Metrology

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Module-3
Lecture-16
Design of limit gauges

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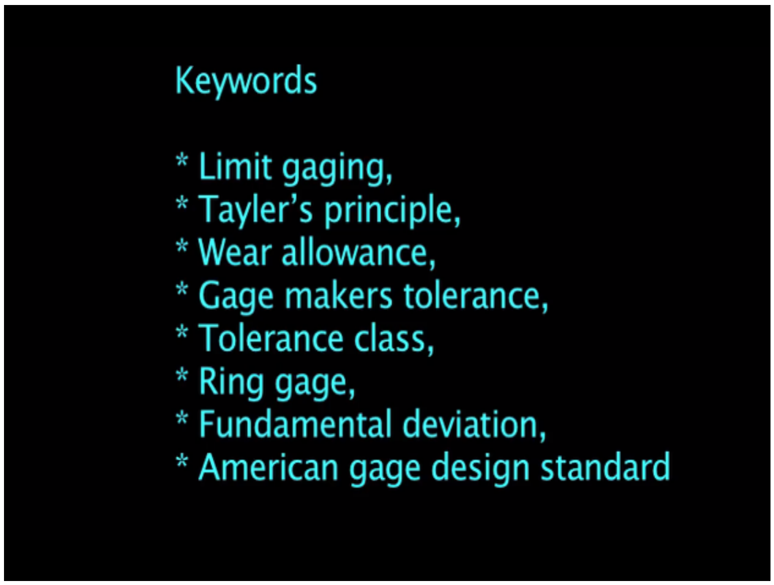

I, welcome you all for module 3 lecture 8. In this lecture we will be discussing about Taylor's principles of gauge design and also we will be discussing about the gauge tolerances, wear allowances provided on the gauges and then we will see some numerical problems.

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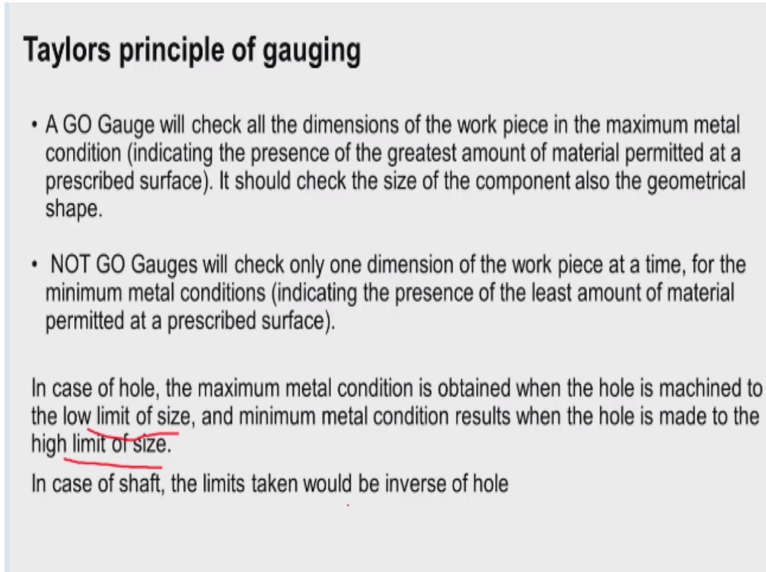

Now will start the Taylors principle of gauging, Taylor has given some principles which are useful while designing the gauges. The first principle is a GO gauge will have to check all the dimensions of the work piece in the maximum metal condition indicating the presence of the greatest amount of material permitted at a prescribed surface. It should check the size of the component also the geometrical shape.

Whereas NOT GO gauges will have to check only one dimension of the work piece at a time, for the minimum metal conditions indicating the presence of the least amount of material permitted at a prescribed surface. In case of hole the maximum metal condition is obtained when the hole is machined to the lower limit of the size and minimum metal condition results when the hole is made to the high limit of the hole. In case of shaft the limits taken would be inverse of hole.

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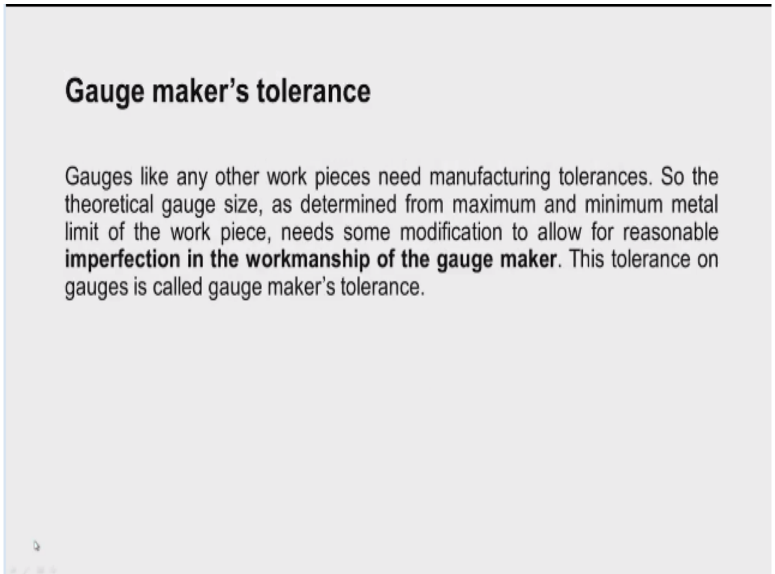

Now we know that in the case of manufacture the machining of the components to the exact size will not be possible it will be very very difficult and it will be very expensive. So, to achieve the economy and to meet the functioning some manufacturing tolerances are provided on the work parts. So, similarly in the gauges some tolerances are provided gauges like any other work pieces need manufacturing tolerances like any other engineering components wherein some manufacturing tolerances provided to achieve the economical production.

In the case of gauges also some tolerance is provided which is known as gauge maker's tolerances and it is always very expensive be produce the gauges exactly to the maximum and minimum metal limit work pieces as suggested by the gauge designer. So, in order to achieve the economy some modification is allowed for reasonable imperfection in the workmanship of the gauge maker. So, this tolerance on gauges provided is called gauge maker's tolerance.

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Plug and ring gauge tolerances (American gauge design standard)

Above (in)	To and including (in)	Class (in)				
		XX	X	Y	Z	ZZ
0.029	0.825	0.00002	0.00004	0.00007	0.00010	0.00020
0.825	1.510	0.00003	0.00006	0.00009	0.00012	0.00024
1.510	2.510	0.00004	0.00008	0.00012	0.00016	0.00032
2.510	4.510	0.00005	0.00010	0.00015	0.00020	0.00040
4.510	6.510	0.000065	0.00013	0.00019	0.00025	0.00050

All values are in inch

XX- Precision lapped (Plugs or male masters only)
X - Precision lapped plugs or rings
Y - Lapped plugs or rings
Z - Ground and polished
ZZ - Ground rings only

No this is American gauge design standard, they specify different classes of tolerances. This is for plug and ring gauge only. So, different class of tolerances are XX tolerance, X class, Y class, Z class and ZZ class. ZZ class is applicable only for ground rings only ring gauges only. And XX they are very precise lapped gauges and they are used as masters and these X and Y they are used as inspection gauges and Z for the normal working gauges.

Now this table shows that for a particular size that is 0.029 inch all the values are in inches for 0.029 inch to 0.825 inch what is the tolerance that is allowed. If the gauge is XX class then the tolerance that is allowed is 0.00002 and if it is the X class tolerance then that double of this value that is 0.00004. And for Y class it is 0.00007 inches and for Z class 0.0001 inches and for ZZ it is 0.0002. So, similarly for other range of sizes the tolerance values are mentioned here.

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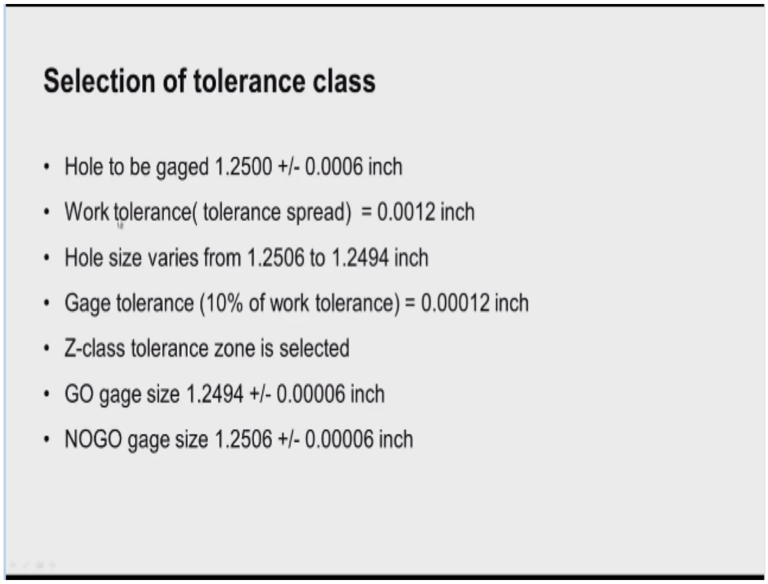

Now will take a simple example to show the tolerance class can be selected. So, let us assume that we have a hole to be gauged with the size basic size 1.25 inch +/- 0.0006 inch this is the tolerance that is provided on the hole. So, the work tolerance or the tolerances spread will be equal to double of this value that is 0.0012 inch and in that case the hole size varies from the maximum size will be 1.2506 inch and minimum size will be 1.25–0.0006 inch that is 1.2494 inch.

Now the gauge tolerance which is normally taken as 10% of the work tolerance, so in this case work tolerance is 0.0012inch, 10% of this will be 0.00012 inch. So, if this is the case from the table we can see for this particular hole and for this gauge tolerance, so the nominal size is 1.25 it falls in this range and the tolerance spread is 0.00012 inch. So, the Z class tolerance is selected, so Z class tolerance zone is selected.

So, now the GO gauge size will be equal to now the lower size of the hole GO gauge is made to check the lower size of the hole, that lower size of the hole is 1.2494 inch + this the gauge tolerance is to be added that is 0.00006 inch okay that is 10% of this work tolerance. That is GO gauge size will be 1.2494 +/- 0.00006 inch for NOGO the maximum size of hole is 1.2506 +/- the gauge tolerance that is 0.00006 inch.

So, like this we have to select the tolerance class and then we have to design the GO side and NOGO side of the either plug gauge or ring gauge.

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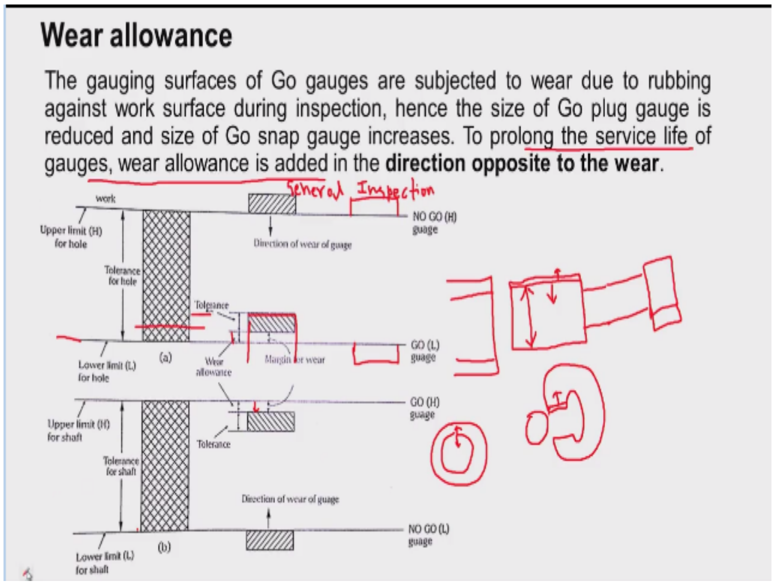

Now let us try to understand what is the meaning of wear allowance. Now we in the previous classes we discussed about the use of gauges, plug gauge, ring gauge etc., etc., and we understood the limit gauges that come in contact with the work piece. For example this is the hole to be checked, so we are using the say double ended GO NOGO gauge. So, NOGO size will be bigger now this GO end will enter into this and there will be contact between this surface gauge surface and the work surface.

So, there will be always wear occurring on the gauging surfaces. Now in order to prolong the service life of gauges wear allowance is added in the direction opposite to wear. That means when we use this gauge due to continuous usage of the gauge the diameter of the GO plug gauge will reducing, that means the direction of wear will be in this direction which is shown here. And if snap gauge is used okay it is used to check the diameters and there will be wear of this.

So, wear direction will be in the opposite direction in this direction opposite to this particular direction. So, in order to increase the service life of the gauges we have to allow some wear allowance in the direction opposite to the wear direction see the wear is occurring in this direction. So, we have to add wear allowance in the opposite direction, so in case of snap gauges wear is occurring in this particular direction.

So, wear allowance is given in the opposite direction like this, so that is shown in this picture . This is the hole and this is the work tolerance for the hole and this is the upper limit of the hole and this is the lower limit of the hole. Now GO gauge is designed to the lower limit of the hole. Now since the wear is occurring in the gauges we have to allow wear allowance in the opposite direction that you can see here wear allowance is provided.

So, in this direction and then the gauge tolerance is provided. So, similarly for NOGO gauge is designed to this particular limit upper limit of hole and the tolerance is given outside the tolerance for. This is the we say general class of gauges, so there are different types classes of gauges, general types of gauges, work shop gauges, inspection gauges and in the case general class of gauges the this is how the tolerance is provided.

The gauge tolerance is provided inside the work tolerance and hence wear allowance is also provided inside this consuming some portion of the work tolerance. And the tolerance and GO NOGO gauge is outside the work tolerance whereas in the case of the inspection gauges the allowance I am sorry the tolerance gauge tolerance is provided outside the work tolerance like this.

Now there is some problem with this method used. So, we are consuming some potion of the work tolerance, now let us that the work piece hole is somewhere here okay actually it is within the work tolerance, so it is acceptable. But since we are consuming some portion of the work tolerance the GO gauge is designed up to this size. So, when we try to insert this GO gauge into the hole it is obstructing **it** it will not enter.

Because the hole is up to this, so the operator will decide to reject that particular piece. So, that is the problem with this type of assigning the gauge tolerance and wear allowance. So, in the case of inspection this problem is the tolerance is given outside the working tolerance if some pieces are rejected by using the general gauges. So, such rejected pieces are sent to the inspector he will use inspection type of gauges.

And now this GO gauge will enter into the hole and it can be accepted. Now similarly for shaft this is the work tolerance that is shaft tolerance and this is the lower limit of the shaft and this is upper limit of shaft and we can see here the use to check the shaft whether we use ring gauges or snap gauges. So, the will be in the reverse direction in this direction, so the tolerance and wear allowance is provided in the reverse direction as shown here.

So, wear allowance is given in the opposite direction in which opposite to the direction in which the wear is occurring. And similarly for NOGO gauge the tolerance is outside this tolerance of the shaft.

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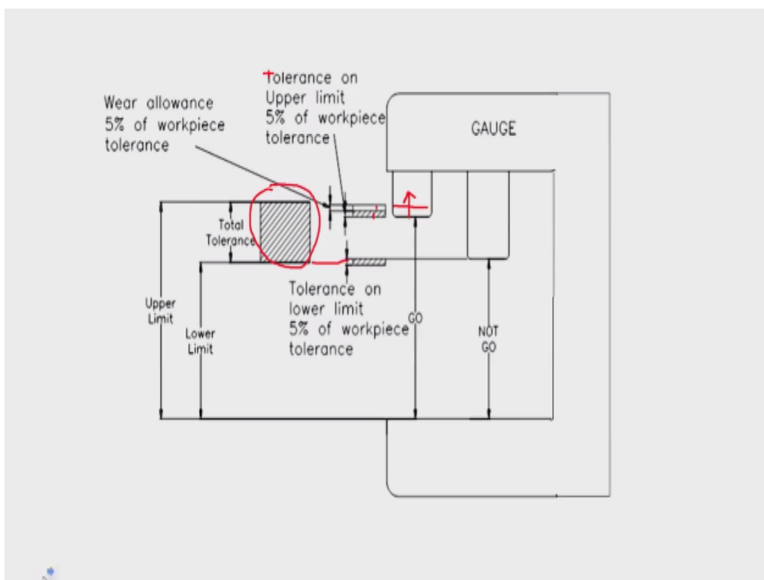

Now we have taken an example of snap gauge here, now this is the GO limit and this is NOGO limit and this is the tolerance for the shaft. So, this is shaft tolerance or work tolerance now we know that when we use snap gauges to check to the work pieces shafts. The wear is occurring in this direction and so the wear allowance is given in the opposite direction. So, wear this is the tolerance, tolerance on this gauge tolerance which is taken as 5% of the tolerance, this is Toe tolerance 5% of this is taken as gauge tolerance.

In addition to that wear allowance is given which is again taken 5% of the tolerance. So, wear then the gauge tolerance is provided due to this the GOs size will decrease, because we are consuming this much of work tolerance GO size will reduce. So, this in the inspection type of gauges the tolerance is given outside the work tolerance. Similarly for NOT GO gauge you can see from 5% of the work tolerance is taken and it is given outside the work tolerance.

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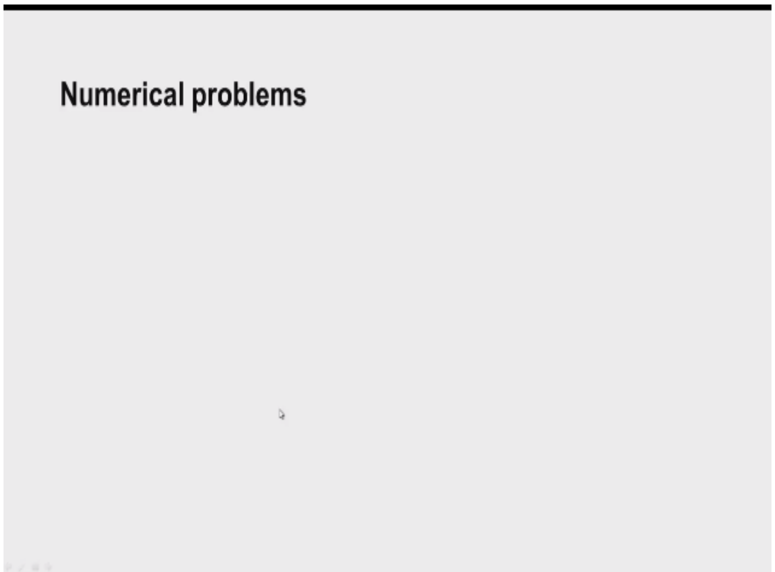

Now we will take u problem on gauge design. So that the concepts will be clear.

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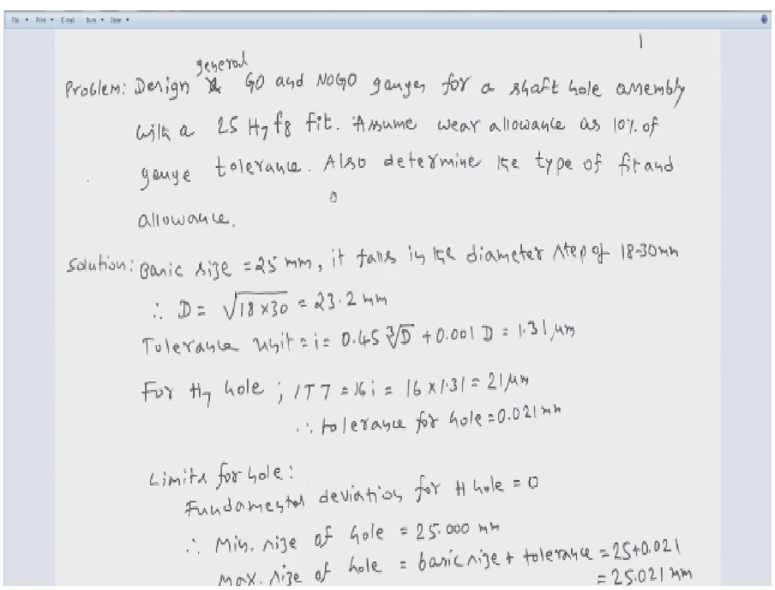

Now the problem is given here the we have to design general type GO and NOGO gauge NOGO gauges for a shaft hole assembly with a 25 H7 f8 fit. And we have to assume a wear allowance of

10% gauge tolerance also we have to determine the type of fit and allowance. Now this 25 is the basic size and it falls in the diameter step of 18 to 30 millimetre. So, we can find the mean diameter using this relationship, so mean diameter will be equal to 23.2mm tolerance unit also we can find using this relationship it will be 1.31 micrometer.

For H7 hole the tolerance grade is IT7 which is equal to 16 times i, so 16 times 1.31 gives us tolerance for hole of 0.021 millimetre.

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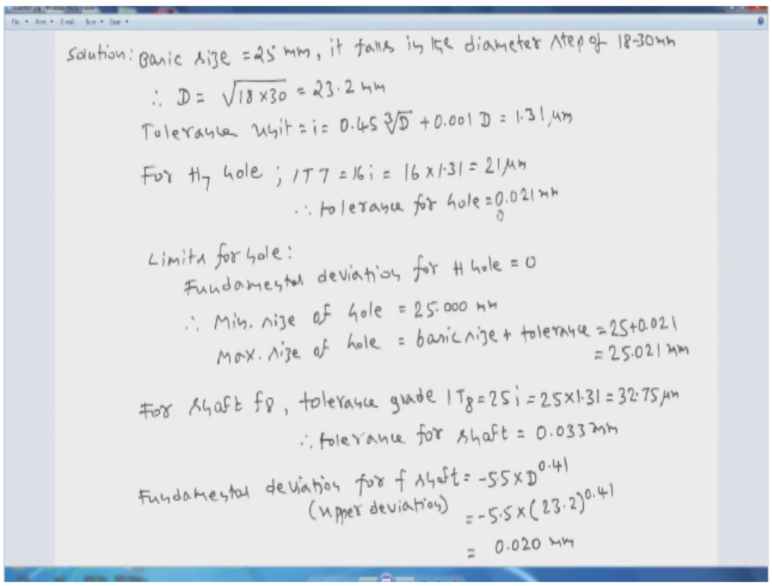

So, once we know the tolerance value for hole we can find the limits for the hole we know that fundamental deviation for H hole is equal to 0. So, minimum size of the hole will be equal to 25 millimetre and maximum size of the hole can be obtained by adding tolerance to the basic size. So, the maximum size of hole is equal to 25.021 millimetre.

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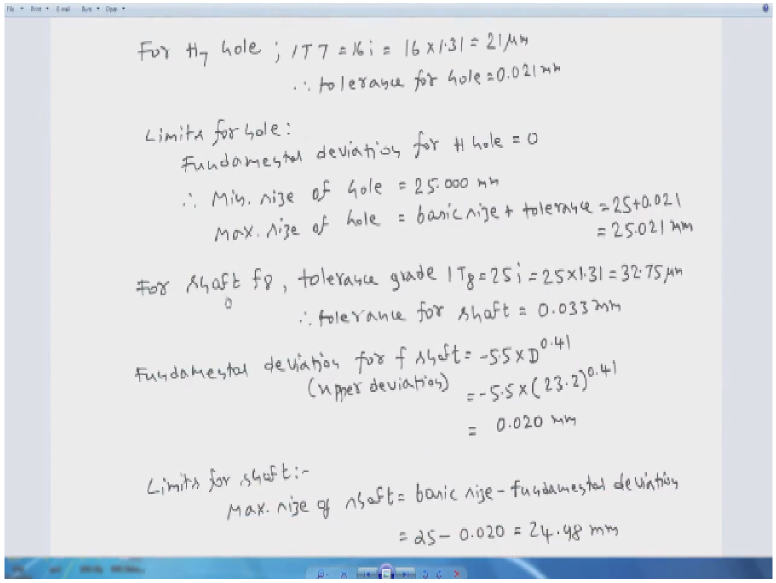

Now moving to the shaft for f8 shaft tolerance grade is f8 that is IT8 is equal to 25 i. So, this will give us a tolerance for shaft of 0.033 millimetre and fundamental deviation for f shaft is equal to –5.5 times D to the power of 0.41. So, we get the fundamental deviation for f shaft, that is nothing but upper deviation to be -0.020mm.

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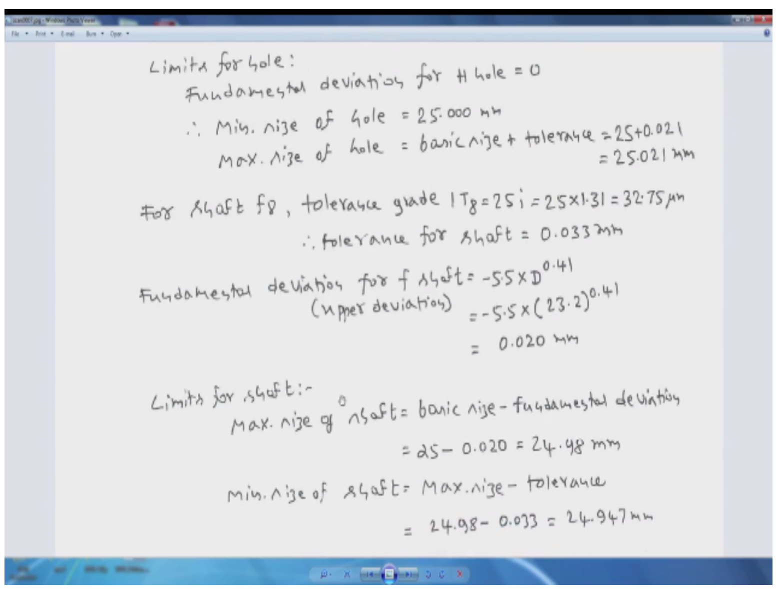

Now once the find the tolerance value for the shaft and the upper deviation we can get the limits for the shaft that is maximum size of the shaft is equal to basic size of the shaft-fundamental deviation.

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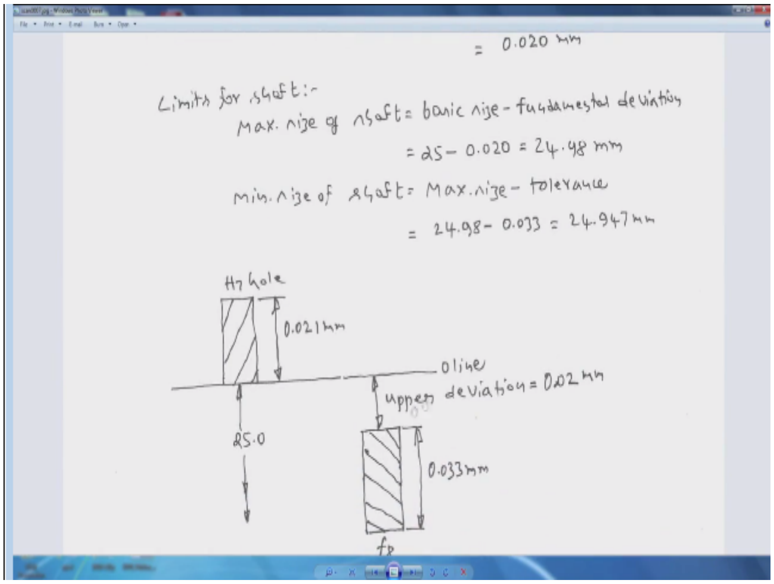

You can see here we have this 0 line and the upper deviation for the shaft is negative value negative 0.020. So, we are the upper deviation 0.02mm and the tolerance value for the shaft is 0.033mm. So, when we detect this upper deviation from the basic size we get upper limit for the shaft that is 24.98 millimetre. In order to find the minimum size of the shaft we have to detect this tolerance value for the shaft from maximum size of the shaft that is maximum size of the shaft–tolerance will give us 24.947 millimetre.

So, all these dimensions are shown in this picture H7 hole with the tolerance 0.021mm and this is the basic size and we have 0 line upper deviation f8 shaft with tolerance of 0.033 millimetre.

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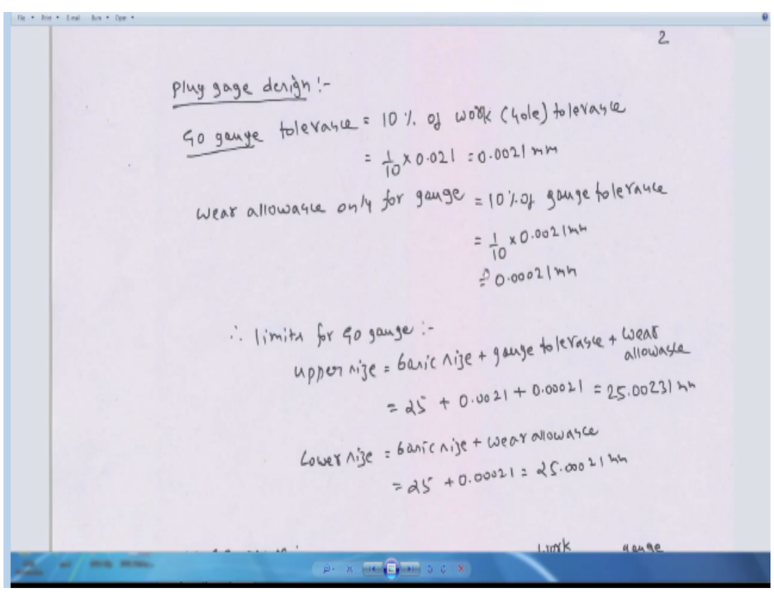

Now once we get the tolerance limit for hole and shaft we can proceed to design the plug gauge for checking the hole. The GO gauge tolerance is taken as 10% of the work tolerance, so work tolerance that is hole tolerance is 0.0121 millimetre 10% of that will give us 0.0021 millimetre and wear allowance is provided only for GO gauge. The reason is only GO gauge and trust the hole and that is subjected to wear.

So, wear allowance is provided only for gauge which is taken as 10% of the gauge tolerance. So, 10% of 0.0021 millimetre will give us 0.00021 millimetre. So, this amount of wear allowance provided on the GO gauge, so once we find the gauge tolerance and wear allowance.

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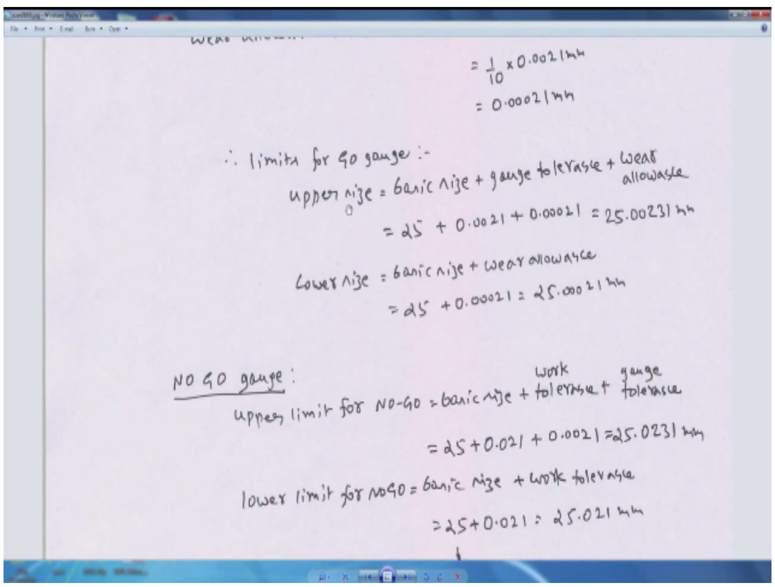

We can fix the limits for the GO size. So, upper size of the GO plug gauge will be basic size+gauge tolerance+wear allowance. So, basic size is equal to 25 millimetre and gauge tolerance is 0.0021 millimetre and then wear allowance is 0.00021 millimetre. So, when we add these values we get the upper size for the GO plug gauge, that is 25.0023 millimetre. And then lower size of the plug gauge will be equal to basic size + wear allowance that is 25.00021 millimetre.

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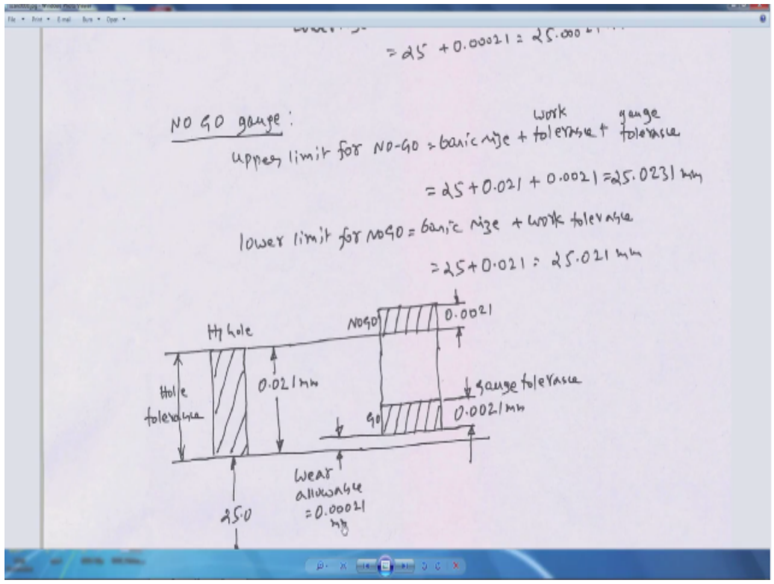

And coming to the NOGO gauge, so this is the GO gauge, the work tolerance is 0.021 millimetre 10% of this is 0.0021 millimetre this is the gauge tolerance and 10% of gauge tolerance is taken as wear allowance. So, wear allowance amount is 0.00021mm, so now the wear allowance is provided in this direction the direction which is opposite to the direction in which the wear is occurring. And then this is the wear allowance this is gauge tolerance.

So, the upper limit for GO gauge will be this one and lower limit will be equal to this basic size+wear allowance.

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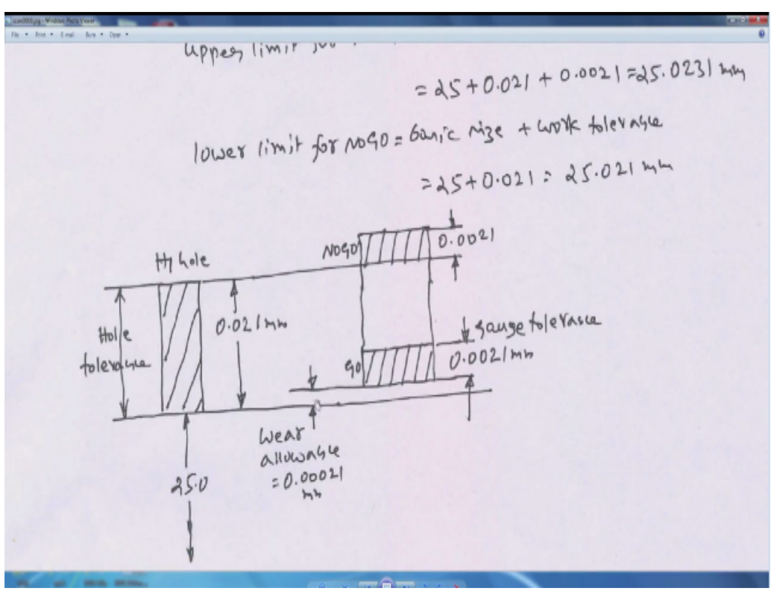

That means this much tolerance is provided for the GO gauge. Now coming to NOGO gauge, so we have the NOGO gauge here with gauge tolerance of 0.0021 millimetre. So, the this level will give us the upper limit for NOGO gauge. That means in order to get this we have to add basic size + work tolerance + gauge tolerance. So, this will give us the upper limit for the NOGO gauge that is basic size + work tolerance + gauge tolerance.

So, 25+0.021+0.0021=25.0231 millimetre. So, this is the upper limit for the NOGO gauge and this is the lower limit for the NOGO gauge. So, in order to get this lower limit we have to add 25 with the work tolerance that is basic size+work tolerance that is 25.021 millimetre will give us lower limit for the NOGO gauge.

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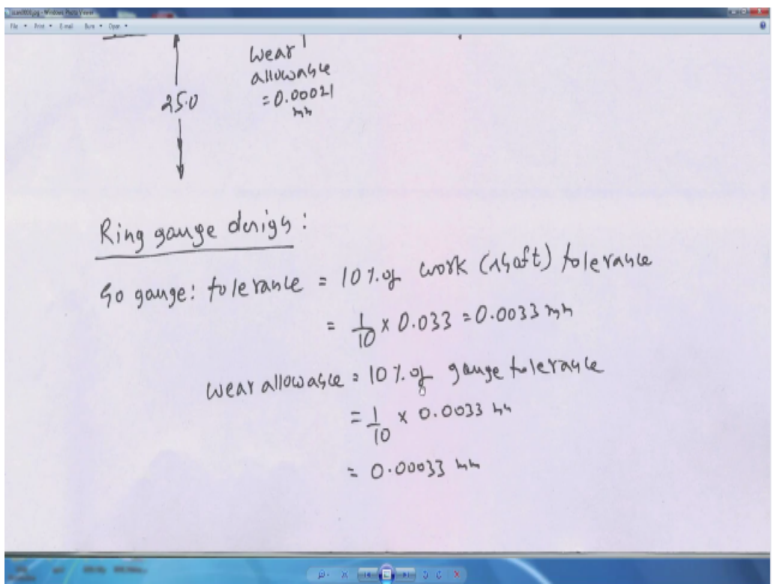

Now coming to the ring gauge design which is use to check the shaft gauge GO gauge GO ring gauge tolerance is again 10% of the work tolerance that is shaft tolerance is 0.033 millimetre, 10% of this is 0.0033 millimetre and again GO NOGO ring gauge wear is provided. So, which is taken as 10% of gauge tolerance, so gauge tolerance is 0.0033 millimetre, 10% of this will be 0.00033 millimetre.

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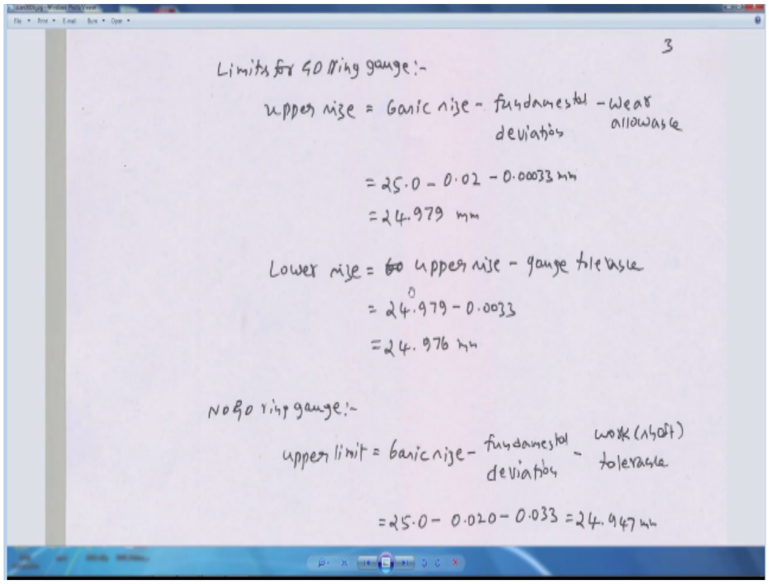

Now once we calculate the gauge tolerance and wear allowance now we can fix the limits for GO ring gauge. The upper limit for GO ring gauge will be equal to basic size–fundamental deviation–wear allowance. So, this will give us 25 -0.02 this is the fundamental deviation and this is the wear allowance 0.00033 millimetre. So, the upper size will be equal to 24.979 millimetre and lower size for GO ring gauge is upper size–gauge tolerance, so that is 24.976 millimetre.

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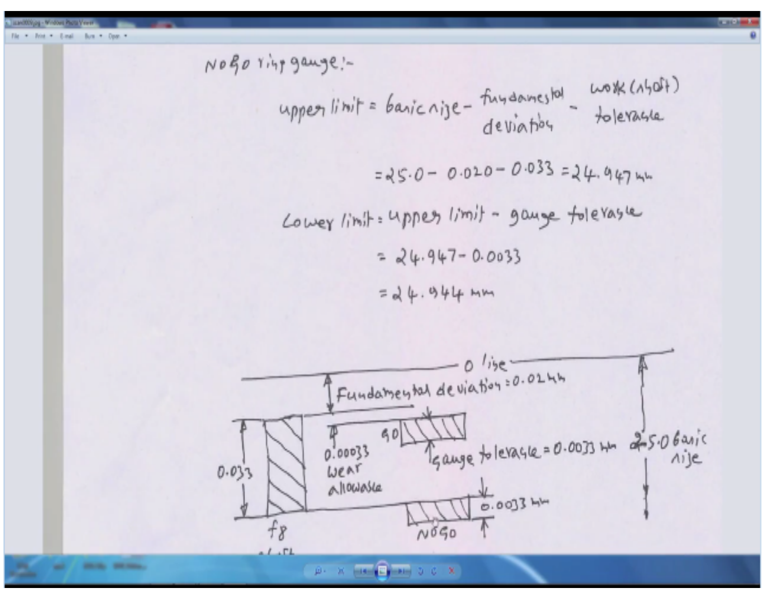

So, coming to the NOGO ring gauge, so this is the NOGO ring gauge and this is the upper limit for the NOGO okay. this is the upper limit for the NOGO ring gauge. So, this can this we can calculate by this relationship upper limit is equal to basic size, so this is the basic size 25 millimetre – fundamental deviation that is 0.02 millimetre–work tolerance that is 0.033 millimetre. So, upper limit of NOGO ring gauge will be equal to 24.947 millimetre.

So, this will be upper limit and this equal to 24.947 millimetre and this is the lower limit for NOGO ring gauge this we can obtain subtracting the gauge tolerance from the upper limit, so limit of NOGO ring gauge is equal to upper limit–gauge tolerance that is 24.947 millimetre–0.0033 millimetre which is equal to 24.944 millimetre.

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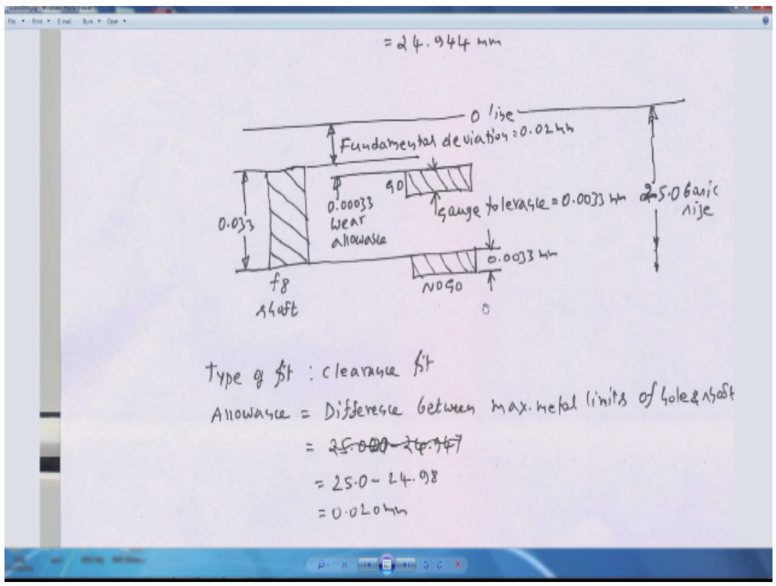

So, now since the shaft size is smaller than the maximum size of the shaft is smaller than the minimum size of the hole we have clearance fit here and then allowance is equal to difference between the maximum metal limits of the hole and shaft. So, maximum metal limit for hole is 25 millimetre and maximum metal limit for shaft is 24.98, so the allowance is 0.020 millimetre. So, like this we can calculate we can design the limits for GO gauge as well as NOGO gauge.

So, with this we will complete this lecture. In this lecture we discussed about Taylor's principles of gauge design and we also learnt about gauge tolerances wear allowances and also we saw a numerical problem to understand the gauge design. So, with this we will close this session thank you.