Failure Analysis & Prevention

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Lecture - 18
General Procedure of Failure Analysis: STEPS

Hello, I welcome you all in this presentation related with the subject failure analysis and prevention in this presentation basically will be talking about the general procedure which is used in the failure analysis of the metallurgical or the mechanical components. So, we see, what is the purpose of the failure analysis? That is what will try to talk little bit first.

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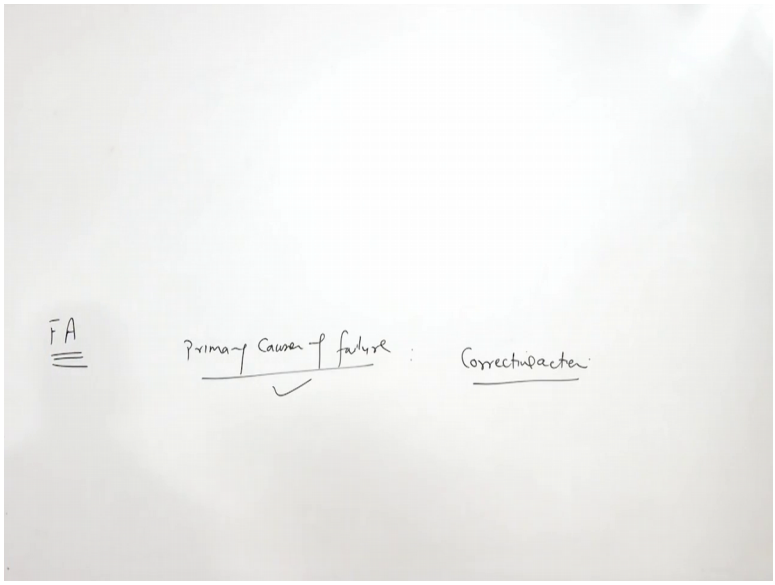

See, whenever any failure of a component or met metallurgical failure occurs will notice that it will be leading to the disruption of the services, improper functioning of the component and the systems.

So, it is required that we the failure is properly investigated so, that we can identify some primary causes related with the failure. So, basically failure analysis helps to identify the primary causes of failure, which has led to the disruption of the services. So, once the primary causes are identified through proper investigation, it will help us in taking the suitable corrective action so, that the similar kind of the failures in future can be avoided. This is the main objective identifying few primary causes of the failure, so, that after the

corrective action can be taken in order to avoid the sub subsequent similar kind of the failures.

So, how it is done so, we know that engineering components or the systems are made of the variety of the materials which may range from like say the metals, non metals.

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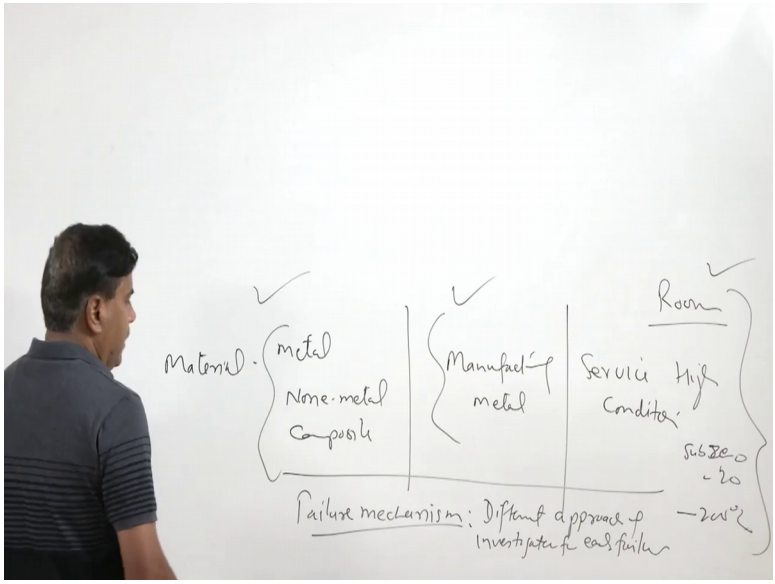

In non metals we may have like the plastics wood concrete and then it may be like composites. So, the varieties of the materials are used for making the number of the components and these components will be manufactured manufacturing of these materials for making the components which can be used for the services. The manufacturing approaches are also different for each kind of the material like the metals are processed in different way than the composites and the non metallic materials like plastics.

So, variety of the materials variety of the manufacturing processes are used for each category of the material and in addition to this these materials and their components which are made of variety of materials prepared by or manufactured by different manufacturing processes they will be working under the different service conditions. So, service conditions also very significantly right from the room temperature conditions like ambient condition to the high temperature or like sub 0 condition temperature like minus 20 cryogenic temperature conditions like minus 200 degree centigrade. So, the service conditions under which these components can work is also very large.

And therefore, the failure mechanisms since the different types of the materials which are processed by the different manufacturing processes and which are expected perform under a range of the service conditions. So, the failure mechanisms are also different so, failure mechanisms are different and since the failure mechanisms are different so, we need a different approach of investigation for each failure and that is why each failure analysis becomes unique the sense that materials are different manufacturing conditions are different and the service conditions are different. So, we need the different steps in order to establish the primary causes which have led to the failure of a particular component.

So, it is important to assert in, what is the material of the component?

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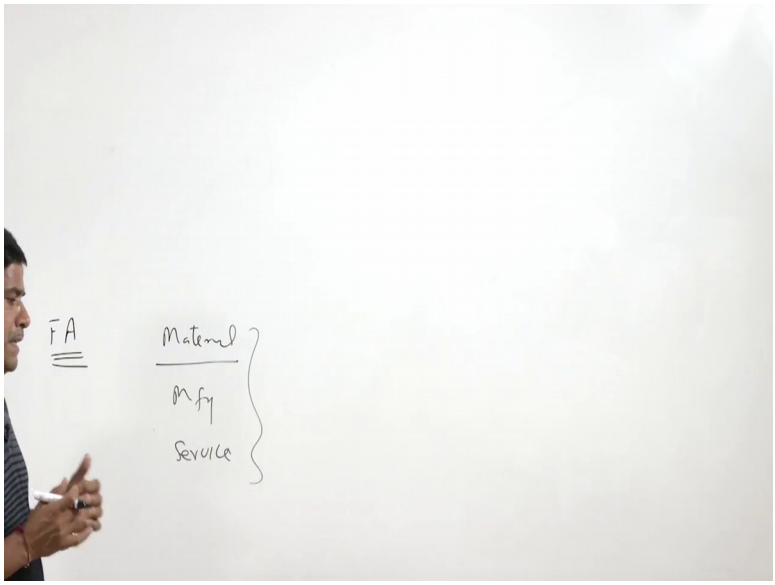

What manufacturing processes have been used for manufacturing? And what the service conditions under which component has walked? Probably this can help us in better way of formulating the strategy for the failure analysis.

So, next step is to be what analysis of which kind of the failure should be carried out?

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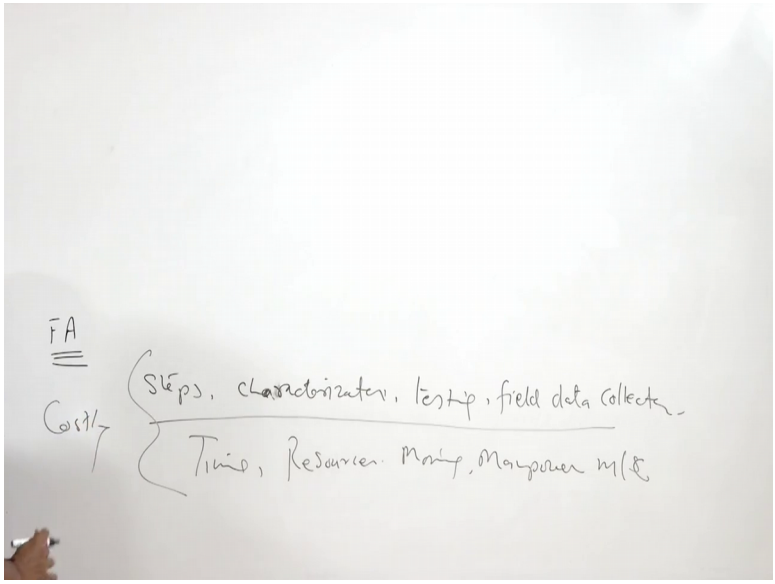

We know that the failure analysis is requires the number of steps extensive like say the extensive characterization and testing, field data collection. So, since large number of things needs to be done for undertaking the failure analysis, this involves all these things involve basically lot of time use of resources in terms of the money, man power and machines since the number of things are involved.

So, the failure analysis in general is a costly affair so, where it should be applied, the failure analysis should be applied only under those situations where the failure of a particular component or the system is leading to the loss of property, life or huge loss of the production, rate or the production volume or it is disrupting to the services to the public at large.

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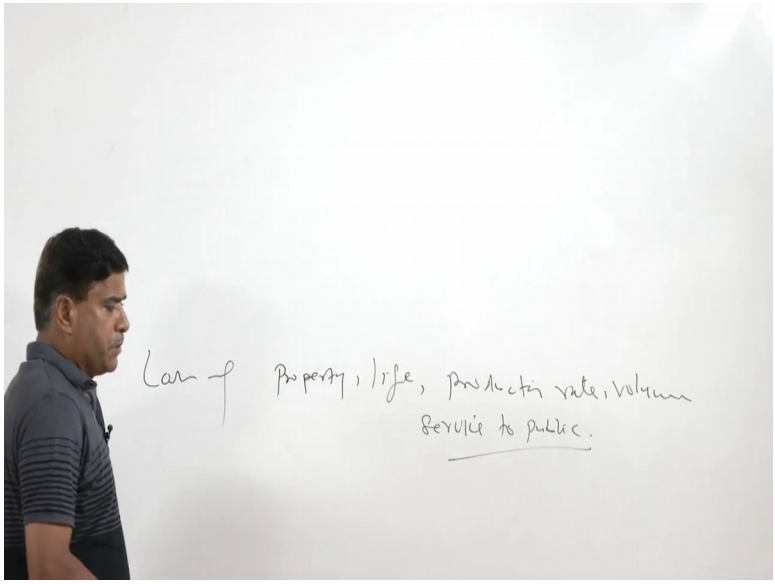

So, all those things which are really important and will adversely affect the service is being provided to the public as a whole or it is adversely affecting to the economy of a particular system or of the industry then all those failure must be investigated. If something is off not that big importance which can severely affect the economy or the productivity production or which is not really thread to the life to the loss of a property and the life. So, it is not required to undertake the failure analysis systematically may be, it will simply to just get it replaced by the, another sample and get it repaired using the suitable techniques.

So, what is basically the failure analysis, as I have said the purpose of objective of analysis to identify the primary causes so, that we can take the correct direction what kind of things should be what kind of the object or the systems are the component for which failure analysis should be undertaking that is also I have talked, but what it is.

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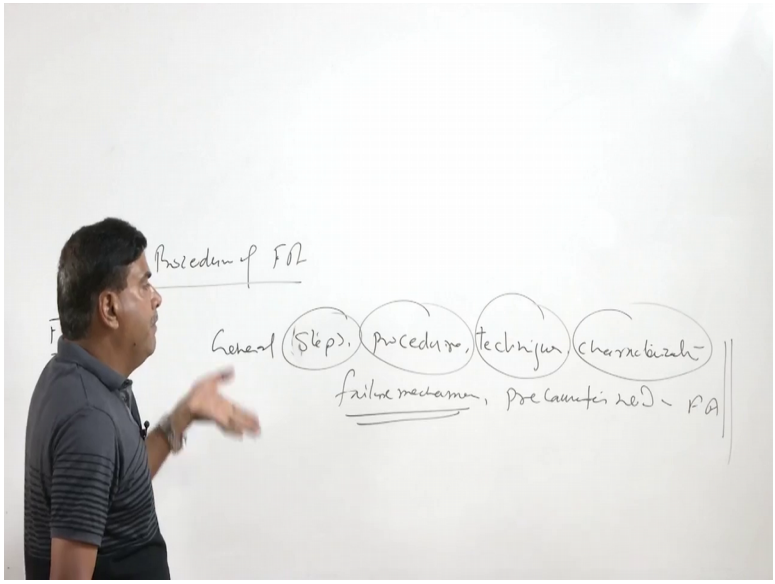

Basically in the general procedure of failure analysis what we need to talk about is all the general, steps, procedures, techniques, characterization and the failure mechanisms, the precautions needed in FA need to be a talked about under the heading of the general fail procedure for the failure analysis. We need to take what steps to be followed? What will the general procedure or the sequence in which these steps will be followed? What are the techniques available under to undertake the failure analysis? What are the various characterizations that we need to take the failure analysis or to establish the possible causes of the failure?

If you understand the mechanism by which a failure of metallic component can occur then those the mechanism we need to understand and what kind of precautions we should take care when the failure analysis is being carried out otherwise it can be like a the entire efforts can be a wastage or we can have the misleading results or the purpose of the failure analysis may itself be defeated if the due care is not taken a suitable precautions are not taken while performing the different steps related with the failure analysis.

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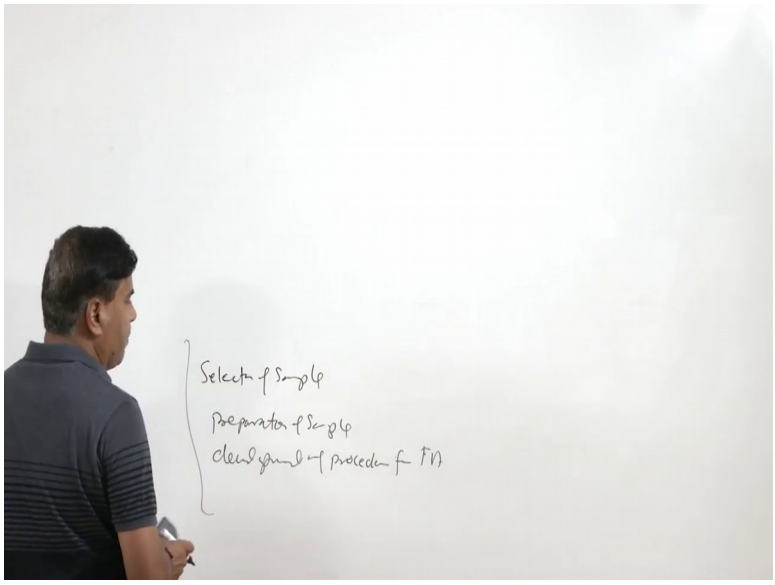

So, different time to times will be talking about what kind of precautions we need to undertake right from the likes say selection of samples to the preparation of sample or development of procedure for failure analysis, all these things need proper precautions we need to go systematically for performing these steps selecting samples or developing procedure for failure analysis or sample preparation for cleaning or making them ready for their studies.

So, we need a proper care for undertaking the different steps related with a failure analysis ah. So, now, we will see their different steps related with this which we need to follow like about this have already talked in the field of engineering mechanical components are made of variety of materials they are manufactured by variety of the processes.

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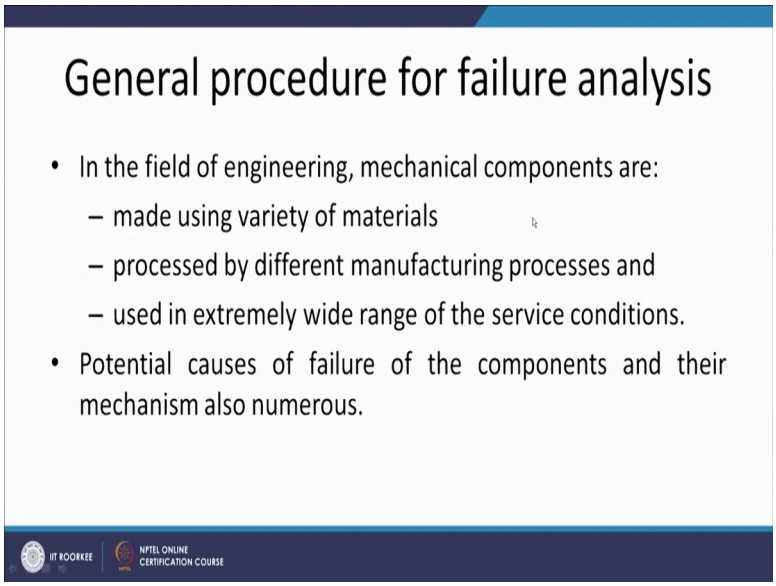

And they work under the range of service conditions and therefore, the causes for the failure also very significantly and since the each cause will be leading to the failure of component through different mechanism. So, the approach for the failure analysis should also be different.

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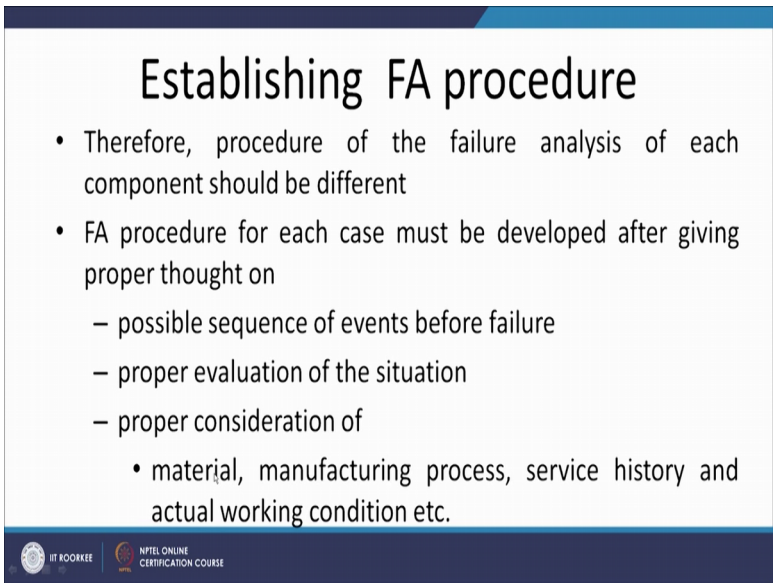

So, therefore, procedure of the failure analysis for each component should be different and failure analysis for each case must be developed after giving proper thought on we need to see really what kind of the possible sequence of events were there before the

failure and we need to evaluate the situation properly. So, that we can we can have idea about the possible sequence of events and the failure mechanisms and in addition to that we need to also consider the material of the component manufacturing process which have been used service history of the product and the actual working conditions which has been experienced by the component. So, these things we need to keep in mind while developing the general procedure for the failure analysis.

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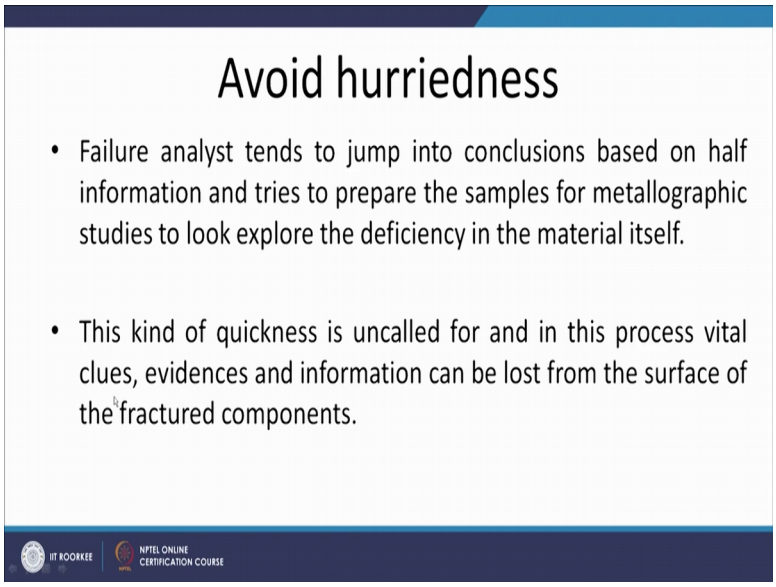

See why it is important to establish the general procedure for the failure analysis of a specific component, after thoroughly consideration of the situation with regard to the service conditions models and manufacturing process and the sequence of events the working conditions which were there before the failure all those things we need to consider while devising the procedure for failure analysis.

We need to avoid the hurriedness and jumping into the conclusions especially when the sample is received we try to prepare the sample and try to find if there is any metallurgical discontinuity of the problem with the material itself. So, in this process we may lose lot of information which is present on the surface of the or on this which is present on the sample. So, failure analysis basically failure analyst tends to jump into the conclusions based on the half information and they tried to prepare the sample for the metallographic studies so, that they can explore the deficiency in the material itself.

So, this is we can say uncalled for hurriedness and we should avoid this kind of these kind of a steps because in this process we may lose lot of information and useful evidences which are present on the surface of the component. So, this kind of quickness is uncalled for and in this process vital clues, evidences and information can be lost from the surface of the field component if it is there.

So, what we should do for the failure analysis, for the failure analysis different steps are there like 13, 14 number of the steps are there which may not need to follow systematically and sequential and in light of the material manufacturing processes used for making that component on the service conditions the possible failure mechanism. We need to device the proper sequence of a steps which we should which will be followed right from the beginning the sequence of steps followed for failure analysis will large living govern by the findings at any stage.

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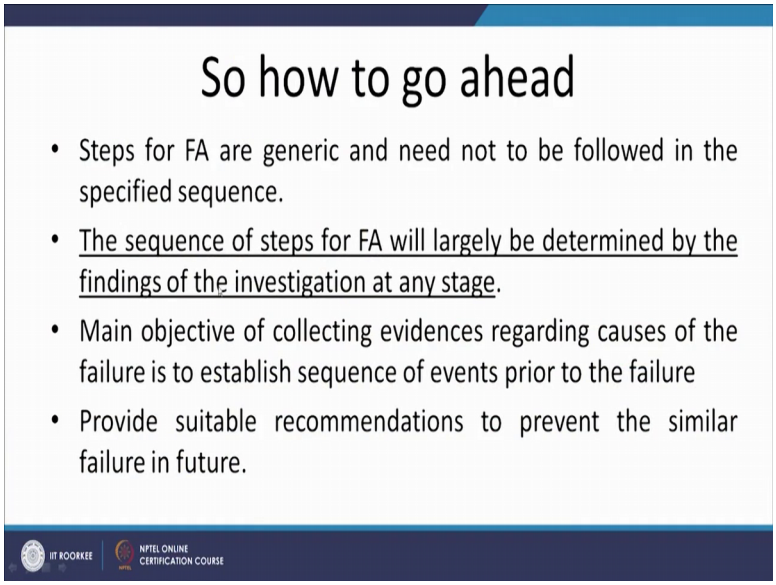

So, like we initially we have device the some number of the steps like after collection of the background information.

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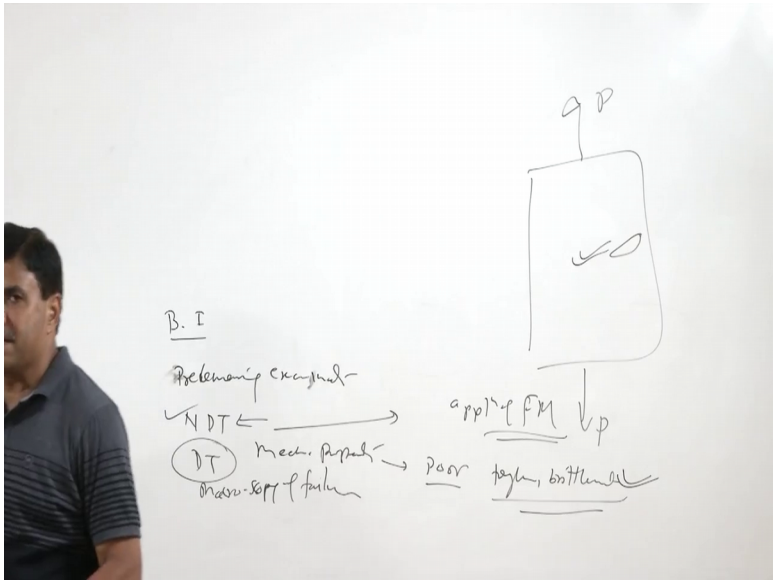

And the preliminary examination, N D T, D T, the microscopy of the fracture surface, so, like in which direction we need to move these are the say general steps. So, after the N D T if you find there a lot of cracks and discontinuities are present in the materials then it will simply indicate that material had a discontinuities and which might have continuity towards the failure. So, what we would like to do after this? After this basically will do, will try to use the fracture mechanics application of them fracture mechanics to analyse if this discontinuity have contributed towards a failure under the given service conditions.

Like this is the component and it is subjected to the load P and if there is a discontinued of large size we can analyse it and this kind of the size of the discontinuity and it is shape if it has been identified through the N D T and if the failure has and so, to see if this kind of the discontinuity has contribute towards the failure we can apply the concept of the fracture mechanics to analyse it if it has contributed towards the failure if it is established through fracture mechanics that the size of discontinuity is good enough to trigger the fracture then probably it can be attributed for the failure like the presence of discontinuities in the component can be activated towards the failure.

Second step after the N D T if you do not find anything wrong with regard to the presence of discontinuities then what we need to do will be checking the well forming N D T testing or like the mechanical property characterization and it at this step also if we

refined that materialized like this has a poor like toughness it is brittle and it is very of very high strength very low ductility as compared to what was the specified in the specifications so. This system it also will be as one of the indicator that probably the poor mechanical properties have led to the failure of the component.

So, what I mean to say the, what kind of a steps and sequence will be followed that will be governed by the findings of a particular step and that finding will guide which kind of a steps to be followed subsequently. So, this is an important line with regard to the general procedure which is to be followed for the failure analysis. Sequence of the steps for failure analysis will largely be determined by the findings of investigation at any stage. So, future is it mean further stages will be govern by the findings of any state which is an in the order and the main objective of like in failure analysis we try to collect the physical evidence is so, that they can be related with the possible sequence of events which have led to the failure.

So, these physical evidences basically in the failure analysis through the various stress tests and characterization efforts are made basically to collect the evidences. So, that the causes to the failure can be identified so, as to establish the sequence of events prior to the failure and once the causes for the failure and the sequence of event is sequence of events is established then the these will act as a basis for suitable recommendation so, that the similar kind of failure can be avoided in future.

Now, will be talking about the general steps which are followed in the failure analysis there about 13, 14 number of the steps which are followed. These steps are very generic in nature and need not to be followed in a specific sequence as I have said the any means after the 1 or 2 steps the findings of each step will guide in which direction we need to move in for collection of the further information so, that the failure analysis ah. So, that primary causes for the failure can be identified for establishing the possible sequence of failure which have led to the failure of the component.

So, under this the first point is like the collection of the background information about the failed component. So, under this, this is the first step of the failure analysis of any failure analysis what we try to understand is, which component, which system has failed so try to familiarise with that component which has failed with regard to certain things like, what kind of the, what was the design of particular component which has failed?

What, how it was manufactured and what were the service conditions under which it has been used? Now there after, after the failure where the different broken pieces were present for this is done and breakage analysis so, the first step is too familiarise with the failure itself and try to see what kind of material design manufacturing process service conditions under which the component has worked earlier and who and whose failure analysis to be carried out.

The second step in the failure analysis is the preliminary examination of the field component. So, preliminary examination of the field component is this like observing each and every part of the field component closely. So, that we can identify if there is some impurity traces paint, oil, soil, corrosion product or any change in colour, any discontinuity is present in the fracture surface or in the near fracture zone. So, these things can be observed under a during the preliminary examination of the field component and in this stage also systematically photography is done throw by throwing light from the different directions so, that the failure mechanisms and the possible fracture surface features can be revealed and also inventory of the different field parts is maintained.

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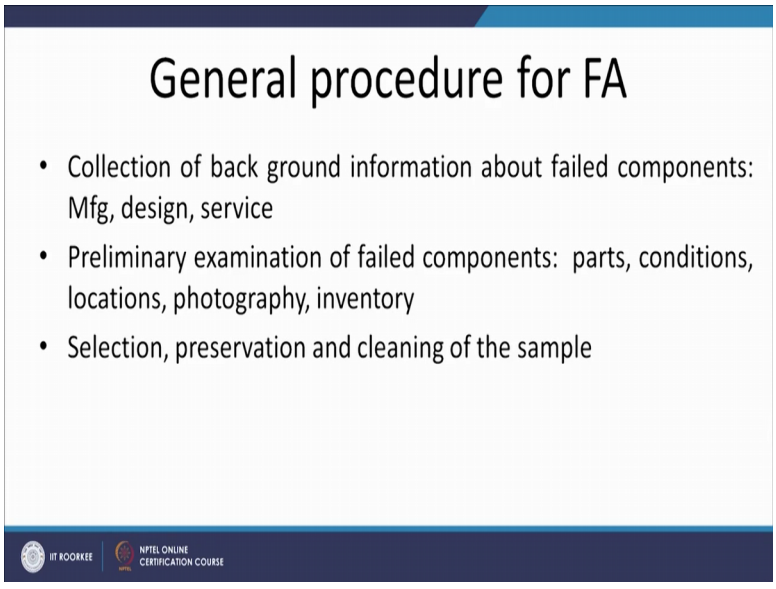

There after the third step is the selection, preservation and cleaning of the samples so, after identifying the location where from samples to be collected ah. So, we have to cut it down for cutting we may use like mechanical method of thermal method. So,

accordingly suitable location where from samples to be collected is identified and after taking this sample it has to be preserved.

Preserved means the in ambient condition will put the sample it make rust or a eat if it if the fractured sample or fractured component was in outside service, then in the rain or during the transportation also the failed sample can be damaged. So, we need to preserve the sample collected properly during the transportation or during the storage itself and after that once the sample reached in the lab we need to clean it properly. So, what precautions we need to take care? What precautions we need to follow while cleaning the sample that will be discussed.

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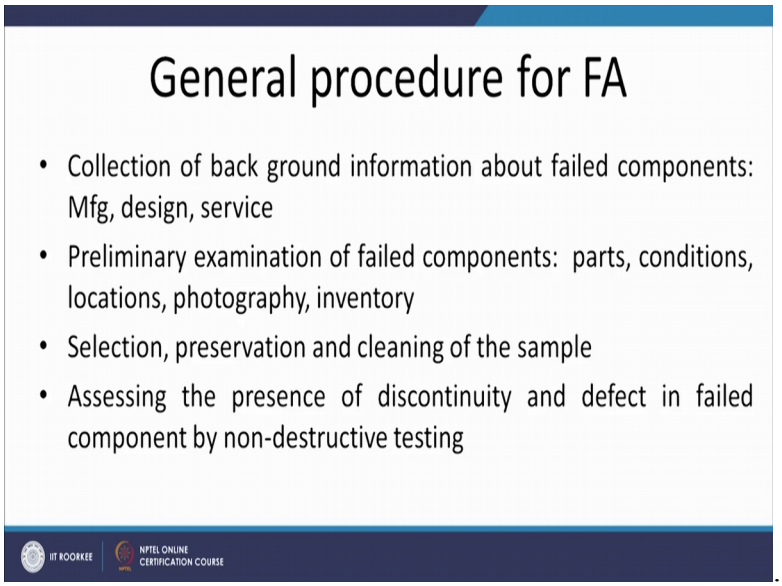

And the fourth step is about assessing the presence of discontinuities and defects in failed component. So, once the sample is ready for further studies the first step is to identify the N D T on the component. N D T will help us to see if there are internal discontinuity in the failed component or not and that will tell us whether the component whether these can tribute towards a failure or not through the use of proper fracture mechanics approach. So, presence of discontinuities and the defects in the field component are identified through the N D T, after the N D T the component is evaluated with regard to the mechanical properties.

Whether it had the specified set of the mechanical properties are not like the yield strength, ultimate strength, toughness ductility or not. So, the component is evaluated

through the proper through the suitable destructive tests with regard to the hardness, toughness, yield, strength, ductility ductile to related transition temperature or any other property which is of the relevance for a particular service conditions.

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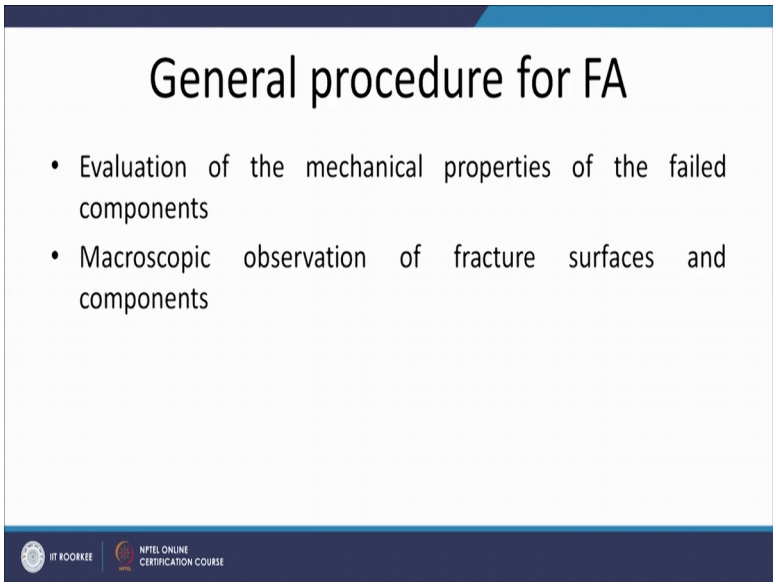

Then next is the macroscopic observation of the fracture surface this is very important steps because it helps us to see where from fracture has initiated, what in which direction it has grown? What was the general fracture mechanism ductile in brittle fracture? And what kind of the general gradient with regard to the colour, texture, the smoothness or the roughness on the fracture surface suggesting about the possible change in the failure mechanisms.

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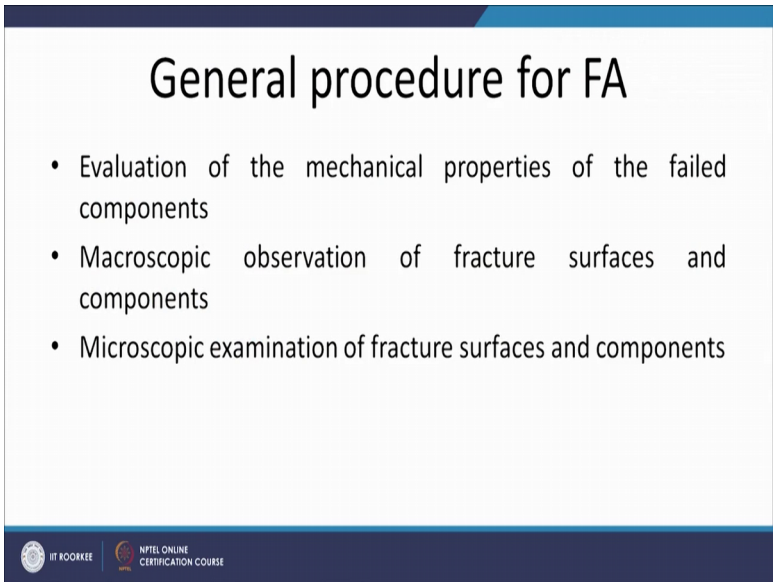

There after we have microscopic examination of the fracture mechanism fracture surface, the microscopic examination of the fracture surface shows the macroscopic mechanisms of the fracture surface like whether there is a dimple fracture, there is a brittle fracture in terms of that cleavage facets or intra granular fracture or their restrictions due to the fatigue fracture. So, these are the 4 fundamental a microscopic fracture mechanism which can be established and studied through the microscopic examination of the fractured component.

There after we have the metallographic examination of the failed component where in the material is prepared through the polishing, etching and thereafter we try to study the microstructure of the field component to see if the component microstructure has been modified during the service or it has any service effect or it can be compared with the any other new component.

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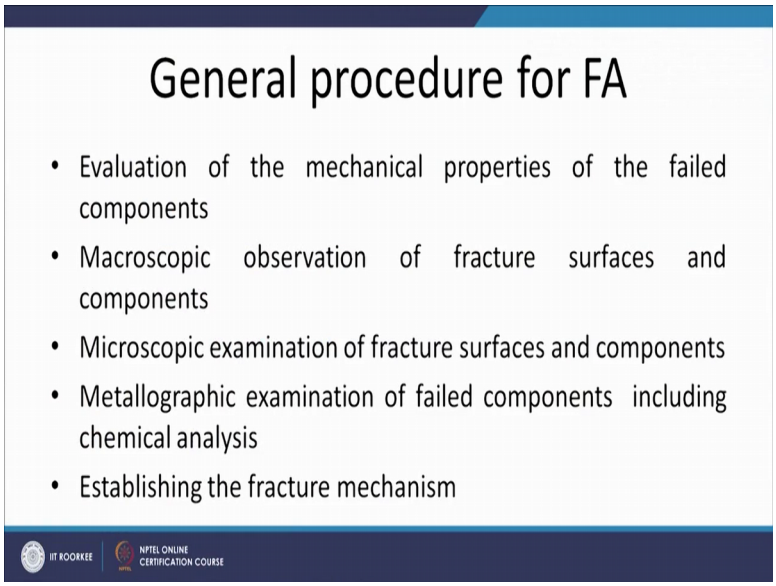

Or the it the microstructure can also be compared from the sample which has been taken from any other location which has not failed just for the sake of comparison to show that if the service conditions have contributed towards the modification in the microstructure. There after this also includes the chemical composition to see if the composition has been modified in course of the service like decarburization or the corroboration has taken place or the component chemical composition of the component which has failed had the same as the composition as per the specification or it had something else.

There after establishing the failure mechanism in light of the step number like a macroscopic observation, macroscopic examination, and the metallographic examination we try to relate all these things to see what kind of the failure fracture mechanism would have been there like it is ductile fracture brittle fracture through the proper sequence of events through the proper correlation of the different information which have been collected so, far through the different tests.

So, this will help us in establishing the fracture mechanism, then the failure analysis using the fracture mechanics approach. So, in light of the discontinuity if they have been identified through the N D T and the service load conditions in light of the design parameters we try to relate it if the component should have failed in the presence of such kind of discontinuities or not that is what is analysed through the fracture mechanics approach and is still if the component has been subjected to some unique kind of the

service conditions for which data is not available. Then we may have to conduct the test under the simulated conditions so, that the behaviour of the material under the actual service conditions can be studied.

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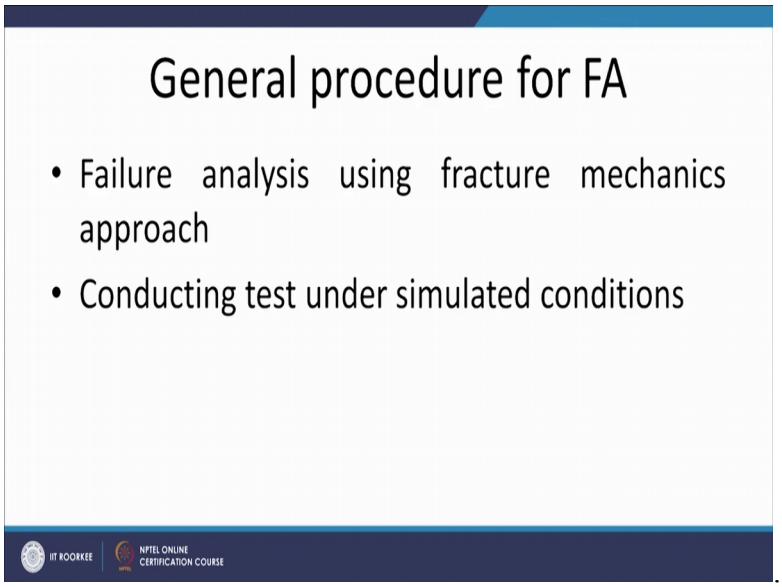

So, but this is needed only if we find that no really data is not available for those service conditions then we need to conduct the test under the simulated conditions and after this analysis of the finding of the investigation this is very important step because we now we have to put enter the information which has been collected through the different characterization and testing techniques and then they are aligned in such a way that it helps us to explain the sequence of events and it also suggests the possible primary causes of the failure.

So, after the analysis we should be in position to identify the possible causes of the failure and thereafter will be writing the report and based on the possible causes of the failure will be making the suitable recommendations.

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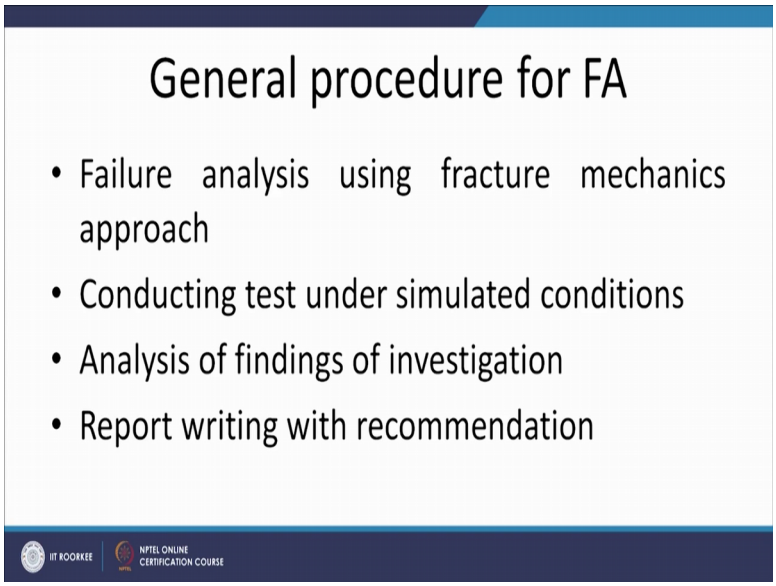

So, this is what is there the first presentation on the general procedure of the failure analysis now I will conclude this presentation in this presentation basically I have talked about the need of the failure analysis and what are the general steps of the failure analysis.

Thank you for your attention.