Inspection and Quality Control In Manufacturing
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Lecture – 19
Gear Measurement

Hello my friends now we are going to start our new chapter that is the gear measurement. So, before going to start about the gear measurement just let us know that what is gear?

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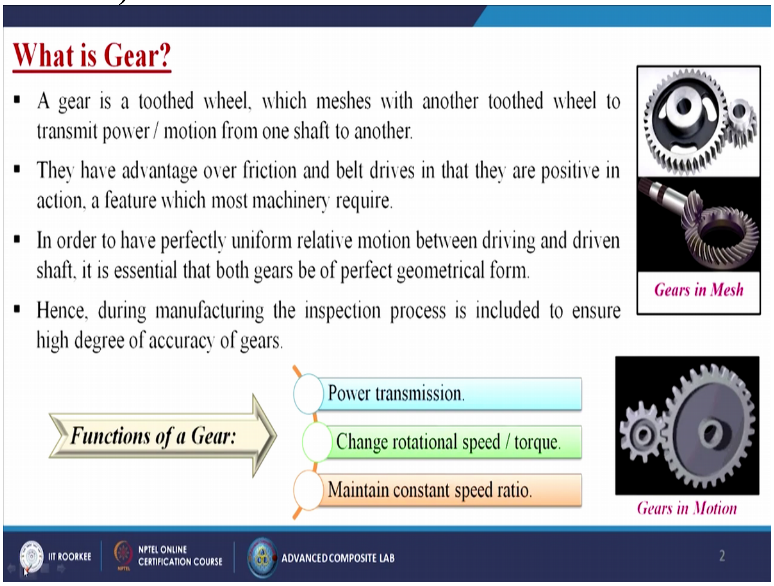

So, generally the gear is a toothed wheel which meshes with another toothed wheel to transmit power or motion from one shaft to another. So, I am having two shaft and two gears so one gear will rotate and either another will or sometimes both are rotate so, what will happen these motions will transmit to that another shaft. So, they have a advantage over frictions and belt drives in that.

They are positive in action a feature which most machinery require in order to have perfectly uniform relative motion between driving and driven shaft it is essential that both gears be a of perfect geometrical form. So, you see I am having two shafts so one shaft is rotating and that is rotating the, another one or maybe from smaller to bigger or maybe the bigger to smaller not only that we can vary the speed also.

So, one is rotating into the high speed so if I increase its diameter then if I put the smaller one so automatically the speed will reduce only the speed will increase so that depends is upon how much speed is required. Not only that, it is always into the parallel position sometimes it is in these particular positions also that it can rotate. Hence during manufacturing the inspection process is included to ensure high degree of accuracy of gears what are the functions of gears, first one is the power transmissions, second one is the change of rotational speed and torque and the third one is the maintain constant speed ratio.

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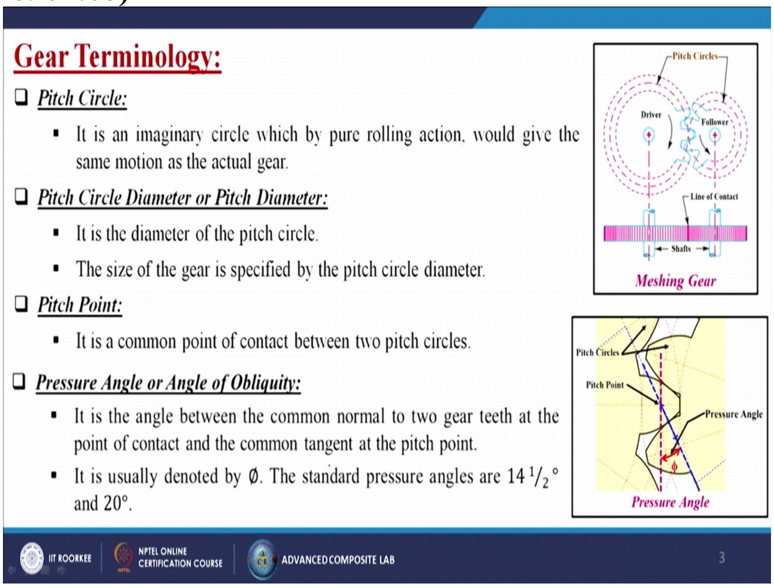

So, now come to the gear terminology let us know in depth about that gear. So, what is pitch circle it is an imaginary circle which by pure rolling actions would give the same motions as the actual gear. So, now I am having the driver, driver means it is an engine so it is rotating and whichever it is rotating that is known as the follower. So, this is the pitch circle over there in these particular cases so where it is mating at the center.

Next pitch circle diameter or maybe the pitch diameter it is the diameter of the pitch circle the size of the gear is specified by the pitch circle diameter just you remember this point. The size of the gear is specified by the pitch circle diameter. Then come to the pitch point it is a common point of contact between two pitch circles. So, here in this particular case you see the common point okay so where it is actually meeting each other.

Pressure angle or angle of obliquity so it is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point it is usually denoted by Phi. The standard pressure angles are 14 and 1/2 degree and 20 degree.

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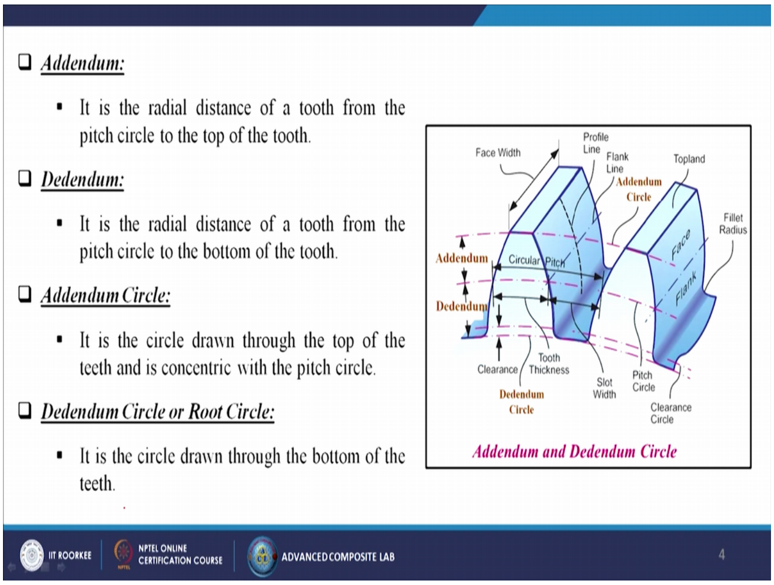

Next come to the addendum so it is the radial distance of a tooth from the pitch circle to the top of the tooth so this is known as the addendum circle over there. So, this is top of the tooth okay then come to the addendum it is the radial distance of a tooth from the pitch circle to the bottom of the tooth so this is the addendum. So, this is the bottom part over there. Next addendum circle it is a circle drawn through the top of the teeth and is concentrated with the pitch circle. Addendum circle it as a root circle also it is a circle drawn through the bottom of the tooth.

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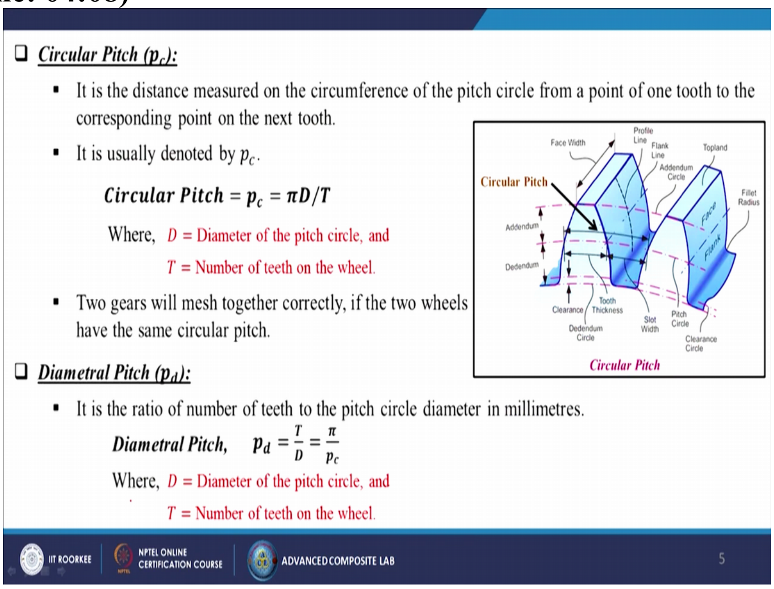

Next come to the circular pitch or in short generally we are calling it as a Pc it is the distance measured on the circumference of the pitch circle from a point of one tooth to the corresponding point on the next tooth. It is usually denoted by Pc as I told already so circular pitch Pc = PI D / T, so where D is the diameter of the pitch circle and T is the number of teeth on the wheel itself. So, now this is the circular pitch over there two gears will mesh together correctly if the two wheels have the same circular pitch they the matching will be proper.

Next called the diametral pitch that is Pg it is the ratio of number of teeth to the pitch circle diameter in millimeters. Diametral pitch Pd T / D that is equal to pi / pc where same D is the diameter of the pitch circle and T is the number of teeth on the wheel.

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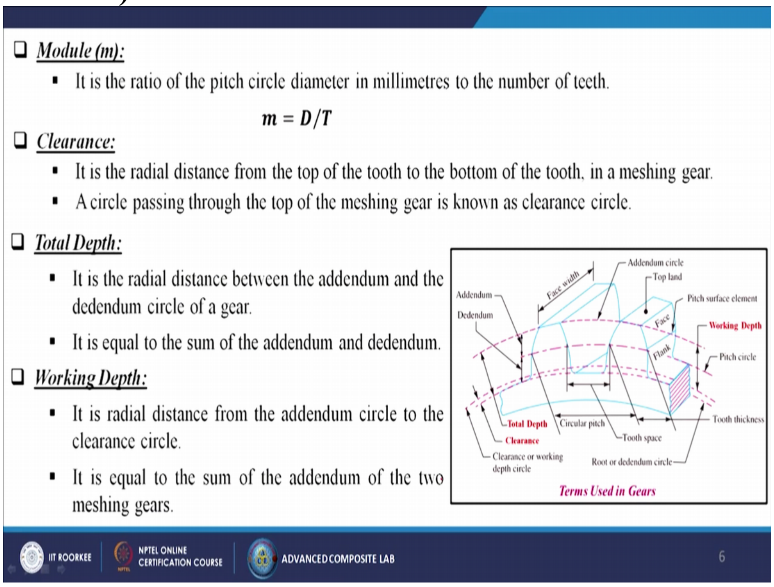

Next come to the module m it is the ratio of pitch circle diameter in millimeters to the number of teeth so m=D/T then come to the clearance because if we do not put the clearance so high friction will be generated and there is a chance that gear teeth can break so that is why you are giving certain kind of clearance or maybe the tolerance value over there. So, it is the radial distance from the top of the tooth to the bottom of the tooth in a meshing gear.

A circle passing through the top of the Machine gear is known as the clearance circle so in this particular case you can understand the whole thing over there. So, now we are having that circular pitch we are having the addendum we are having the dedendum this is known as the addendum circle this is known as the root of or may be the dedendum circle over there. Now this is the pitch circle over there and now we are going to put the clearance value over there.

So, here you can see that clearance or maybe the working depth circle now come to the total depth it is the radial distance between the addendum and dedendum circle of a gear. So, maximum to the minimum it is equal to the sum of the addendum and dedendum value. Now what is the working depth it is radial distance from the addendum circle to the clearance circle it is equal to the sum of the addendum of the two meshing gears.

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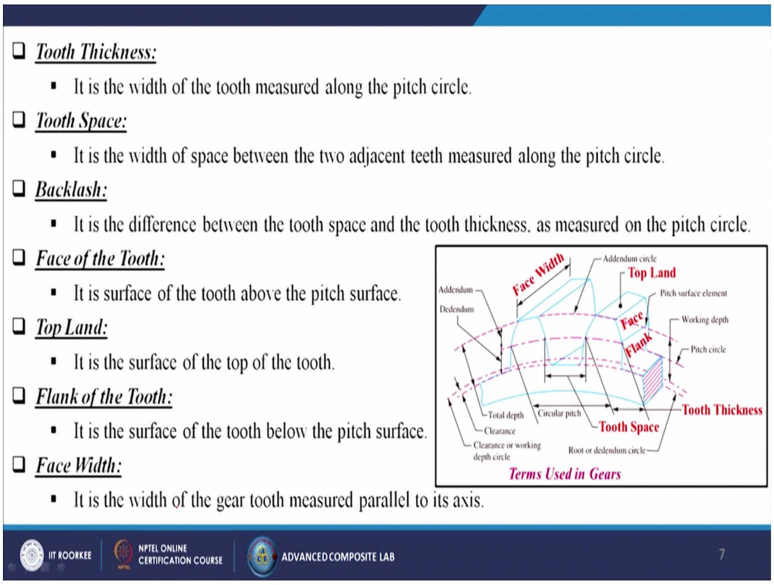

Now come to the tooth thickness it is the width of the tooth measured along the pitch circle. So, now when we are seeing this one is known as the tooth thickness over there now tooth space it is the width of space between the two adjacent teeth measured along the pitch circle. So, now we are having that tooth space is this one and two thickness is this one. This is the thickness of the tooth and this is the gap in between the two gears that is known as the tooth space.

Backlash it is the difference between the toothpaste and the two thicknesses as measured on the pitch circle that is known as the backlash. Then face of the tooth it is the surface of the tooth above the pitch surface so this is the face width and the, this is called the face over there. So, face surfaces means that the surface generally we can see from the outside itself. Then top land it is the surface of the top of the tooth.

So, this is the topmost surface over there that is known as the top land. Flank of the tooth it is the surface of the tooth below the pitch surface so this is the flank this jaw, face width it is the width of the gear tooth measured parallel to its axis.

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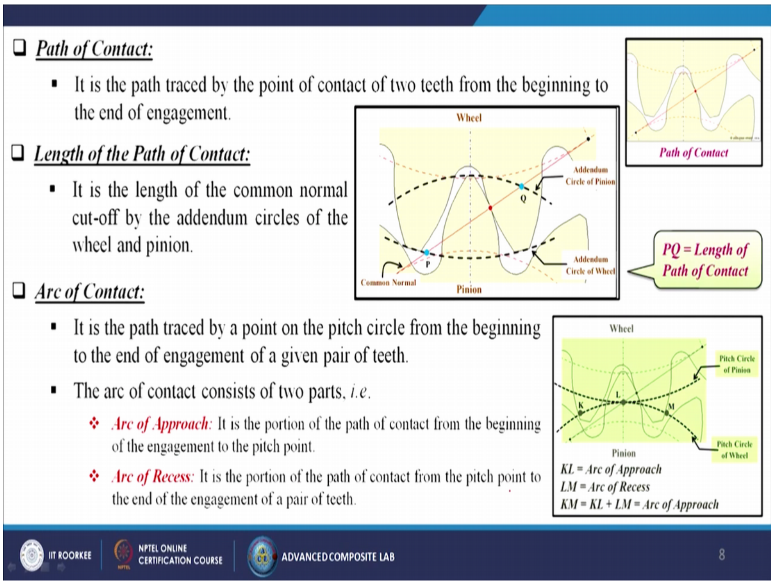

Then path of contact it is the path traced by the point of contact of two lengths from the beginning to the end of the engagement so that is the path of contact. Length of the path of contact it is the length of the common normal cut off by the addendum circles of the wheel and pinion. Arc of contact it is the path traced by a point on the pitch circle from the beginning to the end of the engagement of a given pair of teeth.

The arc of contact consists of two parts arc of approach it is the portions of the path of contact from the beginning of the engagement to the pitch point. Arc of Recess it is the portions of the path contact from the pitch point to the end of the engagement of a pair of teeth. Simple when this is touching that is the approach and when it is living that is the arc of recess.

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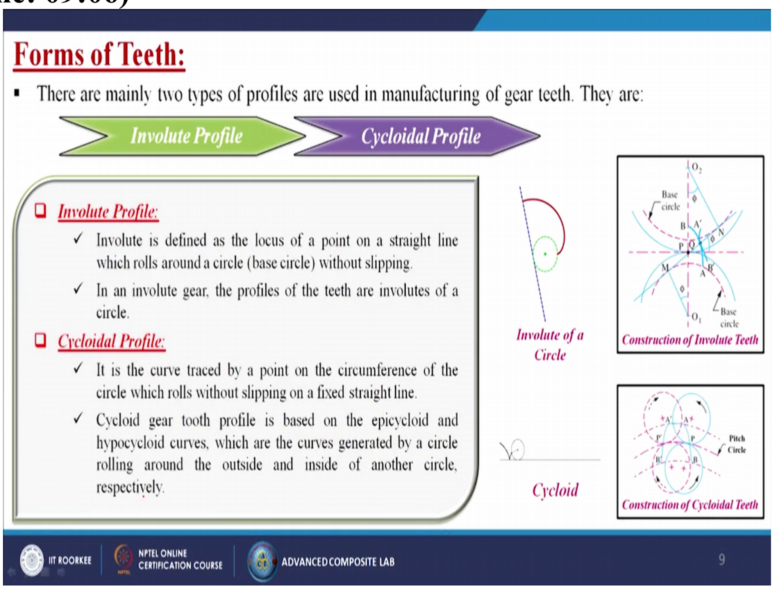

Now forms of teeth so there are mainly two types of profiles are used in manufacturing of gear teeth what are those one is called the involute profiles another one is called the cycloidal profile. So, what is involute profile involute is defined as the low of a point on a straight line which rolls around a circle without slipping so in this particular case you can understand easily. What is cycloidal profile? It is the curve traced by a point on the circumference of the circle which rolls without slipping on a fixed straight line.

So, like this way cycloid gear-tooth profile is based on the epicycloid and hypocycloid curves which are the curves generated by a circle rolling around the outside and inside of another circle respectively. So, this is the difference that how we are forming the teeth.

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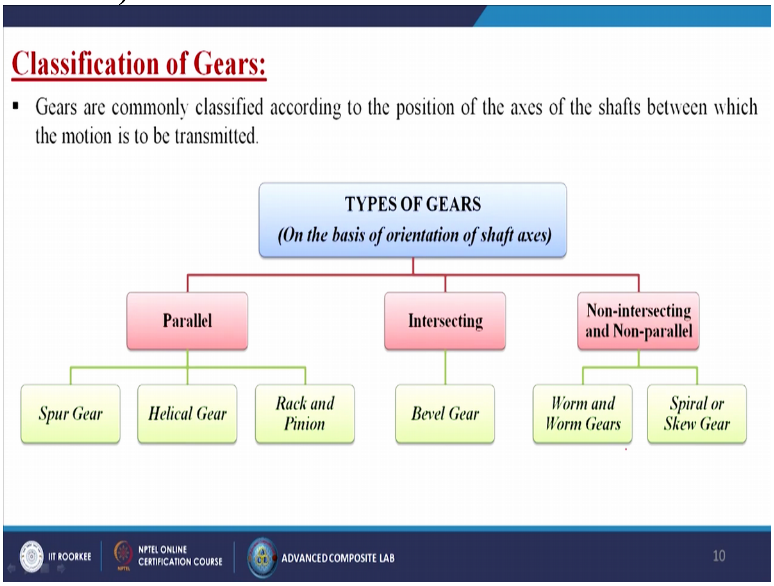

Now come to the classification of gears so generally gears are commonly classified according to the positions of the axis of the shafts between which the motion is to be transmitted. Generally there are types of gears on the basis of orientation of shaft axis if we divide so it will be three first is parallel intersecting non intersecting and non parallel. So, when you are talking about the parallel first one is called the spur gear then helical gear and the rack and pinion.

If we talk about the intersecting that is the bevel gear if we talk about the non intersecting and non parallel then warm and one gears and last one is the spiral or may be the skew gear.

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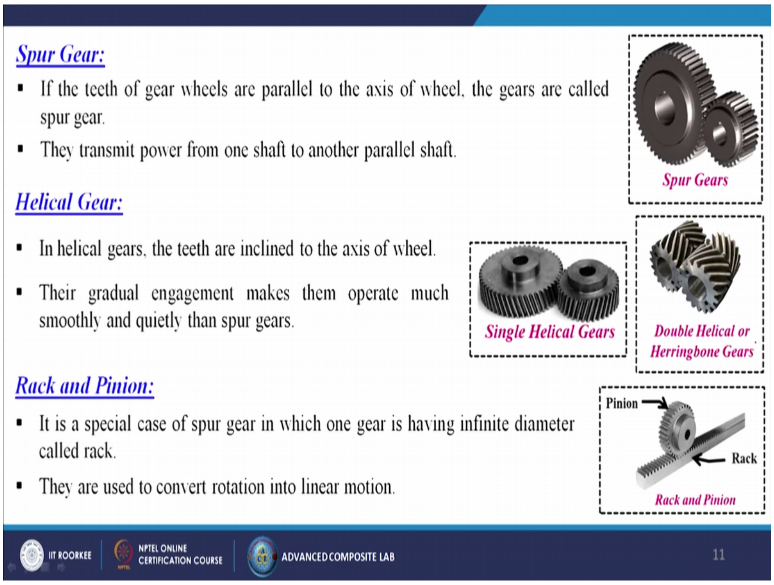

So, now what is spur gear if the teeth of the gear wheels are parallel to the axis of the wheel the gears are called spur gear they transmit power from one shaft to another parallel shaft you see they are mating front to front. Next come to the helical gear in helical gears that teethes are inclined to the axis of wheel their gradual engagement makes them operate much smoothly and quietly than the spur gears.

So, this is the image so single helical gears here is that double helical or maybe the herringbone gears so both sides the angle is different, gear direction is different. Now come to the rack and pinion it is a special case of spur gear in which one gear is having infinite diameter called the rack this is the rack and they are used to convert the rotation into linear motion so pinion, so when it will rotate so automatically these rack will move forward or maybe the backward positions.

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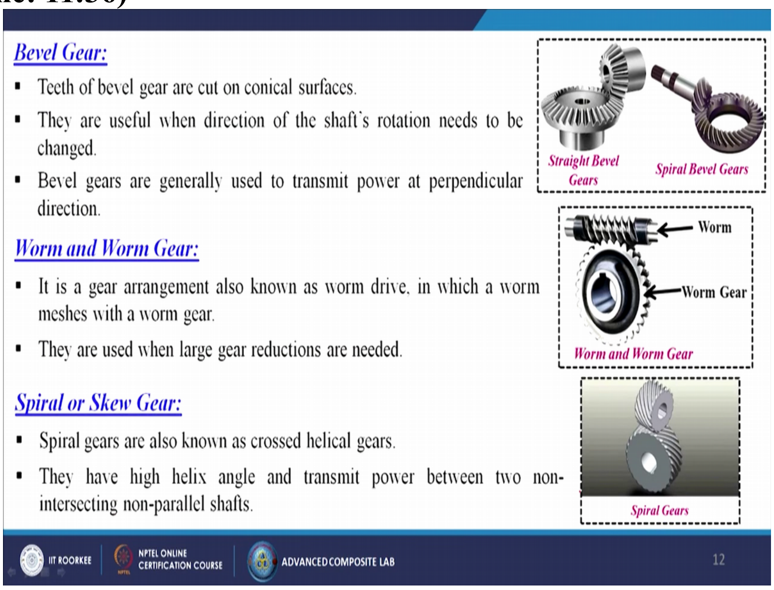

Now come to the bevel gear so teeth of bevel gear are cut on conical surfaces they are useful when direction of the shafts rotation needs to be changed. So, from these directions we are changing these directions rotation of the shaft. Bevel gears are generally used to transmit power at perpendicular direction. Worm and worm gear it is a gear arrangement also known as one drive in which a worm meshes we take worm gear so in this way this is known as the worm and this is known as the warm gear.

So, when it will rotate so automatically this will rotate they are used when large gear reductions are required. Spiral or Skew gear spiral gears are also known as crossed helical gears they have high helix angle and transmit power between two non intersecting non parallel shafts so once shaft is in this direction once shaft is in this direction so any directions we can change the movement.

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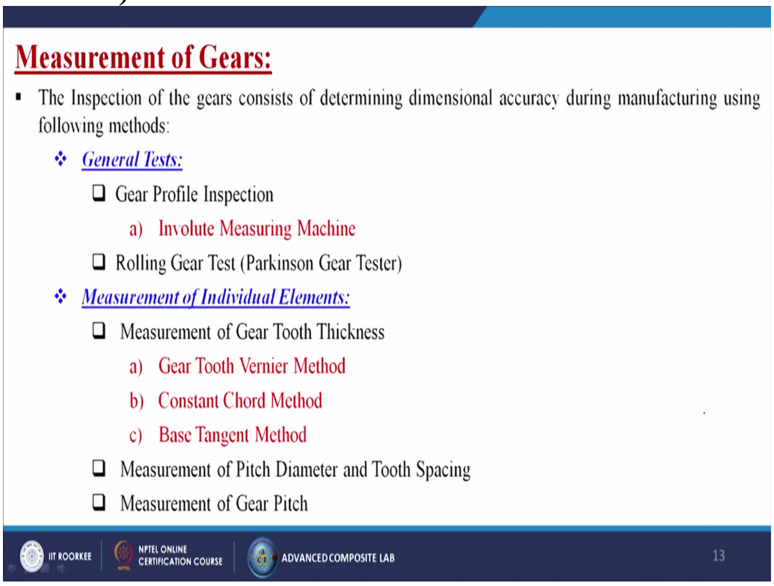

Now come to the measurement of gears then how we can measure that about the gear teeth and all the details. So, the inspection of the gears consists of determining the dimensional accuracy during manufacturing using the following methods. First one is the general tests what are those gear profile impact inspections like involute measuring machine and the second one is the rolling gear test that is known as the Parkinson gear tester.

And the second one measurement of individual elements like measurement of gear to thickness. There are three components one is gear to vernier method constant chord method and the third one is the base tangent methods and then measurement of piece diameter and the tooth spacing and the measurement of the gear pitch. So, these all are the different kinds of measurement techniques.

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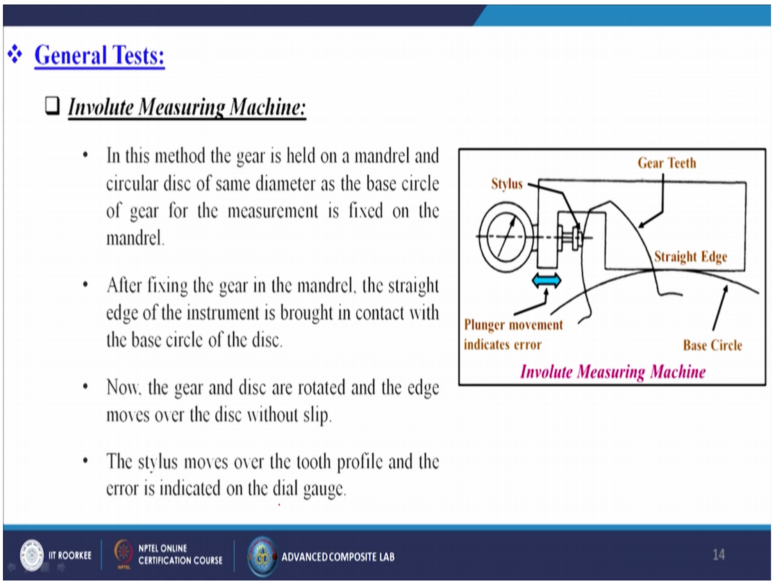

So, first let us discuss about the general tests so when you are talking about the involute measuring machines in this method the gear is held on a mandrel and the circular disc of same diameter as the base circle of gear for the measurement is fixed on the mandrel itself. After fixing the gear in the mandrel the straight edge of the instrument is brought in contact with the best circle of the disk.

Now the gear and the disk are rotated and the edge moves over the disk without slip the stylus moves over the tooth profile and the error is indicated on the dial gauge itself. So, now you can see now plunger movements so these can go forward or maybe the backward directions. So, when it will touch from here then automatically it will go like this so automatically you can see the reading over there. So by seeing the stylus reading so simple you can do the normal general test over there.

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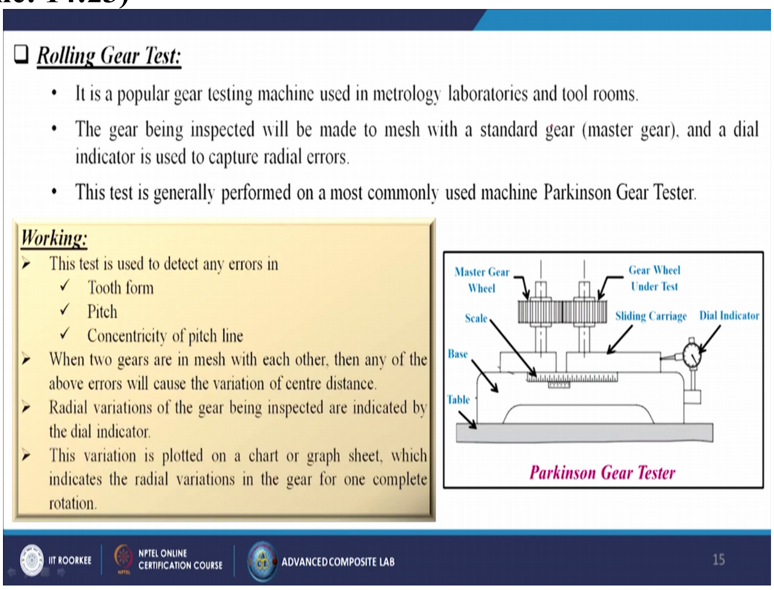

Now come to the rolling gear test it is a popular gear testing machine who used in metrology laboratories and the tool rooms the gear being inspected will be made to mesh with a standard gear generally known as the master gear and the dial indicator is used to capture the radial errors. So, simple I am having that one standard gears and then my gears will match and then there is any deflections so that means there is some kind of problems.

This test is generally performed on a most commonly used machine Parkinson gear tester. Working this test is used to detect any errors in the tooth form pitch concentricity or pitch line. When two gears are in mesh with each other then any of the above errors will cause the variation of Center distance. So, in this particular case you can see we are having that sliding carriage over there this is the scale this is the rest tables and we are having that dial indicator.

Now two gears are matching properly okay if that will not match so what will happen this will try to sit so in this particular case your dial indicator will change the value or maybe it will be deflected. Now how much shifting is taking place that you can get it from this particular scale. So, radial variations of the gear being inspected are indicated by the dial indicator the variation is plotted on a chart or graph sheet which indicates the radial variations in the gear for one complete rotation.

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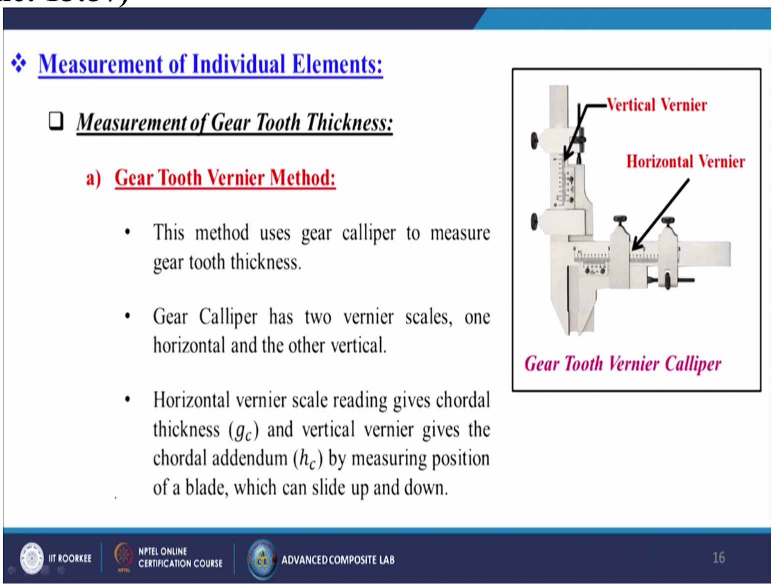

Now measurement of the individual elements like measurement gear tooth thickness here tooth vernier method first one this method uses gear caliper to measure gear to thickness. Gear caliper has two vernier scales one horizontal and the other one is the vertical so you can see this is the horizontal vernier and this is the vertical vernier. So, this is the combinations of actually two vernier scales.

So horizontal vernier scale rating gives the chordal thickness that is gc and the vertical vernier gives the chordal addendum by measuring positions of a blade which can slide up and down.

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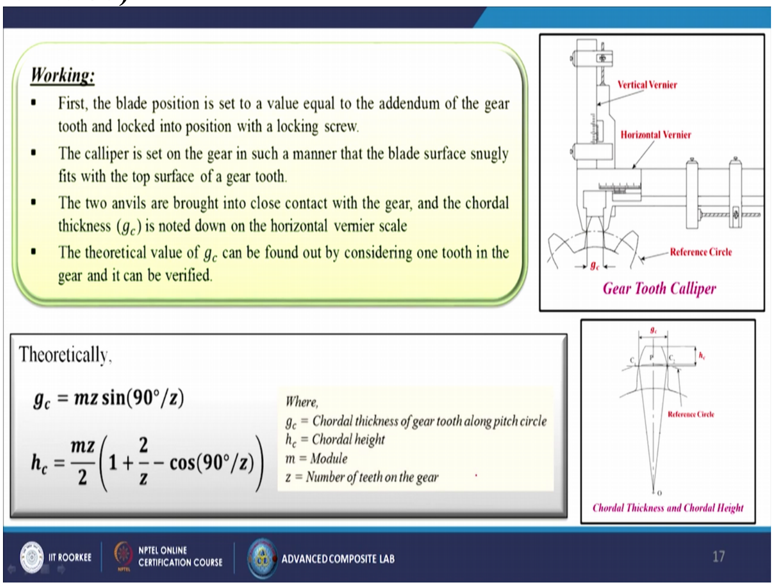

Working principles so in this particular case first the blade position is set to a value equal to the addendum of the gear tooth and locked into position with a locking screw the caliper is set on the gear in such a manner that the blade surface snugly fits with the top surface of the gear teeth. So, now you can see that it is rigidly tighting your gear teeth. The two anvils are brought into the close contact with the gear and the chordal thickness is noted down on the horizontal vernier scale.

So, this will give you this value the theoretical value of gc can be found out by considering one tooth in the gear and it can be verified. Theoretically gc = mz sine 90 degree / z. So, how to then from this particular case hc = m z /2 * 1+ 2 / z - cos 90 degree /z so gc chordal thickness of gear tooth along pitch circle hc chordal height m is the module z is the number of teeth on this particular gear so by theoretically also we can measure and we can check the results with this test.

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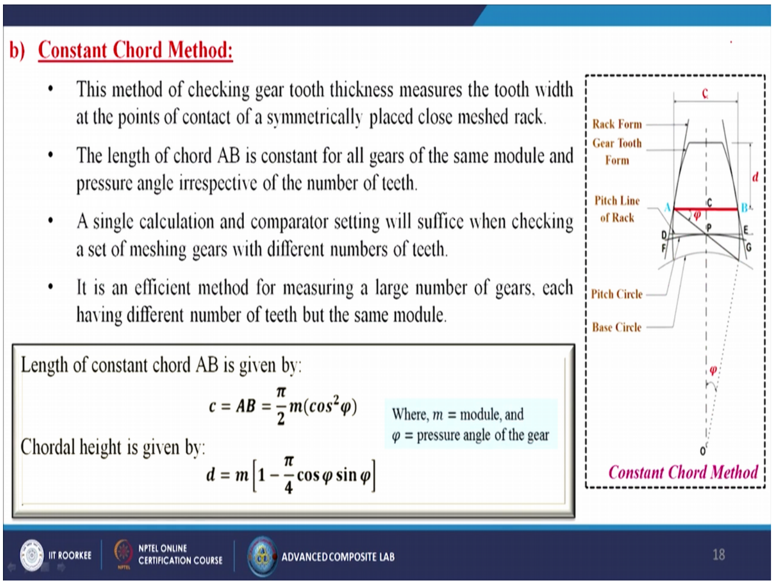

Next is called the constant quad method this method of checking gear to thickness measures the tooth width at the points of contact of a symmetrically placed close missed rack. The length of chord AB is constant for all gears of the same module and pressure angle is irrespective of the number of teeth. A single Galatians and comparator setting will suffice when checking a set of machine gears with different numbers of teeth.

It is an efficient method for measuring a large number of gears each having different number of teeth but the same module so in this particular case we are going to measure by applying the constant chord methods right. So, how we are calculating the length of the constant chord AB is given by so this one first we are going to measure this one. So, c = AB = PI / 2 mcos square Phi and chordal height is given by d = m* 1 – PI/ 4 cos Phi sine Phi. So, from there you can measure the c value and the d value.

So, this is your d and this is your c so these two values easily you can measure where m is nothing but the module and Phi is the pressure angle of that particular gear.

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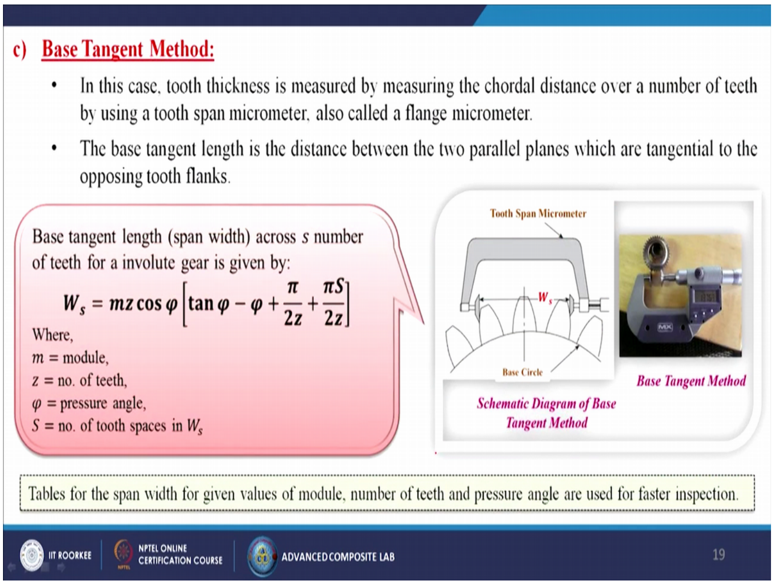

Now next one is the Base Tangent method so in this case tooth thickness is measured by measuring the chordal distance over a number of teeth by using a tooth span micrometer also called a flange micrometer. The base tangent length is the distance between the two parallel planes which are tangential to the opposing tooth flanks. So, base tangent length spent generally known as the span width across is number of teeth for a involute gear is given by so this one we are going to measure this Ws value so Ws = mz cos Phi * tan Phi - Phi + PI / 2 z + PI S / 2 z.

So where m is the module z is the number of teeth Phi is the pressure angle S is the number of tooth spaces in Ws. Tables for the span width for given values of module number of teeth and pressure angles are used for the faster inspections so this is the technique. You see directly we are getting the value it is something like that 13.763.

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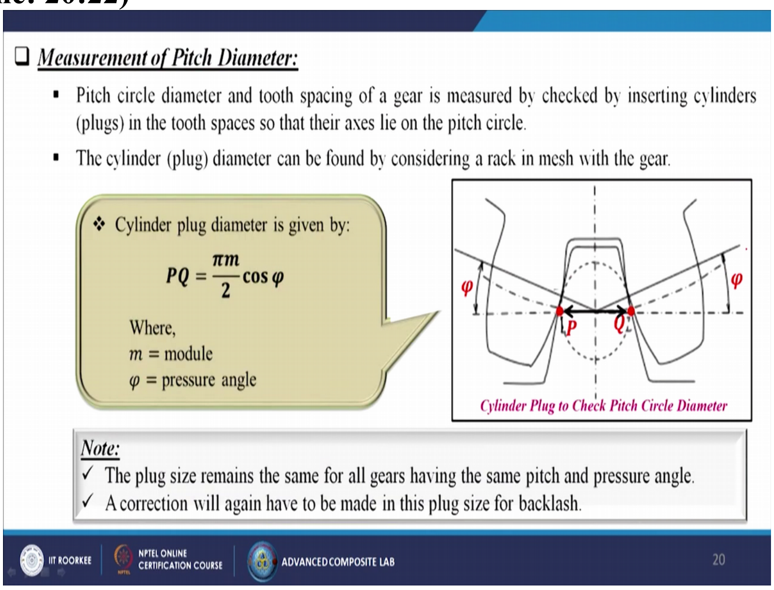

Now measurement of the pitch diameter this is the very important one. So, generally the pitch circle diameter and tooth spacing of a gear is measured by check by inserting cylinders generally known as the plugs in the tooth spaces so that their access lie on the pitch circle. The cylinder or maybe the plug diameter can be found by considering a rack in mesh with the gear. So, now cylinder plug diameter is given by PQ = PI m / 2 cos Phi where m module and Phi is the pressure angle that is the normal one.

So, simple I am having this cylinder I am inserting it and then I am if I know this diameter over there so easily I can make the measurement. But some cases what happened that exactly whether detecting these particular two points is sometimes difficult. Note the plaque size remains the same for all gears having the same pitch and pressure angle a correction will again have to be made in this plug size for the backlash.

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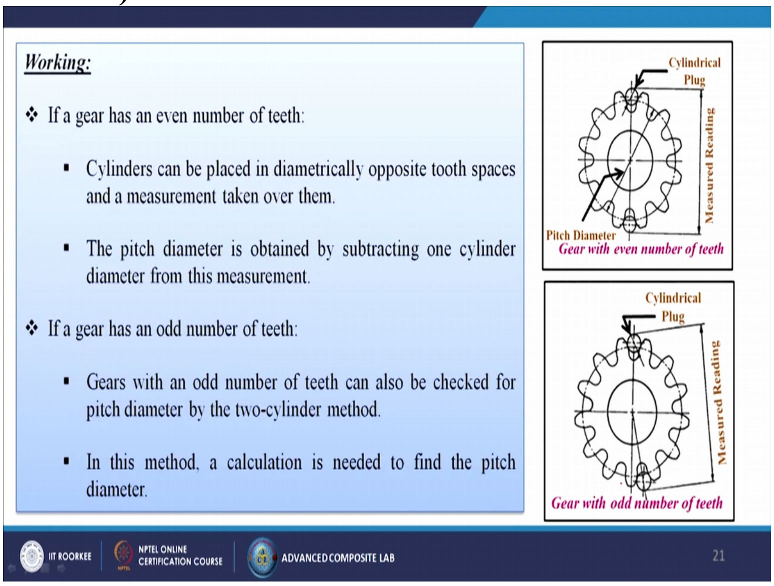

Now working principles if a gear has an even number of teeth cylinders can be placed in diametrically opposite to spaces and measurement taken over them so easy so one is here and another one is here so this is the measured readings over there this is the cylindrical plug and this is the pitch diameter over there. So, the pitch diameter is obtained by subtracting one cylinder diameter from this particular measurement so easily we can measure.

If a gear has an odd number of teeth gears with an odd number of teeth can also be checked for pitch diameter by the two cylinder methods. So, in this method a calculation is needed to find the pitch diameter.

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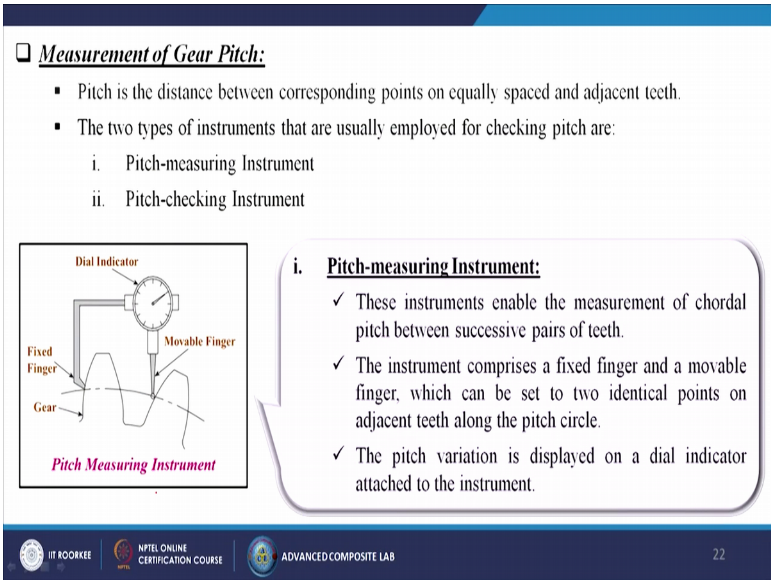

Next measurement of the gear pitch, pitch is the distance between corresponding points on equally spaced and the adjacent teeth. These two types of instruments that are usually employed for checking pitch are pitch measuring instrument and the pitch checking instruments. So, what is pitch measuring instrument so you see so simply we are having that dial indicator and this is of course it can go up and down motions so wherever it will touch if it will come over here so automatically it will come down up to this one.

So, this will give you the value over there. So, this instruments enable the measurement of coral peach between successive pairs of teeth the instrument comprises a fixed finger and a moveable finger which can be set to two identical points on adjacent teeth along the pitch circle. The pitch variation is displaced on a radial indicator attached to the instrument.

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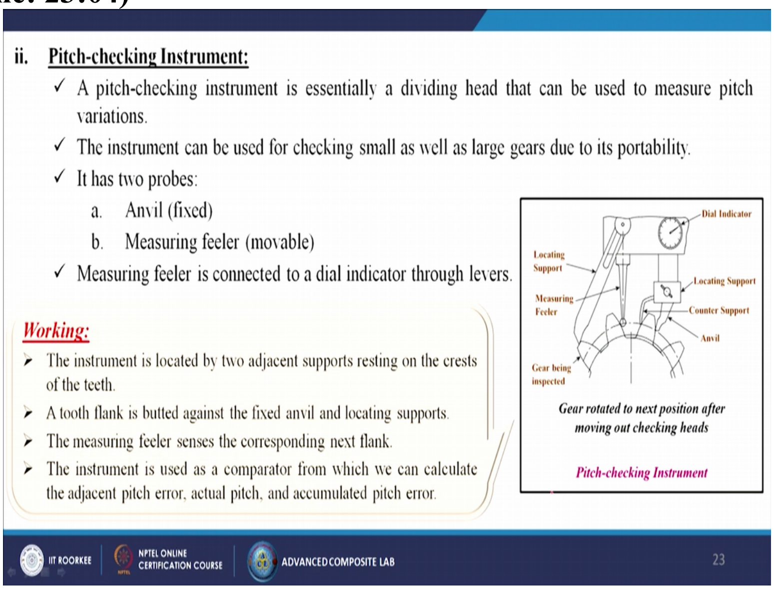

Next one is the pitch checking instrument so pitch checking instrument is essentially a dividing head that can be used to measure pitch variations. The instrument can be used for checking small as well as large gears due to its portability. It has two probes one is called the anvil that is the fixed one another one is called the measuring filler that is the movable part. Measuring filler is connected to a dial indicator through levers.

So, simple you can see we are having that anvil that is the fixed one and then another one is that measuring filler which is movable. So, automatically what will happen simple by touching that one is the fixed one sight another one I am just moving and then I am fixing and I am getting this dial indicator value. So, how it is working the instrument is located by two adjacent supports resting on the crest of the teeth.

A toothed flank is butted against the fixed anvil and locating supports the measuring feeler senses the corresponding next flank the instrument is used as a comparator from which we can calculate the adjacent pitch errors actual pitch and the accumulated pitch error. So, this will give you this kind of information's.

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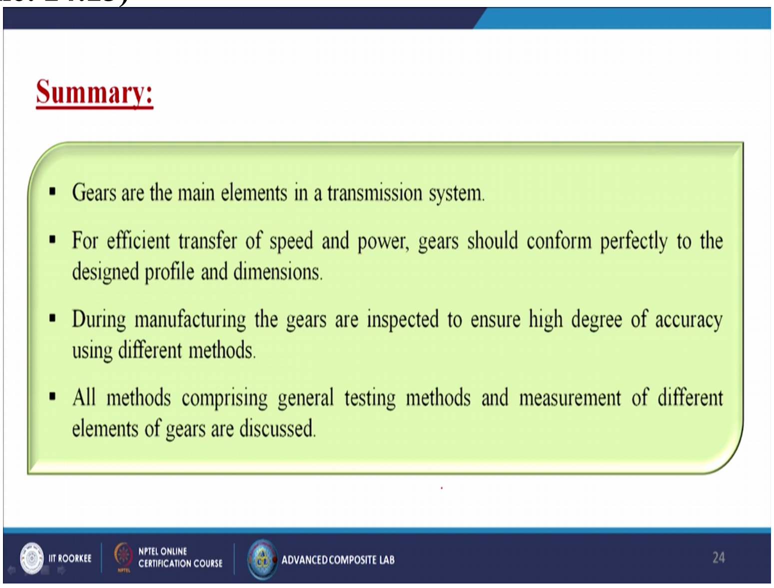

Now we have come to the last slide of this particular lecture so in summary we can say that gears are the main elements in a transmission system say simple it can transmit the speed or maybe it can transmit the power from one shaft to another. So, for efficient transfer of speed and power gear should confirm perfectly to the design profiles and the dimensions. During manufacturing the gears are inspected to ensure high degree of accuracy using different methods.

All methods comprising general testing methods and measurement of different elements of gears have already been discussed in this particular lecture in elaborate manner, thank you.