Machinery Fault Diagnosis and Signal Processing
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Lecture - 60
Future of Condition based Monitoring

Well, we have come to the end of a 3 month course and that this would complete the 12 week course on machinery fault diagnostics and signal processing. I hope those of you who have registered online had a wonderful learning experience, as I had told right in the beginning in the introductory video in this lecture on machinery for diagnosis and signal processing. Well, there are limitations as to know this is not a formal classroom where there are students live and interacting with me and asking me questions.

And let me tell you this is I am not a movie star and all this recordings which have been done we were uncut and they were done on the fly there were no retakes. So, there would have been mistakes and slips in some terminology some spelling mistakes some mispronunciations. So, please excuse me for that ok. This is I knew I was as formal as I could be, but then being formal by a teacher has limitations in the classroom. A lot of things does not flow through you know and being in the internet I cannot cut too many jokes and so on.

But then you would have got a flavor of what machinery for diagnosis and signal processing is. And you yourselves would have also come up to the idea that what are the new trending areas in a condition based monitoring.

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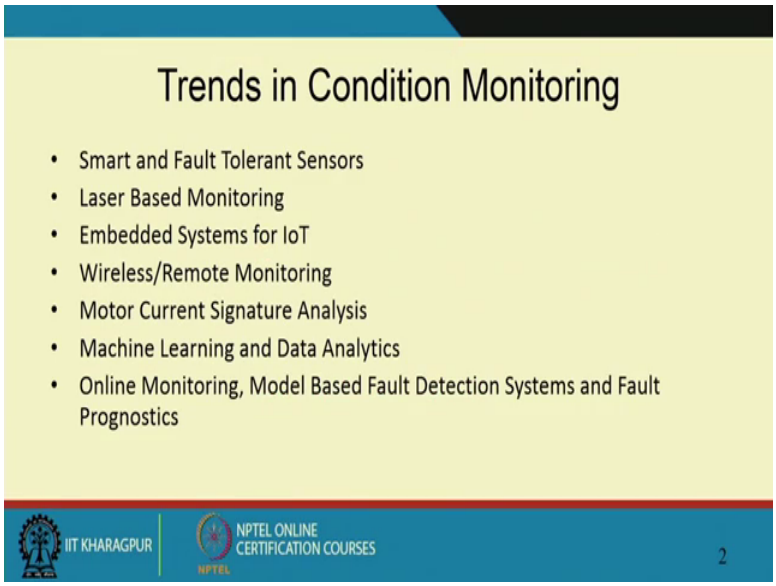

So, I have listed some of them and these are the future trends in condition monitoring and so I will go and explain one by one these techniques or this trends which are happening.

Well, the first one is this smart and fault tolerant sensors. Today the technology in instrumentation electronics is such that we can have sensors which will autocorrect themselves imagine because as I told you wrong measurements is no measurements.

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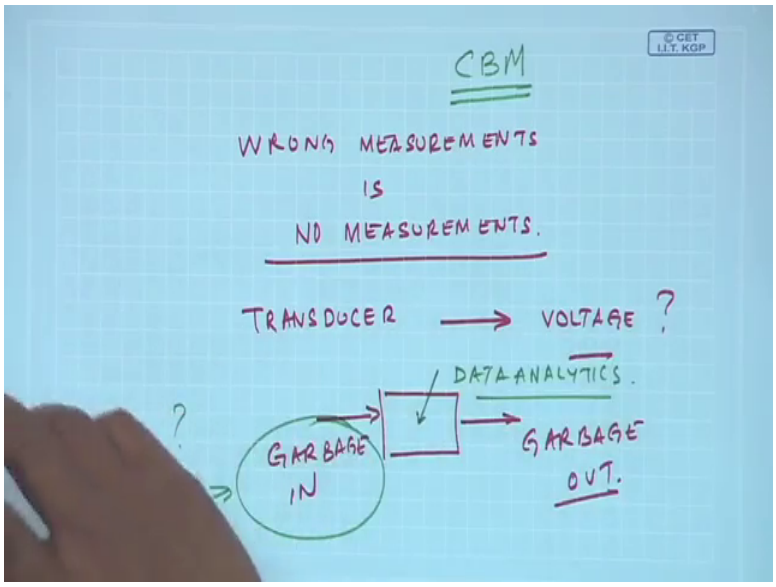

So, when we use a transducer how do you know whatever voltage signal you are getting is correct that the first question you need to ask yourself, because in a system which is driven by software if I have some data in I will definitely get it out.

But garbage in garbage out you may be having the best software on the earth; you know best way people are talking about data analytics. You have the best data analytics software in the market I am sure many many of my friends are doing a lot of work in data analytics in artificial intelligence. And IIT, Kharagpur we have proudly announced that we are going to have an artificial intelligence center working on data analytics.

But then my four friends and should also wonder about the data which is going into the system is it correct ok. And as you would have seen in CBM everything relies on the signal coming out of the transducers. So, what I say is smart and fault tolerant sensors. So, sensor must be able to give you a signal if they have a fault in them ok, either an open circuit or a short circuit or over range

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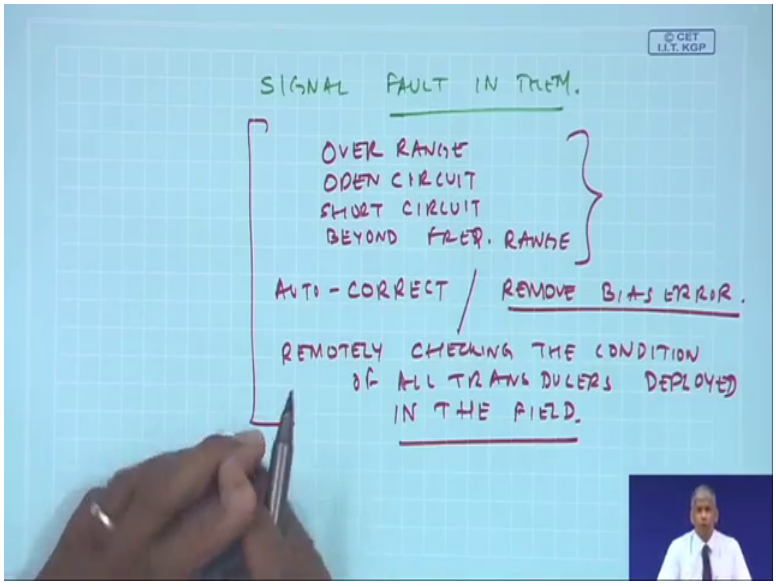

So, these are issues over range open circuit of course, you will not get any signal, short circuit, beyond frequency range ok. So, this needs to be built into the sensor systems and then autocorrect, autocorrect maybe remove the bias error ok, and remotely checking the condition of all transducers deployed in the field.

This goes without saying because you know I a strong believer of doing you know measurements on CBM most of my career so far and analyzing them. I have seen my students producing nice color graphs, but they fail to understand or demonstrate the basic physics ok. So, always have this sanity check in it no, suppose somebody says you know you are measuring the temperature in the classroom and says you know the temperature is you know 70 degree Celsius you can build all his theory and models based on that, but you know 70 degree centigrade in a classroom does not make sense at most maybe even it in a hot summer it could be 40-45. So, these are sanity checks good field engineer also needs to have or do on the data which has measured.

And of course, coming to the next point on laser based monitoring ok. You would have seen there are cases where I have to measure on large structures and from large distances and structures or light are light when structures are light I cannot put a physical transducer because it would load the structure.

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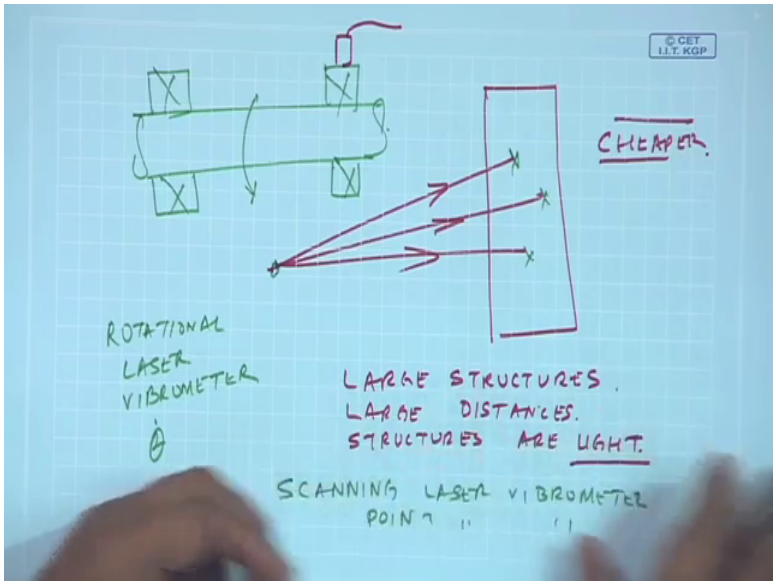

So, I can shoot laser beams from one location and because of the doppler shift I can find out the vibrations at any point I want ok. So, I can have scanning, laser vibrometer, I can have point laser vibrometer and I would have seen in rotational machines many times we put our transducers on the bearings, the accelerometers because if this is rotating. I cannot, but then with rotational laser vibrometer you can measure the rotational velocity theta dot.

So, in the torsional domain lot of studies can be done and we have seen in our laboratory, but measuring the rotational laser parameter the signal to noise ratio is very high and they are non-contacting as opposed to your contact type accelerometers ok, but then the trend is that these equipment are very costly. So, they need to become cheaper. So, that everybody can afford. So, a lot of research needs to be done on this laser based imaging I can give you an example.

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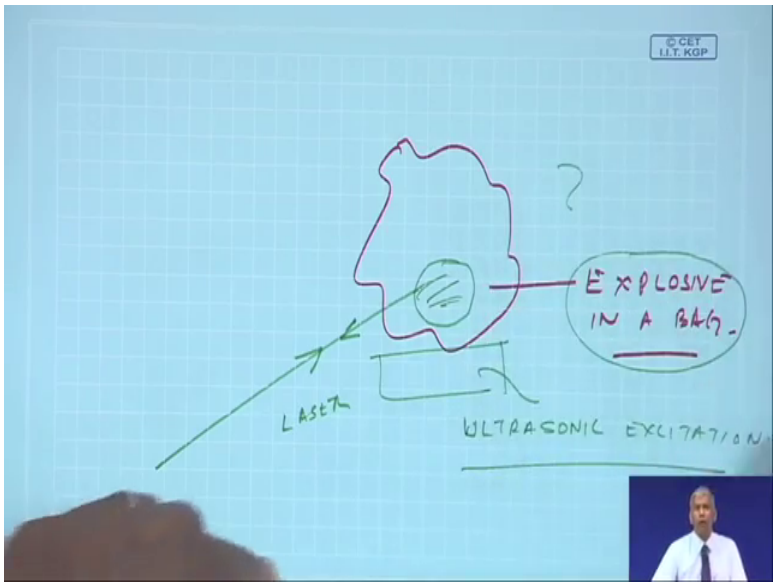

This has been happening suppose somebody is carrying explosive in a bag, I am giving you some ideas. So, if I shoot a laser beam ok, and then if I get the reflection at different locations if I find that suddenly that the vibrations are suddenly damped we can do a correlation as to this damping is because of a particular damp material which could be an explosive. So, quick scanning of bags by such lasers wherein we give some sort of an ultrasonic excitation where or damp really would reduce the vibration.

So, this is one way. So, there are a lot of applications of this laser based measurements and yesterday I was totally and talking about in the last class on mode shapes.

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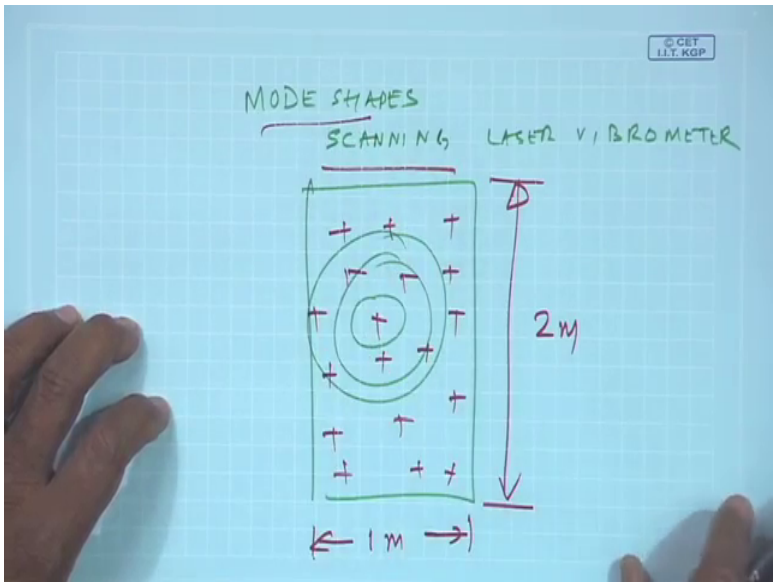

So, we can have scanning laser vibrometers where in one go you can get the mode shapes of a plate or a structure ok, by putting a laser beam in one. So, there will be different paths you know this could be enough some distance maybe 2 meter by 1 meter or 2 meter wide and shoot a laser beam an array of laser beam this can also happen ok.

So, laser based monitoring is again an emerging area. Now, you are talking about embedded systems for internet of things.

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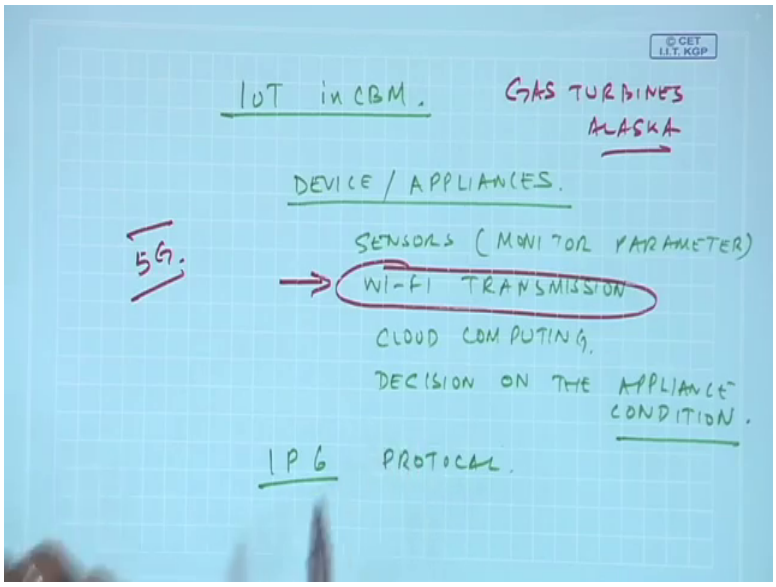

Today when we are talking about you know IoT in CBM because the device or appliances we can have sensors to monitor parameter, and they can have Wi-Fi transmission, then we can have cloud computing and then we can make a decision on the plans condition did.

Today with this IP 6 protocols every square inch of the earth's surface could not have any unique IP address both on the ground underground above the ground with IP 6 protocol. So, if every device has an dedicated IP address and then it has a sensor inbuilt in it or an appliances build in it the signal is measured, it is transmitted and then run on the cloud of servers and this data could be accessed by different people at different locations and then a decision can be made on their plan this could be done for.

For example, in a setting in Kharagpur, I could be monitoring gas turbines in Alaska ok, this is to be science fiction you know maybe 20 years ago, but no it is a very thing which is happening now and Wi-Fi wireless transmission. Of course, you know I had told you the limitations of wireless transmission with the speed rates of transmission today our friends in the electronics industries and communications are talking about five g spectrum. So, this is also good to happen and which is going to help we mechanical engineers collect data send it at high speeds do the analysis as per the algorithms which we know be it any algorithm ok.

I mean its soft computing support vector machines and neural networks plain simple regression and then we can come up to a decision ok. So, wireless monitoring is again a thin which is going to happen on a very big way and today transducers are available which in you can have an Wi-Fi module and then we also have this drone survey ok.

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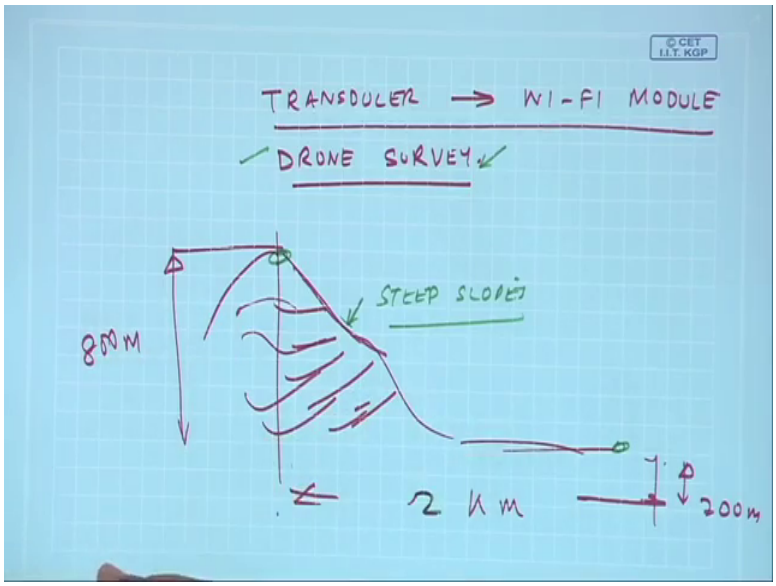

I will give you a recent example you know you are working on a mine ok, where I do not know it needs to be come up this distance is about 2 kilometers and this elevation is about 800 meters.

And this is about you know 200 meters. So, you can imagine these are all iron ore mines. So, it was very steep as you go and if you do the contouring on this. So such and because the raw material here has to be conveyed and brought to this location, so we do lot of drone surveying wherein we can have an elevation and the map of this location with the distance from this location. So, this was earlier you know people used to take theater lights you know walk up the steep slopes of the hill, but these are things of the past ok. So, such drone surveys are helping us you know decide on the metal handling equipment we put on the top of the mine to the base of the loading point or unloading point we have loading here unloading here.

So, what kind of material handling equipment do I need to put here? What kind of drives conveyor systems and which are environmentally friendly people are talking about you know not trough converse or flat converse, but other pipe conveyors metal handling units and then what should be the life of the motor. So, these whether do we have enough space to keep the material ok? So, this drover survey is helping us.

So, imagine technologies progressing in all directions, but we need to use them for CBM orbit for machinery also. So, we have this wireless remote monitoring also which is happening.

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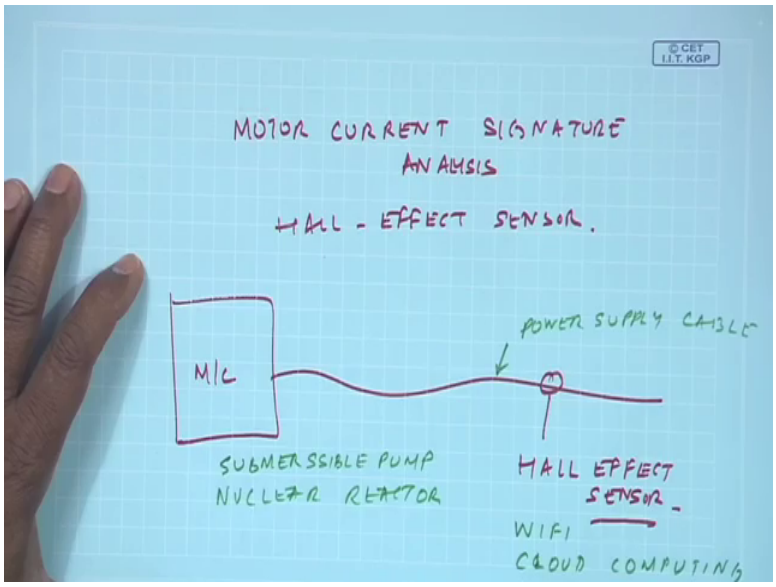

And then another technique which has come up is this motor current signature analysis. You have seen how by using a simple hall effect sensor which is very cheap. Any machinery which is remotely located I can put an hall effect sensor and then I can measure and this could be mission could be undergone like a submersible pump or nuclear reactor or anyplace where it is humanly not possible. So, we not worried about this machine just measure the know there will be a power supply cable to the machine. So, put the hall effect sensor around the current carrying conductor and do the current analysis. So, this again is a very very emerging technique and let me tell you proudly again this is out of the research we did at IIT, Kharagpur about twenty years ago.

And this has become very popular. So, MCSA clubbed with Wi-Fi, cloud computing, and embedded technologies it can be very effective in handling many of these fault diagnosis fallen.

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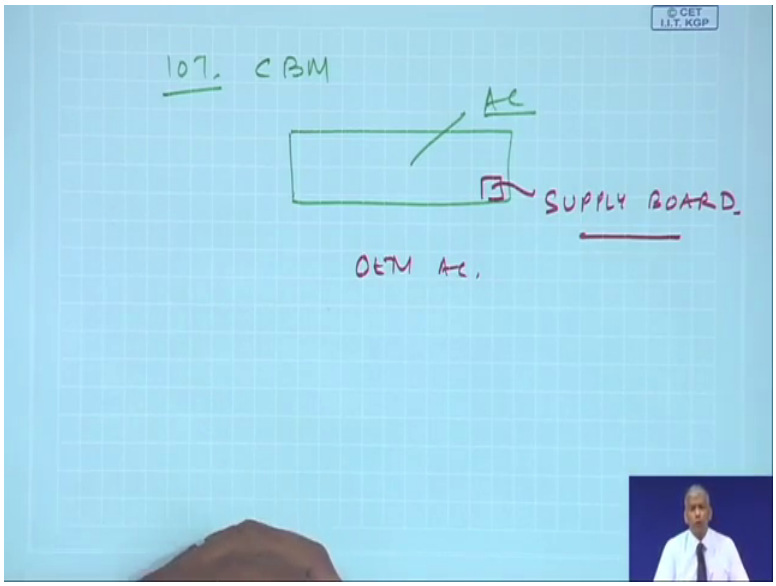

So, when you are talking about IoT and CBM imagine if you have an AC in your house and you did not even bother to maintain its condition. Suddenly technician walked up to your door and said you know your AC blower needs certain maintenance and a blower is fouled or your electric supply board there is a defect you would be wondering how did they come to know about it.

So, today the technology is such that in this appliance if I put an hall effect sensor and with an Wi-Fi transmitter it is transmitting and then if you have the right protocol set it could be put in this data onto the cloud and the OEM of the AC company could be analyzing the data of course, for a fee. And then they could be only deep-rooted integrations where we do not have to worry about this technology. You must have heard about this and Amazon stores where in you know you just walk into the store and fill it with your shopping bag and just walk out of the store. How is this happening? Because every product is RFID track, tag and then whatever product you put and then you just walk out the doors it will be automatically debited from your account and you will get a bill. So, this is the technology which has come to Amazon stores and it can come anywhere ok.

Imagine you know you are a just you are taking a bath in your bathroom and then suddenly you realize that you have run out of shampoo ok. So, you have to run up to the store to remember that you did not buy a shampoo or the next day, but imagine if this is

track that you have run out of shampoo and then automatically it will be informed to your nearest or they will be delivered to your house and then it will be automatically debited from your account the amount will be an automatic debited from your account. So, if you have this pad which on which you just place that shampoo bottle and then things takes care of it.

So, you save time in the long run and the hassles of going to the store finding out the parking for the vehicle finding out the transport you know maybe you are busy the whole day. So, this is how technology is has helped and this technology is also helping us in CBM. And then of course, you know there is no end to the stories of machine learning and particularly great analytics which everybody is talking about. But let me tell you data analytics is not new and this is as an hardcore mechanical engineer I am telling you. When we did y is equal to m x plus c and simple regression I am sure all of you have done that in your engineering labs. Was that not data analytics? That was ok. So, it is I would say it is old wine in a new bottle is people have phrased it analytics, but more important than that is if data is wrong everything is wrong ok.

I mean you can develop nice algorithms, you can generate synthetic data through software and analyze it, but we need to wake up that real time data real data actual data issues of signal to noise ratios, issues of instrumentation, issues of measurement errors they will never go. One has to realize this ok. So, I agree that data analytics is fine, but application of data analytics and real engineering field to help CBM is very important and I am very pretty vocal about it. Excuse me for saying so, but this is what life is going to be. I mean we cannot be that inner everything will be solved by data analytics we are grossly wrong ok. So, we need to have the right data.

And of course, towards the end you would have seen this online monitoring because if the data is available we can do online monitoring and whatever CBM I had done right in the beginning was a signal based, but today it is going to be system based and then we can have a lot of model based fault detection systems and fault prognostics being developed for rotor dynamics models.

And many professors in the universities and the researchers are developing model based systems for such rotor dynamic systems. And we are at IIT, Kharagpur are also doing it of course, it goes without saying that continuing education which we did in this 3 month

course has to go ahead because the industry or the people outside the academia needs to be informed about the developments which is happening.

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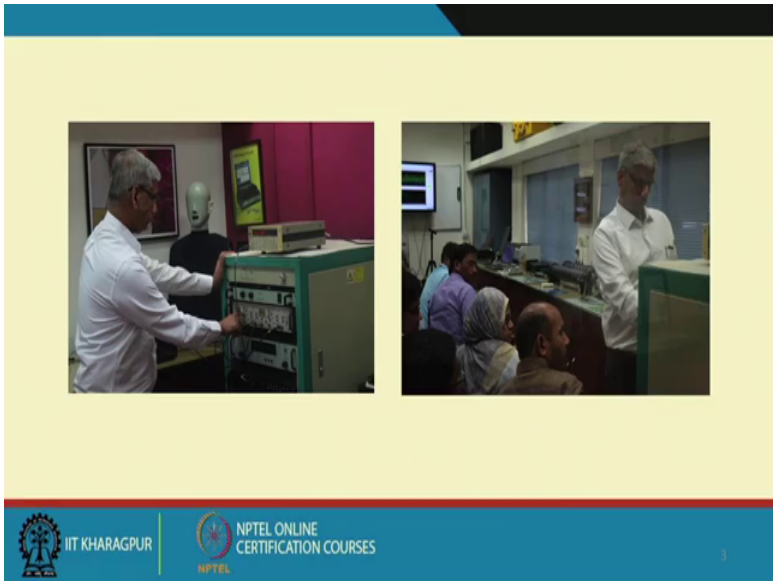

And I regularly conduct even you know 1 week, 2 week customized courses on condition based monitoring acoustics and noise control where students get to see the practical demonstrations in the laboratory as well.

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We have almost every year a one week program on condition mounting, we have international guests delivering in some of the lectures and so on. So, this has to continue

continuing education be it offline online real time has to happen because knowledge is every day you know different domains of knowledge and expertise are becoming available and that needs to be told.

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Of course you know towards the end I must acknowledge even those of you who are online I must acknowledge two of my TA's. One is Mister Basijith Sahu who is a research scholar working on condition monitoring with me, who is the TA whose will be helping you with the forums with the assignments. And another is a Chinmay Mahapatra, she is also a research scholar in the areas of acoustics source identification and noise control.

So, these two folks have helped me run this course. Of course, I must also thank the folks at our continuing education technology center who are doing a wonderful job, video recording, the courses and prodding me to finish the course recordings and so on and so forth. I must thank all the people in the background who are doing all those excellent job of video recording and reproducing and putting the contents online.

So, at the end I would say if there are slips and mistakes please excuse me and then of course, you can always see, go to my book contact me and then my email and they say that this email is going to change instead of ernet it has become going to become ac.

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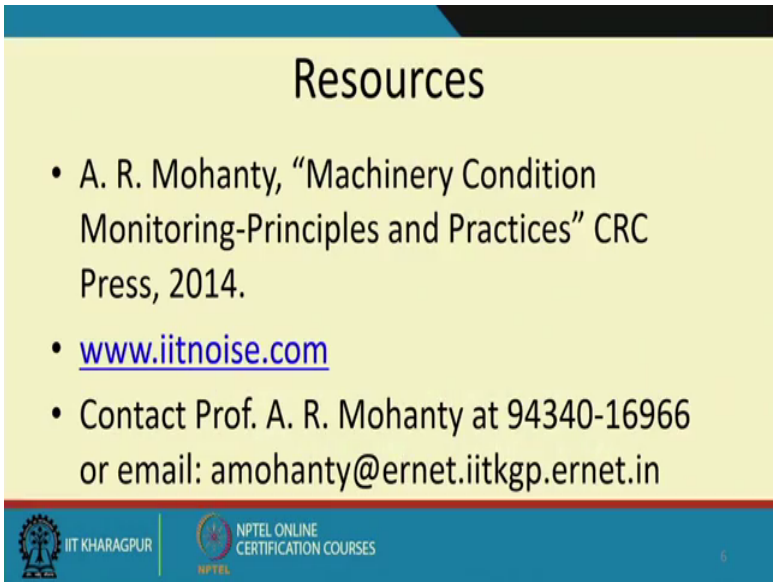

So, I really keep you informed you at iit noise dot com. And those of you who still do not have an access to my book please find them in Amazon and that will be very good and then I hope you all had a good learning experience. I look forward to getting emails from all of you on a feedback to this course.

Thank you.