Engineering Metrology

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Lecture – 07
Limits, Fits, and Tolerances (Part 3 of 4)

Welcome back to third lecture in Limits, Fits and Tolerance. Till now we have seen how to calculate tolerance then how to calculate allowance then to find out what is the fit and then later we will also it what is the fit and we will also try to see what is the best fit available the hole base system and shaft base system these are the topics we have covered.

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Now, we will try to cover some more in fits and finally we will see the systems of limits and fits limiting gauges and Taylor principle.

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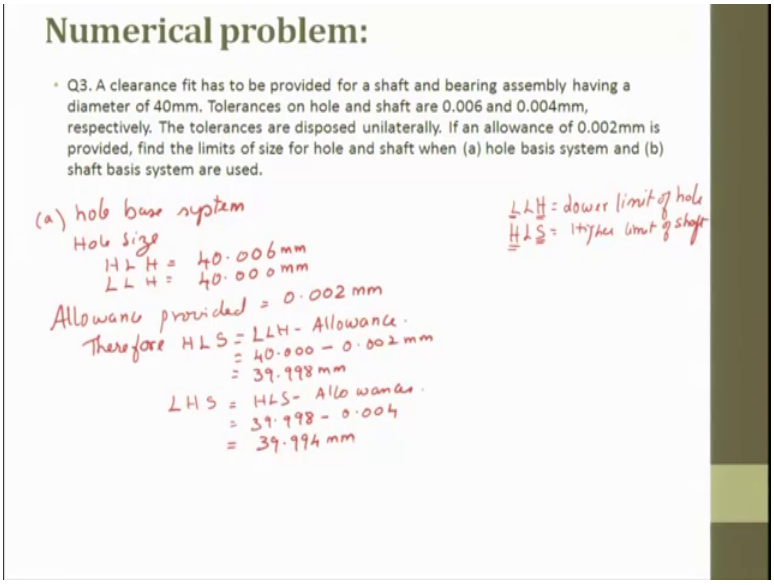

So, continuing to yesterday’s lecture the next problem we will try 1 or 2 one problem more. So, that we have more clarity how to solve these problems a clearance fit. What is a clearance fit? Where the hole size is larger than the shaft so the shaft can slip inside. The clearance fit has to be provided for a shaft and a bearing assembly, a shaft and a bearing assembly having a diameter of 40. So, the basic size diameter is 40 the tolerance on the hole and the shaft are 0.006 and 0.004 millimeter respectively.

The tolerance are dispersed unilaterally if an allowance of 0.002 is provided, find the limits of the size for hole and shaft when hole base system and b will be a shaft base system. We will be using LLH that is nothing but Lower Limit of Hole you might use a terminology call as HSL this is the Higher Limit of Shaft. So, this is H is for hole shaft lower limit and higher limit, so this these acronyms we will be using in problem solving. So, let us solve the problem so you will take a hole base system; for a hole base system hole size is HLH is going to be 40.006, so the lower level of the hole is going to be 40.000 these are all in millimeters ok.

So, now the allowance provided what is the allowance provided in the problem it is 0.002. So, allowance provided is equal to 0.002 millimeter ok. So, therefore HLS is equal to LLH minus allowance correct, so this is what we saw in the formula allowance equal to this minus this we saw ok. So, when you substitute it back you will get 40.000 minus 0.002 millimeter, so this is nothing but 39.998 millimeter ok. So, now we will try to take LHS that is nothing but HLS minus allowance which is nothing but 38.898 minus 0.004, so what we get is 39.994 millimeter ok. So, this is for the hole based system.

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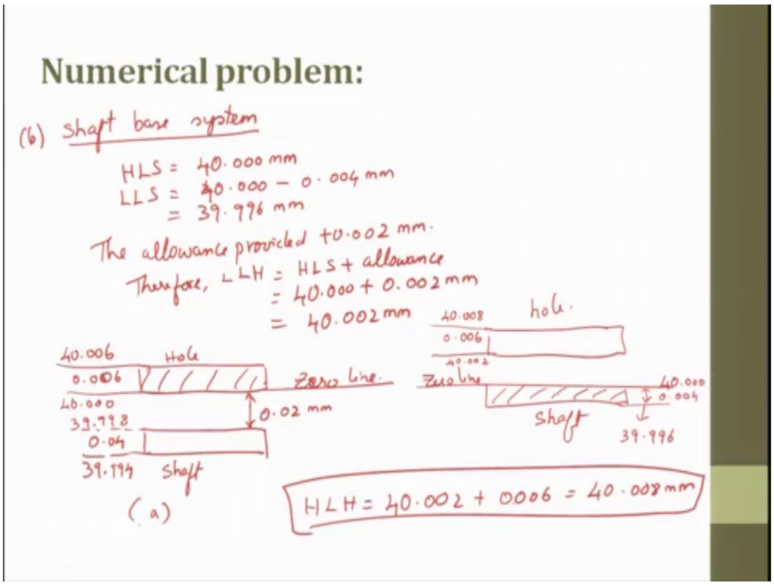

So, let us try to solve for shaft based system. So, for a shaft D for a shaft base system HLS is nothing but 40.000 millimeter. So, the LLS is nothing but 40.000 minus 0.004 millimeter which is nothing but 39.996 millimeter ok, the allowance here provided is going to be plus 0.002 millimeter. So, therefore the LLH is equal to HLS plus allowance, which is nothing but 40.000 plus 0.002 millimeter so this is 40.002 millimeter.

So, if you wanted to express it in a pictorial form, so then it can be this is hole this is a shaft. So, here it is 39.994 and here it is 0.04 this is the zero line and this difference is going to be 0.02 millimeter and here it is going to be 39.998 and here it is going to be 40.006.

So, this difference is going to be no sorry this is going to be 40 this is going to be 40 and this is going to be 0.006 and this is going to be 39.998 ok. This is for a hole base system, let us draw the same for a shaft based system this is your zero line and zero line here is your hole and here is your shaft, so this is your shaft and this is your hole ok. So, now this is going to be 40.000 so here this is going to be 40.002 and this is going to be 40.008, so the difference is going to be 006 ok.

So and here in the shaft base system this is going to be 39.996 millimeter and this is going to be 0.004 millimeter ok. So, finally if you want to put the closure so the H you are not filled up 1. So, HLH is equal to 40.002 plus 000.006 which is nothing but 40.008 millimeter, so this is important to solve it and the rest is taken from here.

So, by solving these 2 3 problems to a large extent you should now have a feel for a hole base system hole base system a shaft base system and then allowance tolerance maximum material condition and minimum material condition we also have to find out the fits. So, these are the possibilities you can expect a problem in your examination in this domain.

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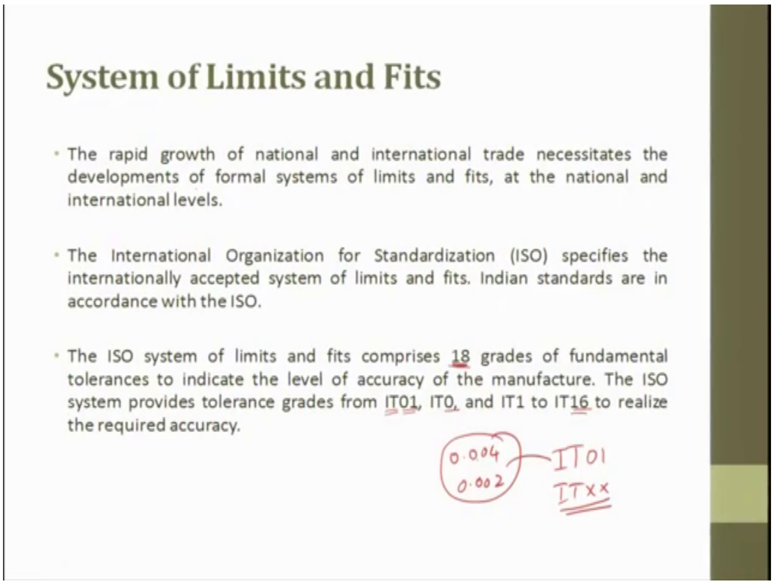

So, let us keep moving system on limits and fits the rapid growing of national and international trade necessitates the development of a formal system of limits and fits at the national and international level. So, today we are talking about moving parts and products sub assemblies from one country to another country and assembly happens at some other country. So, if that is the case then there has to be standard established, so now the standards see we say that hole of 0.002, 0.006 how is this 0.002, 0.006, 0.004 is decided this is decided based upon the process which is involved in generating it ok.

So, now what is happening we have to now set a standard, so that by looking at the tolerance we should be able to understand ok. What is the process which is involved and what is the standard in one country should also be the same standard in the other country, so that the path manufactured can directly get into assembly they need not undergo instruction once again.

The international organization of standardization I also specifies the internationally accepted system of limits and fits, Indian standards are in accordance with the ISO. The ISO system of limits and fits comprises 18 grades of fundamental tolerance to indicate the level of accuracy of the manufacturer. The ISO system provides tolerance creates from IT. IT tolerance International Tolerance of 001 0 to 1 16 1 6 to realize that required accuracy.

So, rather than writing 0.004, 0.002 may be there might be a type or this or that. So, now this is replaced by a grade which grade is IT0 sum 1 or it can be IT xx. So, people will look at IT xx value and then understand this is the tolerance they have to be, so we can avoid mistake to realize the required accuracy.

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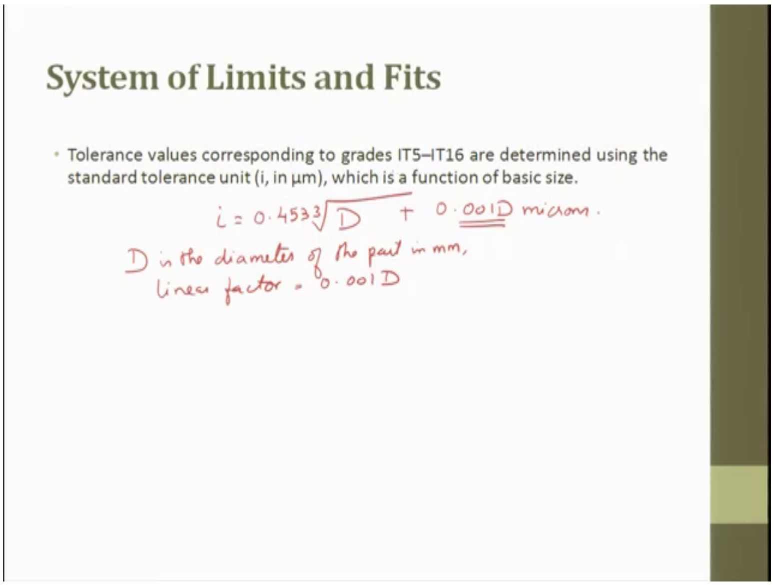

The tolerance value corresponding to the grade IT 5 to IT 16 are determined using a standard tolerance unit I is in micrometer which is a function of the basic size. So, what they say is I is a is this is a empirical formula 0.453 cube root of D plus 0.0.01 D in microns.

So, whereas D is the diameter of the part in millimeters right in millimeter, the line linear factor is nothing but 0.001 D is a linear factor which is counteracted linear part this is a linear factor which is counter acted the effect is measuring inaccuracy this is taken care by this. So, the tolerance grade values to grades IT 5 to 16 can be determined by using this formula.

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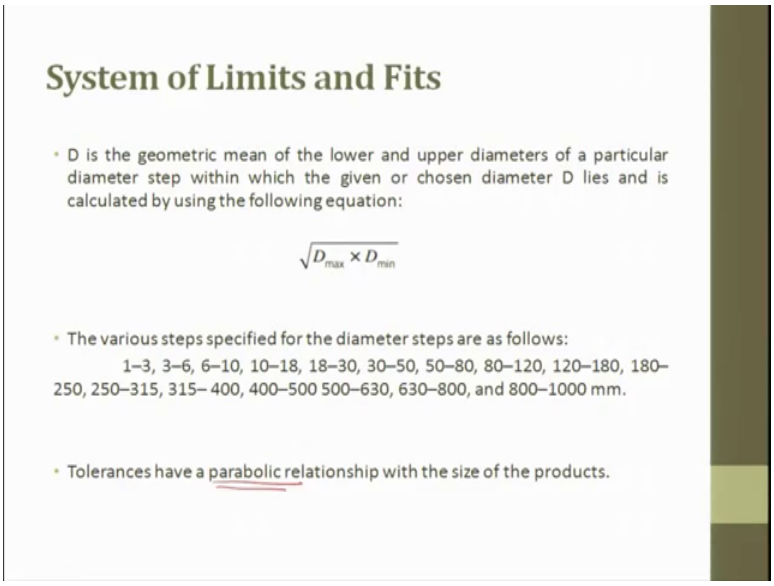

So, you try to find out what is the grade, D is the geometric mean of lower and upper diameter of a particular diameter step within which the given or the chosen D lies and is calculated by using the formula D max into D min by root. The various steps specified for the diameter are as follows 1 to 3, 3 to 6, 10 to 6 to 10, 10 to 18 and it goes on from 800 to this. So, we can try to take the maximum minimum try to take a root and then go back for this b and use it in this D to get the I so, the tolerance have a parabolic relationship with a size of a product. So, this is this relationship is very very important and these D max and min are these D which are given in the step.

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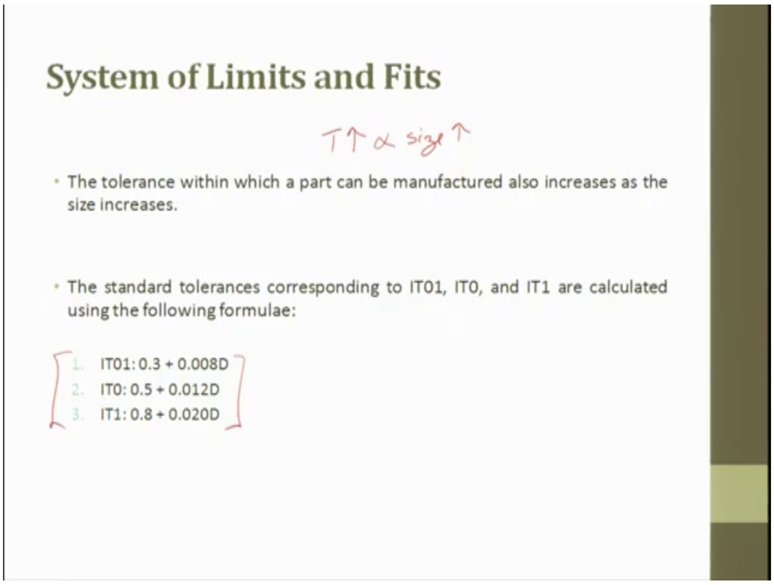

The tolerance within which the tolerance within which a part can be manufactured also increases as the size increases please understand that, what are we trying to say tolerance T increases or is directly proportion to size increase as and when the size increases the tolerance also increases. The standard tolerance corresponding to ITo1 IT0 and IT 1 are calculated using the formulae, IT 01 is nothing but 0.03 times plus 0.008D. So, these are formulas which are available in the handbook. So, what are we trying to do is that we are trying to find out the tolerances given for this IT.

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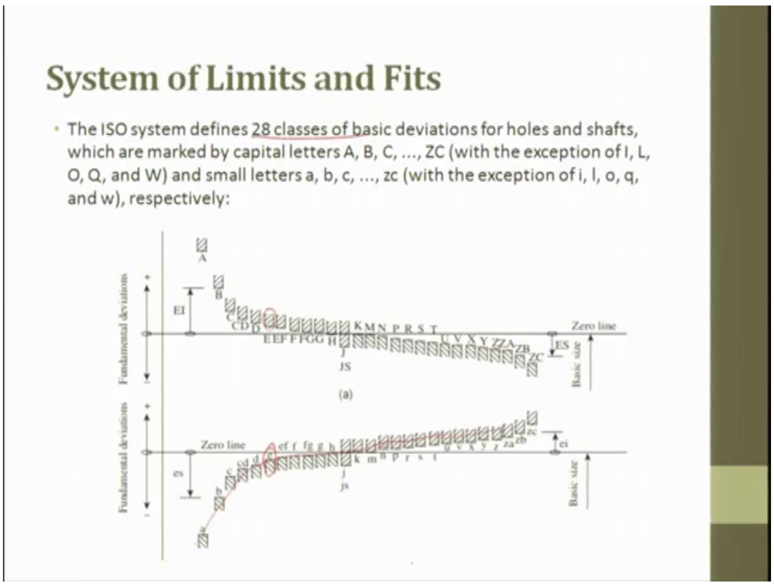

So, if you look at the ISO system defining 28 classes of basic deviation for hole base system and for shaft base system. So, this is for a hole and this is for a shaft this is for a shaft the bottom whatever is there is for a shaft and this is for a hole. So, here is the zero line so it is basic line zero line and here you can see the fundamental deviations. So, here the deviations of the hole and shaft which are marked by capital letter A B C to Z C with the exception of I L O Q and W are the smallest letter a b c to z c with the exception of I l o q, so these are these are different ways of the alphabets are given.

So, what happens is now when you have to choose a clearance fit or a interference fit or a transition fit. So, then what happens is we try to choose the shaft what is the what is the letter and corresponding to it we chose we this is a hole this is a shaft we choose and based on this we try to talk about the clearance fit. So, this is for transition and this is for suppose you take E and you say E S, so it is a interference fit ok. So, this is what we are trying to say the ISO system defines 28 class of basic deviation for hole and shaft base system with this what we can do is we can try to figure out what should be the tolerances which are given for the hole and for the shaft to have the necessary fit.

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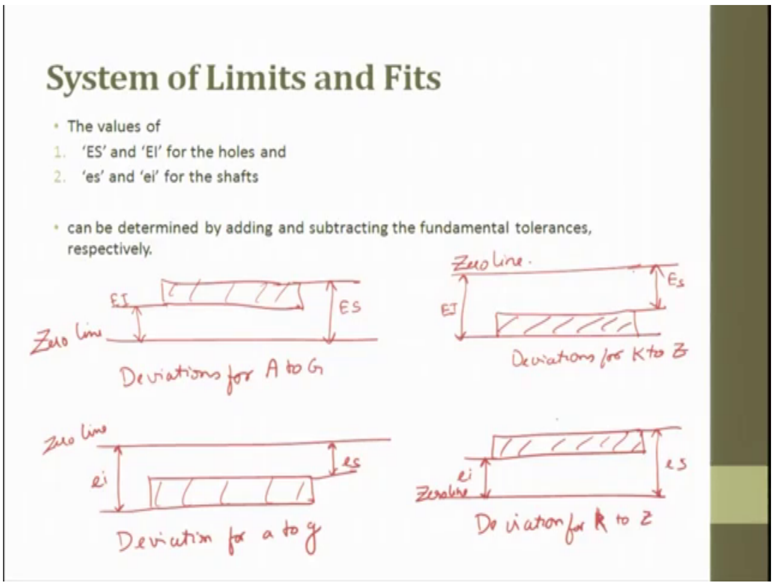

The values of ES and EI are for the hole and value of e s and e i are for the shaft, can be determined by adding and subtracting the fundamental tolerance respectively. So, what we are trying to say is you take a zero line then you try to take this is your ES and this is your EI this is for a deviations for A to G and if you try to take this is your zero line ok, this is your ES and this is your EI. This is for deviations for K to Z it will be like this.

Next if you want to have for the other one so this is your zero line this is your zero line this is your ES and this is your EI and this is for deviation for A to G this is for a shaft base system. Then you will have your zero line this is your EI and this is your ES this is for deviations for K to Z, this is K to the small k to z this is for a shaft. So, this is for a hole and this is for a shaft so the values of ES and EI for a hole can be expressed from A to G can be expressed like this. So, this is your deviations this is your hole based deviations right.

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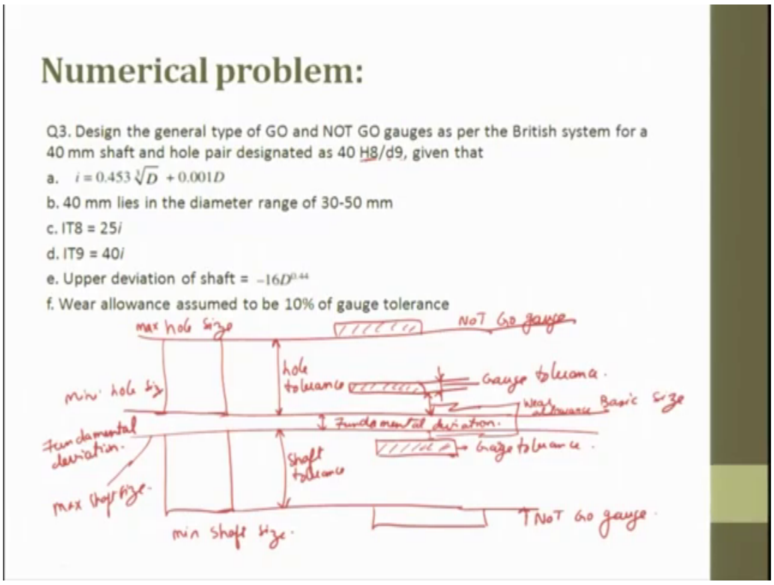

So, let us try to solve 1 simple problem design the general type of go to no go gauge as per the British system for a shaft of 40 millimeter and a hole pair designated as 40 H8; H8 and d9, given that i equal to 0.453 cube root of D plus 0.001 of D this is linear factor. So, there are several divisions given so let us try to solve each subdivision and try to get the answer.

So, let me first try to draw the figure this is going to be your zero line maximum hole size maximum hole size, this is going to be a hole tolerance this is for not go gauge we will see go gauge and not go gauge little in detail. But as of now you will see only the tolerances part of it.

So, then you will have corresponding gauge tolerance this is your basic size, this deviation is the wear allowance this is your fundamental deviation and this is for minimum of shaft size ok. This is the shaft tolerance this is your gauge, this is you gauge tolerance and this is your not go gauge and this is your fundamental deviation fundamental deviations and this and this space if I try to take these 2 are going to be the wear allowance.

This is the minimum hole size and this is minimum, so this is a hole size and this will be the minimum of the hole and this is a minimum of the. So, here it will be minimum hole size and this will be maximum shaft size, so this will be maximum shaft size ok.

So, this is the pictorial representation of whatever we have understood till now, so we have put all those things here. So, now, next we will try to solve the problem.

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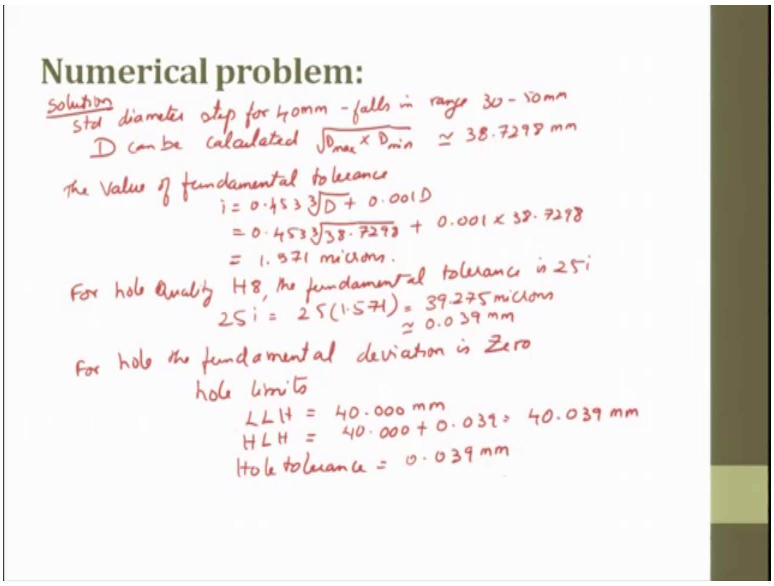

So, first let us solution first what we have a standard diameter standard diameter a step for 40 millimeter and this 40 millimeter falls in range of what 30 to 50 ok. So, when we have to calculate D can be calculated from the formula root of D max into D min ok. So, this is approximately equal to 38.7298 millimeter approximately.

The value of fundamental tolerance is i equal to zero formula given 0.453 cube root of D plus 0.001 D, so which is approximately which is nothing but 0.453 cube root of D which is 38.7298 plus 0.001 into 38.7298 which is equal to is equal to 1.571 microns ok, we have calculated the i from the D is also given. Now let us get into for hole quality what they have said H8; H8 the fundamental the fundamental tolerance is nothing but is 25i to go back 8 is i which is given in the this thing formula. So, it is 25 i so it is 25 i equal to 25 into 1.571 which is nothing but 39.275 microns or it can be set as 0.038 millimeter ok.

For a hole the fundamental deviation is 0 ok, so hole limits are going to be the hole limits are LLH lower limit for hole is going to be 40.000 millimeter and the higher limit of hole is going to be 40.000 plus 0.039 millimeter, which is nothing but 40.039 millimeter ok. So, the hole tolerance is going to be 0.039 millimeter ok.

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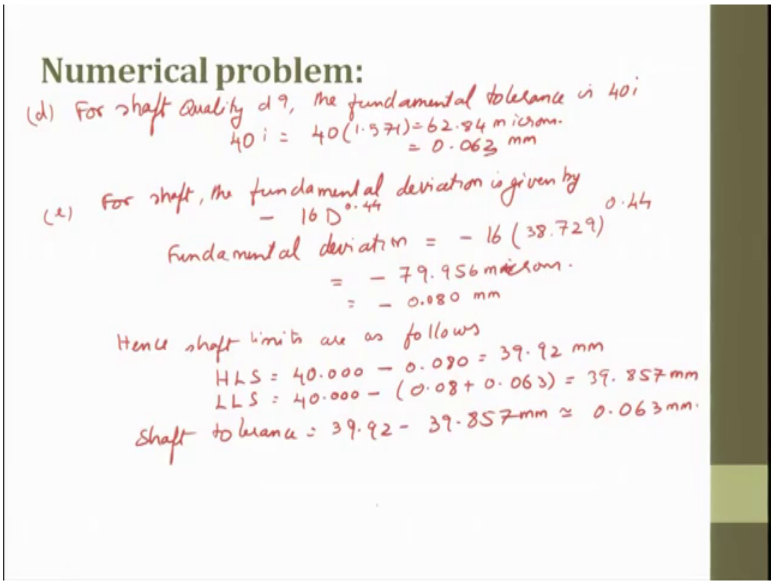

Now, let us go for a shaft now for a shaft, for a shaft quality shaft is small capital d 9, the fundamental tolerance is so we have 40 i which is nothing but 40 into 1.571 which is 62.84 microns or which is nothing which can be written as 0.062 millimeter. So, the fundamental tolerance is 40 i which is also given in the problem, by the way it is also given in the problem 40 i right is 0.062 are 62 63 we will make it 63 which is pretty close 63 we will make it ok.

So, now for shaft the fundamental deviations the fundamental deviations is given by what minus 16 D to the power 0.44 ok. So, where is this coming from e upper deviation of the shaft so this is e this, so this is e this is d this is also given. So, this so the fundamental deviation is nothing but minus 16 into D which is 38.729 to the 0.44 ok. So, where did this 38.729 come from 38.729 this is 38.729 came from here D max minus t, so this is a D we get and we have substituted in the (Refer Time: 30:54) so minus this. So, this is nothing but minus 79.956 millimeters approximately ok.

So, no it is microns it has to be in microns, so if I want to convert into millimeter it is going to minus 0. 80 minus 0.080 millimeter. Hence the shaft limits are as follows what are they are shaft is nothing but 40.000 minus 0.080 which is 39.92 millimeter, then for lower level of the shaft is going to be 40.000 minus 0.08 plus 0.063 which is equal to 39.857 millimeter. Now the shaft tolerance shaft tolerance is going to be 39.92 minus 39.857 millimeter which is approximately 0.063 millimeter.

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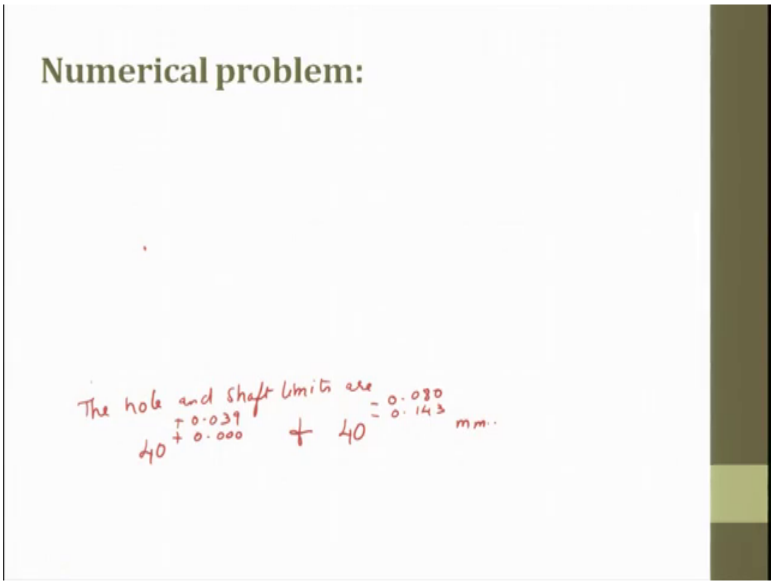

So, the hole and shaft limits are 40 plus 0.039 plus 000 and 40 minus 0.080 and minus 0.143 millimeter ok. If you want this to be represented into a figure form then let us draw the figure so it is like this.

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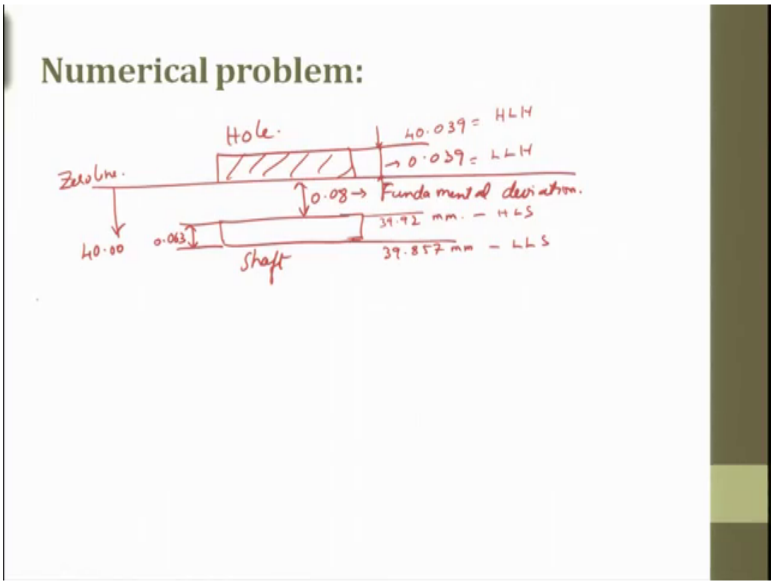

You have zero line this is your zero line this is 40 milli 40 ok, then you will have a hole this is your hole and this is your shaft and here the 0.08 will be the fundamental deviation here ok. Here it will be and this difference is 0.063 and this difference is going to be 0.039, so the value here is going to be 40.038 and this is 40 which we have already told and here it is going to be 39.92 and here it is going to be 39.857 millimeter ok.

So, this is a fundamental deviation this is nothing but the higher limit of hole this is lower limit of hole, this is going to be the higher limit of shaft and this is going to be the lower limit of shaft ok. So, now the last part of the question is going to be what should be the wear and tear which is given as of 10 percent ok.

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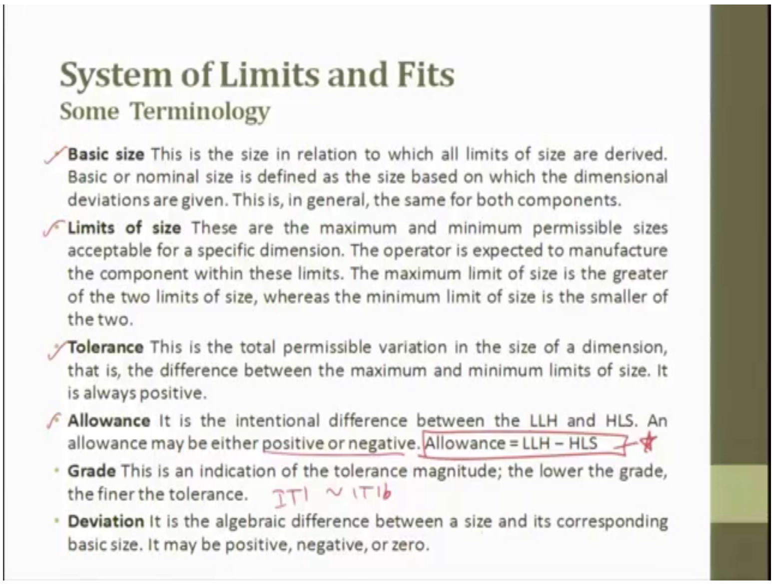

So, let us see some of the terminologies which are used in tolerances basic size, is the size in relation to which all limits of size are derived. So, 40 plus or minus that 40 is the basic size basic size or nominal size is the same is defined as the size based on which the dimensional deviations are given, this is in general the same of for both components.

What are the limits of size? There are 2 limits maximum and minimum permissible size acceptable for a specific dimension, the operator is expected to manufacture within the maximum and minimum limits within these limits. The maximum limit of size is greater of the 2 limits of size, whereas the minimum limit size is the smaller of the 2. What is tolerance the tolerance is the total permissible variation in the size of dimension, for example 40 plus or minus 0.2 we say know so that is what.

So, the difference between the maximum and the minimum limits of size is nothing but the tolerance. So, limit of size maximum and minimum within that they have to do tolerance is the difference between maximum material and minimum material. Allowance is the next important thing it is the intentional difference between lower limit of hole and higher limit of shaft and allowance can be either positive or negative, the allowance this is a formula which is used very important then we talk about grade it is an indication of the tolerance magnitude IT 6.

So, it is the 6 talks about the magnitude lower the grade finer the tolerance, for example if we talk about IT 1 we compare it to IT 16 IT 1 as the tighter or tolerance or a lesser tolerance. Deviation it is the algebraic difference between the size and its corresponding basic size between a size and its corresponding basic size it may be positive it may be negative or it may be 0. So, these deviations are the A B C D which we saw for a hole base system and for a shaft base system.

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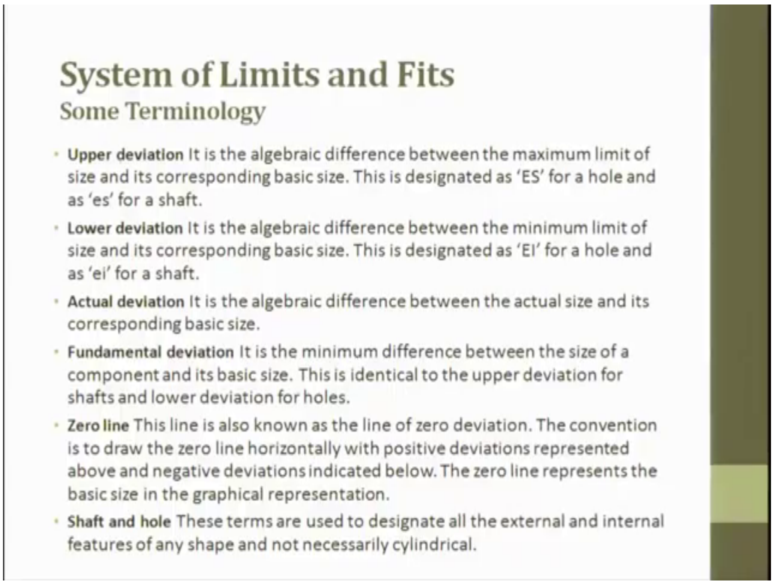

Upper deviation it is the algebraic difference between the maximum limit of the size and the corresponding basic size it is designated as ES for a hole and es for a shaft ok. When we talk about upper there should be naturally a lower limit also, so they are in tern talked as EI or the minimum limits for the hole and ei for the shaft these are the deviations.

So, please try to understand deviation it is the algebraic difference between a size and it is corresponding basic size is the deviation. So, upper lower what actual deviation it is the algebraic difference between the actual size and it is corresponding basic size is the actual deviation.

Then we talk about fundamental deviation it is the minimum difference between the size of a component and its basic size is called as fundamental deviation, this is identical to the upper deviation for a shaft and a lower deviation for a hole so this definition is also very important.

Zero line the line is known as a line of zero deviation the conventional case to draw a zero line horizontal with positive deviation represented above and the negative deviation represented below. A shaft and a hole these are terms which are used to designate all the external and internal features of any shape and not necessarily cylindrical ok.

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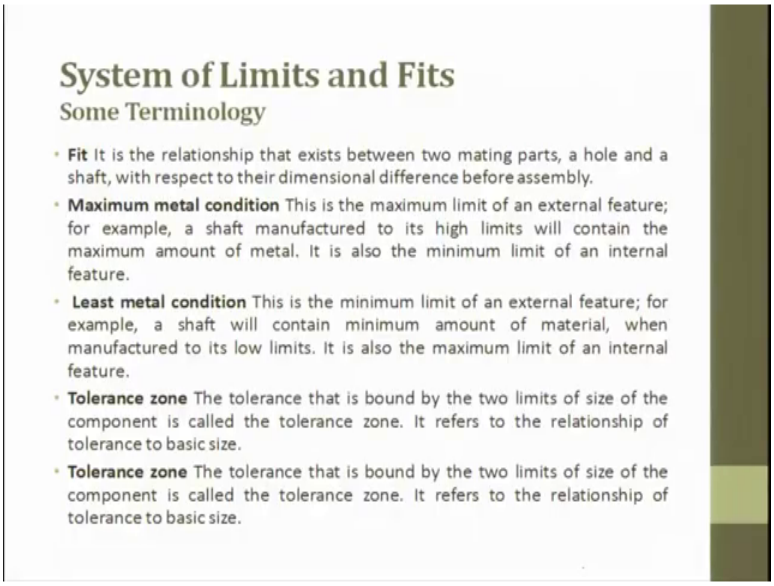

So, these are some of the terminologies which are which we have been going through in this chapter. Fits it is the relationship that exist between 2 mating parts a hole and a shaft clearance fit transition fit interference fit, maximum material condition this is the maximum limit of an external feature for example a shaft measured to its high limits with will contain the maximum amount of metal. Least metal condition is the minimum limit of an external feature for example a shaft will contain a minimum amount of material when the manufacture to it is lower limit.

Tolerance zone, the tolerance zone that is bound by the 2 limits of size of the compound are called as tolerance zone, it refer to the relationship between the relationship of tolerance to basic size.

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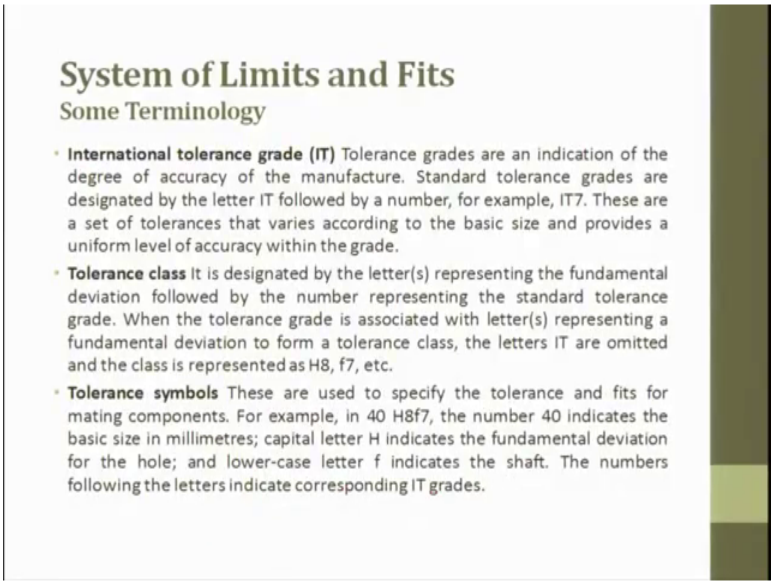

So, then it is international tolerance grade, tolerance grade are indicated of the degree of accuracy of manufacturing it is used for international, so that it can be produced from one place and it can be move to the other.

Then tolerance class it is designated by the letter here letters representing the fundamental deviation followed by the number representing it is standard tolerance grade. So for example, it is IT in the tolerance grade the letter IT are omitted and the class is represented as H8 f 6 you can represent see. When the tolerance grade is associated with a letter representing a fundamental deviation to comma tolerance class, the letters IT are omitted and we directly write H8 and f 7.

So, here it is IT 7 it is international tolerance grade tolerance class is H8 f 6, then tolerance symbol is going to be there are specific tolerance and fits for a mating component. For example, it will be represented like this is a basic size this is the hole deviation this is a shaft deviation; 40 indicates the basic size H indicates the fundamental deviation of a hole f indicates the indicates the fundamental deviation of a shaft. This 8 and 7 is what we are trying to get the class and this can be calculated by the formula which we used in solving it.

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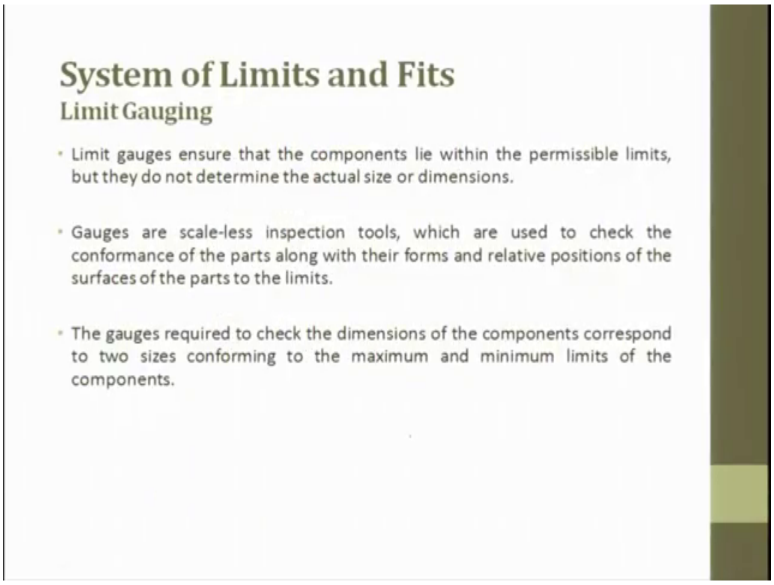

The last topic of discussion is going to be the limiting gauges, limit gauges ensures the component lie within the permissible limits but they do not determine the actual size or dimension. For example, I try to have a gauge which only checks whether the dimension is or not ok, so gauges are scale or scale less inspection tool.

So, here it is only yes no which are used to check the conformance of a part along with their form and the relative positions of the surface of a part to the limit. The gauge requires to check the dimension of a component corresponding to 2 sizes confirming to the maximum and minimum limit. So, whatever we say maximum material maximum condition minimum condition whether the component falls within that and whether it is ok or not ok; we do not measure the actual size.

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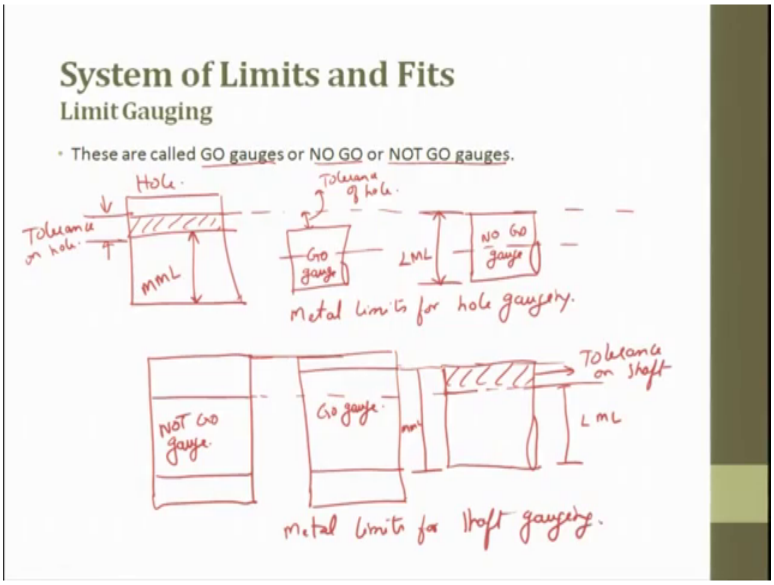

The limit gauge there are 2 types of gauge they are called as go gauge or no go gauge or not go gauge. So, if you try to take a hole this is a hole this is the tolerance of on hole this is the maximum material limit.

This is the tolerance of the hole this is a go gauge, this is no go gauge and this is the lower material limit. So, this is for a metal limits for hole gauging. So, we can also have a same for shaft so here not go gauge this will be your go gauge this tolerance on shaft ok. This is your maximum material limit and this is your lower material limit this is for a metal limits for shaft gauging.

Thank you.