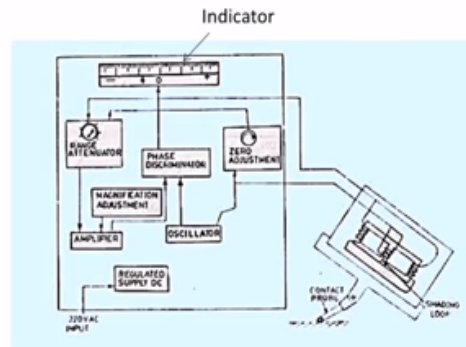
The work piece to be inspected is pushed onto the table, between the gauging plungers, and the indicating panel will display whether the 4 dimensions are OK

Now this shows multi gauging device in the previous case we have one set of contact that is given vertical at any given point of time check with the one dimension where as in multi gauging devices multiple sizes can be checked at a time for example we have a work piece wherein we have 4 dimensions to be inspected is the first dimension, second dimension third dimension and fourth dimension four dimensions are to be checked.

In such cases we can have a multi gauging device since 4 dimensions are to be checked we can have 4 gauging units so the work piece to be inspected placed on a table and the work parts will come in contact with these gauging units so depending upon the actual size of the different dimension of the work piece the yellow light , green light, red light glow depending upon the size and they will indicate.

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Electronic comparator



Principle of frequency modulation: When the work piece is placed on the table, the **oscillator frequency alters** because of change in dimension from preset value, which is displayed on the meter in terms of linear dimension.

Now we will move to the discussion on electronic comparator so this diagram shows the general arrangement of an electronic comparator so this is the contact probe or stylus which comes in contact with the work piece the work piece is inserted between the contact probe and the table so depending upon the height of the work piece this contact probe will swing. Now the electronics like the comparators are like this.

We have oscillator and then we have regulated supply and there is a provision for adjusting 0 the range also can be adjusted different ranges can be selected and then magnification can be adjusted. Now these electronic comparators they work on principle of frequency modulation when the work piece is placed on the table the oscillator frequency alters that is because of change in the dimension of work piece from the preset value for the desired size of the work piece.

There is a particular frequency when the size of the work piece differs from the desired size then the frequency gets altered which is indicated by the display unit in terms of linear dimension so there by we can inspect the work piece and then we can decide whether it should be acceptable or rejectable.

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Now let us study how we can use an electrical comparator, now we can see the slip gauge box which is used as reference to set the comparator for the basic size now we are watching the electrical comparator fixed to the stand you can see the indicator which indicates the deviation of

the work piece from the basic sides we can see 2 knobs are there to set the limits upper limit and lower limit.

We can connect 2 comparator at a time A and B and this is for adjusting the sensitivity of the comparator now it is set to 100 units 100 microns so the highest sensitivity is 0 to 3 microns now we can see the knob set to 100 microns so the range is from 3 microns to 1000 microns now you can see the back view of the indicator so we can observe the power connection this is the power connection power cable and we can connect comparator to A and B at a time.

We can connect 2 comparators now the power connection to the indicator now you can see the comparator electrical comparator fix to the stand this is the stand it is fix to the and the height of the comparator can be adjusted by moving it up and down and then we can clamp it using the knob so this is the clamp to clamp the electrical comparator.

Now we can see the object we inspected the basic size is the size of the component is measured using the vernier caliper so basic size is 19 millimeter now basic size of work piece is 19 millimeter so I have to take 2 I have to build a pile of slip gauge of 19 millimeter, so I am taking 2 slip gauges first one is 9 millimeter and second one is 10 millimeter thickness slip gauge and I am bringing the 2 slip gauges are them.

Now you can see the slip gauge pile of 19 millimeter thick so this is the basic size of the component so I am inserting the slip gauge pile between the table surface and the plunger of the electrical comparator and then indicator is set to read 0 when the size is 19 millimeter now you can see the pointer is reading 0 with small error now the reading is 0.

Now removing the slip gauge pile and then I am inserting the work piece to be inspected depending upon the actual size of the work piece the pointer will move to the positive side or the negative side if the size is $>$ the 19 millimeter the pointer will to the positive side now it is reading 4 so we are selected arrange sensitivity of 100 so we have to read the top scale.

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Advantages of electrical and electronic comparators

- Measuring unit can be remote from display unit
- Less number of moving parts, hence less friction
- Very high magnification (Ex. 10,000 times)
- The measuring unit can be small and portable

Now let us discuss on advantages of electrical and electronic comparators now in these of comparators the measuring unit can be at a remote place and display unit can be in a control room so in the control room we will come to know whether the work piece can be accepted or rejected or how many work pieces are rejected.

How many work pieces are accepted in a particular shift can be that details can be obtained in the display unit placed in the control room now there are less number of moving parts and electrical and electronic comparators, hence the frictional losses are very less so very high magnifications are possible as high as 10,000 times the measuring unit can be small very compact and hence it is easily portable.

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Disadvantages of electrical and electronic comparators

- External power (electric power) needed
- Fluctuations in electric supply affects the results
- Heating of coil in the measuring unit may cause zero drift, altering the calibration
- If scale is fixed with moving pointer, then working range is small with high magnification
- Generally more expensive when compared to mechanical comparators

Now what are the disadvantage of electrical and electronic comparators these type of comparators they require external power supply that is electrical power supply is needed for the operation of the comparator if there is any fluctuation in the electrical power supply it will definitely affect the results obtain from the comparators and since in some cases heating the coils magnetic coils are there because of heating this coils the measuring unit may cause 0 drift which alters the calibration of the comparator.

So at regular have 2 recalibrate the comparator to ensure that the comparators are working with correct calibration. If the scale is fixed with moving pointer then the working range is very small with high magnification of the comparator. Generally, these electrical and electronic comparators are more expensive when compare to mechanical comparators.

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Advantages of electrical and electronic comparators

- Measuring unit can be remote from display unit
- Less number of moving parts, hence less friction
- Very high magnification (Ex. 10,000 times)
- The measuring unit can be small and portable

Now in these type of comparators the measuring unit can be at a remote place and display unit can be in a control room so in the control room we will come to know whether the work piece can be accepted or rejected or how many work pieces are rejected or how many work pieces are accepted in a particular shift can be that detail can be obtain in the display unit placed in the control room now there are less number of moving parts in electrical and electronic comparators.

Hence the frictional losses are very very less so very high magnifications are possible as high as 10,000 times the measuring unit can be very compact and hence it is easily portable.

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Disadvantages of electrical and electronic comparators

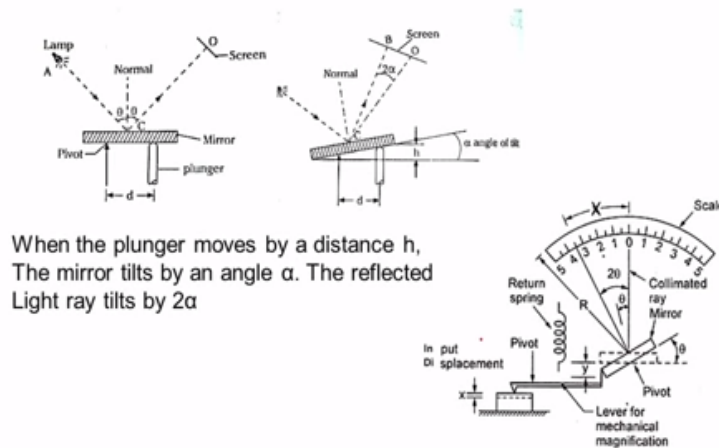
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So at regular have 2 recalibrate the comparator to ensure that the comparators are working with correct calibration. If the scale is fixed with moving pointer then the working range is very small with high magnification of the comparator. Generally these electrical and electronic comparators are more expensive when compare to mechanical comparators.

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Principle of optical comparator



Now let us move on to the optical comparator now let us study the working principle of optical comparator we can see here we have a mirror which is pivoted at point at a distance of D we have a plunger so this plunger moves up and down when we insert the work piece between the plunger and the table so when the plunger moves up and down the mirror gets tilted.

Now when there is no movement when the mirror is horizontal they have a light source here this is the light source and this is the reflected light source and then we have a screen with scale now

the angle this angle this is equal to the angle that is available here this is the normal to the mirror surface this is the light ray and this is the reflected light ray so this angle is equal to this angle.

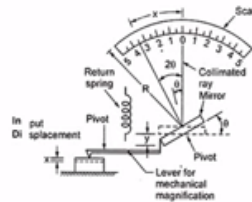
Now when the plunger moves up when the plunger moves up by a distance H then the mirror gets tilted by an angle α now we can observe that the reflected light tilts by an angle 2α the mirror tilts by α the reflected light tilts by 2α and this how we get magnification in optical comparators now this picture shows the arrangement of optical comparator we have the table surface and the work piece.

So depending upon the height of the work pieces the we have input displacement x so this is the deviation from the desired sides we have lever and there is a pivot here and the one end of the lever is in contact with the work piece surface and the other end is in contact with the mirror so when the pivot when the pointer the one end of the lever moves by distance of X the other end moves by a distance Y because of this mechanical amplification now when this end of the lever moves by Y the pivot again we have a mirror here and a pivot here.

So because of the movement of this movement Y the mirror tilts by 2θ and the reflected light moves by 2θ so if the movement at this point is small x the movement of the pointer over is capital X so hence we get the this movement is magnified here so we have mechanical amplification as well as optical amplification.

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- Optical comparators are based on the **principle of projection of image**. A simple optical comparator for measurement of linear dimension is shown. The arrangement consists of mechanical system which causes a plane reflector to tilt about an axis so that the image of an index is projected on scale on the inner surface of a ground glass screen.
- The actual difference x between the two dimensions is amplified by a lever to give an angular displacement θ of a **pivoted mirror**. The reflected ray is deflected through an angle 2θ from the original line and gives a reading of X on the scale.
- The main advantage of an optical comparator is that it is capable of giving higher degree of magnification due to **reduction of moving members**.



Now the main advantage of optical comparator is capable of giving higher degree of magnification due to the reduction of moving the less number of moving members and higher degree of magnification is possible because the use to types of magnifications 1 by mechanical amplifications and further it is magnified by optical means.

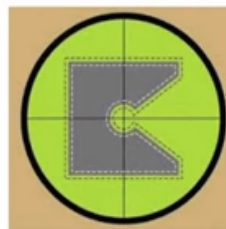
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Comparison by chart gages

The **chart-gages contain lines**, which denote the **tolerance limits** of the parts.

The chart-gages are used on **optical comparators**.

The **shadow of the part** is made to fall on the chart gage and should be within the tolerance zones on the chart-gage, to be acceptable.



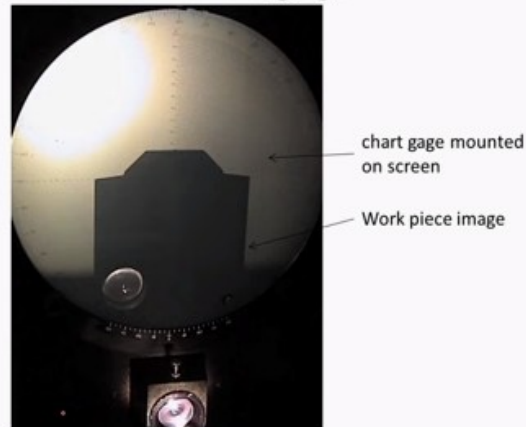
So far we discussed about the different kinds of comparators wherein the there is a plunger in the comparator which comes in contact with the work piece surface and then the plunger moves depending upon the size of the work piece and the movement of the plunger is sensed and then it is amplified and the amplified value is compared with the size of with the desired size of the work piece.

Now let us study about the another method of comparison wherein we use chart gauges the chart gauges contains lines, which denote the tolerance limits of the parts Now you can see here we have a diagram here this is the screen of the optical projector optical comparator and then a chart gauge is fixed or mounted on the screen of optical comparator these chart gauges contain lines you can see here this is line corresponding to the upper limit of the work piece.

Then we have a another one line inside corresponding to the lower limit of the work piece and this is the shadow or image of the work piece so image is meant to fall on the chart gauge if the shadow is within the tolerance zone that means you can see here the shadow the edges of the shadow all between upper limit and lower limit now if this is the case the work piece is acceptable.

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Image compared with chart gage



Apart from comparison, chart gage is used to check fillets, chamfers, threads, etc.

Now you see here how the comparison is made this is the screen of optical profile projector wherein on the screen a chart gauge is mounted you can see here we have different lines corresponding to different radius values and then we have secular scale using which we can measure the angle so this is the work piece image and this the chart gauge mounted on the screen.

So these apart from the comparison this chart gauges are used to check fillets, chamfers, threads etc for example so we have work piece like this and then using the radius chart gauge we can measure the radius of this fillet that means the shadow of this work part is made to fall on the chart gauge say this is the shadow of the particular part and we can see to which radius line this shadow is coinciding and that particular radius will that particular line will indicate.

What is the radius of the fillet so now we can measure the chamfers and then we can also check the threads screw threads using this chart gauge.

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Designing chart-gages

The following considerations are important in designing chart-gages

- It should be made of a dimensionally stable material. Rigid material is preferred. (Ex. plastic or soda lime glass)
- The humidity and temperature coefficients must be considered.
- The lines on the chart-gage must be uniform in width with sharp edges.
- The lines must withstand normal usage and cleaning.

Now how do we design the chart gauges the following considerations are very important in designing the chart gauges the chart gauge should be made of dimensionally stable material. Rigid material is preferred so normally plastic sheets clear transparent plastic sheets are used or the chart gauges are made on the soda lime glass plates.

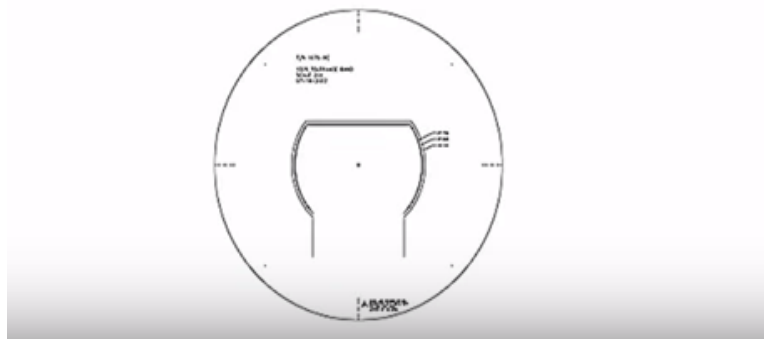
The humidity and temperature coefficients of the chart gauge material must be considered. The line from the chart gauge must be uniform in width with sharp edges the line must withstand the normal usage and cleaning operation. The chart gauges should be calibrated at regular interval determined by the usage the chart gauge master image should be produced by a precision plotter to 0.025 mm or better accuracy.

The calibration fiducial marks should be included for dimensional control. They should be stored the chart gauges should be stored flat and there should be never rolled and they should be stored in a normal gauge room environment wherein proper temperature and humidity is controlled.

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Custom chart-gages

A CAD file or a marked-up print along with the chart size and magnification is required for preparing custom chart-gage.



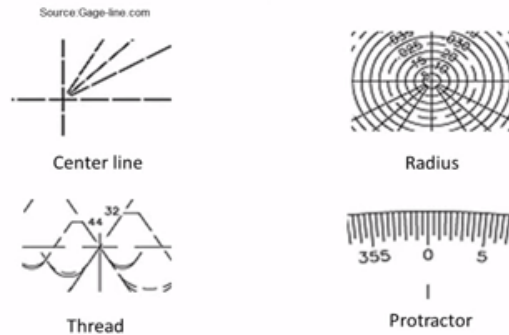
Now there are custom chart gauges depending upon the application the customer usage these custom build chart gauges are made by using a CAD file or a marked up print along with the chart size and what is the magnification needed is also should be known to prepare custom chart gauges Now we can see here this is the custom chart gauge with the upper limit and the lower limit of the work piece.

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Standard chart-gages

They are **readily available in the market** and are reproduced under controlled conditions from precision master on to dimensionally stable plastic sheet or soda lime glass.

Standard chart-gages are available with **various line patterns** at **various magnifications** in English or Metric.



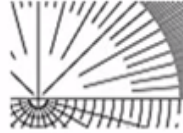
Commercially standard chart gauges are available in the market and they are reproduced and a controlled conditions from precision master on a dimensionally stable plastic sheet or soda lime glass standard chart gauges are available in various line patterns and in various magnifications like 10X, 20X, 50X so different magnification chart gauge with different magnifications are available in English as well as in metric units.

I can see some of the standard chart gauges so use center line chart gauge radius chart gauge radius chart gauge for example so we have a work piece round work piece so the round work piece is placed on the table of the optical comparator profile projector and shadow is obtained in the screen which contains in the radius chart gauge the image is compared with the lines printed on the chart gauge.

So with which line with which circular pattern it is coinciding that gives the radius value and the diameter value and similarly the thread screw thread chart gauges are available, protractors are available, using which we can measure the angles.

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Combination chart gages



Radius angle chart gage: A versatile gage that is used to check fillets, chamfers, threads, holes.

So this picture shows the combination chart gauge you can see here one side we have which gives the radius values and other side we have angle. Angle can be angle of the work pieces can be measured so this is the radius angle chart gauge.

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Now we can see a component which is having an angle that is placed on the table of profile projector we wish to measure the angle between these 2 edges. Now we have selected an objective of 10X, I am using a chart gauge of 10X, it is mounted on screen of profile projector so this angle chart gauge is used to check the angle on the work piece.

Now we can see one edge the shadow of one edge of the work piece is coinciding with 0 line and the other edge of the shadow is coinciding with 45 degree line so the left angle on the work piece is 45 degrees like this we can use the chart gauges for measurement of angles, so this is the complete view of chart gauge radius can be measured as also angles also can be measured using this particular chart gauge.

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Advantages of optical comparators

- It has **small number of moving parts** and hence a higher accuracy.
- In the optical comparators, the **scale can be moved past a datum line** and thus have **higher range and no parallax errors**.
- It has a very **high magnification**.
- **Optical lever is weightless**.

Now what are the advantages of optical comparators which uses chart gauges so these optical comparators have a small number of moving parts. Now let us study what are the advantages of the optical comparators so these optical comparators have small number of moving parts and hence less friction and higher accuracy is possible in the optical comparators the scale can be moved past datum line and thus have higher range and no parallax errors. It has a very high magnification and optical lever is weightless so effects are very less.

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Disadvantages

- As the instrument has high magnification, heat from the lamp, transformer etc. may cause the setting to **drift**.
- An **electrical supply** is necessary.
- The apparatus is usually **large and expensive**.
- When the scale is projected on a screen, then it is essential to use the instrument at a **dark room** in order to take the readings easily.
- The instruments, in which the scale is viewed through the eyepiece of a microscope, **are not convenient for continuous use**.

Now there are some disadvantage of optical comparators as the instruments has a high magnification heat from the lamp, transformer etc may cause the setting to drift. An electrical supply is necessary for operation of optical comparators to light up the lamp. The apparatus is

usually large and expensive when compared to other types when the scale is projected on a screen then it is essential to use the instrument at a dark room in order to take the readings easily.

If there is too much of light in the room where the optical comparator are placed then the reading then taking the readings becomes bit difficult. The instruments in which the scale is viewed through the eyepiece of the microscope such instruments are not convenient for continuous use since the operator is subjected to high fitting.

Let us conclude this lecture 2 in this lecture we discussed about the different and kind of mechanical comparators such as Sigma comparator, Johansson mikrokator we discussed the construction and working of theses sigma and Johansson mikrokator also we discussed about the various advantages and disadvantages of mechanical comparators then we also discussed about the electrical and electronic comparators.

In this section, we discussed about electro limit gauge, visual gauging head, electronic comparator, and various advantages and disadvantages also we discussed about the optical comparators so in this section we discussed the working principles of optical comparators and also discussed about the use of the chart gauges the different type of chart gauges and how to use them and also we discussed the advantages and disadvantages of optical comparators.

In the next lecture, we continue the discussion on the comparators, Thank you.