Failure Analysis & Prevention
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Lecture – 02
Introduction: Engineering Disasters and Understanding Failures

Hello I welcome you all in this presentation related with the subject failure analysis and prevention. This subject is extremely important for the heavy engineering industry and all those involved in manufacturing of the mechanical component and users of the mechanical component.

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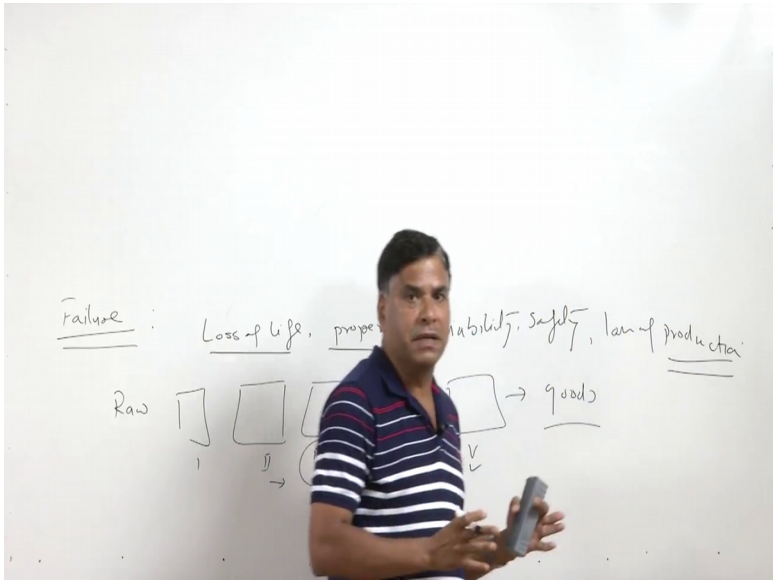

The main issue is that whenever there is a failure of any component it leads to the disruption to the services and sometimes failure of the mechanical components like a lathe machine or the boiler or the car or aircraft, all these failures lead to the different kind of the problems issues related with the services, and which these kind of failures leads to the loss of a life sometimes.

If it is very catastrophic and fatal, and it leads to the loss of the property also, it leads to the reduced reliability and the safety are related with the product or the component, which is being used. So, sometimes it also leads to like in line production, the number of machines are installed and they are working to deliver to process the stock material and deliver the final finished goods at the end.

So, like say here we have the raw material which is entering at this stage 1 and then it is processed subsequently at the number of stages and at the end we get the final product in form of the goods. So, after processing from the stage 1 stage 2 stage 3 and then stage 4 we get the final product. So, any failure of a failure of the any of the machines in any of the stages, will lead to the stoppage of the production process.

So, if the machine three phase then piling of the semi processed goods will start the stage 2 or if the stage if the machine at this stage 5 fails in that case the piling up of the product semi finished product will start at this stage 4. So, means it will lead to the loss of production also. So, primarily in those cases where aj the failure is related with the loss of life, property and a huge loss of the production attention must be given to see that the such kind of the failures are avoided.

And to avoid the failures it is important that the way by which any component can fail is understood and precautionary measures are taken to avoid such kind of the failures. But whenever there is a failure it is important to understand the way by which it has failed what were the causes for the failure. So, in order to understand the root causes of the failure, we need to see that the any failure which is occurring is analyzed properly and for that purpose are the failure analysis is carried out.

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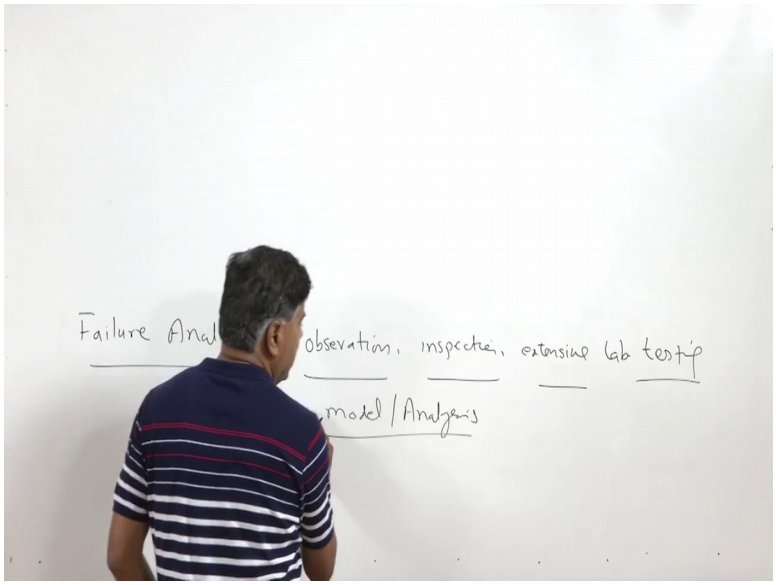

In failure analysis basically we follow a systematic approach; a systematic approach of investigation to identify the potential causes of the failure most important causes of the

failure to determine the most probable causes of failure. So, this kind of the step is also called the root cause analysis.

And in short it is a it is written as RCA root cause analysis. For this purpose basically we need to do the systematic investigation of the any failure. So, that we are able to identify the causes or potential causes or the most possible causes for the failure so that the corrective action can be taken to avoid the reoccurrence of the failure. This analysis basically involves the number of things like observations, inspection and extensive as per the case extensive laboratory testing of the field component from the location where from failure has taken place or the location which is away from the fractured zone.

This is basically done for the different purposes. So, these are the different steps which are normally followed apart from this to see that the component should have worked under those conditions of the service or not, it is also important sometimes to do the modeling and analysis under the conditions of the service to see if the component should have failed under these given conditions are not.

So, these are some of the ways by which efforts are made to find out the probable at causes of the failure. But we know that any mechanical component which is made involves the different kinds of the efforts.

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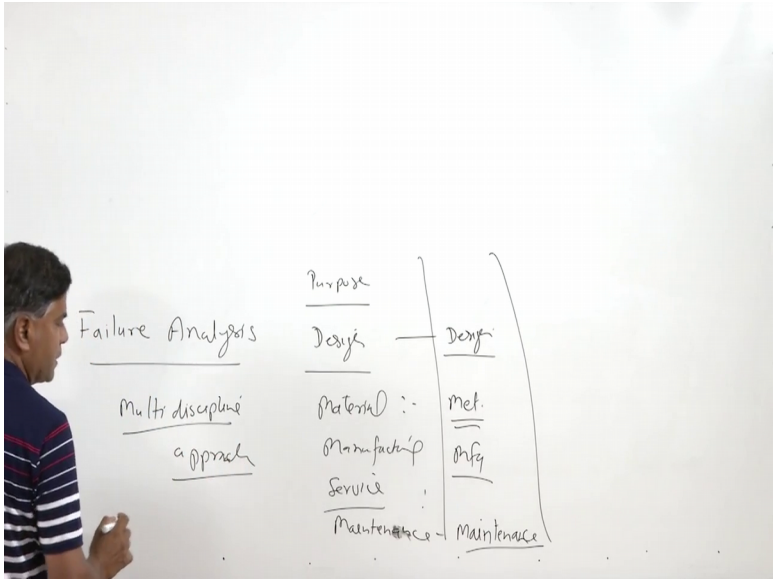

It starts from like say the purpose for which the component is being made and considering that component is designed, which will involve the selection of the material as well and after that it will involve the manufacturing, and after the manufacturing it will be subjected to the service under the specified conditions and it has to be maintained properly during the service.

So, it has to be maintained during the service. So, that it dil it performs the intended function and works for the desired service life. So, since the different zones and the different disciplines are involved in this like we need the design engineer for this purpose to design the product as per the requirement, we need the material or the metallurgical engineer for this purpose that for a given purpose proper material is selected as per the service conditions, we need the manufacturing engineer, we need to see that the supervisors and the people who are there, they are able to ensure that the component works under the given set of the service conditions.

And if it goes beyond that, then those are also recorded and similarly the maintenance engineer for taking care of the equipment and maintain them properly for the given service conditions. So, we need the different disciplines to see that if it has failed due to the improper design or improper selection of the material, the improper manufacturing and improper service conditions for which it was exposed.

So, basically the failure analysis is a multi disciplinary multi discipline approach which involves the expertise which for which we need the expertise of the people of the different areas and the different disciplines in order to conclude something effectively regarding the root causes for the given failure. Failure analysis not only helps to avoid the reoccurrence of the failure, but it also helps in improving the quality of the product increasing the reliability, improving the performance and improving the customer satisfaction.

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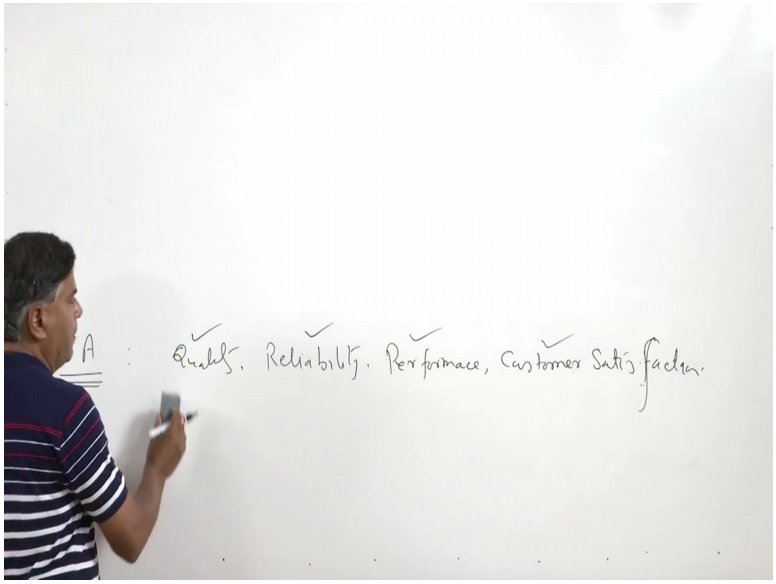

So, whenever any the failure analysis is carried out on the failed component, it helps to avoid the recurrence of the such kind of the failures and that basically helps in improving the quality of the product, that it will not fail in that particular rib for which the filler (Refer Time: 09:34) has been carried out and the correct direction has been taken to avoid the reoccurrence of the such kind of failures. So, it improves the quality and since the failures tendency is reduced now. So, it improves the reliability also; and if the component is more reliable it will be performing well for the long so, performance of the product is improved and which in turn improves the customer satisfaction will be using the product customer satisfaction who will be using the customer who will be using the proctor.

So, whenever failure analysis is carried out, it can also be used in different way in order to improve the quality of the product increase the reliability, improve the performance as well as the customer satisfaction if it is applied properly. So, where we should look in for the failure analysis and what are the things and normally seen for the failure analysis.

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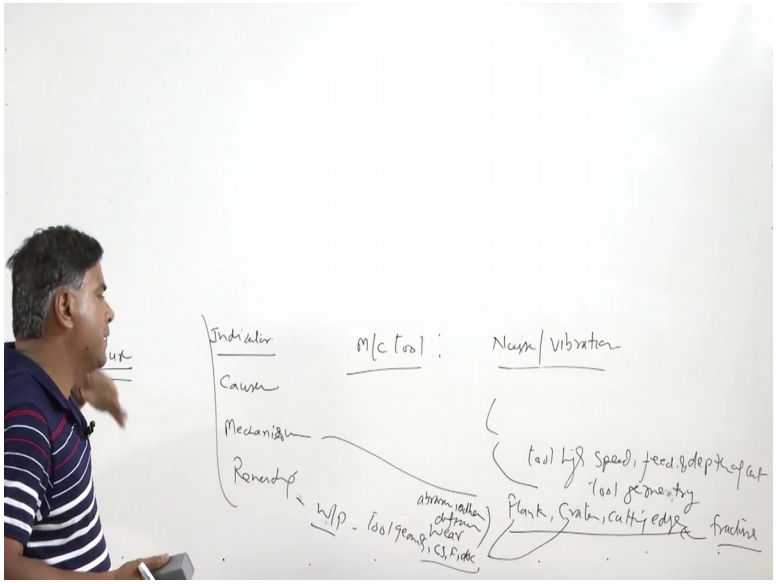

So, whenever failure occurs what we do? Failure how do we identify? So, first of all whenever failure of any component occurs, we will be getting some indicators which you can say as a symptoms. And then these indicators will be coming up due to certain causes. In presence of only those causes it the component which is being failed which is failing will be giving certain kind of the indications and. So, in presence of those causes the certain indications will be coming in, and these causes will be leading to the existence of the certain mechanisms which will be leading to the failure.

So, mechanisms and then here what will be their remedy. So, these are the four things like if we take the example of the machine tool. So, during the machining, if the cutting tool fails, in that case it will start giving lot of chattering lot of noise and vibrations. So, the noise and the vibrations in machine in cutting tool failure the noise and vibrations are the indicators and this will be will be occurring due to the like say excessive the flank wear or the cutter or cutting edge failure cutting edge fracture under the certain unfavorable conditions like we are using the too high cutting speed feed and depth of cut or our the tool geometry is improper or unfavorable for a given set of the cutting parameters and the work piece which is to be machined.

So, the improper tool geometry improper tool geometry. So, these are the causes like too high speed feed and depth of cut incompatible tool geometry for given work material and the cutting parameters will be leading to the flank wear and crater wear edges. So,

basically these are the causes which will be leading to the like the failures in form of the flank wear crater wear or the cutting edge fracture, oh and this can occur through the number of ways. Like here cutting edge a failure will involve fracture while the flank and crater wear will involve the wear by abrasion, adhesion, diffusion. So, all these are the mechanisms by which loss of the material from the cutting edge they will be taking place and that they will be causing the flank wear cutter here and the cutting edge fracture cutting edge failing a cutting edge will be failing due to the fracture. So, these are the mechanisms and the remedy is what.

Now, we have to choose in light of the workpiece material, we have to choose proper tool geometry and the cutting parameters like cutting a speed, feed and depth of cut need to be selected properly. So, that the tool performs the intended function in order to avoid such kind of failures. So, these are the kind of indications that we get and we need to see what are the causes, what is the mechanism, to establish the complete understanding about the failure so that the corrective action can be taken in order to avoid the failure.

Now, we will see what kind of approach we use in order to avoid such kind of the failure, normally what we do like we first of all identify.

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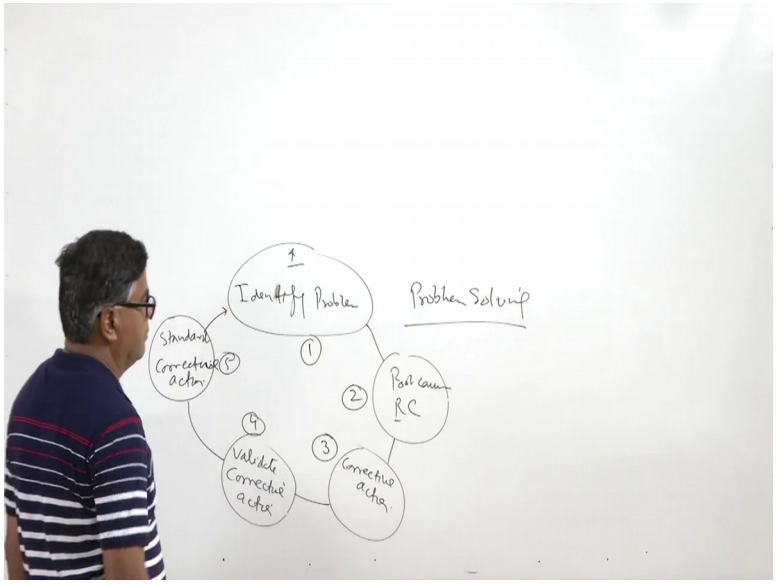

Identify the problem or the failure which is occurring; this is the first step. After identifying the failure what do you basically try to get is what is the root for the failure. So, this is the first stage identify the problem or the failure, which is there in a particular

form, then root causes of the failure root causes of the failure basically. In light of the root causes we need to develop the suitable remedy or the corrective action corrective action needs to be developed.

And we need to see now, the effectiveness of the corrective actions. So, validate the corrective action and once this validation of the correct direction is just to see whatever the corrective action has been proposed, that is effective or not and once the corrective action is validated this one is standardized that for this kind of the problem, this kind for a given kind of the problem identified problem this is the correct direction which needs to be taken so, that the in future such kind of the failures can be avoided.

So, standardize the corrective action corrective action. So, this is how this cycle completes and this is called the problem solving approach for avoiding the failures in future so that the quality, reliability, customer satisfaction and the performance of the component can be enhanced. So, first it starts with the identifying the problem second determination of the root cause through failure analysis, third identification of the correct direction and fourth is the validating the corrective action in order to see that if the correct direction is the effective or not and fifth is standardize the corrective actions so, that such kind of the problem in future can be avoided.

And the component can perform satisfactorily for long as per the requirement. all the products do not show the similar kind of the failure trend, but if you have to see they are say hundreds of the products which are new and being put into the use. So, we will see that different products will show the failure tendency in the different way as a function of the time.

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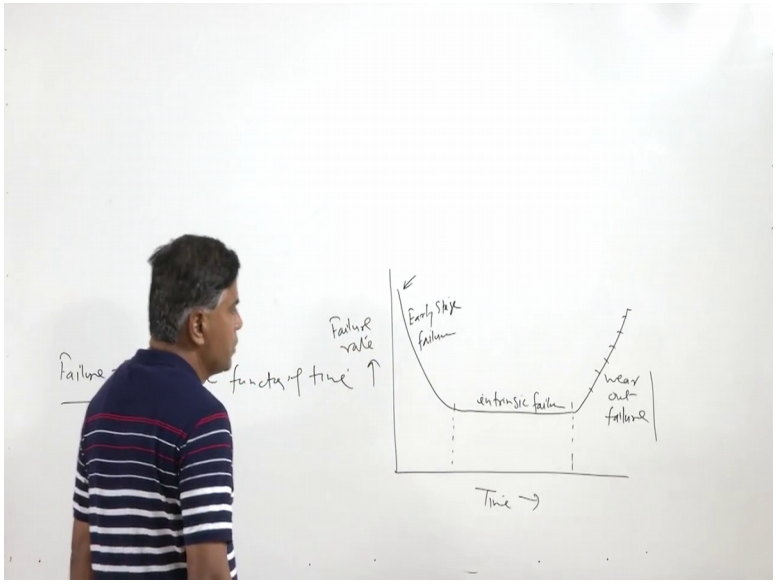

So, if you have to see that the failure of the items new products as a function of as a function of time during the service, what kind of that trend is followed, so the failure rate in the y axis and in x axis the service time and here the failure rate. So, what we will see that the failure rate initially decreases rapidly initially the failure rate is high and then it decreases rapidly and then it becomes fairly constant and then again it starts increasing. So, considering this one there are three phases or three zones during the service of the products, which are being put into the service.

So, initially the failure rate is high then it starts decreasing and then it remains fairly constant and again it starts increasing. So, this third zone is due to the is termed as wear out failures, after giving the useful life failure after giving the useful life. And this is intrinsic failure which by enlarge gives them almost this is by chance whenever the failures of the products occur and it happens at very low rate, and as the failure rate is the initial stage failures these are called early stage failures.

Initially the failure rate is high, but it will start decreasing as a function of the time. So, this happens due to the minor error a at this stage of the manufacturing like the loosened, nuts and bolts a improper setting improper calibration because of which product is not working and thereafter once those issues are resolved in the initial stage; it is it is just like that whenever we buy a new automobile or new vehicle, we are asked to run it under

the lower speed conditions so that it the system is not overloaded and it is subjected to the run in conditions in initially.

The same is true here that innocence the initially whenever the company component is put into the use, it is it feels at much higher rate because of the initial stage hiccups like minor adjustments settings, and thereafter once everything is set and then it gives a fairly useful life and the failure rate is low. And after giving the useful life the different parts components of the component different parts of the component starts wear and wear out. So, due to the wear in tear it and giving the useful life, if this starts to fail at a higher rate as a function of the time during the service.

So, after this stage what is suggested is that, better to discard the product instead of going for the repair and used because maintenance cost will go high otherwise. So, the maintenance and all those things will be useful in the second stage, but in this case better it is to discard and replace the things with the new one. So, the typical geometry of this curve which is similar to that of the bathtub because here the geometry is like this sorry the geometry initially higher rate then fairly constant and then increasing rate.

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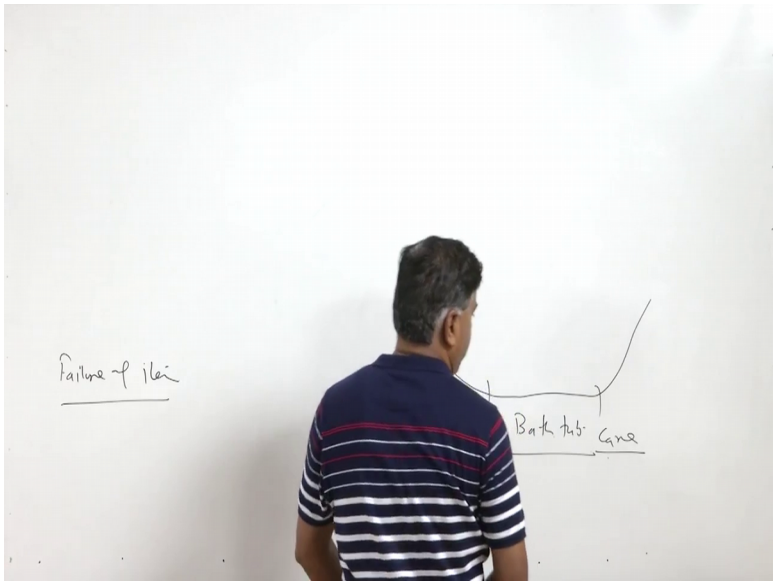

So, these are the three different zones and this geometry is similar to the bathtub and that is why it is called a bathtub curve or the life curve of the product.

Where in it the failure rate will be high in the initial stage and then failure rate will be decreasing and it will become constant after certain time of the service. Now you see that what are the different causes of the failure and how to identify them, how to understand them systematically.

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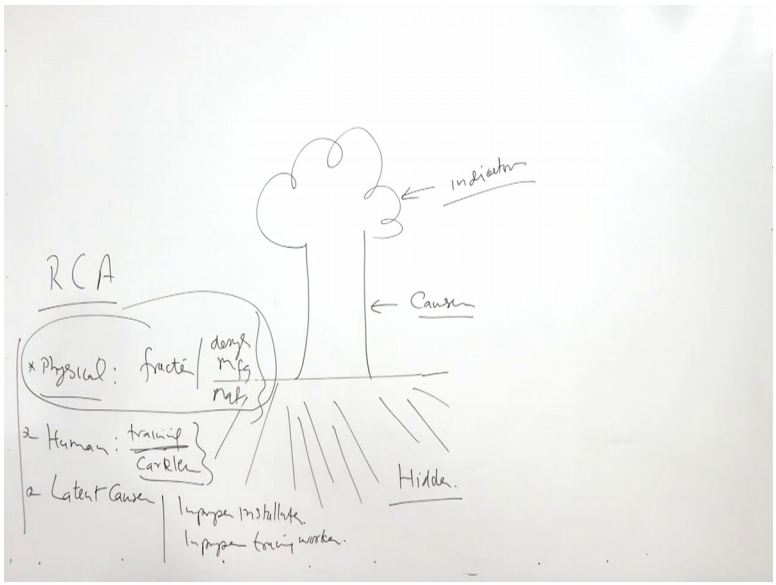

So, for the failures there are few failures, which will be occurring due to the invisible causes. So, these we can understand from the roots of the tree and this is the esteem which is very much visible above the ground surface and this is the these are the leaves and branches of the tree.

So, these we can see very much as indicators of the failure and these (Refer Time: 22:50) shows the causes of the failure, and these causes are occurring due to the many invisible causes which has been there. So, this is what is called a hidden causes leading to the failure. And hidden causes may be in the different forms like improper training, improper motivation, carelessness on the part of the worker, improper calibration improper installation of the things.

So, in order to understand the category of the causes what we see there are three types of the causes one is the physical causes, and the second one is the human related causes, and third is latent causes latent causes. So, physical causes is about like the design is not perfect or material selection is improper or the service conditions which has been

improper. So, these are the things will be leading to the say the fracture due to the design deficiency, manufacturing or the material related issues.

So, these evidence for these things can be established through the proper investigation. There is another category may be procedures and everything is fine, but here what will happen that the training to the human being involved in use of the product or in manufacturing that the people who are involved in the manufacturing of the product are not properly trained or their, carelessness is involved. So, these are the human related factors and there are many latent factors like improper installation; everything is fine the component has not been installed properly or improper the training to the workers.

That there in this case in the human component they were trained, but they did not took interest, they were not motivated to learn and thereafter they did blunders which led to the failures. Here they have not been trained at all properly the workers may be motivated, but if they have not been trained properly then they will not be able to do the expected job. Similarly the component has not been installed properly then it also not be working. So, there is three we have three category of the causes, basically the root cause analysis RCA is carried out to establish the evidences for the physical causes.

And efforts are also made to on the human component and the latent causes, to see that the people who are involved in the design manufacturing fabrication service and maintenance of the any component, they are trained they are motivated so, that the proper care to equipment which is being designed, manufactured, serviced or maintained can be taken simple.

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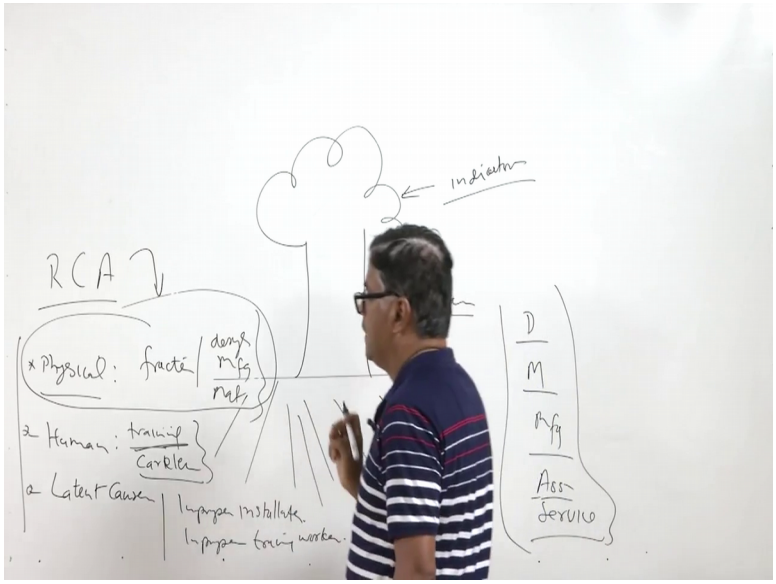

So, basically the focus of the RCA is to look for the physical causes where we will be looking for like say whether the material properly designed, and the component was properly designed or not, whether the proper material was selected or whether it was manufactured properly or not, whether it was assembled properly or not, whether it has been given the proper service conditions or it has been abused during the service and or it has been used under the conditions, for which it was it was not designed and whether it or it has not been maintained properly during the service. So, efforts are made in order to identify the evidence is to establish the causes related with the design material manufacturing, under the category of the physical causes.

So, now I will conclude this presentation, in this presentation basically I have talked about the importance of the failure analysis and what kind of expertise we need to undertake the filler analysis, and how filler analysis can be useful in ensuring the improved reliability quality and performance of the products.

Thank you for your attention.