# Design of Machine Elements – I

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Lecture No - 02

Design and Manufacturing

good day in the last class we have discussed about the design philosophy

so there we learnt that a very important factor in design is actually the decision making

now not only the decision making but several other relevant points are also been discussed in the last class

however you understand that whenever we are going to design a machine or a machine element as it stands in our course one has to take a decision that's fine that what should be the shape size etcetera material everything a designer has taken into consideration but over and ((above)) (00:01:21) one should remember that ultimately one has to give a shape to his product

now to give a shape to a product it requires

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what you understand is that manufacturing

so we will discussed about the ideas of manufacturing in the context of design in this today's lecture which has been given a name as design and manufacturing lecture two

in the case of design when we we want to make the final {ss} (00:02:18) the final actually the final design when we are considering then one has to give a shape as i told you to the machine element and for that you require to get some ideas of manufacturing that as i have already told you

now once again i am repeating the situation because it is very important that means without manufacturing a shape cannot be given

so the first one we can think of in the manufacturing of a machine element is primarily its size

now you understand once we talk about size say the shaft dia is ten mm that means you have to manufacture a shaft whose diameter is ten millimeters

now it is very difficult irrespective of any manufacturing device whatever may be its accuracy be to get a shaft exactly of a ten mm dimension hence what people follow that you mention some tolerances while designing a machine element

so that in one word is called limits and fits we take up the idea of limits and fits in the manufacturing before manufacturing a machine component and let us discuss about that particular point

let us have a look to the slide

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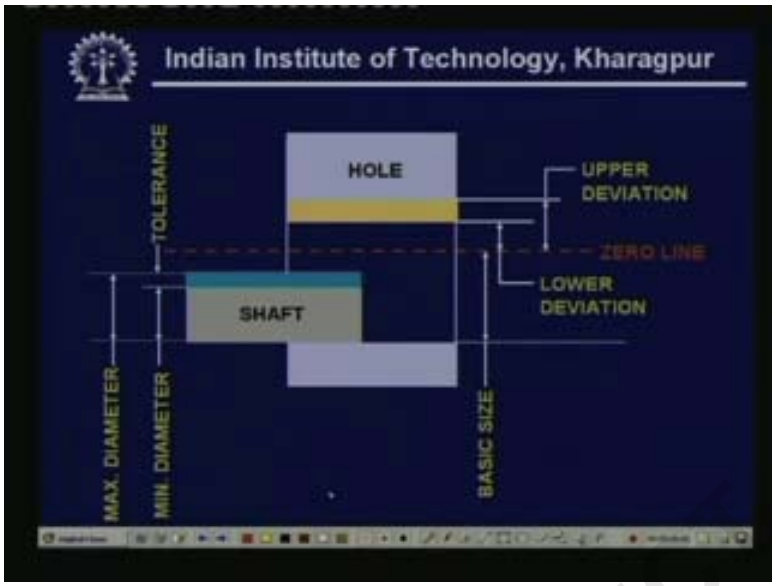


[Noise] first of all we consider a situation which is something like this that this one is a hole means if we consider this portion this is the body where you have made a hole and this is another object solid object we normally we call it a shaft

what you understand that any ((mating)) (00:05:17) parts just like an hole and a shaft are being considered in this manner that means what i mean to say that any machine machine elements which is having a mating parts are normally while describing the limits and fits are referred to as shaft and the hole

shaft is a solid object which goes inside the hole and this hole is also machined and the shaft is also machined and as i told you that this machining or in one word i am using the word machining uh the machining implies at this moment a manufacturing okay

while machining has got a a typical implication that we will see later but still ah here i am just uh loosely speaking let us talking about that it is being manufactured through machining

well when [Noise] considering the dimensions of the shaft or the hole that means you have machined a hole of this size and you have machined the shaft of this size

now here you can see one line in red colour mentioning as zero line this is a zero line has been referred to what is the idea of this zero line

here you can see that onto the hole of course if we take a section so this if we if we consider this one then what we are talking about if we take a section like this

then the one side of the hole this line suppose is in the same line of the shaft or the bottom side of the shaft is coinciding exactly with the bottom side of the hole while we are viewing in the cross section

so if we had made the shaft this particular point exactly touching to this line and the this side of the hole exactly touching to this particular line then what we would have told that this as i given as for the take present example what (( )) (00:08:11) i am just specifying suppose this is ten mm okay or shall i put it that that this particular one if we consider say some arbitrary value x mm

then [Noise] the size of the hole when it comes over here is x mm and the shaft is also x mm so x mm shaft is going inside a x mm hole

that means the dimension as we have referenced from this point that means this point to this point this length what we called as a basic size

so what we understand the zero line referred to be as the basic size with respect to a datum or respect to a reference line

so ideally suppose we do not consider any of the manufacturing tolerances then we consider shaft is of x mm and hole is of x mm thereby the drawing would have been something like the this is the shaft size and this is the other one would have been the the simply the hole size

so this is matching exactly in the same dimension this hole is also x mm shaft is x mm which once again we consider to be the basic size [Noise]

now you understand that just after looking through this drawing that if we make both the hole and shaft exactly as the basic size then it would pose difficulty in putting the two objects in this particular manner as two mating objects

the reasons the reasons being that you will always some inaccuracies in while manufacturing

now in this particular case the shaft might be going inside loosely it might be just a snug fit or it must it could be a tight fit

now depending upon the situation the x mm where the basic size what has been referred to in that drawing will have some changes of whatever magnitude be but there will be some differences from the basic size

normally what happens when you give a preliminary design drawing then we refer to the machine element dimensions in terms of basic sizes

however one has to provide a manufacturing drawing to the manufacturer while your desired tolerance zones are to be specified and this is once again let us have a look at to the figure and get some other nomenclatures normally used in design for giving to the final ah for giving it as an manufacturer's drawing

so once we have understood the idea of the zero line and the basic size then let us come down to some other {defit} (00:12:11) definitions

the blue coloured this blue coloured zone over the ash coloured grey coloured shaft what you can understand is that this is the band of tolerance means if you are manufacturing then the changes over the size could be anything within this particular zone

so thereby you can see the maximum diameter of the shaft could have would would have been this this thin and the minimum diameter of the shaft will be up to this much

so anywhere we are keeping in between these zone and which is referred to as tolerance what we have what i have just uh uttered several times while talking about this particular ah manufacturing tolerances

so this what we talk about is the word known as tolerance

that means you keep your manufacturing of the product or the machine you are using for manufacturing in such a way that the shaft dimension will be somewhere within this zone that means it will be lying somewhere within this zone

so that is what we call the manufacturing tolerances

in this similar manner what is happening that if you consider the hole in this case of the hole this {ss} (00:14:03) particular zone this particular zone what we are considering is the tolerance just like the way we have considered for the shaft

now again with reference to this particular zero line what we are getting we are getting two situations one is that from the zero line you are having the hole up to this much

one condition another one from the zero line you can go up to this portion okay that means the upper limit and that is this particular deviation from the basic size is called the upper deviation this is the upper deviation what we understand means what do you mean by upper deviation

this from the zero line what is the maximum dimension of the hole which we expect and the lower deviation uh uh ah this lower deviation means

this is the minimum diameter so you understand the diameter of the hole should be somewhere is the minimum diameter and it is going to be a maximum diameter

so that uh just it is going opposite to the shaft okay the maximum in this case is going up to the insight and here also this much is the maximum in the shaft

so if we try to find out the same idea that means upper deviation in case of the shaft then this is the upper deviation and the other one will be the lower deviation

that means upper deviation refers to the word always which gives you the maximum dimension and lower deviation on the other hand gives you the idea of the minimum dimension

so this is the lower deviation and upper deviation as i have told you

now all these deviations what has been referred to in this particular figure are always measured with respect to the zero line at the basic size

now in this case there are several ideas one can think of that means if the shaft diameter is suppose ten mm and we refer plus say plus x minus y what it means

that means the shaft is having the nominal size or the basic size of ten mm whereas its dimension can increase by x mm in the upward direction or it can be lowered by y mm in the downward direction means it can be nine point something or it can be ten point something

now this way if you are giving the tolerances both on to the upper side and the lower side then it has got a name which is called bilateral and in case you give the same dimension once again ten mm having minus side zero point zero and plus side say x then it refers to a system that means only in one side you are giving the tolerance and that is sometimes referred to as unilateral

so we understand [Noise] that the tolerances can be of the two types one is bilateral another is unilateral that means both sides you are giving tolerance and ((at or)) (00:19:01) you are giving tolerance to the only one side

so we come across certain definitions the definitions are the basic size sometimes the basic size are the same as the nominal size we understand in the similar manner then we understand the word tolerance and then what we understand the ah deviation tolerance means the typical machine element its bounce are known as the tolerance

wherever we ah we have also heard of an word called deviation now this deviation means that from the basic size how much the actual size of the machine element can deviate that is what we call the deviation

now in this respect one can talk about also another word which is called fundamental deviation

what is understood by the fundamental deviation that means if you are considering either of the upper deviation or the lower deviation from the zero line then either of these two can be referred to as the fundamental deviation

that means in some cases you can consider the fundamental deviation with respect to the upper deviation or sometimes also people can consider the {funden} (00:20:43) fundamental deviation in terms of the lower deviation

i suppose that the figure ah if we look into once again then you understand what i mean to say

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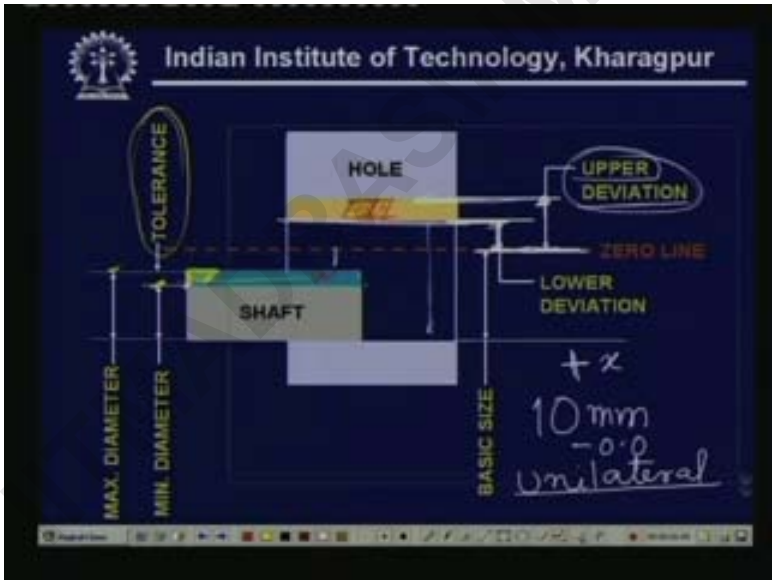


that means here what i am just referring to its is that this is the line

this is the tolerance zone so this could be a fundamental deviation means this is the fundamental deviation or this is also is sometimes also referred to as an fundamental deviation

so these are the some useful notations or the useful words we normally think of when we consider the concept of the clearance ah the tolerance clearance and the deviations etcetera as referred to the manufacturing of a machine element

now

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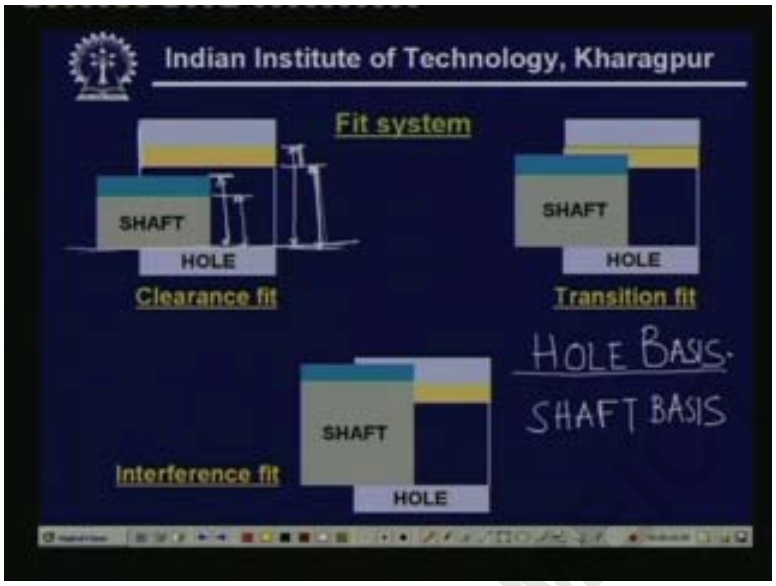


in this case you can see in the slide a word is written it is called fit system what is actually a fit system fit system means simply the English word how it fits how a shirt fits on your body

is it a loose fit or it is a tight fit or it is an over tight fit okay

so normally a people of ah in uh in ah in this particular ah difference i can say like this you will be finding out the shirts are normally a loose fit near the chest but majority of the Indians we do have a tight fit at the stomach level

well so it also refers to the same thing when you talk about the mating machine elements

again we give the reference of the type of fits with respect to the shaft and a hole let us look into this particular aspect

in this case you can see there is a hole as usual as it has been depicted in the earlier picture so this is the hole

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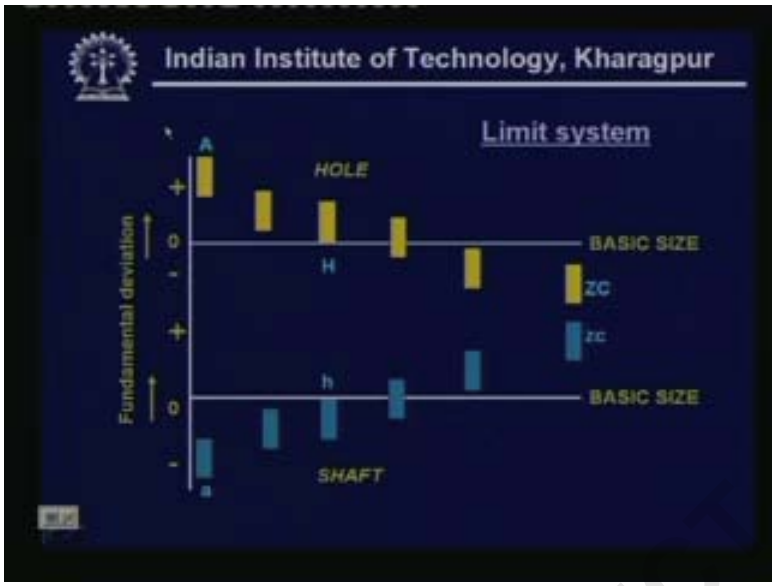


so in this case the hole can have any dimension which starts from here and which ends over here means anything starting from here to here after this much

so this as per our definition we consider this to be the tolerance zone and this is what we are considering the minimum size and this is the maximum size

in the similar manner the shaft can have the maximum dimension and it can have a minimum dimension in this case we are referring all measurements from this size

normally what happens there are two ways of representing this measurements one is the hole basis another is the shaft basis

what is the hole basis that means we consider the dimension of the hole to be the to be the reference over which we make up the measurements and shaft basis is the dimension of the shaft to be as usual being the basis of the measurement but normally it is very popular thing to use an hole basis

the reason is that you how do you make a hole you will be i uh think you from the preliminary workshop practice you know just by using a drill you can make a hole however if you make a shaft you have to normally you have to use a machine

so making a drilled hole always have a more chances to have a fixed size compared to a shaft

so thereby because of the manufacturing process involved in making hole being comparatively more fixed type in nature hole basis are more commonly used compared to the shaft basis

so here we consider a measurement which we will be considering as an hole basis

that means the hole lines are the same and shafts can have the different sizes okay

well ah in this particular case what we are considering is that first of all this is we call as an clearance fit what is clearance fit clearance fit means the shaft will be moving inside the hole in a loose sense means there will be a clearance inside the hole

how it is being seen

see even if the shaft dimension comes out to be of this size you can see that it is never touching the hole surface where all the measurements being made from the same line because the minimum diameter of the hole is always more than the maximum diameter of the shaft and that is what we call as an clearance fit

similarly if we come down to the next one there is also another fit which is called the transition fit

what is a transition fit means you can see that in the similar manner the shaft can have this is the minimum dimension of the shaft and this is the minimum dimension of the hole at this particular condition you can see there is a clearance prevailing in between the hole and the shaft so there could be a clearance fit as i have we have discussed for this particular case

in this same line if we look into it very carefully we can see that if the shaft dimension is this much and the hole dimension is this much then there is an overlapping of the dimension and this {dimen} (00:29:21) overlapping will be creating some sort of tightness in the fitting of the shaft inside the hole

so we define the transition fit in such a way that it can create a clearance as it was shown earlier this is the clearance or even it can create some overlapping fit so this is what we call as a transition fit

normally the press fit or the just a push fits are normally called a transition fits where the clearance fits are sometimes referred to that feather shaft is freely moving inside the hole

the third in its kind is the interference fit if we have a close observation no matter what is the tolerance level okay in both the cases the basic size of the shaft as you can see is basic size of the shaft as you can see is ending over here just one second uh the basic size of the shaft is here and the hole is somewhere here

even if we go to the maximum size of the hole or minimum size of the shaft there is always an overlapping in the basic sizes so that is what we call as an interference fit

this interference fit could be also a from a pressure fit to a tight fit this particular type of a interference fit can be defined where never a clearance fit will occur

so these are the three types of fits we consider while while we consider the ah design of the machine elements in terms of how it is how a shaft is going inside the hole now this is the idea

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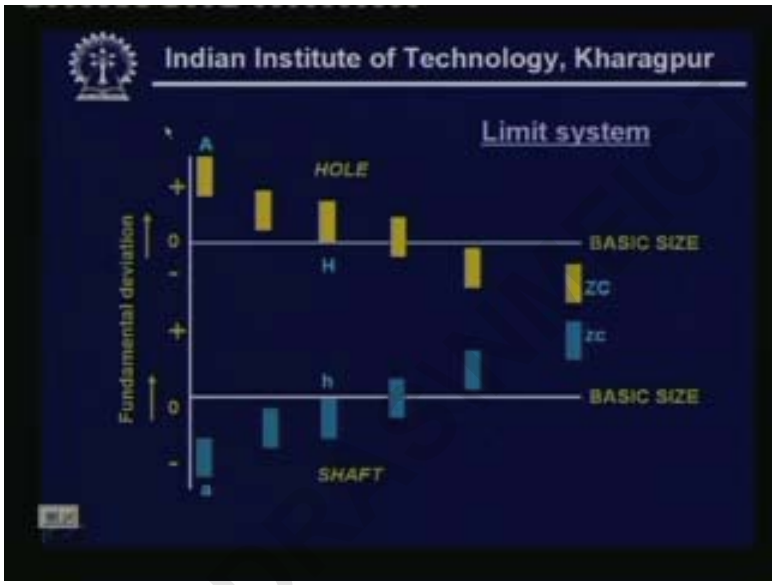


if we just look at the board you can see we have drawn ah schematic view of the another system what is called the limit system

what is a limit system means what are the basically the tolerances or the fundamental deviations from the basic size the limit system goes in this way say this is the basic size of the shaft this is the basic size of the shaft and this is the basic size of the hole this shaft and the hole

whenever you cross i think i should (( )) (00:32:54) whenever it cross this zero point this is more than the basic size when you go down this is the less than the basic size and that is what we understand as the fundamental deviation what we have learnt just before

similarly from the basic size the hole can be larger or hole can be smaller

now here while considering the limit system these are referred to as a tolerance zones where you can see that if we consider this limit system this limit systems are denoted by the letters A to ZC having all twenty-five the twenty-five divisions where H is a special case we will come across

similarly for shaft we have the same A to ZC but these are referred to in the smaller words

so when i consider this feature then you can see one thing something like this say we consider the A we consider this H one that means what is this idea the A means that always the deviation from the basic size is this much whereas the manufacturing tolerance is denoted by this much

now if we consider this is the manufacturing tolerance and this is what we are considering as the fundamental deviation

now just {ca} (00:34:48) before considering this one

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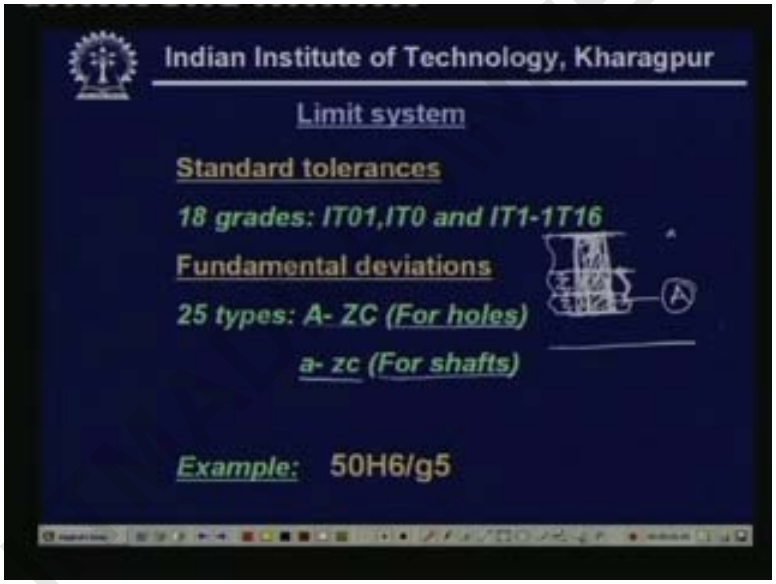


let us have a look to the limit system what it refers

the standard tolerances are there about eighteen grades which are referred to as IT zero one which is referred to as IT zero one IT zero and IT one to IT sixteen so sixteen plus two eighteen grades of standard tolerances are there and as i told you the fundamental deviations are twenty-five types which are A to ZC as i have mentioned earlier for the holes and small a to small zc for shafts

that means you can have a combination like this just you look at this figure suppose we have been talking about the A A for the A this is the standard fundamental deviation okay when considering A this is A when i considering A the fundamental deviation is this much of the however you how you refer to let us refer to this is the fundamental deviation as i told you fundamental deviation is ah referred to with respect to the lower deviation or the upper deviation

well if this is the fundamental deviation then this is the standard tolerance if we are having IT uh i i would like to draw this figure once again and just for a clarity sake uh this is the A i have drawn in a smaller manner than earlier drawing reason is that this tolerance level

let us consider as say IT one in the similar manner if we take IT five say then this tolerance band increases

see the look fundamental deviation is A but i am giving a more tolerance to the manufacturing and if it is IT sixteen then the tolerance again increases that means here one manufacturer can be very comfortable because he has got a wide tolerance

so this is the basic fundamental idea means you are having an fundamental deviation which is of the category A however for A its tolerance in manufacturing could be IT one suppose this much IT ten suppose this much IT sixteen suppose this much

well IT ten means from starting from here i'm sorry not from here okay this is an IT ten say this is all schematic and this IT zero one IT zero and IT one to IT sixteen etcetera has got the standard values in microns and for this you can refer to any standard uh manufacturing catalogue or a design catalogue in both the cases you will giving you will get the standard tolerance values required for a manufacturing

similarly if you go for another fundamental deviations say for B C so and so forth you can {ex} (00:38:21) you can express the fundamental you can get an idea of the fundamental deviation in microns over and above that you can have a tolerance grade for that fundamental deviation which are denoted by eighteen standards

so once again i go back to the earlier slide which shows here that like A you are having another one which is the H the specialty of giving H you can see the fundamental deviation for H is zero that means sometimes this one is that is the that is one we call as an hole basis or something where we do not have any deviation on the lower side from where the measurements are being

made and in the similar manner you can have a shaft having a fundamental deviation zero so this is an if you are measuring the shaft deviation to be zero so this is another way of the shaft basis

that means when when when you consider the hole basis as you understand that we told that all measurements are being made from the hole line that means the hole lines are made to be the referenced lines

now here uh see this particular deviations uh fundamental deviations zero at the lower side but whatever the upper side say this zone if we had taken this much of block this refers to say IT three this much of block say refers to IT four and this much say IT six like that

that means what is mean to say that height of this blocks are basically referring to standard tolerances whereas the later over here is designating you about the fundamental deviations

so if we want to have an clearance fit say for example then uh can we not think of these zone this is a zone where you can have the ah clearance fit because we can see the basic size of the shaft is uh the size of the shaft sorry is lower than the basic size and size of the hole is more than the basic size so there will be a very good clearance fit

however in this manner if you this particular zone once again i think i should mention this particular zone of the H if it is exactly like that we sometimes use a word snug fit okay

so this is the zone if we consider all the H zone

similarly if we go to the higher and higher along this line you can see the fits are becoming the tight that means in this limit system the fit you will be opting you will be getting in the {mi} (00:41:34) in the pair of machine elements will be of the nature of a tight fit what we call as an uh this is interference fit etcetera

now here uh of course uh this is just an idea i am just trying to say this is the clearance snug uh and the weight at if it is normally you know people won't be referring to this zone very ah it's a very rare zone where you have this type of tight fits okay this is mostly a very ah high hammering or pressurizing only can keep two machine elements namely a shaft and hole in a mating condition so this is what we understand by the limit system

so what we have learnt just up to this particular limit system that means we know that a machined element cannot have a unique dimension

uh here the word unique i mean to say is that you cannot uh you cannot have an one you have two ah dimension which should be little varying over nature varying means you have to specify a dimension having a zone and that particular zone is what we call as an tolerance and the deviation from the basic size or the how big or how small from the basic size we call as an deviation

as far as how a shaft getting inside a hole if we want to clarify the condition then we describe this by three types of fits one is clearance interference and transitions and lastly we saw the limit system where we define uh by typical word English words A to ZC all capital for a hole system and small a to small zc all for the shaft system to define what is a type of fundamental deviations normally adopted in in a manufacturing of machine elements and for that we do have this situation which is like this

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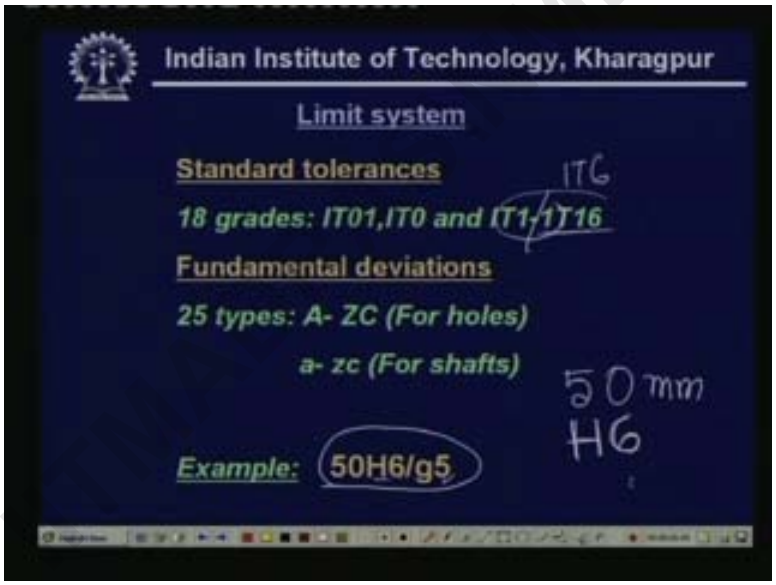


a limit system is defined by standard tolerances which are of the eighteen grades higher the grades means higher the tolerances and fundamental deviations are of the twenty-five types as i mentioned A to ZC

now uh you understand that if you just going and machining on a lathe then maybe this IT one IT zero uh can be achieved ah for ah uh hum very good machining systems and every standard one something like around five six

however ah a larger sides like IT sixteen etcetera ah normally may occur in cases of some rough castings and other things ah you can expect such situations

so as for example lastly if we look at the board please then you can see that i have written an word fifty H six g five what it refers to

it refers to its basic or nominal size is fifty mm H is the hole basis system where you know the limit system using H means you do not have any lower deviation fundamental deviation is zero for the hole and as is hole basis it is written first and six {xx} (00:45:44) shows that in this zone you are using an IT six grade okay

so that means this tolerance grade is six grade

similarly this g five represents that you have used the g as the fundamental deviation where you are using the five as the standard tolerance as for IT five

so this gives you some idea basic idea of how you dimension a machine element what you have designed when it is ready for what ready for manufacturing

now another important fact also comes is standardization and the similar word is also called interchangeability if you make an machine elements taking into these considerations okay that means you are giving an exact uh fundament exact limit and fit exact limit and fit i think ah uh i mean to say that you mention that this machine element has been manufactured with this limits and fits

so that by any chance in a machine one of the machine element goes wrong then you can utilize another machine element of the same dimensions having that much of the tolerance level so it gives you a very good interchangeability

another important factor also comes in this line what i just referred to as standardization means you are {manu} (00:47:41) you are making ah say rods you are producing rods of different diameters or you go to the market you will be finding out you uh you can purchase rods of ten mm size twenty mm size twenty-five mm size thirty mm size like so on and so forth

many varieties or the many sizes are available in the market then what is a basis that which are the sizes one manufacturer should produce

suppose if you are making an shaft then what you do you find out the dimension of the shaft and then to manufacture that shaft you require a material and then you go to the market and you have

you can buy a material of your desired size the desired size should be such that you will be having minimum amount of wastages

however how do the manufacturer knows which size you require if that is so then they have to manufacture rods of infinite sizes infinite steps many such sizes has to be stored in the market but that is not normally not done so what it is being done let us have a look

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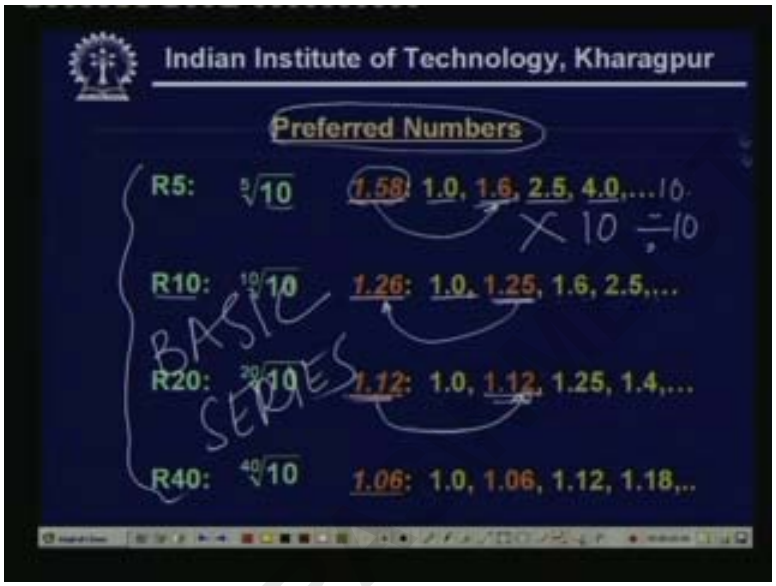


this particular idea is called the preferred numbers what are the preferred numbers means uh it has been seen it has been observed that if we make a size of an any objects of various sizes suppose a size is x then has a y then has a z like that then all the sizes will have what will have a difference something like that uh which always follow uh geometric progression that means in a gp series if it is being made then the sizes comes out to be quite logical

in the same similar {manna} (00:50:09) uh looking at this particular fact these sizes do have a common ratio just as we see in a gp series to be more precise what we understand that what should be the common ratio let us have a look to this particular one

when we call talk about R five series now this word R has got a connotation it is uh to it is known as a Renard series okay named after Renard okay

so this one what we get is something like this that R five means fifth root of ten so which approximately value is one point five eight now what you do is that you conveniently round it off

so what would be the sizes one one point six what is see this one is rounded off to one point six

next you will be having two point five four so and so forth until and unless you reach the ten

similarly if it is R ten it is tenth root of ten and this value comes out to be one point two six see here also it is rounded off in a convenient manners one point two five and you get a series like this

R twenty refers to one point one two here you can see no ah rounding off as such has taken place similarly for the odd forty series that means this R called the preferred numbers and all these are called as the basic series

whereas if we multiply this by ten or divide by ten or hundred anything like that then we get the series what we normally call as the word preferred series

so ah i am sorry ah this the spelling is preferred series okay so this is the preferred series we get so that means this way one can think in the line that you manufactured this products by in such a way that you follow a definite series so that you the in g i mean the designers know that i only get the sizes of this

so that if i design which requires something of say one point one and you are considering this series you won't you know that you won't get anything like one point one so you have to buy one point two five or you can you can {fi} (00:53:51) you can search for this ah series if the product is being made as per this series as i told that if the product is made i can give you some of the examples

as for example this R five R ten and R twenty this series are very common for the speed layout in machine tools you know machine tolls runs at different speeds so these are the speeds which can be as per the series R five R ten or R twenty but most common is this one

that means you can have thousand twelve hundred fifteen sixteen hundred twenty-five hundred like that what i am doing i am multiplying by an {mulitip} (00:54:37) multiplication factor

you can have the powers of a tractor engine may be ten sixteen twenty-five forty something like this you can have the fit in the machine tool as per say R twenty which can be which can be R twenty or R forty these are used as a machine tool feed

okay you know machine tool feed you have just done in your preliminary workshop classes this particular things are made i mean the machines or the diameters of the rod what i what to say that

mean (( )) (00:55:26) or the basic materials what will be used for machine element designs are made as per a standard which are governed by the preferred numbers

the next one we can think of that

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there are several one should have all though i am not going very details i'll be very quickly i will just go through to give you the some ideas of the manufacturing processes

the manufacturing processes could be say the shaping joining machining surface finishing and some non-conventional machining ideas and over and above there is one called a heat treatment

what is this heat treatment

whatever the machine element you manufacture either by all these methods can be ultimately can be going through an heat treatment process and going through an heat treatment process to uh increase its material properties so that is an heat treatment process now here

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once you know this one we just look into the shaping what are the shaping the shaping process is consists of say casting forging extruding rolling

casting you know that means you on to a mould you put a molten metal and that gives you the shape of the machine

forging means in the same way it could be cold forging hot forging you can just uh make the material make the material hot or may be cold also and then you put it into a shape by hammering in an machined way all right

that means you just by pressing the material either hot or cold you can get some shapes and of the machine elements so that machine elements are uh i mean made uh in a rapid way by say casting forging extruding as a very good example how you make out the pipes etcetera

rolling you know sheet metals are being rolled so these are the shaping procedures

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in the similar manner you can have the machining you have gone through i suppose the turning shaping milling and drilling these are the certain procedures you used in lathes and other machines milling machine shaping machine etcetera and then you go

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for the surface finishing procedures which are mostly the buffing horning grinding lapping and electroplating

now these are the surface finishing process you will be learning more about these things i am just giving you an just brief idea of the processes that's are involved and

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joining are the processes where you used the welding riveting brazing screw joints screw fastening is also a joining procedures

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and lastly i go for a non-conventional procedures which you can see are given over here as ultrasonic machining laser beam machining electrochemical machining and chemical machining there are several other varieties you know the ultrasonic uh machining utilize an chemical energy the labor laser beam machining utilizes a thermal energy so this is an thermal energy this

electrochemical machining uses an electrical energy and chemical machining uses of course a chemical energy

the ideas of non-conventional machining is coming out in a very big way and that we will learn later

so i feel that you have got some ideas of the machining processes how it is related to the design so we continue our discussions further on machine design in the next class

thank you