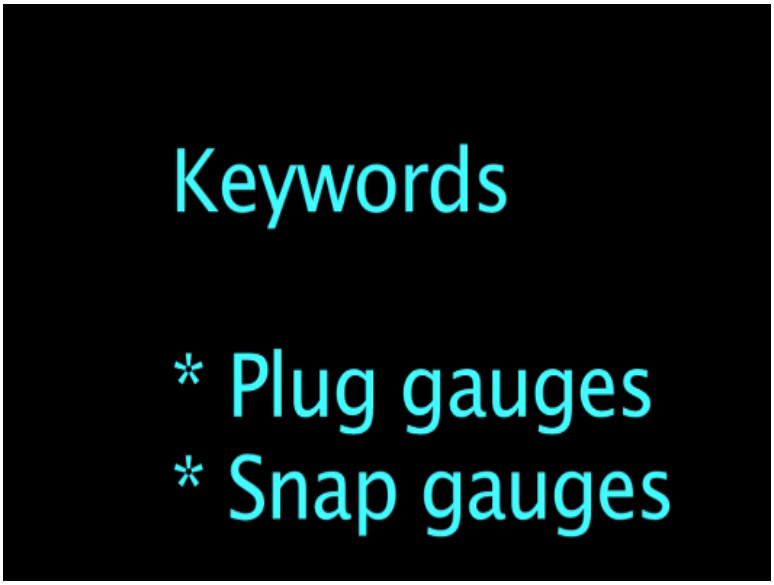
Metrology
Prof. Dr. Kanakuppi Sadashivappa
Department of Industrial and Production Engineering
Bapuji Institute of Engineering and Technology-Davangere

Module-3
Lecture-6
Limit gauging-1

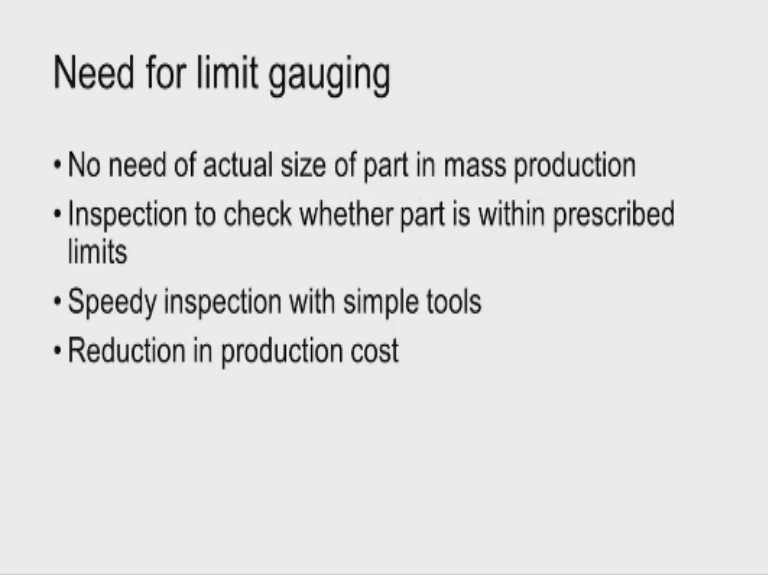
(Refer Slide Time: 00:13)



I welcome you all for todays lecture module3 and lecture6 in this lecture we will studying about limit gauging what is the meaning of limit gauging why it is necessary and then what are the various kinds of gauges used. How there manufacture and what are the materials selected for manufacture of cages and what are the precautions to be taken while using the gauges.

And the different kinds of gauges used for checking extended features like diameter, depth etc, etc also what are the various cages used for measuring for checking holes. And then house of we will different types of gauges like pitch gauge, radius gauge etc. Also we will study about air gauge. And then we will move to the design of limit gauges.

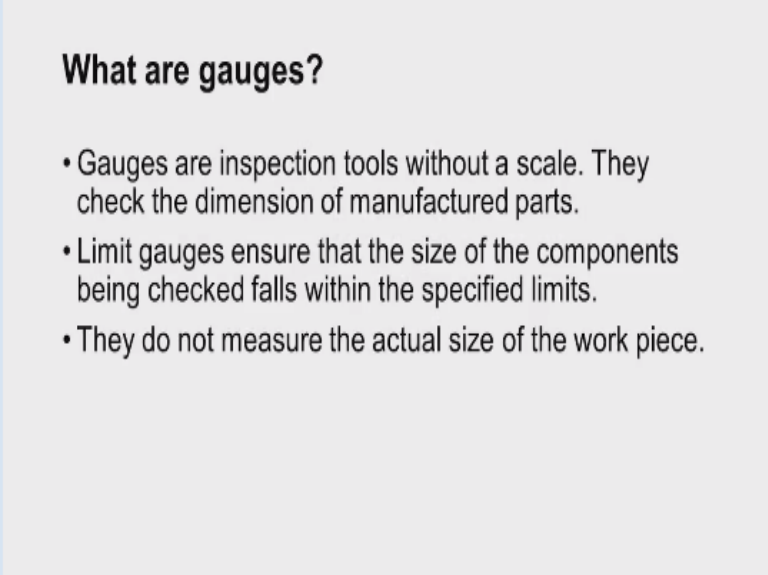
(Refer Slide Time: 01:23)



Now let us start the lecture let us understand what is limit gauging. Now in the mass production the components are manufactured in large quantities and many a times it is not needed to check the dimension of each and every component and if we can just check whether the work pieces or within the prescribed limits upper limit and lower limit. And it will be enough and there not be need to check the actual size of components using measuring instruments.

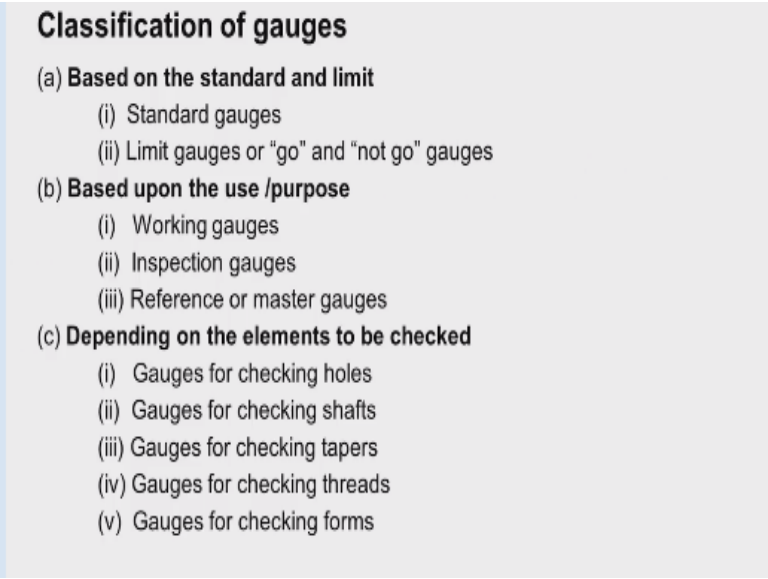
In such cases to check whether the components are within the prescribed limit we use the gauge instruments called limit gauges. Now what is the advantage of this limit gauging, since we are not measuring the actual size of the component. And then we will be using only gauges the inspection of the parts will be very quick. And the cause associated with the inspection will also be less.

(Refer Slide Time: 02:39)



Now what are in gauges these are inspection tools without a scale, there will not be any scale built into the gauges. They check the dimension of the manufactured parts, and there will tell the status whether the work piece is acceptable or whether it is acceptable or not only that information it will give. And the actual size will not be given by the gauges.

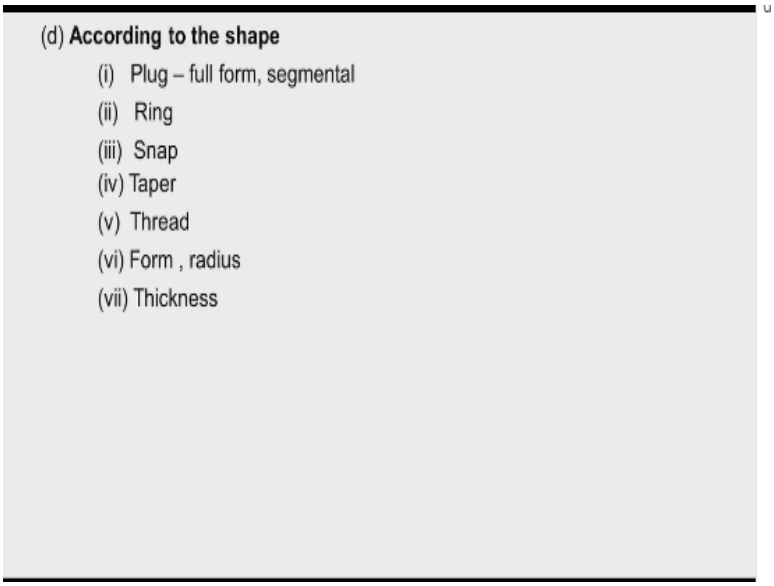
(Refer Slide Time: 03:12)



Now how these gauges are classified there are many ways waste in which these gauges are classified based upon this standard the type of limit gauge, whether it is standard gauge or limit gauge. They are classified and then based upon the use or purpose, whether they are use for working cages or for inspection purpose or for reference or master gauges depending upon the elements to be checked.

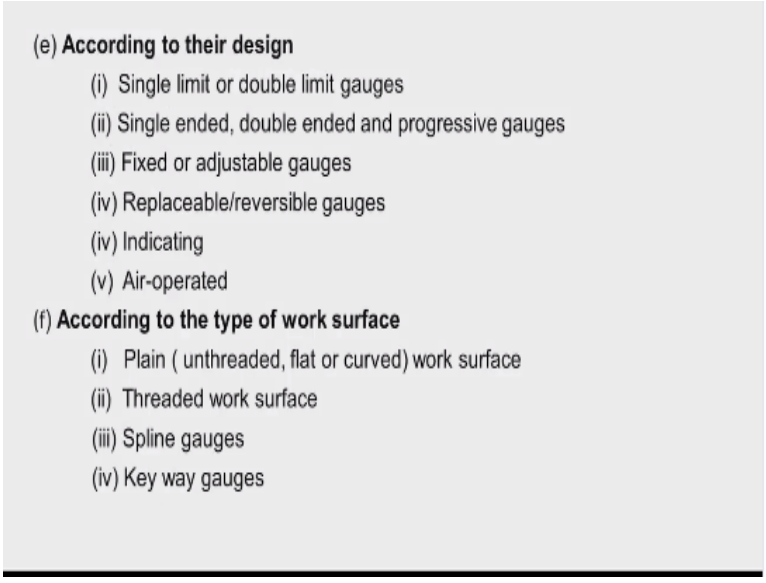
They are classified as gauges checking for holes and then gauges check used for checking the shafts, tapers, threads and different kinds of forms.

(Refer Slide Time: 03:57)



And then according to the shape of the gauges there classified as plug gauge like full form plug gauge, segmental plug gauge and then ring gauges, snap gauges, taper gauges, thread gauges, form gauges and also thickness gauges.

(Refer Slide Time: 04:17)



Now according to their design they are classified like whether they are single limit gauges or double limit gauges, single ended, double ended or progressive gauges. Whether they are fixed

gauge or adjustable gauges, whether they are replaceable gauges or reversible gauges if there is an indicating mechanism is there, they are called indicating gauges and also if air is used for gauging purpose we say.

Air gauges and according to the type of work surface that is checked they are classified as plain work surface gauges thread gauges. Then the plain gauges and then key way gauges.

(Refer Slide Time: 05:04)

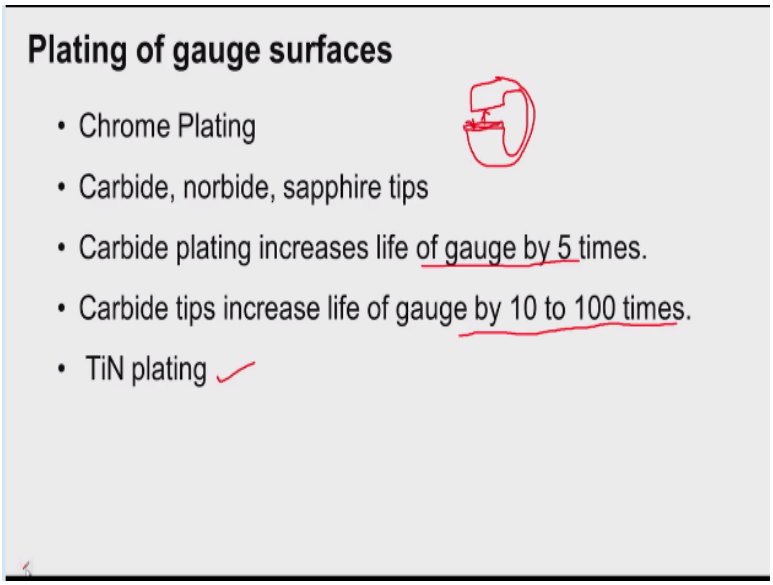
Now what are the gauge materials used for manufacture of gauges different kind of materials are used like high carbon steel and then sometimes mild steel also used, case hardened steel is used, oil hardened steel, cast iron also used. And sometimes glass and ceramic and invar are also used. And while selecting these gauge materials there are some selection criteria like the material should be wear resistance.

Since the gauge comes in contact with the work part and there is sliding motion the gauge material should have wear resistant property and the stability to preserve form and size. The geometric shape of the gauge and then size the gauge should be should not altered. Because of changes in the environment, so stability aspect also considered. And very important thing is **gaze** gauge is should be corrosion resistant.

Since the gauges come in contact with the working environment like they come in contact with the coolant oil etc., etc., there should not be any corrosion on the surface the gauge. So, corrosion resistant materials are selected for manufacture of gauges. Also the machine ability of the gauge material is very very important. It should be possible to machine to the required size and required shape to the required accuracy level.

So, these gauge material that is selected should have good machine ability and also should be thermally stable. Sometimes it comes in contact with higher temperatures like 40, 50, 60, Celsius. The size of the gauge should not alter, so should have sufficient thermal stability.

(Refer Slide Time: 07:05)

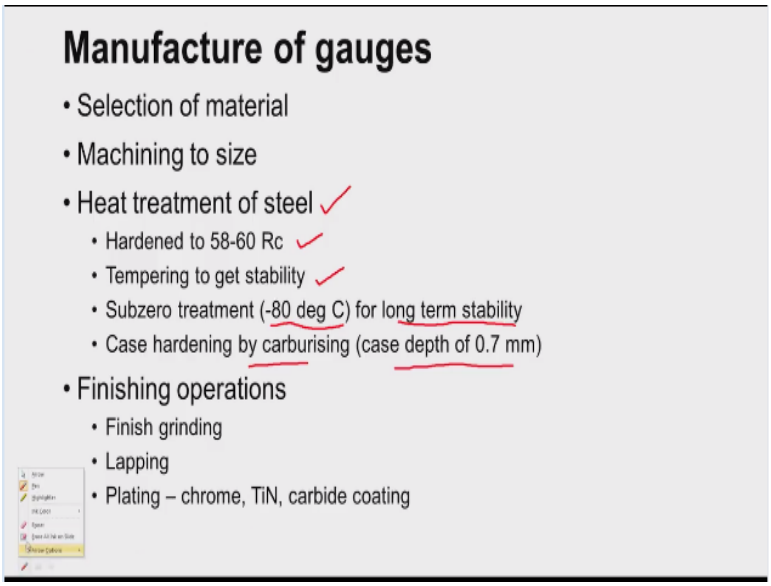


Now sometimes the plating is also made on the gauge surfaces. For example say we have a gauge surface like this. So, this is the surface of the gauge and then this is the gauging surface and this is also gauging surface. Now in order to improve the wear resistance some kind of coating can be provided on these gauging surfaces coating like chrome plating and then carbide coating, norbide coating, sapphire tips also used at this place.

And then carbide the advantage of carbide plating is it increases the life of gauge by 5 times as compare to the only steel gauges. And carbide tips if we are using the carbide tip can be mounted on this which will increase the service life of the gauge by 10 to 100 times. And the TiN plating

right Titanium nitrate plating is also provided on the gauging surface. So, that the service life enhances.

(Refer Slide Time: 08:38)

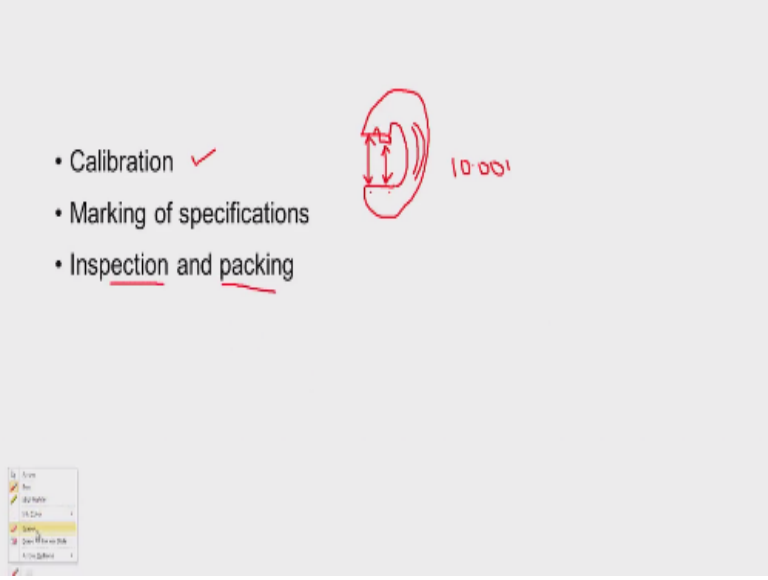


Now coming to the manufacture of gauges initially the proper material should be selected. And then machining to size initial machining is made like turning operation or milling operation. If it is flat surface with some allowance machining is to be performed and then heat treatment of if it is steel material some kind of heat treatment is required to increase the hardness to 58 to 60.

And then tempering is also performed on the material to get the stability and in sometimes subzero treatment that is the gauge blanks are placed at – 80 degree Celsius for long term stability. And then case hardening by carburising also is sometimes performed and the gauges to improve the hardness for the gauging surfaces. So, in that case, case depth of 0.7 millimetre maybe required.

So, after this heat treatment the gauging surfaces are ground and then they are loft and all sort of finishing operations are performed. And then if plating is required plating is also performed and then again after the plating is over again they are ground and lapped to get the proper size.

(Refer Slide Time: 10:15)



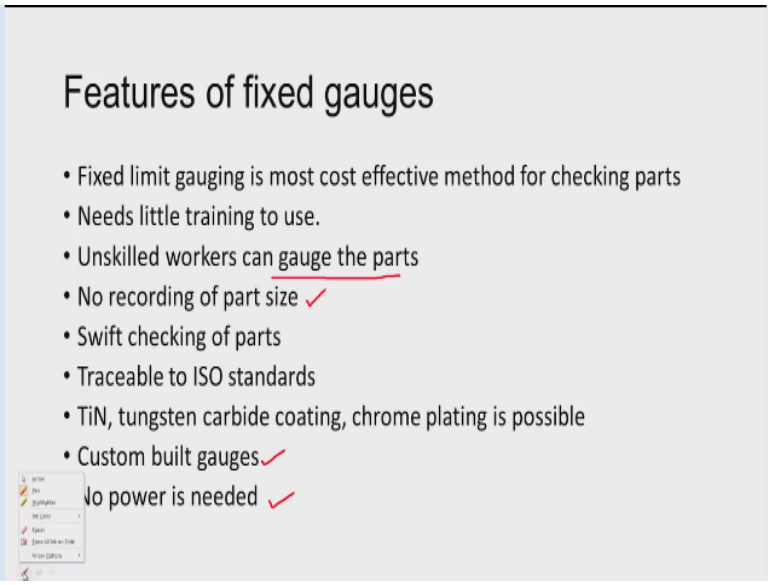
And then after the finishing is over you need to calibrate. For example if you take a snap gauge like this. So, what is the distance between these 2 surface this is very important. So, now say we have finished the these 2 surfaces and what is our requirement whether it is 10.001 millimetre or 10.005 millimetre we fix up some size here whether we have really achieve that requirement.

We have to check by using slip gauges. And then after calibration is over we have to mark the specifications like, what is the go size limit, and what is the NOGO size limit and which side is if it is some progressive type like this. Then one is the go limit and the other one is NOGO limit. So, one corresponds to the upper size of the work piece.

And the other one corresponds to the lower limit of the work piece. So, in that case we have to properly mark the go and NOGO and also the manufacturer details the brand manufacturer name is also marked on the gauge. And then final inspection should be carried out with respect to the size of the marking of size of the gauges and whether all the details are provided or not the like the tolerance.

What is the tolerance and what is the big side which is side is NOGO all such things should be marked properly. And so the inspection is carried out which are colours details and finally they are packed.

(Refer Slide Time: 12:25)



Now what are the features of fixed gauges, so these fixed limiting the gauge that means the size cannot be altered. There are some limit gauges varying some slighted just meant can be made there known as adjustable gauges. We will be studying the about those adjustable gauges in a short while. So, fixed limit gauging is most cause effective method of checking parts. Since the time taken to check the part is very less.

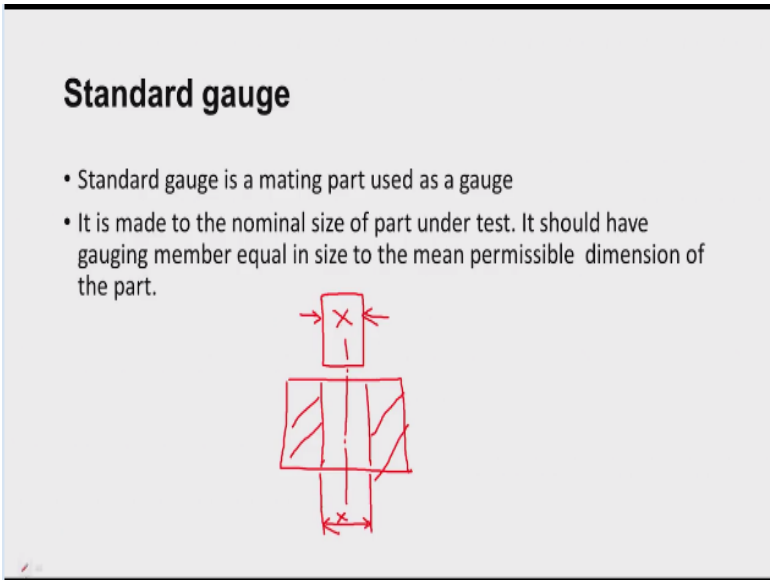
So, what were operated will do it will take the work piece even a clean the work field surface and you will take the gauge and you will take the cleaned gauge surface and you will try to insert the work piece into the gauge. If it enters the go side and if does not enter the NOGO side then the work piece is accepted, like that so, no actual size is measured in the gauging system. So, the inspection will be very fast and then it requires very little training.

Since the gauges are very simple to use and not much detail training is required to train the operators. And unskilled workers can be can use the gauges and can check the work pieces, and no recording of the part size, no measurement is made and no recording of the work piece is made. We just say whether the piece is acceptable or not and the quick checking of the parts and all these gauges there traceable to ISO standards.

And then different kinds of coating is possible to enhance the life service life of the gauges. And then also custom built gauges can be made depending upon the requirement of the user and very

important thing is in order to use these gauges there is no external power needed, only man power operator takes the gauges and he checks the work pieces, no external power is required except air gauges where pneumatic air supplies required.

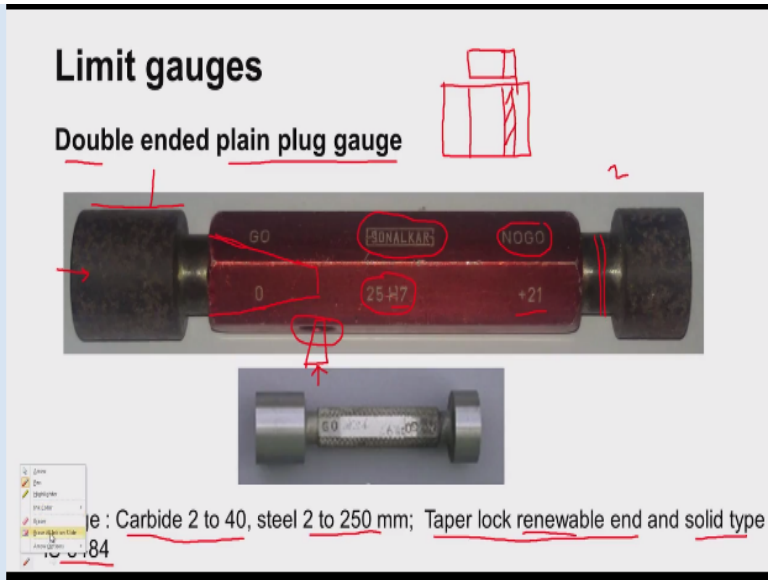
(Refer Slide Time: 14:45)



Then let us move to the various kinds of gauges. Now what is the meaning of this standard gauge. So, it nothing but a mating part, mating part is used as a gauge. For example if we have a work piece like this with a hole, with some mean dimension of x. So, the mean size of this hole is x. Now there will be a mating part for this particular hole a shaft again with same mean size.

So, the mating part itself is used as gauge to check whether the hole is proper or not. But in actual practice what we check using limit gauges is whether the work piece is within the allowable limit some tolerance is given to the work pieces. And there will be an upper limit for the work piece when there is a lower limit for the work piece. So, that status we have to check, so this concept of standard gauge varying both at the hole and shaft at the work piece at the gauge there mate to the mean size. So, this concept is only theoretical concept and it is not used in practice.

(Refer Slide Time: 16:23)



Now let us move to the other types of limit gauges. So, this shows a double ended plain plug gauge. Plain means the surface that is to be checked is plain, that means there are no threads, so it is called plain plug gauge. This is a used as a plug, so we say it is a plug gauge, since the 2 gauging surfaces are there. So, this is the first one first gauging surface and this is the second gauging surface.

So, we say and there mounted on both sides of the handle, this red part is the handle. So, the gauges are mounted on both the ends of the handles. So, we say this is double ended plain plug gauge. Now what we should understand here there are 2 gauging ends. So, this corresponds to the maximum material limit that is this is go gauge, so this is use for checking the holes.

So, go gauge corresponds to the maximum material limit, and then NOGO gauge corresponds to the minimum material limit or here this is use to check what is the minimum size of the hole and this is use to check the maximum size of the hole. And we can see here the go end, go end is longer than the NOGO end, see how we use this to check the work piece we will be having a work piece with a hole.

And there will be always some tolerance, so this is the tolerance for the work piece. Now we take this plug gauge and we try to insert go side. So, this is go side this portion we try to enter go should enter the hole. So, when it enters then we remove it and then we try to insert NOGO part

okay, NOGO side of the gauge. NOGO side we try to insert into the hole, NOGO should not enter into the hole.

Now you can see here NOGO it is slightly greater than the upper limit, so this NOGO will not enter. That means when go enters into the hole and NOGO does not enter, then that hole is acceptable. That work piece with that particular hole is acceptable. Then what are the other things here you can see this is the 25-H7. So, 25 is the basic size and then H7 is the tolerance. So, basic size is also mentioned on the handle of the gauge and what is the tolerance that is allowed, that is also mentioned.

And actual values are also mentioned. Since this is H, the basic the fundamental deviation is 0, so the basic size will be equal to the lower size of the hole. Lower limit of the hole will be equal to the basic size, so this is exactly 25 millimetre. And the see exact 25 millimetre is always very difficult to manufacture. So, some allow some tolerance is also provided for manufacture of gauges, there called gauge tolerance.

The, this we will see after sometime and you can see here this is +21, that means the diameter of this is equal to 25.021 millimetre. That means when compare to the basic size this is greater by 0.21 millimetre and we can also observe one more thing the manufacturer name is marked here. So, all these things are as per Indian standard IS 3484. So, what should be the length and what should be length of this novo potion what should be the diameter this place, what should be diameter at this place what should be length of the handle all those things are specified in this IS 3484.

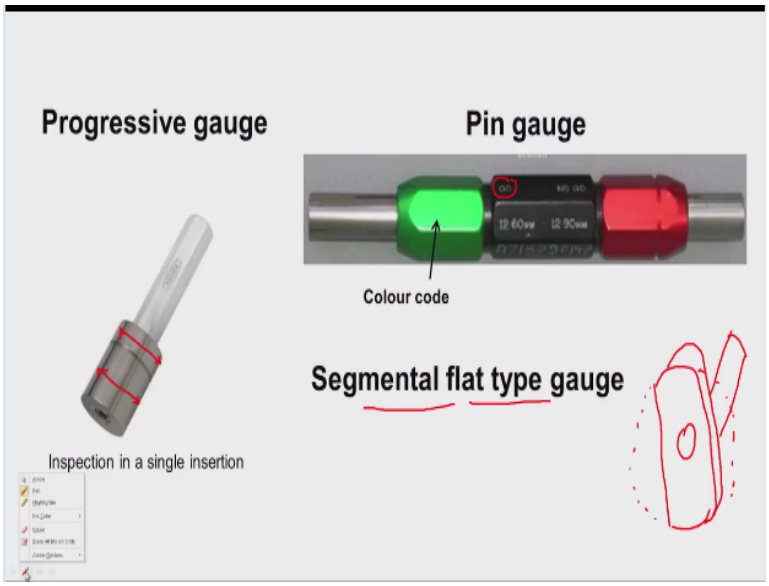
So, they are made as per this IS 3484. And most of the times a red mark is provided on NOGO side. So, NOGO is marked on the handle as well as red paint is provided at this place to indicate that it is NOGO side. Now we can observe one more thing here in the handle we have a hole here. So, this is called tapper lock renewable end, so this first red gauge it is tapper lock renewable end what is the meaning of tapper lock see here.

This double ended the this particular gauging potion it will have a tapered shank. It will have a tapper shank and there will be mating tapper in the handle. So, what we have to do we have to press this gauging O gauge into this tapper in the handle and then we have to press it, so that it gets fixed into the handle, how do we remove it say we want to after sometime this is worn now and we want to replace it with new one.

So, that is why it is called renewable end, so what we have to do is we have to take a drift or tapered part and we have to push it here into the hole. In that case this gauge will come out and then we can insert a rod to remove this NOGO end, and then new ends can be mounted on this handle. That means handle can be reused and coming to this, this is solid type you can see here the handle and then GO gauge and NOGO gauge all are made in a single unit.

So, this is a solid type plug gauge. The size nominal size is less we can go for solid type, if nominal size is more like 25, 30, 35 then we go for renewable tapper lock renewable type. And what is the range of availability there available if it is carbide, carbide coated or carbide gauges, then the range is up to 2 millimetre to 40 millimetre they are available. And, if it is hardened steel from 2 millimetre to 250 millimetre gauges there available also if special requirement is there, there can be built as per the customers requirement.

(Refer Slide Time: 23:53)



Now in the case of go, NOGO end that is double ended type what happens is where to take the work piece in which there is a hole which is to be checked we have to take the double ended plug gauge, we have to insert go side and then we have to remove that gauge. And then we have to insert the NOGO. So, like this the time taken to gauge the work piece or the hole will be more.

So, to save time progressive gauges are made, you can see here there are 2 potions with the handle. This is the go gauge, so this diameter corresponds to the go limit and this one corresponds to the NOGO limit. So, in 1 insertion inspection of the hole can be completed. That means time for checking the hole can be saved and another if the hole size is very less like 2 millimetre, 3 millimetre, 1.5 millimetre like that.

Then we say pin gauges, pin gauges are used and you can see here this is the handle okay. And this is the green colour is used, so this will indicate that this potion is go. It is also marked here, go side is marked and also the colour indications this is go. And then we have red colour here which indicates that this potion is NOGO. And the limits are also the exact sizes are also mentioned here.

This is this diameter is 12.80 millimetre and this diameter is 12.9 millimetre. And sometime if the hole that is to be checked is big one like say 250 millimetre or 350 millimetre, 300 millimetre it is a big hole. In that case what happens is if we use full form gauge, that means the plug gauge with full form round gauge. Then it becomes very heavy, so using that heavy gauge becomes difficult.

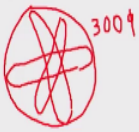
So, in such cases segmental flat type gauges are used, they look like this. Now this is the segmental gauge with the handle, now you can see here full round form is not used. So, this much is removed and we are using a segment part of that full form. So, we there called segmental, since there flat pieces flat type gauges. The advantage is the material that is required is less and the weight is less.

So, that operator can comfortably use them also if the diameter the hole to be checked is large then we have always go for single ended plug gauges in order to reduce the weight of the gauge.

So, we use 1 gauge for checking the upper limit and one more gauge for checking the lower limit. So, there called single ended plug gauges.

(Refer Slide Time: 27:36)

- Up to 10 mm -solid type double ended plug gage
- 10–30 mm - taper lock double ended plug gauge
- 30-63 mm - fastened type double ended plug gauge
- 63–100 mm -single ended plug
- 100–250 mm- flat type single ended plug (segmental gauge)
- 250 and above – rod (pin) gauge with spherical end



Limitations of plug gauge

1. Hole conditions like a taper hole, bell mouth, out of round hole are difficult to distinguish.
2. Gauging surfaces and square edges are unprotected and hence they must be handled and stored carefully.
3. They have an easy tendency to roll or fall off from the bench.
4. They may get corroded if not properly protected from a grease/oil layer.
5. The gauge may freeze in the hole if worker exerts **undue pressure** on gauge.

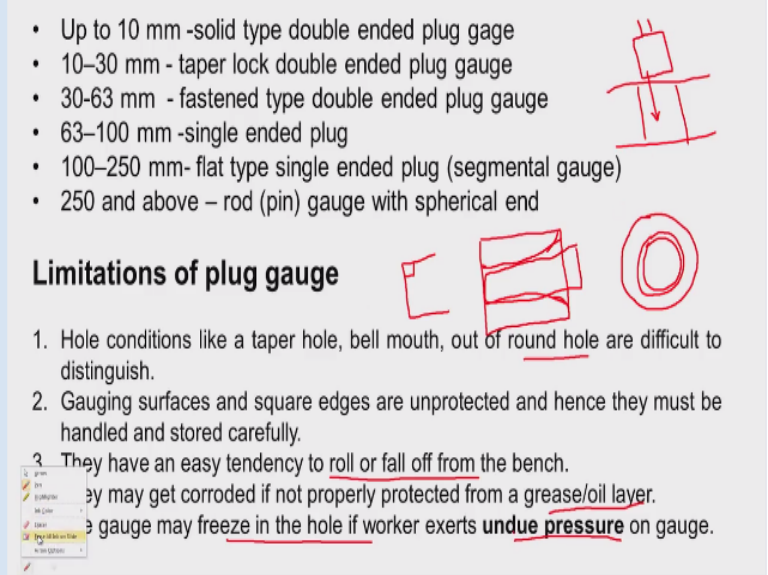
Now you can see some details of plug gauges up to 10 millimetre solid type double ended plug gauges are made and then from 10 millimetre to 30 millimetre are tapper lock double ended plug gauges are made. In which case the ends can be renewed when the ends are worn out new ends can be replaced from 30 to 63 millimetre fastened type double ended plug gauges are used they are not tapper locked where the ends are fastened to the handle.

And, then from 63 to 100 millimetre single ended plug gauges are used. So, we need to have to 2 gauges one for go limit and go and other NOGO. And from 100 to 250 millimetre flat type single ended segmental type plug gauges are used and above 250, 250 and above rod type gauges or pin gauges are used with spherical ends, they look like they say we have to check the big hole and the diameter of this say 300 millimetre, so diameter is 300 millimetre.

In such cases if you use full form gauge to be very very heavy. So, what we the practice is to use pin gauges with spherical ends like this. So, the length of this is control, there will be 1 pin for go the lower limit and 1 pin for upper limit. So, we have to insert it and then we have to rotate it or we have to remove it and again we have to insert like this some 2, 3 times we have to do like this.

So, these are called pin gauges, there will be very light in weight, so easily operator can use them. Now what are the limitations of plug gauges sometimes the hole conditions like tapered hole, bell mouth or out of round hole, it will be very difficult to distinguish.

(Refer Slide Time: 30:06)



So, it will be something like this we have a work piece like this with a hole like this. So, it is tapered sometimes it is bell mouth like this, it is opened up like this. So, what the operator will read he will take plug gauge and he will just insert it. So, whether it is tapered or whether it is bell mouth and whether there is any out of round is there. That will be very difficult to check by using the plain plug gauges.

So, say we have a work piece with a hole like this and then we use the round gauge. Now you can see here it is entering, go is entering and not go is not entering. But there is some ovality in the hole. So, that cannot be checked by using these plug gauges. Then gauging surfaces and square edges that means the end of the plug gauge it will be square. So, these square edges are unprotected they are open.

And hence they must be handled and stored carefully, if the proper protecting coat is not applied the work the gauging surfaces may get corroded and they become unusable. And then they have an easy tendency to roll off or fall off from the work bench. Since the work piece the gauges are

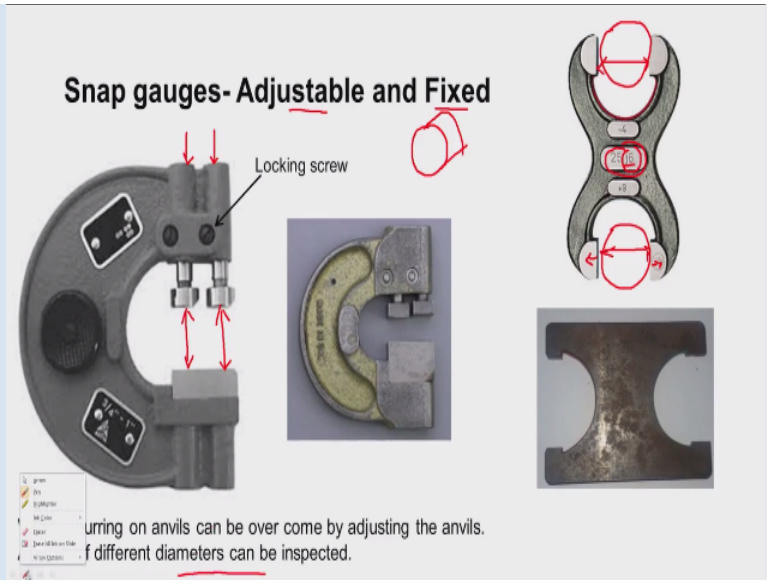
round they will roll of from the tables. So, proper care should be taken to place them in proper place, so that they will not fall.

If they fall then the work surface the gauging surface may get affected and they become unusable. And they may get corroded if not properly protected from grease or oily layer whenever they are not used for a longer time, it is necessary that some oily layer is put like petroleum gel is put on the surface and then they should be stored otherwise they will get corroded.

And then gauge may freeze in the hole if worker exerts undue pressure on the gauge, this is very important, see we should not force the gauges into the hole what happens if we force the gauge into the hole it is entered but it will defend the hole, the hole may expand. So, undue pressure should not be exerted. So, what we the operator should do say we have a hole like this and then the gauge side of the go side of the plug gauge should be just held here.

So, that it most in side without exerting any own weight it should enter. So, that is the practice followed in industry and undue pressure, if it is not entering undue pressure should not be exerted. And if required before using we may apply some oil, thin oil. So, that it easily flows into the hole.

(Refer Slide Time: 33:36)



And then the coming to the snap gauges, these are used for checking the shafts, the size of the shaft . There are 2 types one is fixed type snap gauge we can see here it is the fixed type double ended. Double ended because one side this is 1 working side this is other working side okay, so this is called double ended fixed snap gauge okay.

And here we have an adjustable snap gauge what happens with the fixed gauge after some usage maybe after 1000 times insertion, 2000 times insertion the gauging surface is subjected to wear and the size will change. See here you can see it is marked 25 j6, 25 is the basic size and j6 is the tolerance that is allowed. So, actual size is also mentioned here -4 microns and +9 microns.

So, here it is 25.009 millimetre this is go and then this is -25-0.004, so that is NOGO side. So, due to continuous usage this gap will change. So, in that case one thing is we can send these gauges worn out gauges for repair. That means there will coat maybe chrome plating or TIN coating, T I N coating they will do. And again they will repair it. Otherwise say the tolerance itself changes.

The design engineer will change the design itself, the tolerance itself. In such cases we cannot use such cases whereas here the adjustable gauges can be changed. If tolerance change is these anvils can be mould and they can be set to the new required sizes. We can see here the arrangement this is long anvil. We say this is fixed and here we have movable anvils. Now how we can move we can see here the locking screws are there.

And here there will be a screw and one more screw for this, so we have to unlock these screws. And we have to take a screw driver and we have to operate these screws. So, that these anvils will move in and out and then using slip gauge we can fix what is the size that is required for go and what is the size that is required for NOGO. And then after fixing this sizes using slip gauge we have to **sc** lock these 2 anvils by locking these screws.

And then these all these screws are waxed, so that unauthorised adjustments are not done. Somebody may take this gauges and may unscrew these screws and they may adjust it. So, to avoid such things all these screws after making adjustments by proper authorised person they

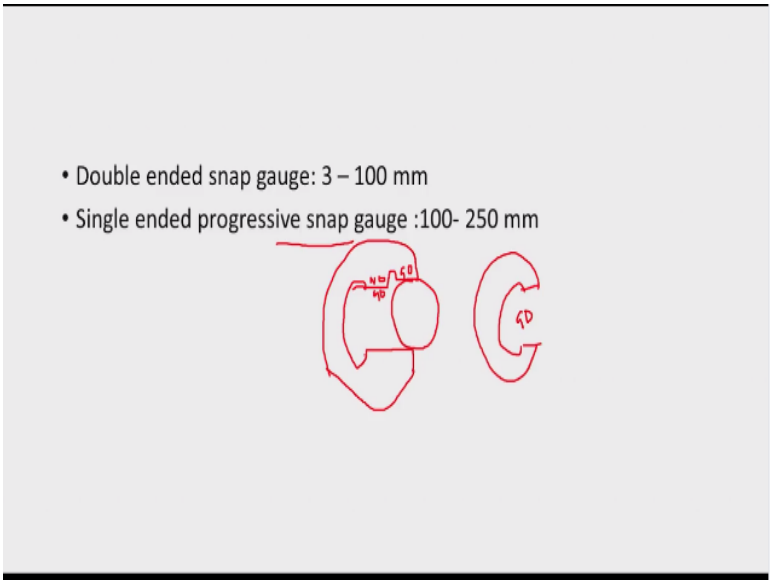
will lock these screws and then they are waxed. So, while using this snap gauge the operator should see whether seal is in intact.

If it is not intact, if it is disturb then you should not use such cases they should be send for calibration only after calibration and waxing they should be again used. And again we can see here one more type different type and this is the handle see we say since it is looking at c, c type snap gauges. Another important thing is again see the work piece will go here like this say go go side.

If we the go side should smoothly enter into the shaft, there should not be any over pressure on the snap gauge. If over pressure is applied then what happens is this these surfaces they move out, they expand. So, it is very essential that the gauges are not forced on to the work pieces. They should move smoothly and this is other fixed type snap gauge plate type snap gauge.

And the adjustable gauges are useful so, that whenever the tolerance changes they can be adjusted also when the anvil when the gauging surfaces are worn out again we can adjust the gap. So, wear adjustment is also possible in adjustable gauges by making adjustment range of diameters can be inspected.

(Refer Slide Time: 39:08)



Now double ended snap gauge they are available within this range 3 to 100 millimetre. And the diameter the shaft increases say it is above 100 millimetre then we use single ended progressive snap gauge. So, it looks like this, so this is single ended that means this is go and this is NOGO. That means the work piece will enter into go side, this is go and this is NOGO.

So, work piece will not enter into this, if that is the case the work piece is accepted. So, this is the progressive snap gauge and the single snap gauges are also available like this. So, 1 for go and similarly 1 for NOGO like that single ended snap gauges are also available. Single ended progressive snap gauges are also available. Now let us conclude this session.

In this lecture we discussed about the meaning of gauging, necessity of limit gauging and then what are the various materials used to manufacture the gauges and what are the different types of gauges. We also learnt about the plug gauges, different kinds of plug gauges and snap gauges. In the next class we will continue the discussion on different types of limit gauges, thank you.