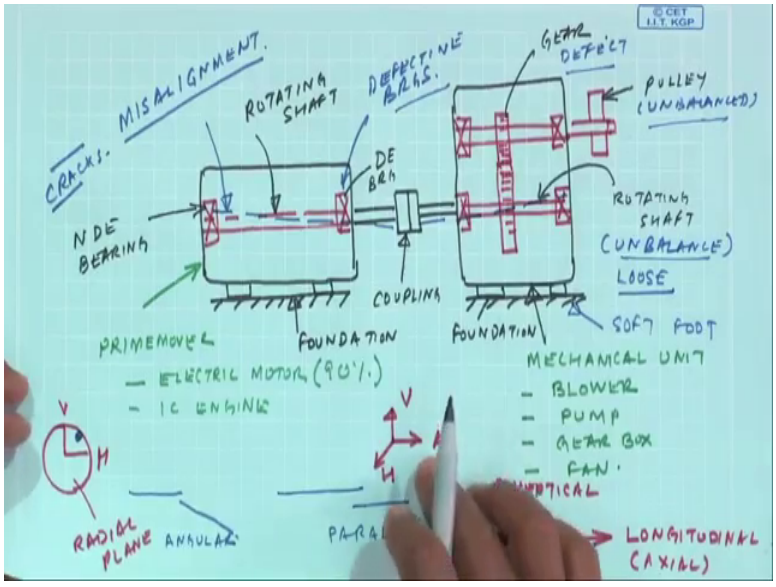
Machinery Fault Diagnosis and Signal Processing
Prof. A.R.Mohanty
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 36
Introduction to Faults in Rotating Machines

You are in this 8th week. We are rather in the beginning the 8th week, will be slowly getting into actual faults which occur in rotating machines. So far, of course, you know we had actually, you can think of where the prerequisites to finding out faults in machines; be it signal processing, little bit of vibration analysis, noise monitoring, instrumentation transducer and so on.

And now starting this week will be mostly focusing on faults in rotating machines and then, what are the common types of fault in rotating machines and what are the other effects of the faults in machines and then particularly, the techniques which are predominantly used to find out faults in this machines. So, before we get into the actual faults, let me give you an overview of the possible faults in a rotating machine.

(Refer Slide Time: 01:17)



Now, if you will realize, essentially any rotating machine is actually combination of a prime mover which is mounted on a foundation and prime mover could be a motor or an engine which is coupled on to a mechanical driven unit which is again put on a foundation. Now each of this machines would have rotating shaft which I am drawing by

this red line, there could be many such rotating shafts and so on and of course, this shafts are supported in bearings, etcetera. So, this is your prime mover which could be a electrical or electric motor and IC engine, wherever we do not have a power source people use IC engine, for example, in remote areas you know like petrol engine, diesel engine, you must have seen, of course, in India, we get to see lot of portable pump sets. Another example is you know the pump sets used by fire trucks, you know, if they are going to rescue, etcetera, we may not have a source of electrical power.

So, IC engines are also used, but as you will see know throughout the world about ninety percent of the prime movers are actually electrical motors, it could be a c motor dc motor depending on the type of application which is driven driving a mechanical unit which could be example could be blower. In the last class, I had shown you the photograph of a blower where we are doing noise monitoring and this blower has actually driven by an electrical motor, it could be a pump it could be a gearbox for speed reduction, it could be a fan, etcetera and this may have you know gears machine a step up, step down, there could be pulleys. So, this is one rotating shaft, this is another rotating shaft, this is known as the non drive end bearing and this is the drive end de bearing and this is a coupling this could be a pulley this could be a gear and then we have this is the; obviously, the foundation another foundation.

So, this gives generic representation of rotating machine which is been driven by an electrical motor now keeping this picture in mind, we will see, what are the possible faults which can occur in this machine am going to list down the faults later, but let me first explain to you through this diagram that what possible could be of fault in this machine. For example, this shaft between the driven and driving shaft they all should be concentric and same straight line that may not happen because of one foundation foot being softer than the other there could be a little change in the angle..

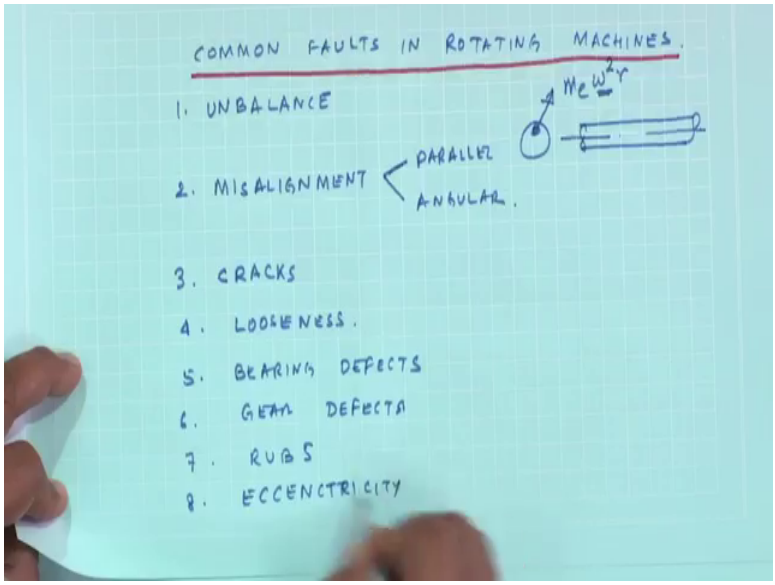
So, this will give rise to a fault which is known as misalignment I am just showing this in one plane. So, this misalignment could be either a parallel misalignment or an angular misalignment by the shafts has queued. So, this is parallel or this is angular, then this, the coupling will also get effected. Now there could be defects in the bearings we will talk about later on defective bearings.

What do you mean by defective bearings? There are as you know, bearings are rolling element which will support a load and this rolling elements are opposed to rotate and give elastration and carry the load, but if there is any foreign particle present in the races of the bearing, the frictional forces would increase the heat generation because of this frictional force will increase and eventually because of this heat the lubricant could get baked and they would form hard carbon residues which could score the races of the bearings and the bearings would be damaged..

So, this are possible gears could be defective the these are truth could be checked could be broken could be worn out pulley could be unbalanced shafts they are supposed to be uniformly homogenous rotating and components which can have unbalance now we will see. So, cracks will having unbalance cracks are having misalignment now this components like gears which are mounted on the shafts or the pulleys they could be loose.

So, whatever I am writing in blue are actually defects which can happen. So, foundation, you can have, what is known as soft foot, then another fault which can occur is things could be loose which I have told now this shaft because of some defects or weak spot because they are loading the while other rotating they get loaded and unloaded there could be cracks in the components ok.

(Refer Slide Time: 09:38)

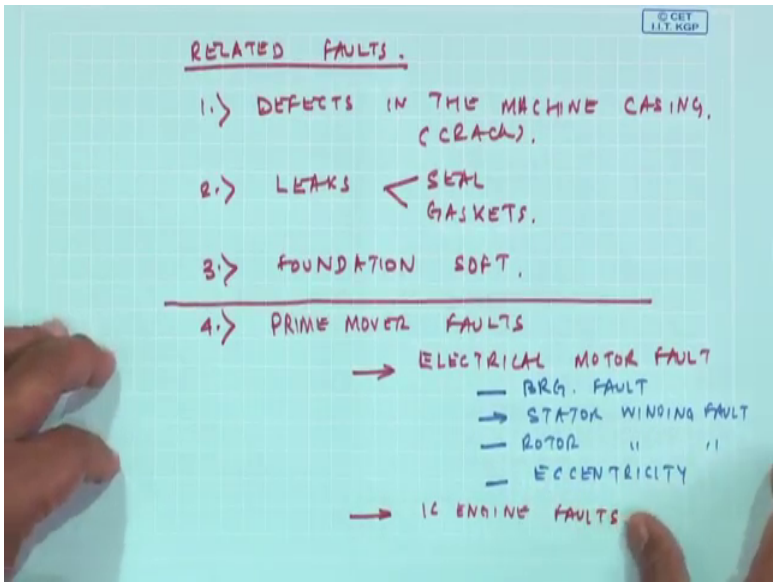


So, it was to list down some of the common faults in rotating machines one is unbalance either in any of the rotating component you can imagine a shaft which is rotating at very high speeds and if you look at the if there is an unbalance mass the force should be me omega square r so, but at very very high speeds you can realize the radial forces which come from this unbalance are extremely high and this could load the bearings and then bearings could get eventually damaged. Let me give you an sense of the orientation which we talk about. Now in this figure here any direction along the length of the machine is known as longitudinal or axial anything in the vertical is vertical and anything into the plane of this paper is horizontal. So, if you look at the radial plane for look at the side view.

So, this is your vertical and this is your horizontal I will denote as. So, this is H. So, this is your radial plane and this is your axial axis. So, as I as you know vibration at any point and in three dimensional point can be represented by three directions axial vertical horizontal and in the vertical and horizontal, it is from the same radial plane now what happens, if there is an unbalance the vibrations in the radial plane would be high and they would give rise to a very high reaction forces on the bearings now another important fault is misalignment the geometric centers of the two shafts which are joined at a coupling may not be same. So, this misalignment can be parallel or angular now another component is the shafts could be having cracks they could be loose and then there could be bearing defects there could be gear defects and another component if one component was just rubbing against another component.

It can create lot of high frequency noise and streak rubs. So, these are some of the common faults in rotating machines.

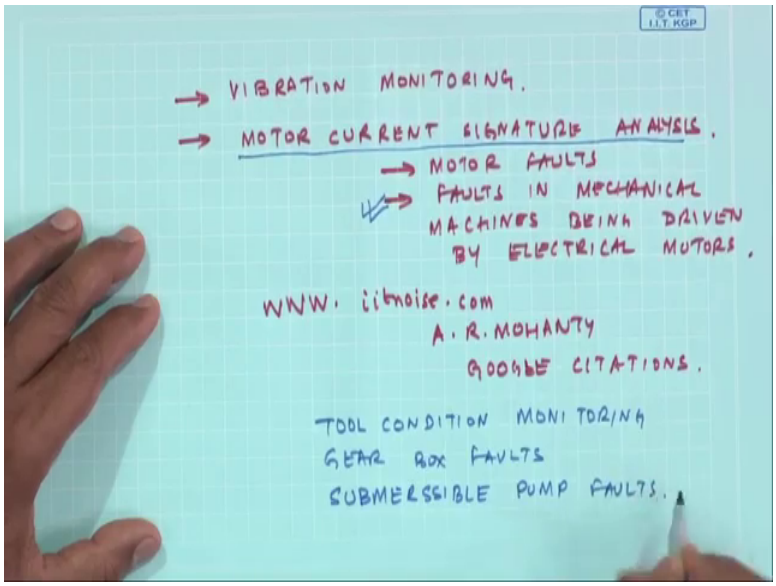
(Refer Slide Time: 13:43)



But then here, I have not discussed some of the other related faults what the related faults defects in the machine casing could be a structural crack leaks out of seals and gaskets foundation soft then of course, something related is you know this was in terms of the prime mover faults prime mover faults. So, if you look at the power supply the electrical motor fault view we can further make it out the what could they may motor fault the motor bearing fault, we will discuss this in later on, the stator winding fault rotor winding fault eccentricity between the rotor and the stator of course, eccentricity can also be there in the rotating machines. So, there could be; so, these are some of the faults of course, in this, you have an IC engine the IC engine faults.

So, with this kind of an overview of the different faults which are occurring in machines we will now in the later classes try to see, how this faults can be identified mostly.

(Refer Slide Time: 16:17)



As I was telling you through vibration monitoring, but since ninety percent of the machines in the world today are actually driven by electrical motors a technique called motor current signature analysis can be used to find out motor faults and then faults in mechanical machines being driven by electrical motors. In fact, you know we were the pioneers about two decades ago at IIT, Kharagpur to find out faults in mechanical machines like you know gear boxes submersible pump through a technique known as motor current signature analysis and details of these you can find out at our website.

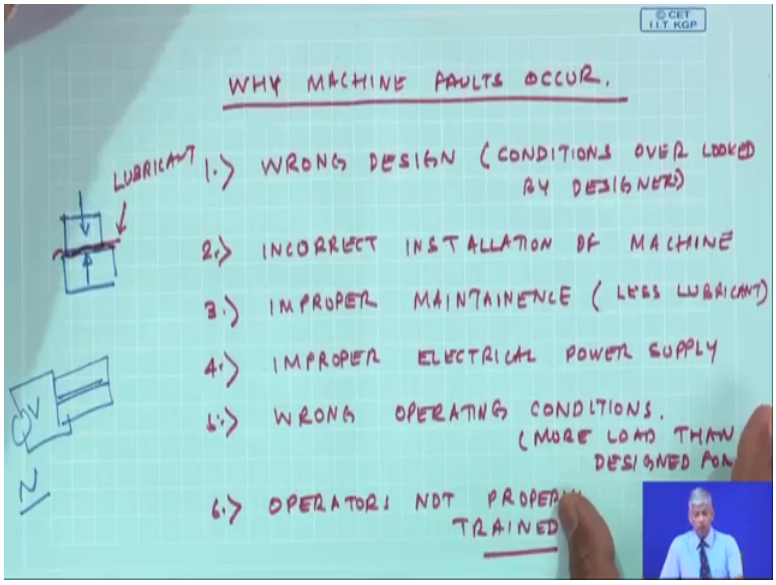
Where you will be referred to mm papers on this are you can Google me and go to my Google column scholar citations and get the relevant papers on MCSA for finding out faults in electrical machine that is those of you want little bit of more self study and reading one good source just you know where we have been successively done tool condition monitoring, then is gear box faults and submersible pump faults because I will just give an idea imagine all of you know that we can put an accelerometer on a mechanical unit and gets its vibration response do a signal analysis and find out the fault in that mechanical unit.

But imagine, if a submersible pump which is you know fifty meters under the ground and there is no wave we can access such a submersible pump to put an accelerometer, how do we monitor the condition of such a submersible pump. So, actually it is this monitor current signature analysis which we can very easily do from a remote location

just by having a; what is known as a hall effects at to measure the current form which is being drawn by the submersible pump and this currents are actually modulated..

So, by doing a demodulation of the measured current which is driving the submersible pump motor we can actually find out the faults in the submersible pump. So, these are very powerful techniques which we will come in detail later on we will discuss about then in detail right now question is we have seen the list of the faults which occur in machines you know your benefit I want to put this slide back again. So, these are some of the common faults which occur in rotating machines.

(Refer Slide Time: 20:24)



Now, the question is why did it happen in first place? So, you must have some idea why such faults occur one is wrong design I am using this statement wrong design or some conditions overlooked by the designer designers in correct installation of machines because as you know in a machine there are many components which rub against each other ok.

So, if things meet and rub; obviously, because of this force there will be lot of heat generation and to liberate this heat or reduce the friction people put lubricant; so, in a regular schedule maintenance, such lubricants are actually changed or it is ensured that the lubricants always exist. So, I would say some of the reasons why faults occur is improper maintenance because you know that could mean may be less lubricant wrong power supply because if the electrical supply frequency many of the motor which we

prime movers are run they are supposed to be supplied with an electrical supply now imagine.

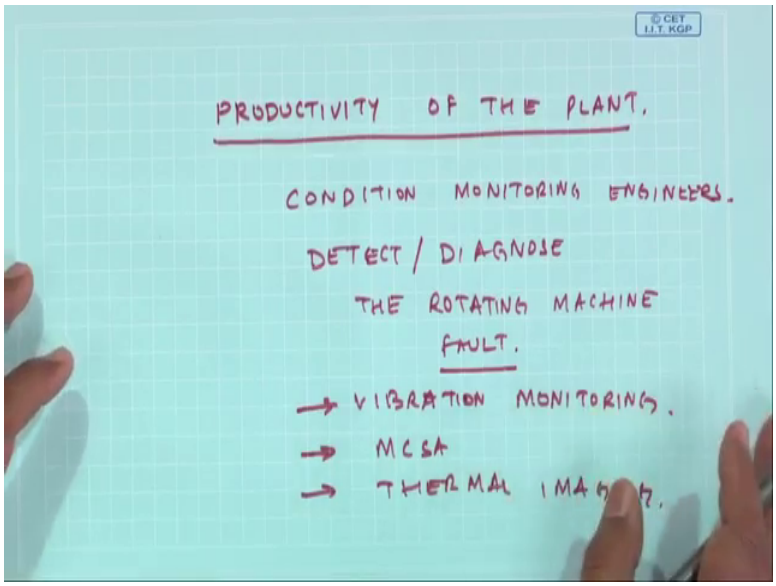
If the speed of the motor is related to the engine power supply frequency we can have a speed fluctuation and which will endure or induce torsional oscillation. So, improper electrical power supply another is wrong operating conditions I will give you a good example of the you know particularly in India, there is an I mention India specifically in this videos are being watched worldwide because from the emails, I get from students from Australia, from Africa, from Europe, I realize you know everybody is watching this videos..

So, my examples related to things in India, see in India, we have trucks, lorries, which carries sand, you know sand from the river bed to the construction sites on, if you be on the highway, you will see many places the truck exiled broken down because of the reason that the truck operator has loaded this truck with more than the designed pay load of the sand more sand, they carry the more money they can make, but they do not realize that they are overloading the load carrying capacity of the axial of a truck, you know, we have 25 ton truck, we have 6 ton trucks and we have still very heavy trucks, dump trucks in mining industries, you know, carrying 240 tons, we have the abseil; the railway wagons which carry iron ore, coal, etcetera and in India, I must tell you of safe design limit to the abseils in rail, roads is about 30 tons per axial.

So, when a designer designs equipment, we have to keep this numbers into account. So, somebody has or more load than design for load then designed for. So, this can happen. So, it is not the fault of the condition monitoring engineer that why this has happened. So, these are some of the reasons and this could be an enlarged depending on the case studies may be do not have the enough finance to have the right tool may be operators not trained not properly trained..

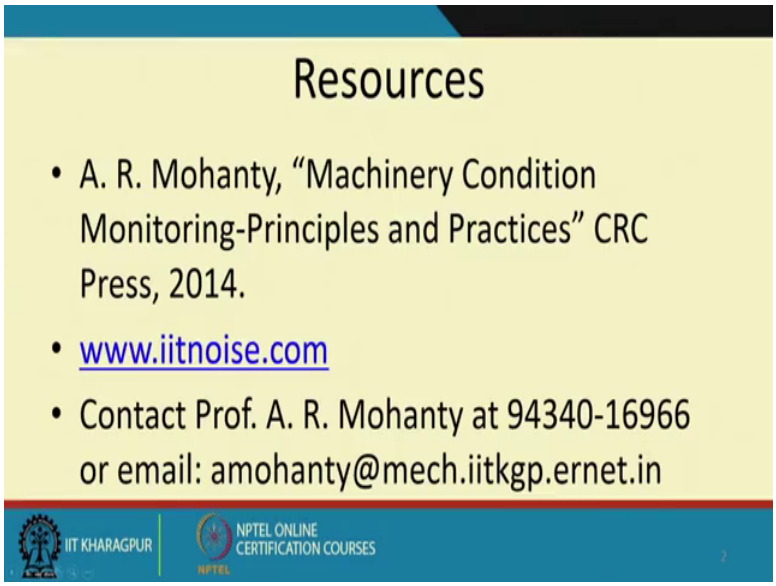
So, I am not denying that this will not happen, this will happen despite our best maintenance affords best of best affords, but even if this has occurred my machines are going to have this faults it could be a combination to this faults it could be only this fault, but all this faults have ramifications into the productivity of the plant.

(Refer Slide Time: 26:22)



I recall my very first lecture on machinery maintenance productivity of the plant is going to get seriously affected because of such faults which have occurred in the machine or in the plant. So, we as condition monitoring engineers our objective is to detect or diagnose the rotating machine fault and we will subsequent causes we will go one by one each of this faults find out the telltale science by vibration monitoring; how such faults can be detected and may be little bit of MCSA and recently which we have also done through thermal imaging. So, this lecture actually sets the ball for the next may be two weeks what we are going to discuss all these kinds of faults and how this faults can be detected and then.

(Refer Slide Time: 28:04)



We will see how machines are healthy. So, more of these, you could find in my book and at this website iit noise dot com.

Thank you.