Engineering Metrology

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Lecture – 05
Limits, Fits, and Tolerances (Part 1 of 4)

The next topic of discussion is going to be Limits, Fits and Tolerance. This is a very very important topic for discussion in the course of Metrology, what happened initially was initially people when they started producing things, it was all more of mass customization and people used to meet a customer, a manufacturer used to meet a customer understand all his requirements whatever it is he use to understand all his requirement then he puts a thought process on it converts that the thought process into a very rough drawing and based on that drawing he tries to manufacture a product and give it back to the customer.

So, what is the advantage of it? The advantage of it was the customers voice could be listened and the manufacturer could produce customized to whatever the customer wants, but what was the disadvantage of this system the disadvantage of this system is he was not able to mass produce. And second thing is they were not many artists who were available to understand customer needs and convert it into a product, so there was a very tight situation where in which the number of products produced were less, the number of artesian available was less and the skill what they were requiring; that means, today the manufacturer should understand right from drawing, he has to understand all the process till he gets converted into a product.

Then the scenario slowly change that the change in scenario was in manufacturing people thought of let us start making mass production rather than mass customization, in mass production what they did was they said let us keep on producing and then let us make the cost come as low as possible and try to cat up to the customer need. So, here customization was not given a priority, but production and giving the product at a economical price was the priority. So, when this has to happen, the complete product manufacturing could not happen and one under one umbrella, due to several reasons available of raw material then availability of expertise all these things were there. So, then people decided is let us try to produce parts given to a drawing and if there is a negative of at all, if there is an assembly which has to happen then there has to be a counter path that path will also be produced to a particular drawing.

So, then what happens is you can take a male part from one country or from one factory a female part from some other factory and both these things match to a particular drawing. So, they were able to produce up to the drawing and then assembly could happen at a different place they could produce. So, from mass customization people move towards mass production. So, in mass production it is very clear the drawing has to be made proper and the drawing whatever is given in the drawing that has to be produced. So, you do not worry about rest of the parts in the product, you worry only about your part.

So, now once they see a drawing and once they start producing then it is a responsibility of the manufacturer to validate his produced path whether it meets to the requirement or not. So, if that is the case, we are supposed to understand what is limits fits and tolerance ok.

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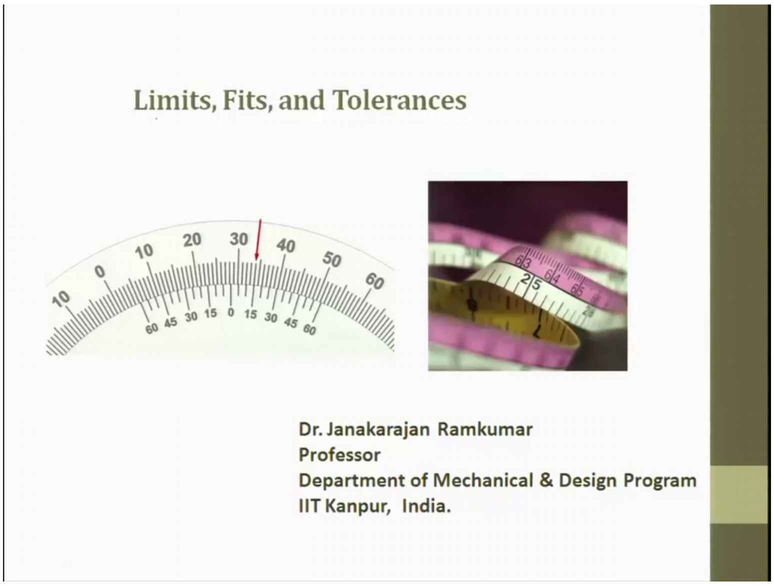

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This is a very very important subject. Today part, the product is assembled at Taiwan, the parts are produced at India and China and some parts are produced in Japan and USA all these things get assembled at Taiwan and the customer is in Sri Lanka, you see for one particular product you see where all the parts are produced and now the question comes is how are these parts produced at different places they are able to get assembled at one place and how are they able to deliver it.

So, when you look at it the entire world goes into this scenario. So, the parts are produced according to the drawing. So and how do you make sure that all parts produced can be assembled? So, then there has to be a small leverage given to the part, which is produced, small amount of error which is allowed. So, then naturally what happens within this error if you produce a part. So, in that counterpart same is also done then it gets assembled. So, this is a very important topic this made a revolution in manufacturing, this made mass production and economical products come into the market.

Today's scenario is much more interesting people are talking about let us make it let us make the product mass customized, but at an economical price. So, they are trying to take the ancient idea mix it up with the industrial revolution idea and today they are coming up with a new evolution of mass customization and produce parts economically which is a big challenge. So, when I say mass customization the bad side what we are talking about is only one. So, this topic becomes very important for all those things to realize.

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So, in this we would the content of today's lecture will be I will have some introduction and just before introduction I will like to cover two three concepts which people have asked questions. So, let me explain those basic 2 3 concepts and then get into introduction for this chapter then principle of interchangeability, interchangeability the name itself clearly says I can change, I can interchange parts and then take it to an assembly, then other thing is called a selective assembly then comes tolerance then I will try to discuss about fits, then I will also finally, try to discuss about system of limits and fits.

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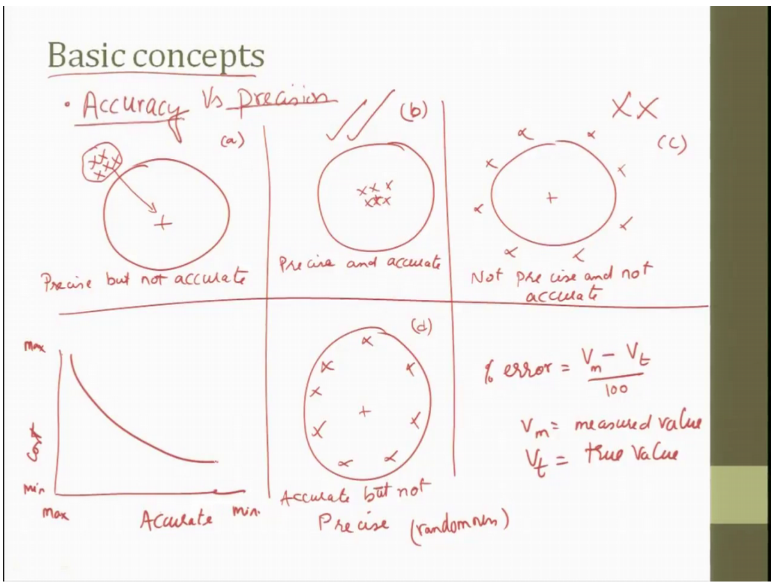

Ok based on some of the queries which are raised by the students I would like to explain first a basic concept called accuracy and precision though I gave you only the definition now I will give it with respect to a figure, so that you can appreciate it.

So, accuracy versus precision, these 2 terms are in English language it is interchanged, but in engineer's language it cannot be interchanged that to especially from the manufacturing perspective if you look at you cannot interchange these 2 words. These 2 words have very different meanings. So, let us try to explain the concept with a bull's eye and a shooter is there, a shooter is trying to affect at bulls eye and he is trying to play. So, let us try to take that condition for simplicity for understanding.

So, here is the bull's eye ok. So, if the shooter hits everything here there can be a possibility, then the next possibility can be there will be, bulls eye is here and the shooter hits everything here exactly at the center ok, the third the four third condition is this is a bulls eye and he hits at all this round the bulls eye he try to hit and the last one is going to be he tries to inside the bulls eye, he tries to hit.

So, this is this condition is nothing, but if his, he is very precise, but not accurate, here he is very precise and accurate, he is not precise and not accurate and the last one is he is accurate, but not precise, not precise ok. So, here if you see he is exactly focusing and hitting at this portion and all his shots go towards here, this is a center, all the shots go just little away. So; that means to say he is precise, but if there is a small correction made then it becomes very accurate, whereas, this player is very accurate he exactly hits at the point where things have to fall here, the process or the machine or a shooter is precise and accurate. Now you understood this is precise, but not accurate, this is precise and accurate.

The next one is he is neither precise nor accurate. So, he is completely hitting (Refer Time: 10:00) and the last one is he is accurate, but not precise; that means, to say he is trying to hit within it, but he can he is not precisely hitting. So, what I said a shooter you can replace it with a machine, a machine can produce path very precise, but need not be accurate. So, in this case what we have to do is there is something called as an error and every time it is there if error is going to be the same.

So, then what we can do is we can shift the precision to accurate by doing some modification, may be when you take a shooter example he has to be given proper spectacles or something. So, that he can accurately see at the bulls eye and hit it and in the same way process you can try to give a fixture or you can try to change the tool to produce this, when this is the very well accepted, this is the very well accepted thing where it is precise and accurate, this is completely not acceptable because whatever is getting produced is scrap whatever it is getting produced in this machine or whatever is a shoot or firing everything is scrap. So, this cannot be accepted at all.

But here what happens is the other thing is it is accurate, but not precision. So, here there is lot of randomness involved. So, we are supposed to understand the randomness and try to convert all this; the accurate one into precision for a smaller thing. So, now, it is very clear you should be now be able to distinguish what are the difference between accuracy and precision.

A process can be précised, but need not be accurate this condition a process can be accurate need not be precise this condition ok, condition a, condition I will put it as b. So, a is also existing, d is also existing what we want is d what we completely do not want is c, when parts are produced in c fashion then immediately the machine is relook reset corrections have been made and they try to bring it back to b state, is it clear. So, now, let us look at the definition for error. So, I discussed in the last class also error is what is measure minus what is the true value divided by suppose if I say percentage then it is divided by 100. So, V m is the measured value and V t is the true value what is expected or whatever it is right.

So, with this we will try to find out error this error is used to correct and make the process more precise and control. So, I would like to bring in one more graph, so that you can appreciate, you can be with respect to you can put it as with respect to 100 or t ok, the other one is we wanted to discuss about cost versus accurate, this is maximum, this is minimum, this is, cost is minimum and this is maximum. Generally it follows a trend like this (Refer Time: 13:26). So; that means, to say if you want to have very good accurate thing then the cost is going to be high ok, this is what the (Refer Time: 13:36), when you want something little less accurate, so then you can see the cost of the production falls down drastically.

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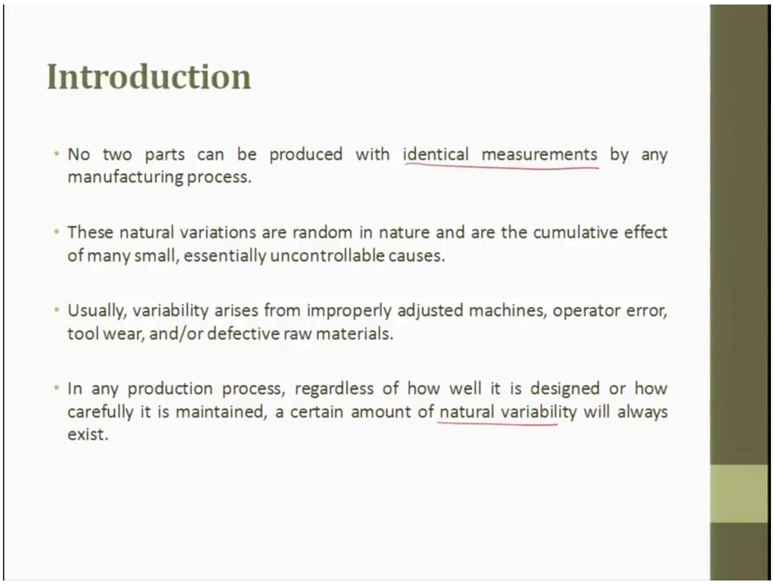

So, now let us get into the topic of discussion for limits fits and tolerance. So, introduction no, two parts can produce with identical measurements by any manufacturing process, any process or any event to happen follow the binomial distribution right. So, if that is the case then any two parts produced if you want to make it as accurate as possible they it is next to impossible. So, there is no manufacturing process in this world, which can make two products very identical.

There will be a small variation right. So, this has to be accepted, these natural variations are random in nature and are the cumulative effect of many small essentially uncontrollable causes. For example, you might say the work piece which is given for producing a shaft should be as precise as possible fine. You can check the dimensions, but moment every dimension is then even after that you will see you go to the microscopical structure you see there is a small amount of randomness within the grain size.

So, these are uncontrollable parameters. So, this is what with a small uncontrollable parameter, all joint together to form to bring in a small variation, so that variation makes it very difficult for manufacturing process to make them identical. So, usually variability arises from improperly adjusted machines operator error tool wear and or defective raw material, this we are talking about the macroscopical state when you look into the microscopical state, there are variations which are coming into and that is why we are trying to say this identical measurements are very difficult to be made ok. So, in any manufacturing process regardless of how well it is designed or how carefully it is maintained a certain amount of natural variability will be existing ok.

Now, you know there is natural existing there is a natural variability will be there. So, now, what you can do, one you can say I will spend hell a lot of time and money and make sure that there is no variation that is one way of doing it, the other way is doing it is I legalize it, I legalize it fine. I will try to allow you to have a small variation, but please make sure you produce everything within that small variation. So, that is the natural variability which is there and you officially declare that is nothing, but the tolerance ok.

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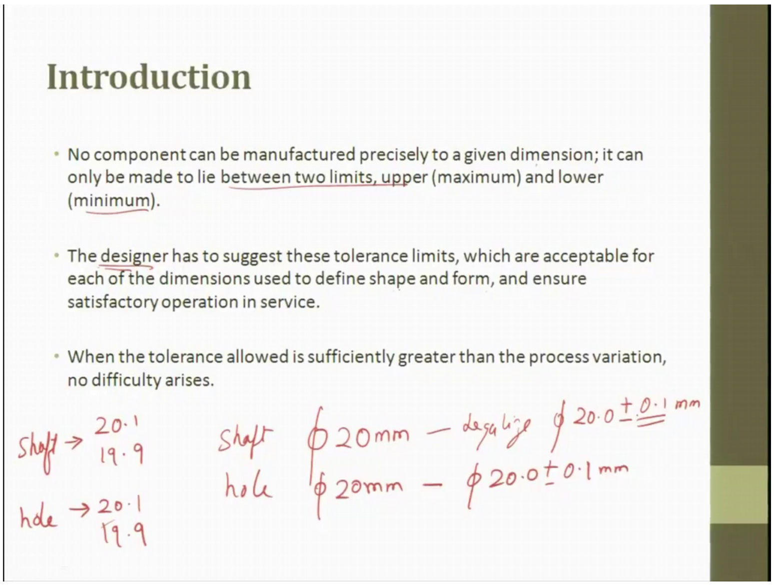

So, no component can be manufactured precisely to give the given dimensions, it can be only made to lie within two limits which is upper and lower limit. So, what we are trying to says we are trying to say if we have to produce a diameter of shaft 20 millimeter exact precise 20 is next to impossible. So, what we do is we try to legalize and say diameter 20.0 plus or minus 0.1 millimeter is accepted for my shaft and correspondingly when I produce this shaft will get into a hole I will also try to produce a hole 20 point something where I will try to say this whole can be produced 20.0 plus or minus 0.0 or 0.05 or something like that or I will try to say make it also 0.1 millimeter.

So, you see there is this is a shaft this is a hole. So, I try to say for this shaft I allow some variation to happen, for this hole I allow some variation to happen. So, now, what is the two extreme ends are called as upper limits and lower limit. For a shaft what is the upper limit it is 20.1 and lower limit is 19.9. For your hole what is your upper limit of your hole and what is your lower limit of your hole; the lower upper limit and lower limits will be different.

So, here also you will have 20.1 and 19.9. So, your hole if it is very 19.9, there is maximum amount of material. So, here you had maximum amount this is 20.1, which is on the upper side, this is on a lower side. When you try to take a hole this will be on the upper side and this will be on the lower side with respect to material.

We will see that little later the designer has to; it is the it is the need for the designer to suggest such tolerance limit which are acceptable for dimension used to define shape form ensure satisfactory operation and service. When the tolerance allowed is sufficiently greater than the process variations no difficultly arises; that means to say the tolerance whatever I give this tolerance if it is higher than the process variation. So, then I do not have any problem in producing and when you try to argue in that way in when you take any machining process you have lot of mechanical moving parts.

These mechanical moving parts over a period of time has wear and tear. Because of this wear and tear there is always a small fluctuation or variation in the values. So, those things when we try to take into existence there is always an upper limit which you have to give and a lower limit which you have to give.

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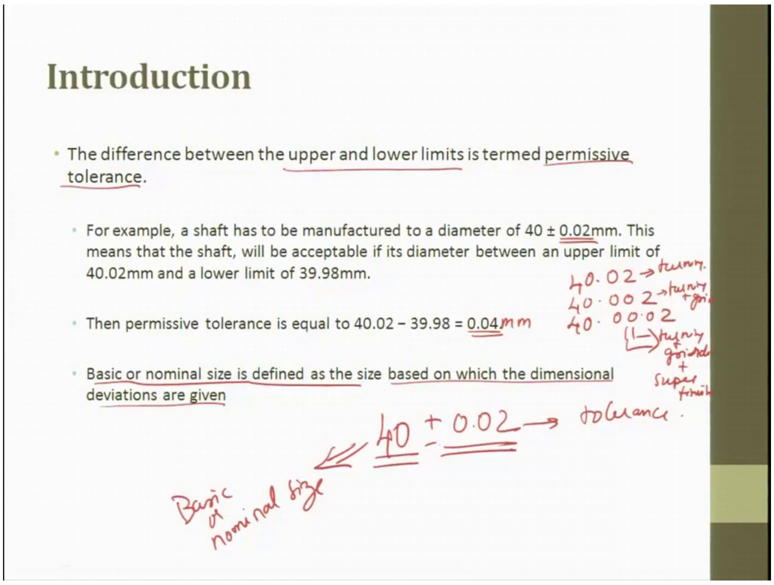

The difference between upper and lower limit is termed as permissible tolerance so I tolerate I tolerate, so that is why it is called as tolerance. I tolerate the variations that is why it is called as tolerance. For example, a shaft has to be manufactured to the diameter of 40 plus or minus 0.02 millimeter, this means that the shaft will be accepted if the diameter between the upper limit of 40.02 and lower limit of 39.98.

So, what is the maximum permissible tolerance? The maximum permissible tolerance is upper limit minus lower limit giving you this unit will be millimeters ok. So, this is what is the same way you can also have for a hole we talk about tolerances and here what we talk about a hole shaft and all it is of 2D you can also extend this geometry in 3D form you will see the tolerances given in today in now a days we also give it in three-dimensional tolerance variation for a part.

So, now, a basic or a nominal size is defined as a size based on which the dimension deviation are given. So, what are we trying to say 40, 40 is the basic size basic or the nominal size. So, plus or minus 0.02 ok, this 0.02 plus and 0.02 this is nothing, but the tolerance which is given ok.

And the other interesting part is why is this tolerance given, looking into the tolerance I can also decide which process used to produce this part. Suppose if the tolerance is very tight for example, let us try to see an example of 40.02 I have to produce the shaft, I have to produce the shaft for 40.002, I have to produce the shaft for 40.0002. So, if you look at it this can be done by turning, this can be done by turning and the next process will be grinding. If you go for this it will be looking forward turning plus grinding plus you will look for some super finishing process some super finishing process, we do not know what is it, but you will look for a super finishing process.

You look at it just by looking at the tolerance now what I have done is I have added processes to produce this part. Now if you go back today just now we discussed as the accuracy goes higher and higher the cost goes high; why does that happen? Because now you see lot many process are getting involved to produce a accurate part.

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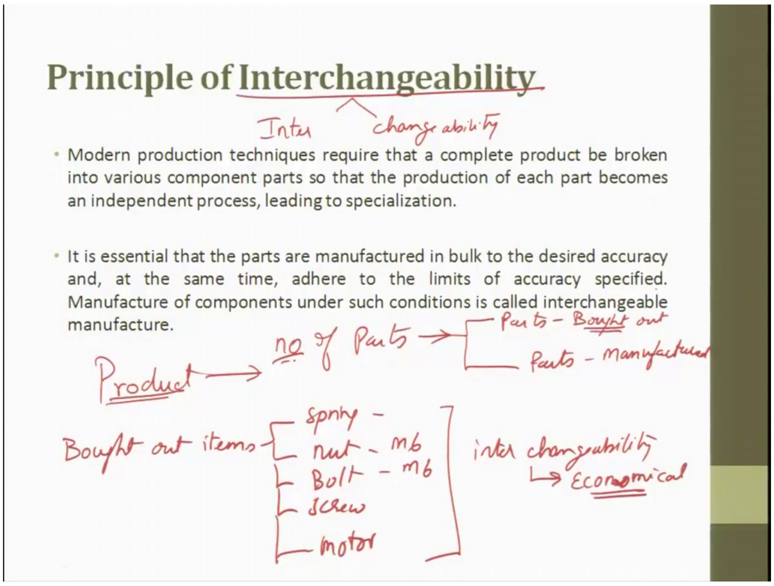

So, after this tolerance and why is all these tolerance very important, this tolerance leads to a new concept called as interchangeability. So, this can be split into 2 words inter and changeability ok, this concept gave me gave manufacturing a big break through modern production technique require that a complete product be broken into various component parts. So, that the production of each part becomes an independent process leading to specialization, see another thing you should also understand product is made of number of parts product is made out of number of parts. So, number of parts can be again classified into parts which are bought out and parts which are manufactured.

And before; so now bought out items means you buy it from the market which can be used to produce a product, certain things are manufactured. So, when you try to buy it from the market you try to give a specification only for example, bought out; bought out items are general items are spring, nut, bolt, screw. So, here we say M 6 nut, M 6 bolt all you go say in the market is please give me M 6 or even a bought out item for the product can be a motor complete motor ok.

So, spring you try to talk about opened open coiled or close coil spring and then you talk about the stiffness that is it you buy it from the market, you try to talk about diameter right, these are all some specification you give this is available in the market why see what happens to all these bought out items these bought out items will follow a concept of interchangeability because these this nut and bolt can be used for fastening of various products.

So, all I do is I produce it in bulk. So, so that I can get into the concept and I may give the parts in a economical manner, economical manner. So, in order to reduce the price this interchangeability has come up in a big way, it is essential that the parts are manufactured in bulk to the desired accuracy and at the same time adhere to the limits of accuracy specified. The manufacturing of a component under such conditions is called as interchangeability interchangeable manufacturing ok.

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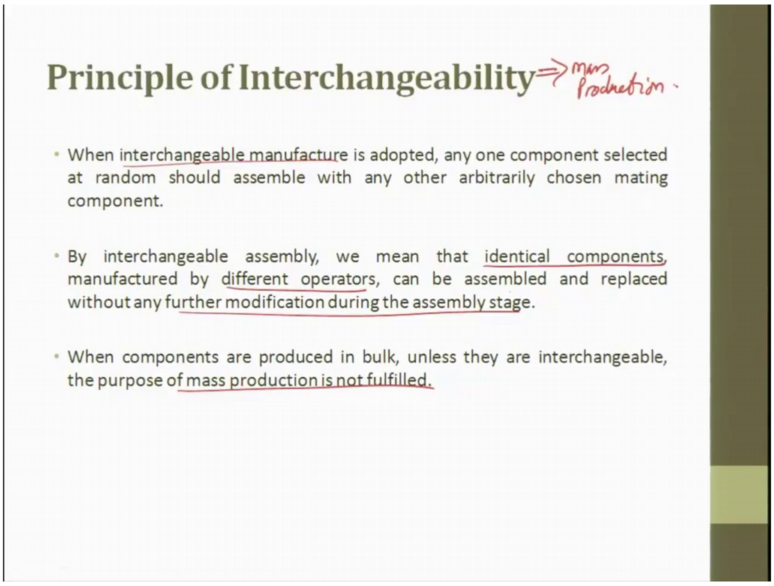

This gave a big revolution, when interchangeability of manufacturing is adopted, any one component selected at random should assemble with another with any other arbitrary chosen mating component. So, I have a nut a box of nut is there I pick one nut I take a box a counter say for example, M 6 nut I take and I have a big box of 1000s bolt I pick one M 6 bolt I should just try to mate it, it should assemble. So, that is the interchangeability in manufacturing.

And if that has to happen and you all we have already studied the nut will have a small variation in the dimensions, the bolt will have a small variation of the dimensions, these 2 are produced in such a fashion that they can get they can small adjustments can be made it can get adjusted and assembled.

By interchangeable assembly we means that identical components manufactured by different operators can be assembled and replaced without any further modification during the assembly stage. When components are produced in bulk unless they are interchangeable the process of mass production is not fulfilled. So, please understand this is for mass production. After the industrial revolution which happened in 1857 the machines which are getting developed followed the concept of interchangeability.

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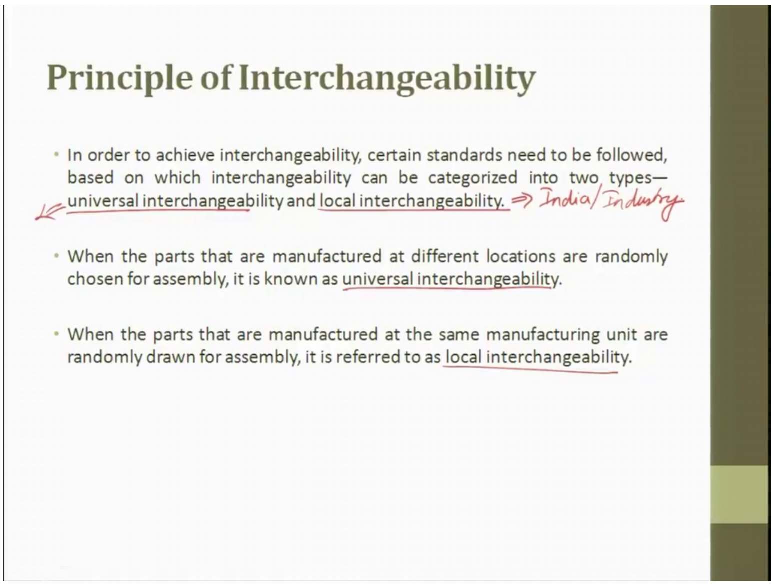

In order to achieve the interchangeability several standards need to be followed. See you should understand when I try to talk about interchangeability and I say interchangeability within India it is not accepted because how long can it be only an Indian supplier, you have to get into the global market. So if has to be into the global market then whatever you produce should match or should need a standard.

So, this certain standard needs to be followed based on the interchangeability concept and that can be categorized as universal interchangeability and local interchangeability. Local means what I was trying to talk about India, but today this scenario is slowly dying we are trying to look at global market. So, a vendor can supply to automobile industry which is located in Pune, which is located in Delhi, which is also located in China, which is located in Japan and US.

So, a single vendor there are companies today in India which supplies to all those people and they are particularly in the fastening industry they do it when the parts are to be manufactured at different locations are randomly chosen workably it is called as universal interchangeability, when the parts are manufactured at the same manufacturing unit are randomly drawn into the assembly it is called as local interchangeability.

So, here what I have done is I have converted this in my explanation I have said this can be your own industry for example, Maruthi is a industry, Hyundai is an industry, they can have their own standards and their standards meet out only within the assembly within their product only, it cannot be generalized to other producers right. For example, what is produced in the industry of automobile they cannot use the same screw which is used for machine tool manufacturer.

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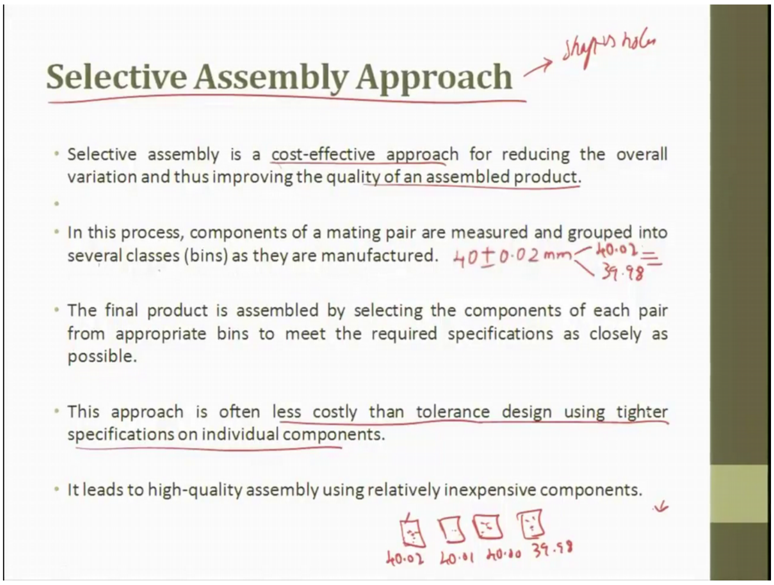

The other interesting this was interchangeability, the other interesting concept for discussion is going to be selective assembly approach. So, selective assembly approach means for I pick one part that part has to be mated with another part, now I either try to machine any one of the part and make sure a single shaft mates with a single hole or with a single housing whatever it is a, a taken nut which is and then take a bolt, now I grind the bolt or I grind a nut and I make sure this nut and this bolt exactly match and if I take any other nut and any other bolt randomly and start doing the assembly it will not match.

So, this is called as selective assembly, this is exhaustively used for various precision component. For example, in diesel injection pumps you have plunger and barrel. So, the inlet which is to be given to the cylinder engine cylinder you have a pump which is there. So, in this pump there is a cam and this cam tries to inject the required amount of diesel into the cylinder.

So, here what they do is the diesel enters into a barrel and then there is a plunger. So, this plunger and barrel assembly is to be very perfect it should not leak out the diesel down. So, they try to make it as selective assembly. Many of the hydraulic valves the cylinder and the piston and the valve whatever it is they try to do selective assembly to make sure there is no leak.

Selective assembly is a costly approach why because you take a shaft and you take a counter of it then you try to choose a counter which exactly matches. So, for producing 1 assembly may be 3 4 we would have set and sorted out and then made. So, this will increase the time and it will also tries to produce you are expected to produce more to make it assemble.

So, selective assembly is the cost effective, cost effective approach to reduce the overall variation thus improving the quality of the assembly product. In this process components of the mating pair are measured and grouped into several classes as they are manufacture ok. So, whatever I told in the beginning for selective assembly I told you it is it is one shaft and one hole one half that is one hole.

And in order to make this economical what you do is you first pick a shaft you first pick a counterpart do the assembly and try to see whether these two fellows are mating if not pick another one and I try to assemble them and keep it separate. So, that is why it is said as cost effective approach for reducing the overall variation and thus improving the quality of a assembled product.

In this process components of mating pairs are measured and grouped into several bins in interchangeability you random pick here you group them several products is assembled. For example, if you try to take 40 plus or minus 0.02 millimeter. So, you can produce at 40.02 and 39.98. So, it is not necessary it that your extreme ends only you get parts, now you also get part in this in between.

So, counter for this shaft I make holes and I also pick this now I do assembly ok. The final product is assembled by selecting the component of each pair from appropriate bin to meet the required specification as close as possible finally, you have to do a grinding and get it done this approach is often less cost costlier than the tolerance design using tighter specification.

So, here interchangeability is one, selective assembly is two, selective assembly here again what we do is we try to put it into several bins and we pick from the bin such that in between these are taken into, for example, this can be 40.02, this can be 40.01 this can be 4.00, 39.98 ok. So, I have all the shafts here whatever it is I have the bolts here.

So, counter I will also have then quickly I can pick from here and pick and assemble here, but here what is the big challenge and why did I say costly you have to first verify and sort it out and even after sorting it out if you want to have very tight tolerances then pick here pick here do some grinding and then get it done ok. So, this is selective assembly, but if you want to have a tighter tolerance the same selective assembly is very expensive tolerance. The next topic of discussion is tolerance.

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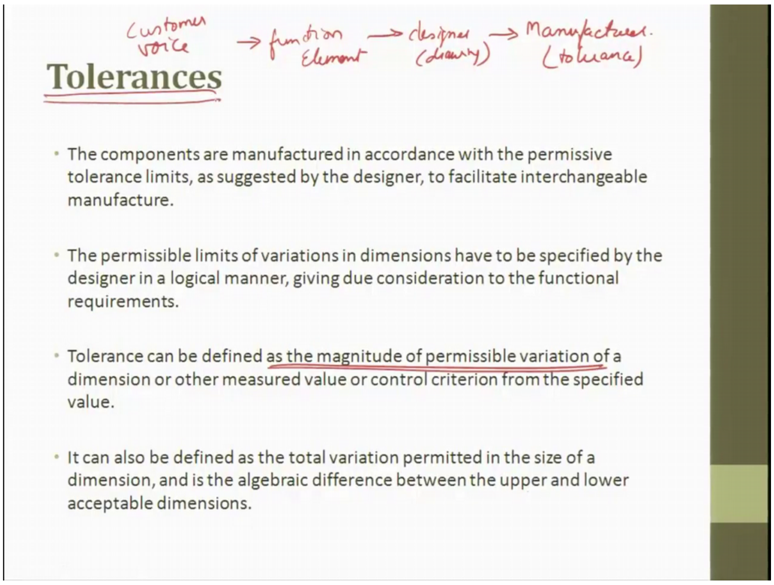

The components are manufactured in accordance with the permissible tolerance limit as suggested by the designer to facilitate interchangeability, tolerance the permissible limit of variation in dimensions have to be specified by the designer in a logical manner giving due consideration to the functioning requirement. So, basically what are we suppose to do is that is a function, function element will be there right. So, how did this function element come this came from the customers voice, customer voice or choice it came he converted into some product and the functional elements are there, functional elements the designer should have a drawing and then he is we are giving it to the manufacturer.

So, the designer has to have an understanding of each function knowing this function he has to logically think and give a manufacturing drawing such that it is manufacturable and it is also economical. So, what is the difference between the engineering drawing and manufacturing drawing it is only the tolerance which are attached to the dimension ok.

Tolerance are defined as the magnitude of permissible variation magnitude of permissible variation of a dimension or any other measured value or control criteria for a for a specified value ok. It is a magnitude of permissible variation ok. It can also be defined as the total variation. So, permitted in the size of a dimension and is the algebraic difference between the upper and the lower acceptable dimension which we have already seen. So, that is nothing, but tolerance I tolerate the variation.

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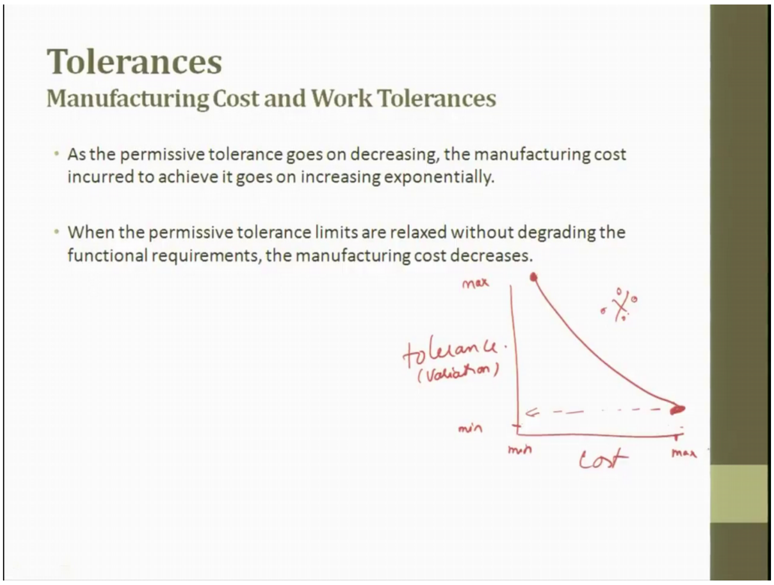

So, manufacturing cost versus work piece work tolerance. As the permissible tolerance goes on increasing which I explained to you in the beginning of this lecture the accuracy I said as the permissible tolerance goes on decreasing tolerance goes on decreasing; that means, to say the tolerance is decreasing, the accuracy is increasing it is becoming tighter and tighter, the manufacturing cost incurred to be achieved it goes on increasing exponentially. So, let it is like this tolerance this is cost.

So as the tolerance goes tighter and tighter and tighter so as the tolerance goes smaller and smaller and smaller so, the cost will be higher and higher and higher, tolerance cost is higher, this is minimum, this is maximum right and as the cost goes lower and lower and lower, the tolerance goes higher and higher and higher something like this.

So, this is minimum and this is maximum. So, tolerance what is tolerance, tolerance is the variation, dimensional variation right. So, as the permissible tolerance goes on decreasing, as that goes on decreasing tolerance, goes on decreasing the manufacturing cost incurred is going to be higher when the permissible tolerance limit are relaxed without degrading the functional requirement, the manufacturing cost goes on decreasing. So, this is a exponential fashion which is followed ok. This is very important graph it and today what we are trying to do is we are trying to convert this exponential into linear and we are also trying to shift rather trying to shift and make the cost as minimum as possible, we are trying to shift this here something like this point. So, that it is very economical for producing the path.

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In order to maintain very close tolerance limit manufacturing capability has to be enhanced which certainly increases the manufacturing cost. So, what we are trying to say is we are trying to say that if you are trying to reduce the tolerance variation then your machine whatever produces machine whatever produces the part there has to be completely under control where there has to be almost negligible uncontrollable variable and the work piece which comes inside variation from the microscopical point of view.

From the hardness point of view everything should be under control then when it comes to a machine where the process is also under control then only you are you will be able to produce very close tolerance limit parts and when this all the sorting out has to happen at several places then the manufacturing cost goes high drastically.

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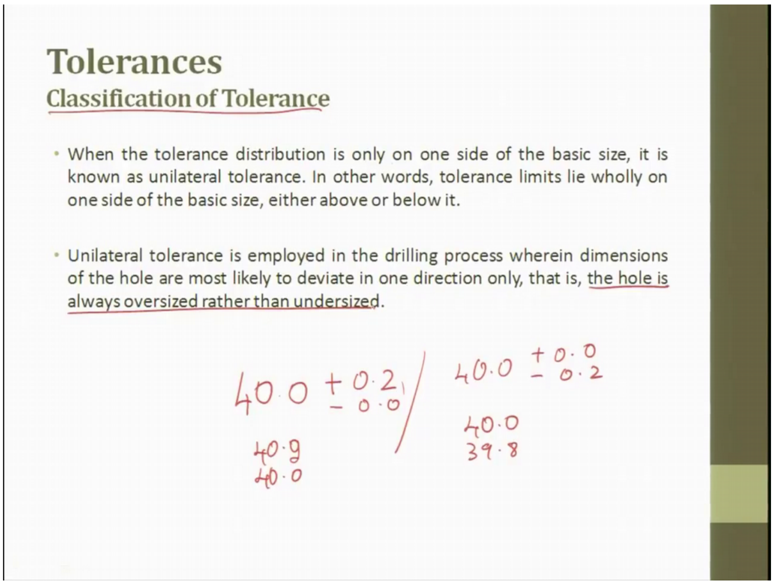

Next is let us start looking into classification of tolerance, when the tolerance distribution is only on one side of the basic size it is known as unilateral tolerance, in the other words the tolerance limit lies wholly on one side of the basic side either above or below, unilateral tolerance is employed in drilling process wherein with. So, what is that let us see so, it is 40.0 I say plus that is all or I can say plus minus 0.0.

So, here it is unilateral tolerance this is one condition or it can be like this 0.0 plus 0.0 minus 0.2. So, if when the tolerance distribution is only on one side of the basic, one side either in the first two side or the. So, here maximum is 40.02 or 40.2 minimum is 40. So, here it is maximum is 40.0, 39.8 ok.

So, it is known as unilateral tolerance. Unilateral tolerance is generally employed in the drilling process wherein dimensions of the hole are most likely to deviate in one direction only that is the hole is always oversized rather than undersize please underline this fact.

You are using a drill of a required dimension may be 6 millimeter and you are trying to drill a hole there it is expected that a exact 6 millimeter is done there if it is not exact 6 millimeter you will be never able to get 5.95 you can get only 6.05, because there can be a ovality or a run out on the spindle that deviates and generates a larger hole as compared to the, in a very rare condition you might get an undersize where the possibility can be the work piece takes in lot of heat and later the heat is dissipated.

There is a hole shrinkage phenomena happening this is a very dominant phenomena when you start working with thermoplastic material thermoplastic drilling you do over because of the heat which is getting accumulated it will try to shrink and when you will get an undersize, but generally in metals it is not possible. So, please make a note this is unilateral tolerance basic only one side there is deviation.

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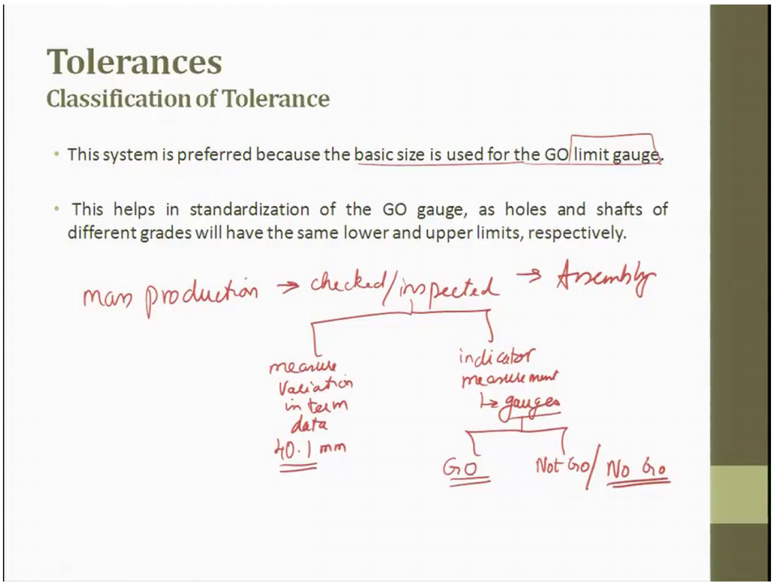

So, the next one is classification of tolerance. So here why is the need for unilateral tolerance? The unilateral tolerance is always preferred because the basic size is used to go for go limit gauge ok. What are limit gauges we will cover little later, but since the word has come I would like to say see it is the in a mass production what happens mass production every component would be like to be validated or checked before it gets into assembly. So, checked or inspected in a in a technical term it is inspected and then it gets into assembly.

So, here we would like when we do the inspection there are two classifications, one classification is you try to measure and note down the variation in terms of data; that means, to say the shaft diameter is 40.1 millimeter, the other way round is why do I need to know this data because anyhow this component is going for the assembly. The other way round of it I just have to say an indicator measurement, indicator measurement means I just have to check whether this component which is manufactured is worth for assembling or not I am least bothered about the values, I just have to check whether the shaft is if it is go, if it is not do not go. So, if the indicator I have to do then I would try to establish something called as gauges. So, gauges are just to find out go no go of the shaft or hole whatever it is.

So, gauges, so in gauges then I will write to have two classification I would try to say this should go or this should not go or it is called as no go. If my gauge of no go enters into or if it enters into a hole then; that means to say this manufacturing process or this feature whatever you have made is not accepted, if it goes then; that means, to say it is accepted. We will say what are the principles followed a little later, but these are the limit gauges.

Limit gauges are gauges which are used to check whether the part produced or the feeds are made on the path is acceptable or not ok. See I would put this way see you take blood sugar every day morning you try to check blood sugar. Suppose if let us assume that the data if it is anything more than 140 is alarming.

So, all you have to know is whether that morning when you try to take blood sugar level whether you are in an alarming situation or not, why at all you have more interested to know if you are in the safe zone, yes you might argue if I am in the border fine, when you are in the border please try to check or I would put this way you try to check once it says alarming then look for the magnitude value otherwise just forget it ok. So, that is what it is. So, why is this gauge coming into existence because in manufacturing industry nobody is going to pay extra money for inspection.

If somebody comes and says here is a pen which is inspected and please pay 2 rupees more you will say I will not inspection has to be done on every part, but it cannot be paid, it is a value addition job, but for this job no customer will be interested to pay. So, the best part is you interpret this inspection right in the manufacturing process or after it try to put a gauge and check and try to say yes or no. So, that is what is the go gauge limit. This helps in standardization of go gauge as hole and shaft of different grades which have the same lower and upper limits respectively. So, we are trying to see this. So, now let us see this grades little later these are tolerance grades.

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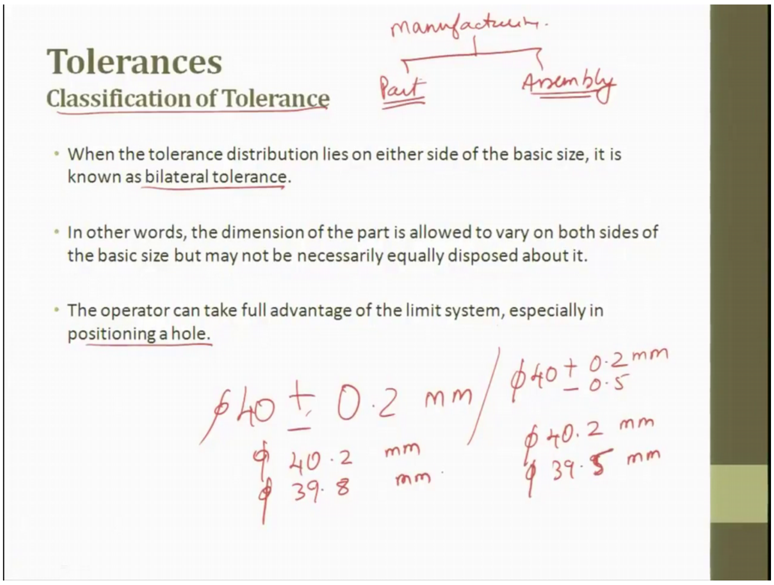

The next classification of tolerance is going to be bilateral uni bi. So, uni means one side, bi means both sides when the tolerance distribution lies on either side of the basic side it is known as bilateral tolerance 40 plus or minus 0.2 millimeter, it lies on positive side as well as it lies on negative side millimeter, this is a shaft this is shaft ok. So, in other words the dimension of the part it allowed to vary on both sides of the basic side, but may not be necessarily equally dispersed about dispersed about that for ok.

So, for example, there can be a possibility which says diameter 40 plus 0.2 minus 0.5 millimeter. So, it can be dia can be 4.02 millimeter or it can be 39.5 millimeter. I am sorry this is 8 40, this is 2, I am sorry this is 2 and this is 8 ok. So, this is what we are trying to say, it can be uniform it need not be uniform, the operator can take full advantage of the limit size limits system especially in positioning a hole when assembly comes into existence all these tolerances play a very important role in manufacturing.

We generally classify manufacturing into 2 major operations, one is producing a part the other one is assembly, today's scenario is interchangeability has come up to such an extent all parts are produced outside the factory only assembly happens inside the factory.

When assembly has to happen parts have to be produced with tolerance. If the parts are to be produced with tolerance then the cost of production becomes economical and it is also by nature that you cannot produce the same part or identical part once again you always give some you permit some variation.

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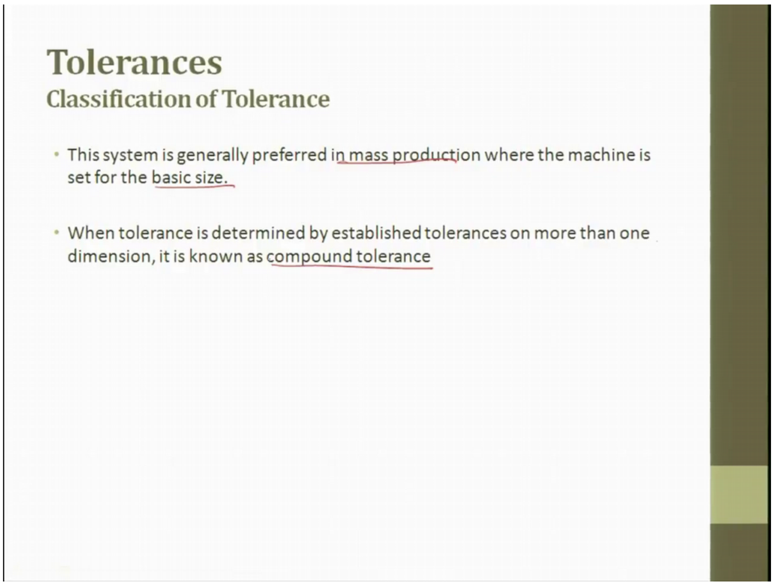

So, this system is generally preferred in mass production where the machine is set to the basic size. The tolerance is determined by establishing tolerance on more than one dimension it is known as compound tolerance. So, we will continue it in the next lecture what is compound tolerance and continue.

Thank you.