Theory & Practice of Rotor Dynamics
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Module - 8
Balancing
Lecture - 37
Introduce To Rigid Rotor Balancing

Till now, we considered various kinds of analysis in the rotor system. Mainly, we considered transfer and torsional analysis of free vibrations, forced vibrations and instability analysis. Mainly, this can be done at design stage. If there is any problem in the machine regarding the resonance, if it is falling within the operating range, or if operating range is within the instability region, we can do design modifications and we can be able to rectify this kind of problems. So, whatever the analysis we have done is very useful at design stage.

But, once we design the rotor considering all the aspect of the resonance and critical speed and instability reasons, in most of the practical case when we fabricate the rotor or machinery, assemble them and operate, we found that there are some inherent difficulties which we face in such machinery. These difficulties are in the form of some kind of inherent fault, which comes into the system, may be because of the manufacturing process or during assembly proper procedure is not followed. Because of this, the rotor may not behave as we expect or as we have designed. In such cases, we cannot be able to modify such machinery because we already manufacture it we assembled it.

So, there are procedures to rectify this kind of faults or the problems in the machinery. Now, we will take up in the subsequent lectures. We will see that in machinery, not only at the stage of commissioning the new machine, but also during operation, various kind of wear and tear of rotating parts and stationary parts take place. Because of that, whatever we achieved in the design stage, that particular performance this machinery may not give. So, during operation and here when we are making major overhaul in this machinery, we need to take care of this kind of faults, which comes into the system inherently and we will try to remove them.

So, in today’s lecture, we will take up a very specific fault which is very common in such rotating machinery, that is unbalance. This will always be there in the rotating machinery. Based on the various method available, we try to balance the rotor up to the extent possible. That will depend upon the type of machine, which we are trying to balance. So, these aspects we will be dealing with, in the present lecture.

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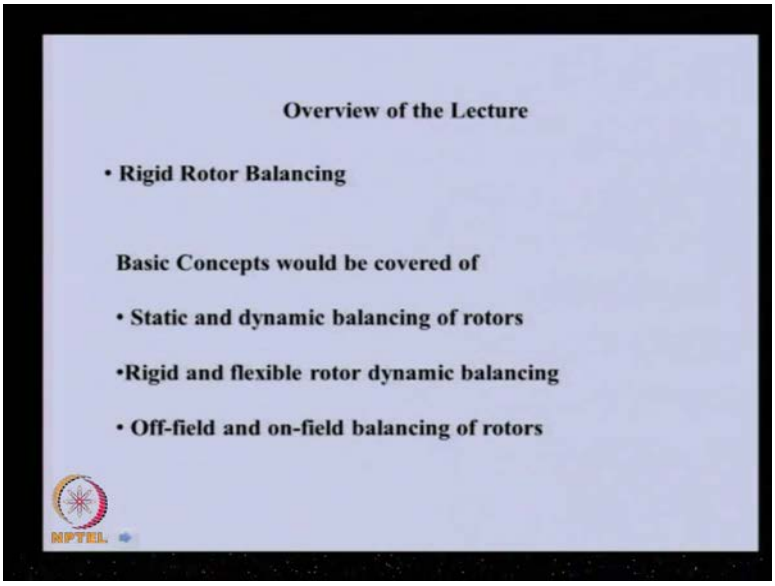

The over view of the lecture is that rigid rotor balancing, we will be focusing in today's lecture, but over all concept of the static and dynamics balancing we will be giving. Apart from this, the rigid rotor and flexible rotor basic concept, we will be introducing in this particular lecture. The off field balancing or on field balancing, especially for rigid rotor, we will try to cover in this particular lecture.

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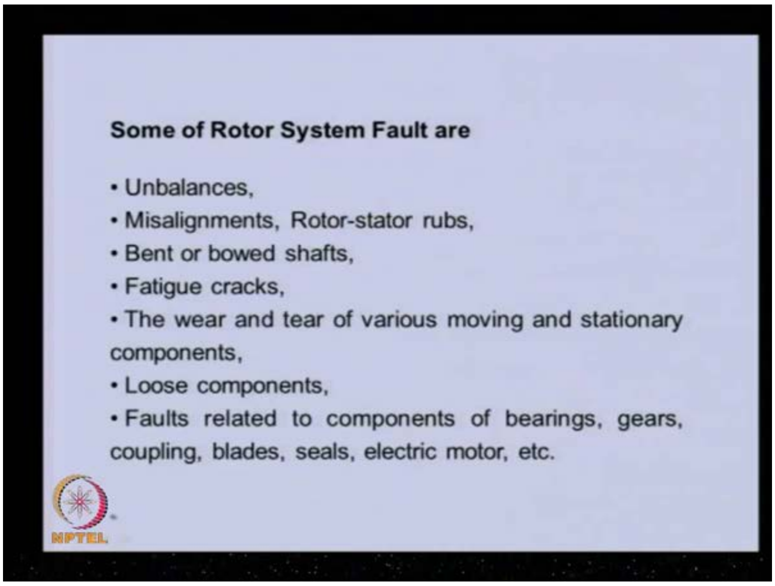

Now, various kind of the fault which the rotor system can have either at the stage of commissioning the rotor or during the subsequent overhaul, so most common as I discussed is the unbalance. Apart from this, the second most critical fault is the misalignment, which generally occur between two shaft when they are connected by coupling or at the bearing when a single shaft is mounted on two bearings. Then, we have misalignments between the shaft and the bearing.

Apart from that, we can have rotor stator rubs, bent or bowed shafts, fatigue cracks on to the shaft, wear and tear of various moving and stationary component of the rotor and stator, loose components, faults related to components of bearings, gears, coupling blades, seals, electric motor etcetera. So, we can be able to see the various fault may come which cannot be able to be handled at the design stage. This automatically comes into the system, if we do not take care of the proper maintenance or the proper procedure of assembly of the system. We will focus on the unbalance.

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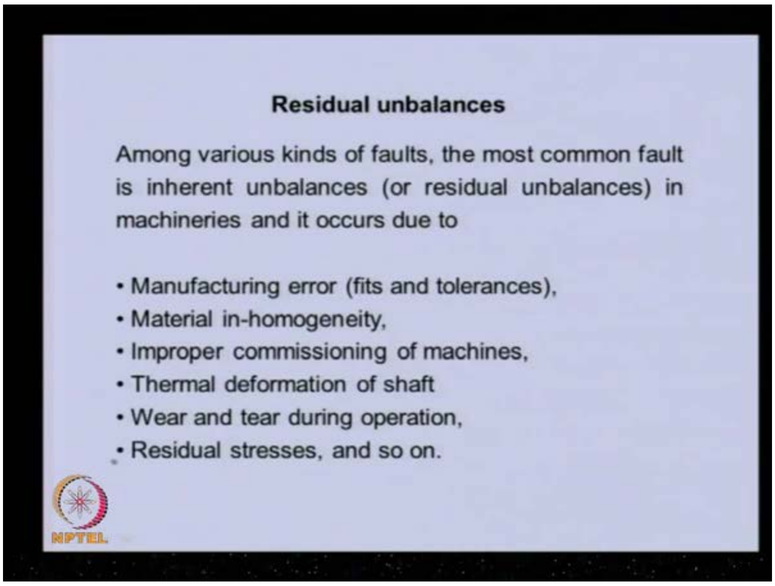

The inherent unbalance, we called that as a residual unbalance. So, this is the most common fault among the various kinds of faults. It occurs because a variety of reasons like manufacturing error fits and tolerances, which we give for various machined components. We may have material in homogeneity, improper commissioning of machines, thermal deformation of shaft wear and tear during operation, residual stresses and so on. So, many reasons because of this residual unbalance may come into the system.

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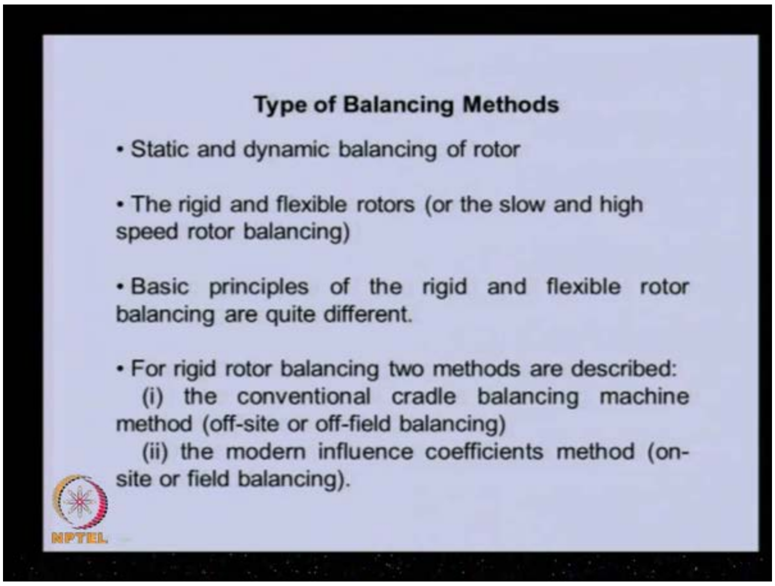

Once we found that there is a severe level of unbalance, then we need to balance this particular rotor. There are different balancing methods available, like static and dynamic balancing of rotor. These methods will depend upon the type of rotor, the application geometry of the rotor and various other parameter, which will go on which type of balance we should be doing? So, at present, I will be introducing this terminology, but subsequently you will be dealing with this method in more detail, so the static and dynamic balancing of rotor. So, in static balancing generally we do not rotate the rotor at operating speed, but at stationary rotor we try to see the condition of that and try to balance the rotor.

In dynamic balancing as the meaning implies, we need to rotate the rotor at a substantial rpm so that the effect of unbalance comes into the rotor in the form of centrifugal force. That will give the idea about the balance condition of the rotor. Based on that, we can be able to balance the rotor. In the rotor itself we have two class of balancing, that is rigid rotor and flexible rotor balancing. Sometime, it is called slow rotor or high slow speed or high speed rotor balancing, as name implies. We will be explaining this in more detail. What is the rigid rotor and flexible rotor? What are the difference between them? But, in general if the rotor is rotating at slow speed, we do rigid balancing.

At high speed, specially near critical speed or above critical speed, then we do the flexible rotor balancing. This is basic principle of the rigid and flexible rotor balancing. We will see that there is a fundamental difference between these two types of balancing that will see subsequently. But for rigid rotor there are two basic methods. One is conventional cradle balancing machines and this we already graded a machine for balancing. We need to take out the rotor from the actual machine and then we need put on the balancing machine.

There we can able to find the condition of the balancing of the machine. Sometimes, this is called off site or of field balancing, because we need to take out the rotor from the actual machine for balancing. There is another method that is modal influence coefficient method. We can be able to do balancing with this online or onside balancing or field balancing. Sometimes, we refer to this particular method while dealing in more detail in the subsequent lecture.

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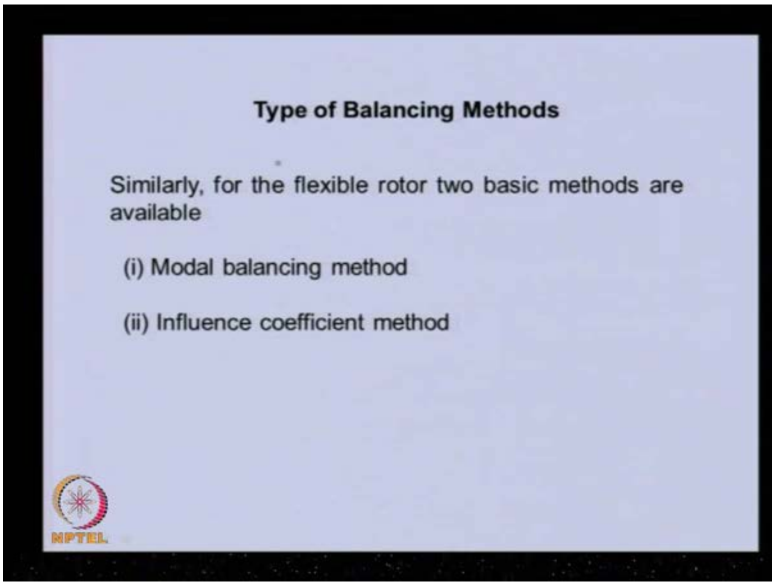

In the flexible rotor balancing again, there are two basic methods; one is the Modal balancing method. In this we try to balance the rotor for various modes that is first mode, second method, third mode, like that. The second is the Influence coefficient method. This is more advanced method in which the concept of the influence coefficient for rigid rotor balancing will be extended for the flexible rotor.

This influence coefficient will depend upon this speed of the rotor, because we are operating at the flexible mode. So, will see that influence coefficient will depend upon speed. This method is more advanced as compared to the Modal balancing method. Basically, the modal balancing method is more difficult, but influence coefficient is relatively easy.

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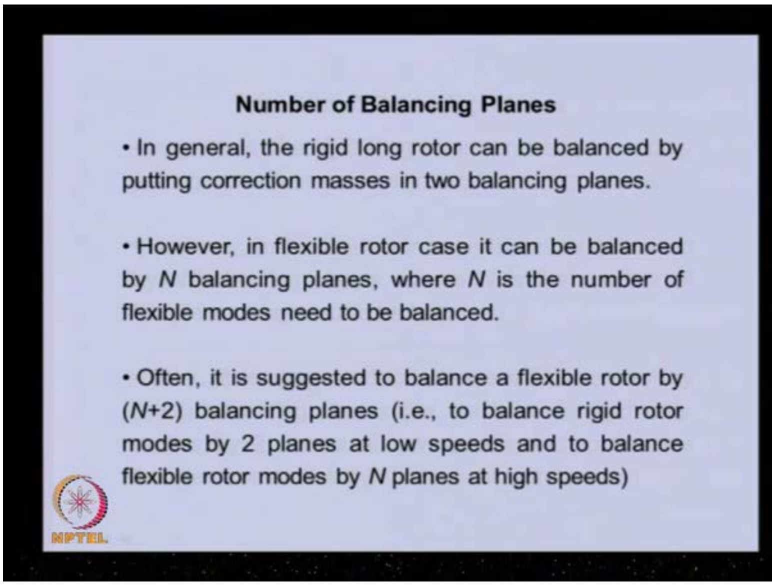

When we are talking about the balancing, then the question arises as to how many number of balancing plane we should have, to balance a rotor? Conventionally, we know that for rigid rotor, we require two balancing planes, because we need to balance the force as well as the moment. So, in general for rigid long rotor, it can be balanced by two balancing planes. But, when we are coming to the flexible rotor, then we need to balance it by N balancing planes, where N is the number of flexible modes we need to balance. That means, if we are operating the flexible rotor at about the third critical speed. Then that many planes, that is 3 planes will be required to balance such flexible rotor.

Sometimes, not only we balance them when we are balancing the flexible rotor. So, often it is suggested that not only we should balance the flexible mode, but also the rigid mode. So, that means for flexible mode, if we are balancing up to N th mode, we require N planes. But, what about the rigid body mode, that is the rigid rotor case? So, total number of balancing planes will be summation of this. That means N plus two balancing planes will be required to balance this. So, these two planes will be required at slow speed and N plane at the high speed. So, total N plus two balancing plane will be required to balance the flexible rotor in whole range of the operating speed.

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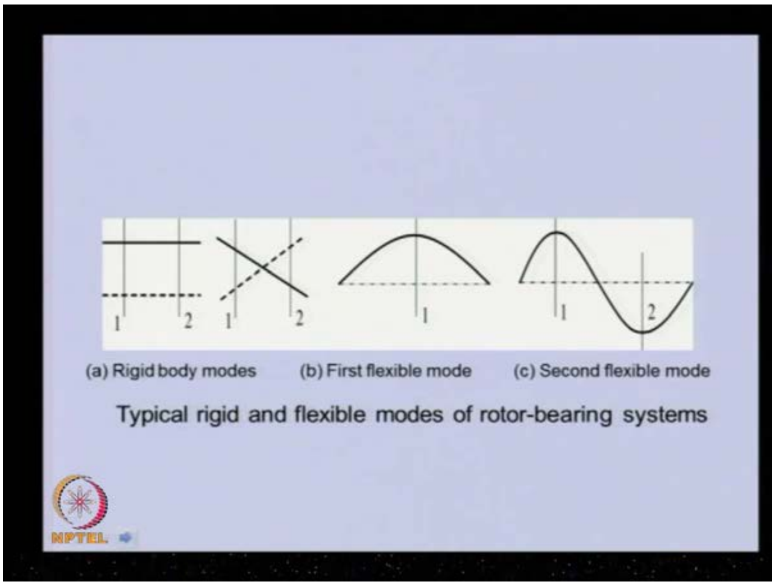

So, this is the concept of the rigid and flexible mode of rigid mode of rotor-bearing system. So, we can be able to see the solid line is in one position of the shaft and may be other extreme is coming here. So, this a rigid body translation mode and this is the rigid body conical wall mode. So, in this because these two are the rigid body modes, so when we are operating the rotor at low speed, when we want to balance these two modes, we require two planes when we are coming to the flexible mode. So, for simply supported rotor, let us say, we have this is the first flexible mode half sin to balance this.

Obviously, if we apply force in this direction, what is happening when we apply force like this, let us say in the form of some unbalance force? So, we will see that we can be able to decrease this particular amplitude of vibration. So, in this if you want to balance the first mode, the single plane is enough to balance this. But, when we are coming to the second mode, in this you can be able to see these are full sin wave and to balance this we require two forces here to balance this, because this we diminish the amplitude here and here. So, up to the second mode we require two planes to balance. So, this is the basic principle of the flexible mode and the rigid mode balancing.

Now, we have seen basic methods of balancing. What are the type of balancing, specially the rigid rotor and flexible rotor balancing? Now, we will go in more detail, especially theoretically. The basic principle, how we can be able to balance a rotor? We will focus first for the rigid rotor case, in which we will be focusing on static balancing and dynamic balancing. So, basic principle based on which this balancing processes are based, that will try to highlight.

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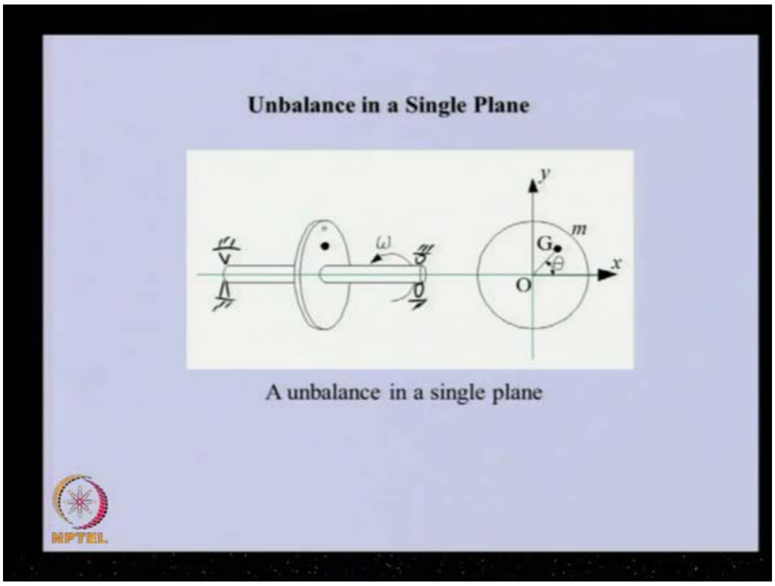

So, let us say unbalance in the single plane. So, in this particular case, if we have a rotor like this, let us say supported for single plane. If we want to do balancing, so basically this depends on the geometry of the rotor. So, for this rotor system you can be able to see this mounted on some kind of a bearing at ends. So, as such the mass of the shaft is negligible, the disc is heavy and we can be able to see that this particular the dark is representing that center of gravity is there.

It has been exerted here just to show that, how the center of gravity can give an unbalance force? Generally, this eccentricity from O to G will be the order of microns in actual rotors. So, in this particular case because of the geometry of the rotor, you can be able to see that we can be able to balance this particular rotor by single plane itself, because most of the unbalance is there in this plane itself.

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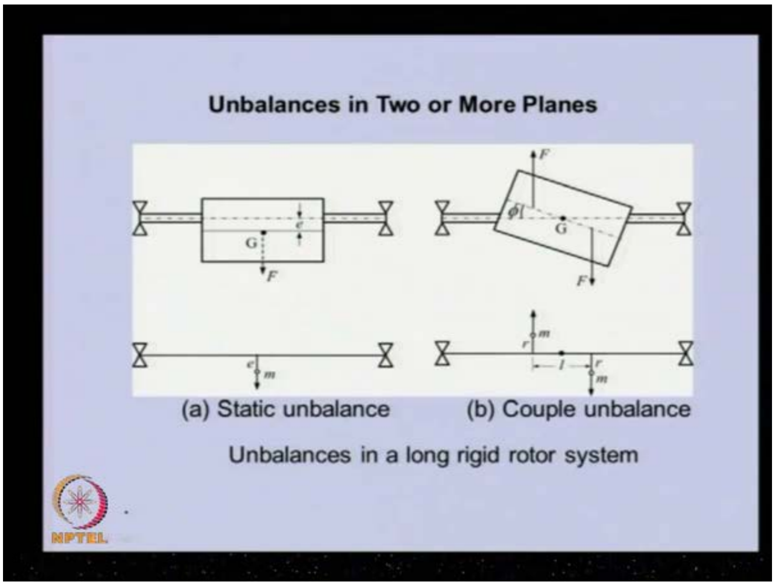

In two plane balancing, so basically in this you can see that this is a long rotor. In this is flexible shaft. In this particular case, this long rotor is offset such that the eccentricity is parallel. So, basically this eccentricity is offset in transverse direction and the eccentricity is constant throughout. So, in this particular rotor, if we want this effect of the centrifugal force, basically it will be acting at middle. We can be able to balance this particular rotor using single plane. That means, we can be able to balance with the static unbalance itself, because once we are doing the balancing in the single plane, the static balancing method is applicable.

But, the same long rotor if the center of gravity is there at the bearing axis, but it is having some tilting by some amount, then we will see that when this rotor is rotating there will be some force. They will form a couple and this particular couple will give two forces and two different planes. So, obviously we need to balance this particular rotor by two planes. So, single planes balancing will not be enough in this. When the center of gravity are at the center, the pure couple will act and that is why we call this as the couple unbalance. If we have a combination of an offset of the disc and like this and the tilting, then that particular unbalance is called dynamic unbalance. So, we will see these three cases subsequently.

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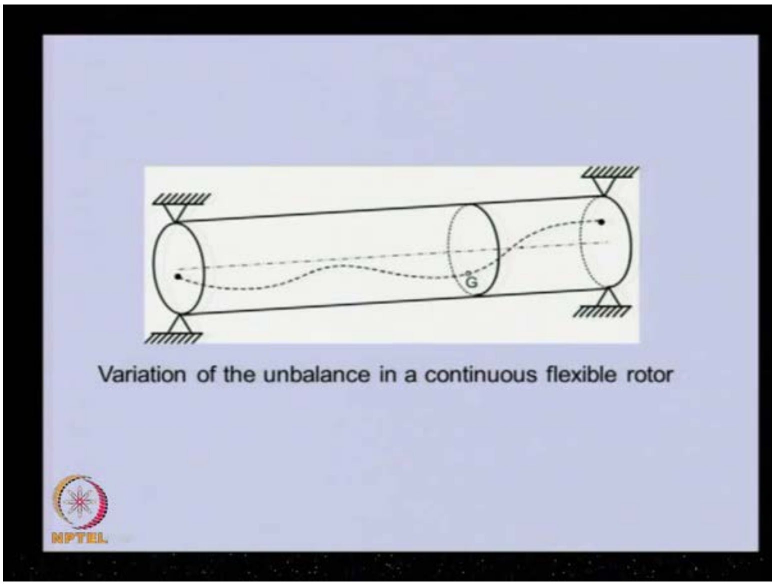

This is another category of the rotor in which rotor is very thick and flexible. In this particular case, this dotted line is the basically the center of the gravity variation. So, if we take a particular slice in between, we will see that center of gravity is here, but center of rotation is here and this is the eccentricity in the radial direction. If we take different slices, we will see that the position of the center of the gravity, not only the orientation, but also the radial position will change. This also we have exaggerated here. Generally, this eccentricity will be of order of microns in the actual rotors.

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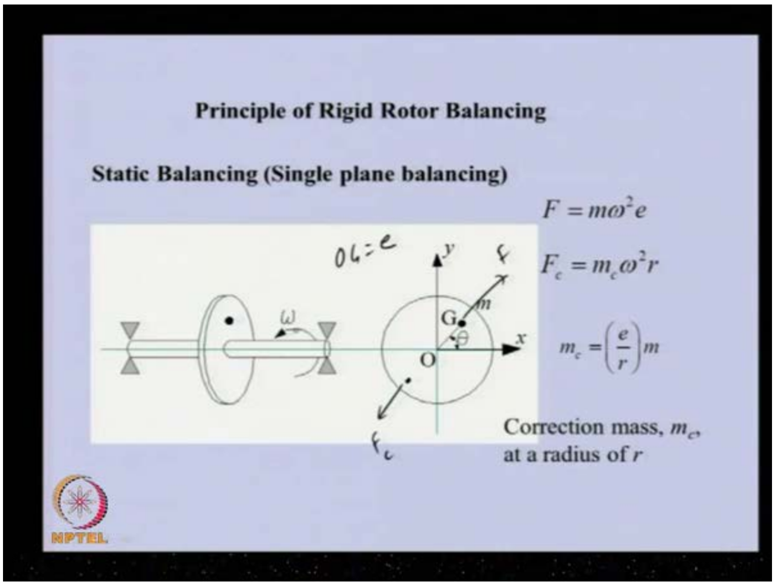

Now, coming to the principle of rigid rotor balancing; so for single plane balancing, as we discussed earlier, we can be able to balance by single mass, if you keep opposite to this particular, this unbalance… So, if because of the actual unbalance which is m e and the unbalanced force will be omega square, if you multiply that it will be the force. So, this is the unbalanced force is because of an eccentric mass. So, rotor center of gravities offset by some amount. So, O G is basically is the eccentricity. As, I told this distance will be very small and this is given centrifugal force of this amount.

So, if you want to correct this unbalance of the rotor, we need to put some correction mass m c and at a radius let us say r. So, this particular mass which were keeping somewhere opposite to this will produce a force m c omega square r. That will be acting opposite to this F c direction. Also, F is acting in this direction, so these two forces if they equal, then this unbalance can be balanced. So, this m c is basically correction mass and at a relatively larger radius, the correction mass will be smaller as compared to the rotor mass.

That is why, at a largest radius here, the rotor mass will be relatively higher. But, this eccentricity will be relatively small. So, if we equate these two forces we will see that correction mass will be given by this expression. So, by this we can be able to obtain the correction mass in a single plane balancing, which we called as a static balancing because in this particular case, as such we do not rotate the rotor at high speed.

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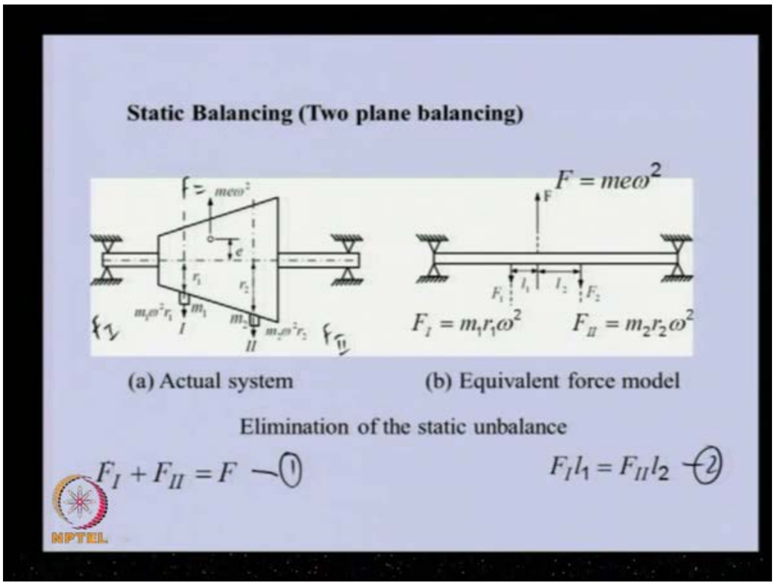

Now, we will see the static balancing, two plane balancing. So, there is a rotor and this there is offset of the rotor. So, there is center of gravity is offset, but there is no tilting of this particular rigid rotor. Because, this is giving the centrifugal force m e omega square, let us say, that particular force is F. Now, to balance this particular unbalance force, we are keeping two masses here in these two planes, because generally we will be having provision to put mass at the sides of the rotor. So, here we are keeping a mass, m 1 at the radius r 1 and here m 2 at the radius r 2.

So, they will give force F I and F II. Obviously, if we want to balance this force, F I plus F II should be equal to the total force. Here, you can be able to see this F is the force of the unbalance and these are the correction masses, force and centrifugal force. So F should be equal to F I plus F II. Apart from this, what were the additional mass, which we were keeping? The additional masses, m 1 and m 2, they should not produce additional couple.

So, to make sure that if we take the moment about let us say this point, this will not contribute to that moment, but F I and F II moment should be balanced. So, if we are satisfying first condition and second condition. From this if we are obtaining what should be the F I and F II, then we can be able to balance this static unbalance using two planes. So, here we are balancing with two planes, but actually this particular unbalance in the system is this static unbalance. So, from these two equations we can be able to solve F I and F II.

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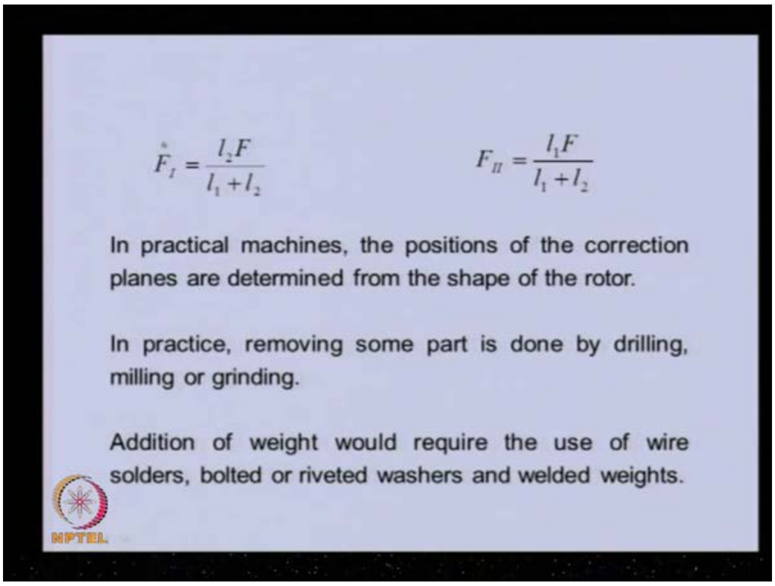

What is the correction mass required in plane one and two? In this particular case, even the rotor was long, but because the eccentricity was symmetrically present in the system, so the system was having static unbalance. Now, in practice and practical machine the position of the correction masses are determined from the shape of the rotor in practice. They are removing some part by drilling, milling or grinding of the rotor. If we want to add some weight instead of removing the material, we require the use of wire solders, bolted or riveted washers and welded weights. So, this is the practical way of adding or removing the mass from the actual machine.

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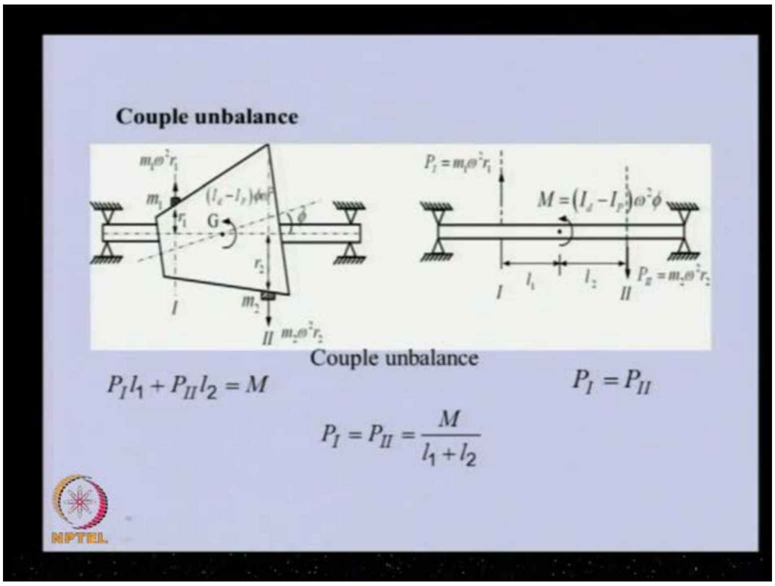

Now, in couple unbalance, the center of gravity of the rotor is at the rotating axis, but the rotor is tilted by some amount, by some angle. So, this will give a couple which will be equal to I d minus I p. This tilting angle is omega square. Basically, I d is the diameter mass moment of inertia of the rotor, I p is the polar mass moment inertia of the rotor, omega is spin speed of the rotor and pi is the tilting angle of the rotor. So, when because of this tilting there is a couple acting to count to balance this couple, we require masses in two planes in this particular case, because we need to make a couple. We need to keep these masses in the opposite phases of this particular rotor and they will give P I and P II force like this.

So, this is the unbalance couple and we are correcting this couple by two masses, m 1 and m 2. So, they will give P I and P II force. So, we should have this condition and the couple produced by these 2 forces should be equal to the unbalanced couple. These two forces should also balance, because they should not give additional force into the system. So, these two forces should be balanced. So, from these two equations we can be able to get a P I and P II, the correction mass and centrifugal force for plane 1 and 2 like this. So, you can be able to see that these two forces should be equal also, because they should produce a couple, but they should balance each other.

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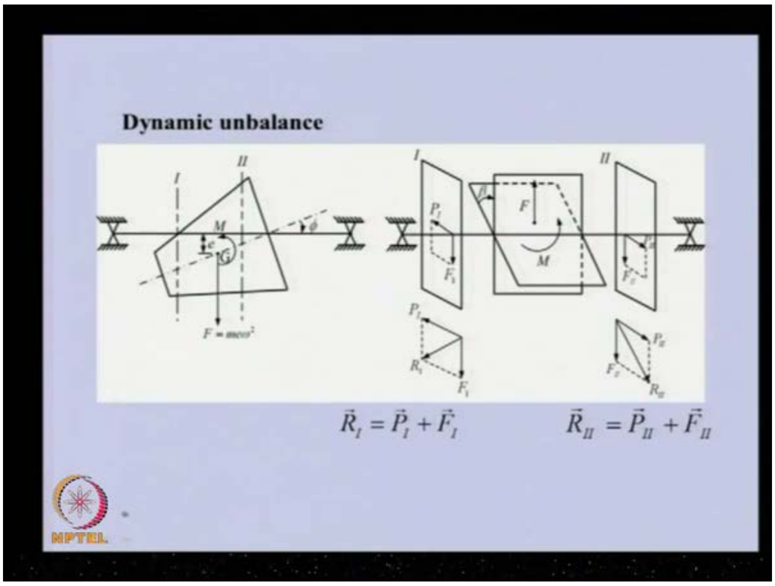

Now, when we are talking about the dynamic unbalance in which case we have not only the offset from the center of gravity from the axis of the rotation of the bearing, but tilting is also there. In this particular case, the offsite of this particular center of gravity and tilting these two plane may be different. This point will be more clear here. So, because of the offsite, let us say we have a centrifugal force F. This particular F, is let us say an a vertical plane and the couple which are coming because of the tilting, is let us say in another plane, which is inclined with the previous plane by beta angle. So, this couple is acting on this inclined plane.

Now, you can be able to see that we need to balance this particular force as well as the moment. For this, what we can do is that we can take one at the time. So, to balance the force we can have two correction planes 1 and 2, if these are the correction planes. So, what is the correction force require to balance F in plane 1? Let us say that comes, F I and in plane 2, let us say it comes F II. Because, we already have seen how we can be able to get the force F I and F II, if we want to balance a single centrifugal force, so those two relations will be valued here. Based on that, we can be able to obtain F I and F II to balance F.

Then, if we want to balance the moment on the couple, then we need to apply P I and P II on this plane, such that they should produce a couple equal to this, they should not add the additional forces as we discussed in the couple balancing case. Now, you can be able to see that in this particular plane we have F I and P I to balance these two forces and couple which are in different planes. Similarly, here we have F II and P II to balance these two, couple and force which are in different plane. Now, to balance the whole system, obviously we need to find the resultant of these two.

So, this the resultant R 1, which is resultant of P I and F I and resultant R 2, which is resultant of F II and P II, so this will be the correction forces in plane 1 and 2. You can be able to see that directions are now different because of the presence of the centrifugal force than the couple unbalance in the different plane. So, that is why this resultant R 1 and R 2 will be at different angle and the different magnitude, which we need to keep in these 2 balancing plane. So, this was the basic principle of the rigid rotor balancing of the static and dynamic balancing.

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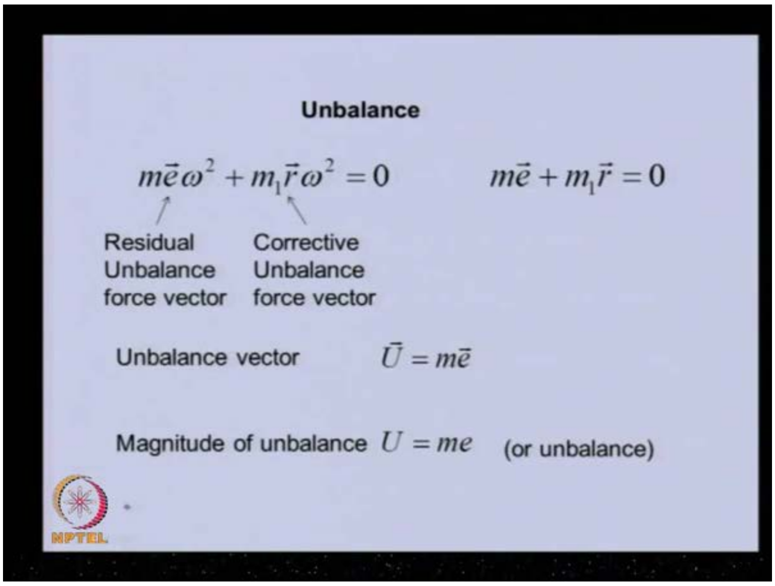

Now, let us define the unbalance more precisely. So, in previous slides, we have seen that generally we are balancing centrifugal force onto the residual unbalance by some correction mass which are keeping at certain radius. Now, you can be able to see that omega square is common here. So, that will go out because both the unbalance and the correction mass are rotating in the same speed. So, basically we will get this equation. So, this product is important.

The mass into eccentricity or the correction mass into the radial position is important. This is called the unbalanced vector. So, this is the unbalance vector and magnitude of this unbalanced vector U is m e, which some time we called it as unbalance. So, the product of the mass into acceleration, the magnitude of this unbalanced vector, the product which is product of the mass of the rotor into the eccentricity, we called it as an unbalance. So, just unbalance if we are saying there is nothing but mass into the eccentricity of the rotor.

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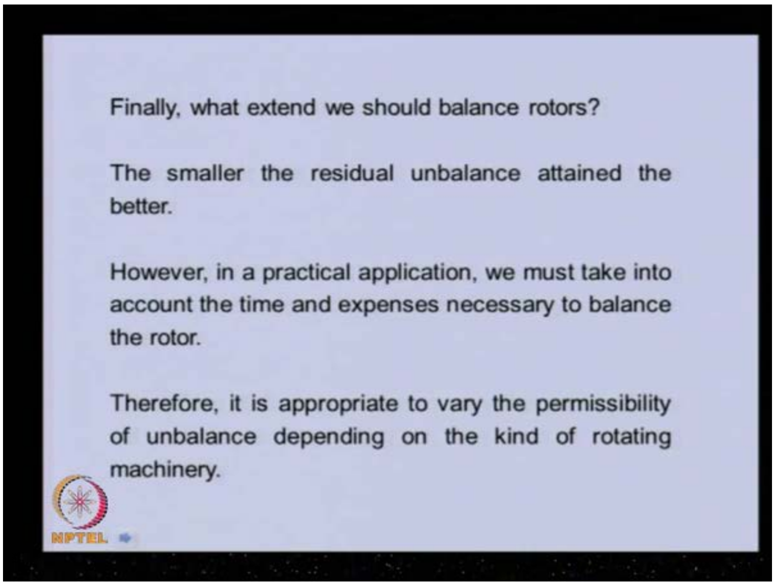

Now, the question comes if you want to balance this rotor, so up to what extent again I am starting at this slide? Finally, we want to know up to what extent we should balance the rotor. This is a question we always think of whether, because we know that practically is not possible to balance the rotor perfectly and some residual unbalance will be left in the rotor. So, this question is very pertinent, that up to what level we should go for balancing of the rotor?

So, smaller the unbalance range, the residual unbalance attending there is better. So, best is if you can reduce the unbalance to very small then it is better. But, how are this in practice and practical application we must take in the account time and expenses necessary to balance the rotor? That is very important in the industry. Therefore, it is appropriate to vary the permissibility of unbalance depending upon the kind of rotating machinery. So, kind of rotating machinery governs what kind of hang.

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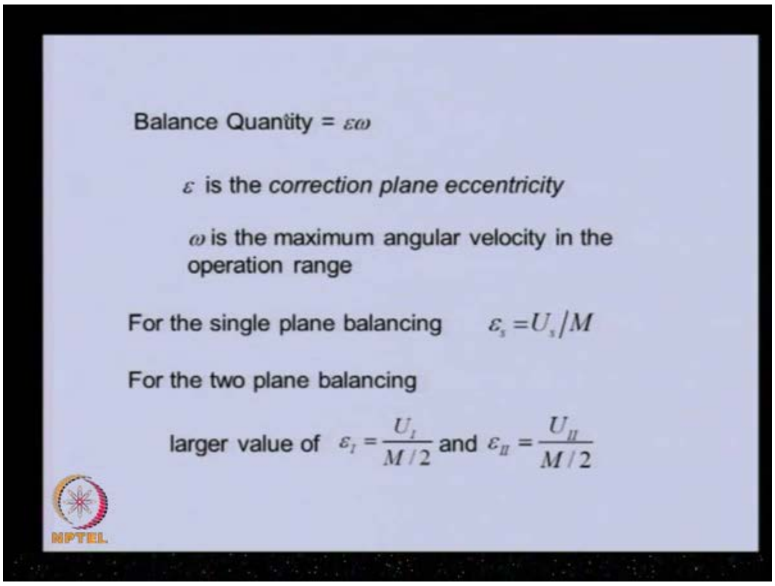

So, we are defining term balance quality, which is epsilon into omega, where epsilon is correction plane eccentricity and omega is the maximum angular velocity in the operating range of the rotor. If we are talking about the single plane balancing, then this correction plane eccentricity for static case will be given as static unbalance divided by mass of the rotor.

If we are talking about two plane balancing, either static or dynamic, then we will be defining 2 parameters, epsilon 1 which will be U 1 by M by 2. This is half of the mass of the rotor. So, this is the unbalance in one of the plane and epsilon 2 is unbalance in the second plane divided by mass of the half of the mass of the rotor. In this case, whichever the larger value, that will be the balance quality of rotor.

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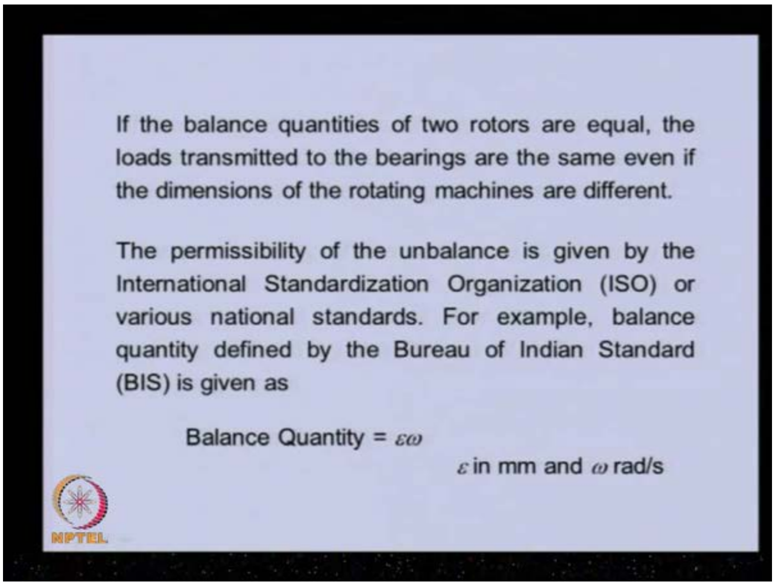

May be now, if the balancing qualities of 2 rotors are equal, the load transmitted to the bearings are same even if the dimension of the rotating machine are different. So, you can be able to see that with balance quality, we can be able to compare two different rotors, because finally whatever the unbalance forces are there, that is transmitted to the bearing. If these two balance quantity of rotor are same, they will produce some force at the bearing. The permissibility of unbalance is given by International Standardization Organization like ISO or various national standards.

For example, balance quality defined by the Bureau of the Indian Standards that is BIS, is given as balance quality. It is equal to epsilon into omega. It is same as the previous one. Only thing is that units are to be noted, that epsilon is in millimeter and omega is in the radians per second.

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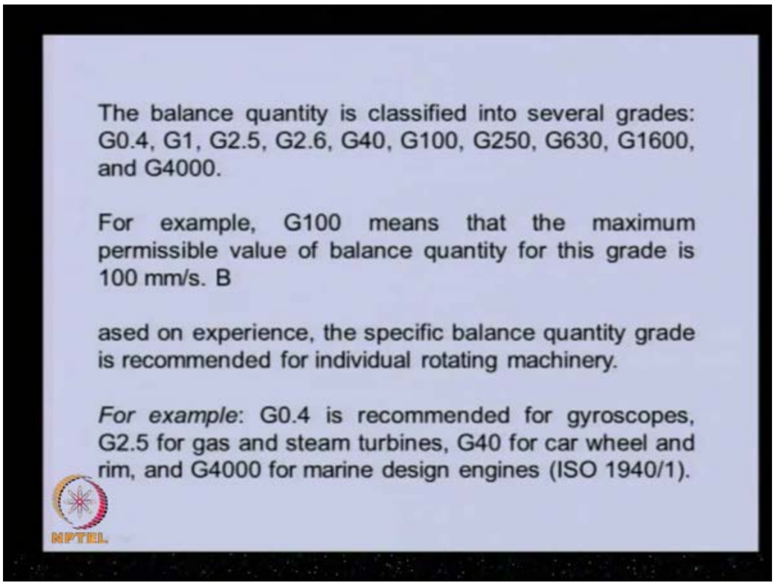

Various balance quality is classified like this. Several grades are there. So, G 0.4, G 1, G 2.5 and that can go up to G 4000. For example, G 100 means that the maximum permissible value of balance quality for this grade is 100 millimeter per second. Based on experience, the specific balance quality grade is recommended for individual rotating machine. For example, G 0.4 is recommended for gyroscopes, which are requiring very high appreciation, G 2.5 for gas and steam turbines, G 40 for car wheels or rims and G 4000 is for marine engines in which lot of vibrations can be tolerated. We can able to tolerate and we can able to refer to various standard. This is one of them.

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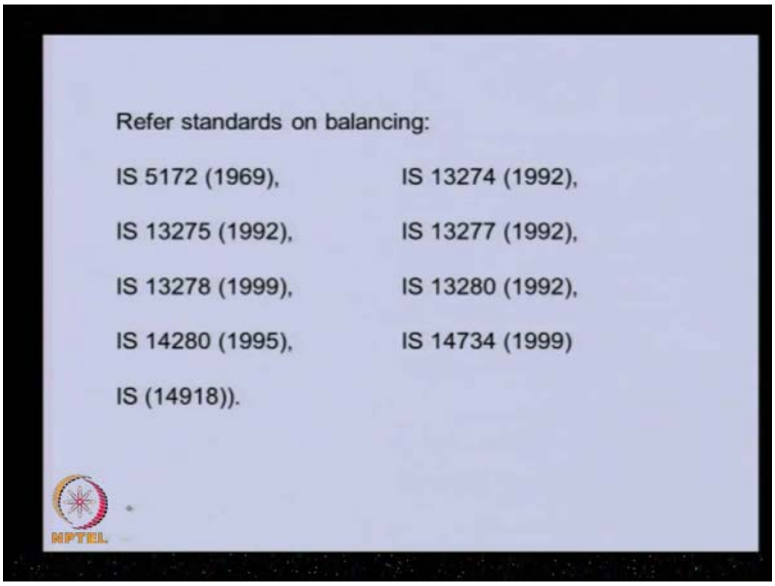

Apart from that, these are the various standards available for balancing, which have been updated over period of time also. Now, we will see how a practical rotor can be balanced and what are the types of method, what are the types of machines available for this and the basic principle of those methods to balance a practical rotor.

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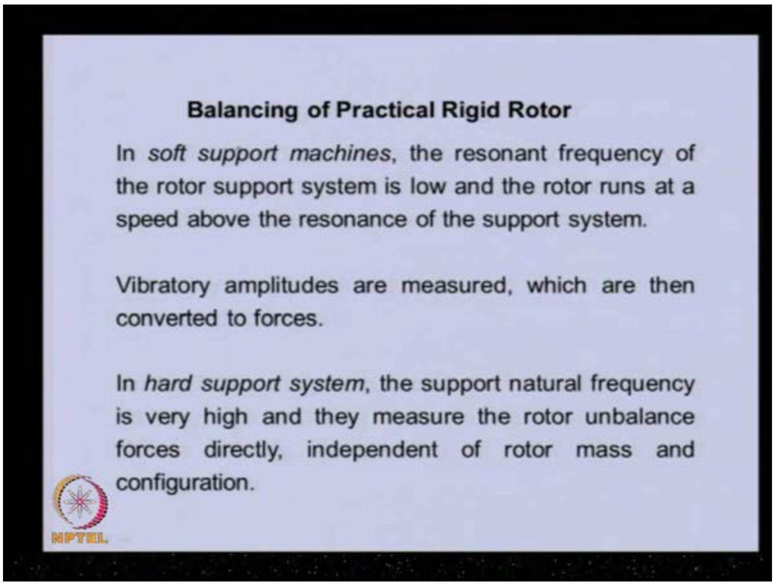

In this, we have two type of machines, one is soft support machines in which the resonance frequency of rotor system is low, because the support is the soft and the rotor inside has a speed above the resonance of the support system. In this particular case, generally we measure the vibration amplitude. Then we convert that into the force. There are other systems into the hard support system. In this, the support natural frequency are relatively high and then the measure at the rotor unbalance force is directly independent of the rotor mass and the configuration.

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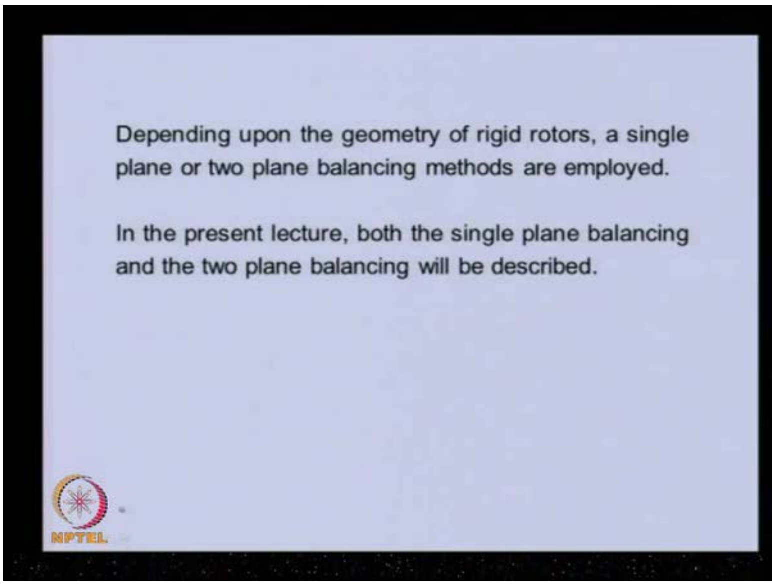

So, depending upon the geometry of the rigid rotor is single plane or a two plane, balancing methods are employed. So, basically the single plane or two plane balancing specially for the rigid rotor, it depends upon the geometry of the rotor. In the present lecture I will discuss single plane and the two plane balancing.

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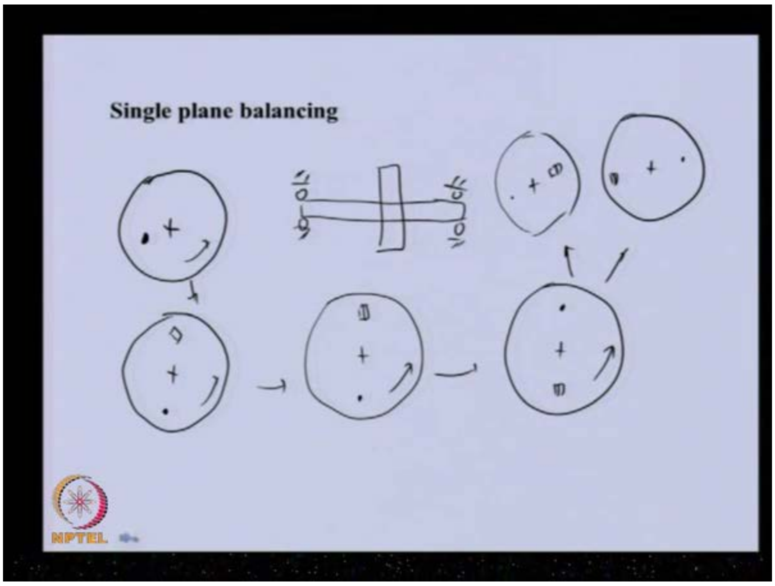

So, for single plane balancing, if our rotor is like this, this is the center of rotation of the rotor. If it is having large eccentricity, let us say, if we mount this particular rotor on some frictionless support. If we rotate this rotor by hand by some amount and if we allow it to rotate because of the friction, after sometime it will stop. So, we expect that because of the unbalance, if unbalance is heavy it will try to stop in this particular position. If we again rotate this, may be it will come and rest in this particular configuration. This will indicate that there is some kind of unbalance in the rotor which is somewhere here. To balance this, obviously we need to keep some kind of correction mass in the other side.

If we are putting this R 1 some value and once we put it, if we are again rotating this, if it comes again to the same configuration after once it stops. That means whatever the correction mass we kept, it is not sufficient. We need to add some more mass in that particular part again. We need to give rotation by hand and see how it stops? If it stops something like this, that means whatever the initial mass, we kept is very heavy and because of this it is coming in this position. So, we need to remove some mass from here.

If we removed some mass and on rotating it, if the rotor is stopping at some indifferent position, once we rotated this is coming here, second time if it is coming like this or any other position, that means now the rotor is balanced. So, basically we need to see this particular part. So, like this we can be able to do the static balancing. Most of the rotor in which most of the mass of the rotor is at 1 plane, they can be balanced using this procedure, like propeller in the aircraft they can be balance like this, in which most of the mass is situated in a single plane.

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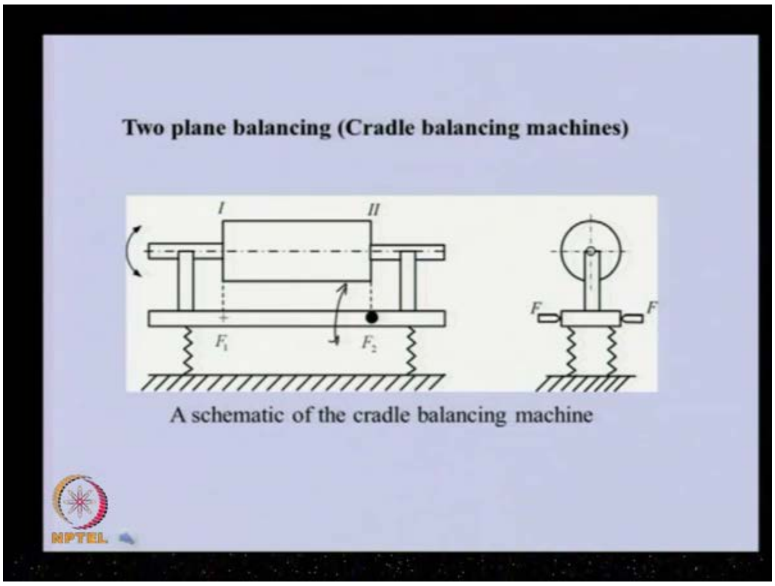

Now, we will see how we can be able to balance a rotor in which the balancing is required for the two planes. So, you can be able to see this as a two plane balancing machine, which we called as a cradle balancing machines. In this, upper part is the rotor which is mounted on 1 support. This is some kind of bearing support, which is frictionless support to the rotor and this whole assembly of the bearing and the base is mounted on some kind of flexible support. This is the rigid disc, the flexible support if we see from the side, is something like this.

So, it is mounted on basically four flexible springs. This is the rotor and this is bearing. In this there is a provision to fulcrum or kiosk this particular frame, either at F I location or F II location, which is just below this plane, this plane basically in the real rotor. We can be able to add unbalance here or here. So, these are the balancing planes 1 and 2 for this rotor. Just below that, we have provision to fulcrum this whole frame at this point or this point. So, if we are to fulcrum at this point, you can be able to see that we will be having motion.

So, we will be having motion of this about this F I. So, the whole assembly can rotate about this point, because we have polychrome, like this F I. Once we fulcrum like this, that means what is the correction mass required for balancing in the rotor second plane we can be able to obtain using this. In the second case, if we fulcrum here at F II, then the whole assembly can tilt like this about F II. In that particular case, we will be having this plane correction mass.

We can be able to obtain this. So, you can able to see that when we fulcrum here at F I, you can be able to obtain the correction mass required at F II. Also, when we fulcrum at F II we can be able to obtain the correction mass required at F I. Now, let us see, how we can be able to balance a rotor?

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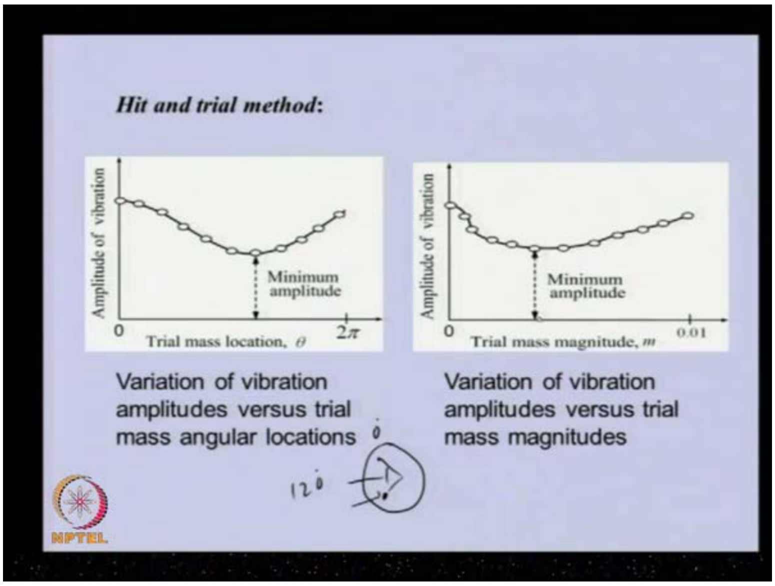

So, if we polychrome, let us say we fulcrum at 1 point F I and we want to obtain the correction mass at F II, so this hit and trial method we are following. So, we will keep some trial mass in plane at some orientation. So, let us say, 0 angles with mass, some angle there we will keep some known mass and then we will rotate the rotor at certain rpm. This will be provision to major the amplitude of the base. In this particular case, we can be able to measure how much this particular base is vibrating. So, that amplitude let us say, this is coming here.

This will change the orientation of the mass at the plane 2. At the different position we will measure where the amplitude we will plot. So, from this plot you can be able to see that when we are keeping the unbalance in this angular position, the amplitude and the vibration is minimum. So, that means this is the correct location of the unbalance, a slight unbalance we need to keep. So, once we found out the rotor angular position, let us say this is 0 angle. So, corresponding to this, if it is let us say 120 degree, so we need to have correction plane at here.

So, this is 120 degree now. Once we obtain this particular angle position, now we can be able to change the magnitude of the trial mass and observe the magnitude in the same place at same speed. All the measurement we are doing at this same speed. We will plot for different trial masses, how the variation of the amplitude is taking place? From this, where ever the minimum amplitude is there, that particular mass will be the correction mass in plane 2. So, from this we got the angular position and from this we got the magnitude of the unbalance. Now, we could able to get the correction mass in plane 2.

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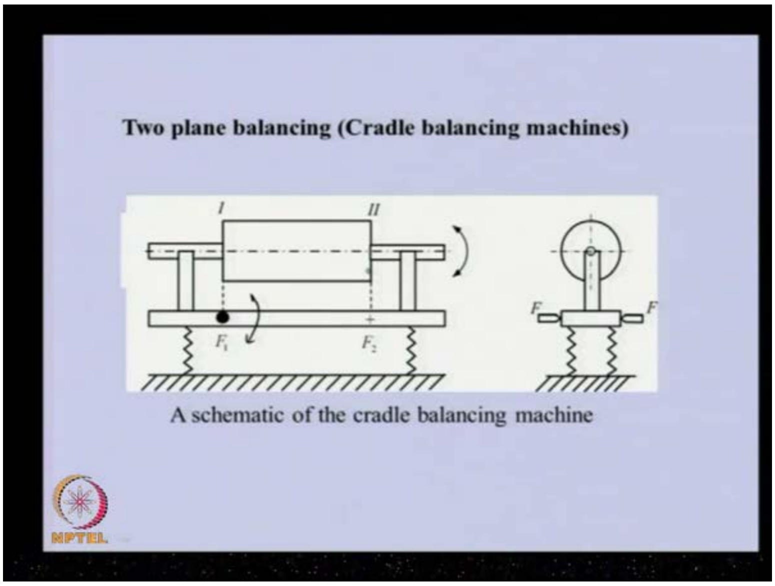

By this hit and trial method, now in second case we will fulcrum here and we will try to do the same experiment to find out the location and the magnitude of the correction mass require in plane 1. So, like that we can be able to do the balancing of this particular rotor using the hit and trial method. So, in today's lecture we tried to introduce very common fault which is inherent in the rotor system, that is unbalance. Apart from that, we introduced there are several other kind of fault, but most common is the unbalance. This particular unbalanced rotor gives unnecessary forces on to the bearing, because the centrifugal force comes.

Because, of the unbalance, this comes out to the bearing and bearing fails because of this unbalanced force, if this unbalance force is of high magnitude. So, we need to balance this particular rotor not only at the stage of commissioning the rotor, but also when we are doing major overhaul we need to balance a rotor. We need to check whether they are having acceptable limit of vibrations or not. We have already seen in the lecture that there are some standards, which gives what should be the minimum tolerable amount of unbalance we can have in the rotor system?

It depends upon application to application. In subsequent lecture will try to go in more depth into the various methods, which are available for dynamic balancing of the rotor, which basically ensures minimum number of measurement to be taken. In the subsequent lecture, we will see even the balancing of the flexible rotor.