Failure Analysis & Prevention
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Lecture – 19
General Procedure of Failure Analysis: Background Information Collection

Hello, I welcome you all in this presentation related with the subject failure analysis and prevention. And we have talked about the general procedure procedural steps of the failure analysis. And we know that failure analysis is carried out to identify the primary causes of the failure so, that we can take the suitable corrective action in order to avoid the reoccurrence of the similar kind of failure. So, you know we have listed in like 13 steps related with the general steps of the failure analysis. So, one by one will be talking about the relevance of the each step in detail and what should be done under the each step.

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We know that in the failure analysis basically it is about the procedure, tests, characterization, testing characterization of the failed component, failed components so, that basically all these things are done so, that we can have some primary causes of failure. We have seen that there are about 13 14 number of these steps 4 related with the failure analysis as a general procedure. for a specific component failure analysis of a

specific component or a specific failure, the general steps need to be customized as per the requirement so that the possible primary causes of the failure can be identified.

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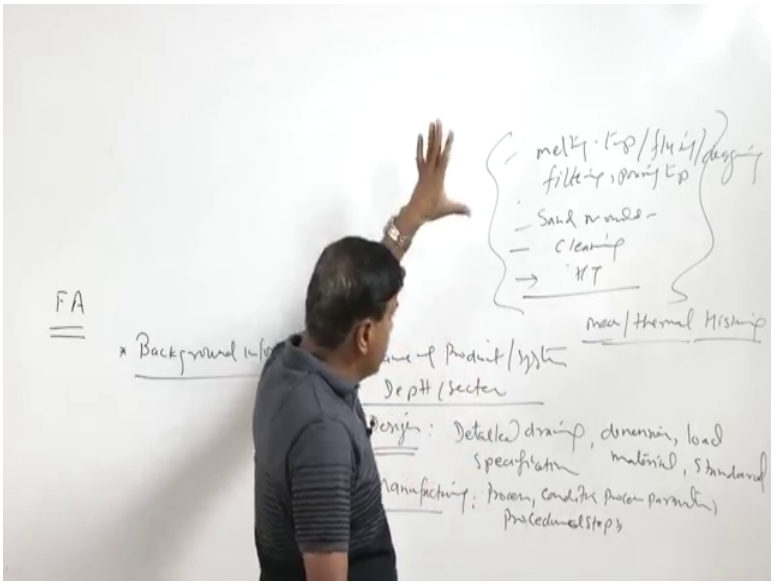

But in any case, we need to follow the first step which is about the collection of the background information, background information about the product. So, basically here will have to start with the name of the product or the system which has failed and for which the failure analysis is to be carried out. Apart from the name other information like the department or the section where it was located. Thereafter the technical information as far as the familiarization with the failed component is concerned, we need to collect the information about certain heads and this includes like information about the design aspects.

So, we need to collect the all about the other detailed drawings of the product so that we have idea about the what are the dimensions; which are expected what kind of the load for which it has been designed and means that the loading conditions for which it has been designed, may be the material which has to be used for making that particular component, and what standards need to be followed should have been followed for making that particular product. So, detail the drawing of the product with the standards and specifications, specifications is obtained.

This is the first thing thereafter we need to collect also information about the manufacturing, how the product was manufactured. So, under this we need to talk about

the processes the process condition means the process, parameters which have been used for manufacturing the product.

And then the procedure of procedural steps which have been used procedural steps of manufacturing. for example, it can be like this the if the something was made by the casting then, sand mould then like say the melting temperature then the fluxing degassing, and then filtering pouring the kind of pouring temperature which was used then putting into the mould. And then you can say the cleaning of the casting post casting heat treatment. So, all these steps need to be mentioned need to be obtained so that we know right from the beginning how it has been made what steps were followed.

And whether the component which has failed has the mechanical or thermal history according to the manufacturing or not thermal history means, the product will show if it has been processed through mechanical approaches or the thermal approaches like casting and welding so, but that thermal history will be present with the product.

And this is what can be obtained through the detailed characterization of the product also, which will suggest if it has been made by the casting or subjected the post weld heat treatment which was right or not. So, it is important that complete detailed information about the manufacturing process and the procedural steps is obtained. And thereafter we have the service conditions service conditions.

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So, there are a number of things which are to be obtained under the service conditions, after the service conditions we have the like the photo graphic of the failed component and thereafter selection of sample, then exploring the possibility of the abnormal conditions, abnormal conditions which can be experienced by the component during the service. And then there is wreckage analysis, breakage analysis which involve the what are the different 4 components which were obtained after the failure of the product. So, these are different things which need different points information about which need to be obtained under the background information collection.

So, that we know actually what it is and what are the different what is the general history of the product under what conditions it has worked. So, as I have said as far as the first point is concerned design. We need to get information through the detailed drawings regarding the dimensions the loading for which it has been designed the material of which components should have been made specifically it is a specification and the standards according to which it should have been made.

So, this information is collected and in light of that subsequently characterisations will help us to know whether the dimensions are proper or not material is proper or not, or it has the correct kind of composition or not. So, it follows the particular kind of a standard as per the specification or not so all that is obtained.

Thereafter the information about the manufacturing processes. We know that for making any particular product a very large range of the processes need to be applied so, that it it becomes workable. say for like if we take up any product, then it will be processed through the number of number of the steps. So, since the manufacturing processes will be involving the number of steps. So, the different steps need to be clubbed together to see, to see that in which way it could be affected by one, approach or the another approach. So, entire range of the manufacturing processes are grouped under the 3 headings.

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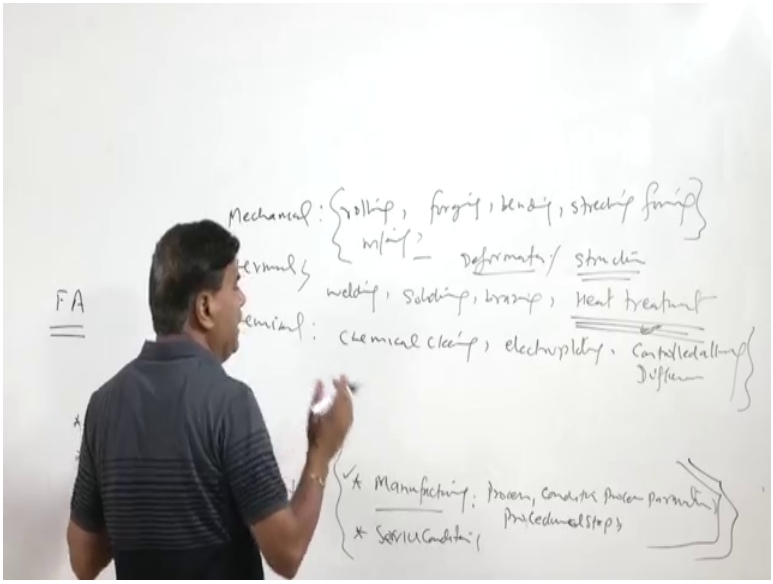

One is mechanical manufacturing processes, thermal processing of the component, and the chemical processing of the component.

Say the component initially from the big thick plates it has been rolled down to the thin sections, rolling, like say forging, bending, all these are the mechanical processes stretching, or stretch forming all these are the mechanical processes where load is applied, machining, mechanical forces are applied so that the control removal of the material can take place. So, whenever the mechanical methods are applied, they will leave their traces in form of the deformation and plastic deformation the magnitude may vary, but the deformation will be there and accordingly it will be leaving behind some unique kind of the structure in the deformed component.

Then we will have we have to see if the component has been also processed through the thermal or based processes. So, under this we have like use of the heat for the fusion in welding processes for shouldering, for brazing or for the heat treatment purpose, for improving the properties of the component if the component has been subjected to the heat treatment. So, if these has been used in course of the manufacturing, then they will be leaving behind their own traces their own effect.

For example, if the component was subjected to the hardened, and thereafter it should have been quenched sorry after hardening it should have been tempered, but if the tempering has been skipped in it ad advertently or by mistake. Then we need to see really

the component will have the poor toughness. So, this may be identified as one of the possible cause like if the after hardening quenching was missed then this has led to the improper toughness and that under the impact conditions had failed.

Similarly the so, unless we know what are the different processes for which component has been subjected, we really cannot identify the possible cause of the failure. So, that is why complete details about the manufacturing steps is also required under the chemical category of the processes, like chemical cleaning was applied chemical cleaning or electroplating was applied or like say some controlled allowing was done control allowing like say through the diffusion-based processes like nitrating carburizing carbonate nitrating etcetera. So, in all these cases the chemical modification has been applied.

So, these will be altering the chemical composition which will alter the microstructure and the mechanical properties of the product. And these can contribute towards the failure if they have not been implemented or they have their implementation has been improper. So, according to the manufacturing process which have been applied, we need to see really the material is having the traces or the features of those manufacturing processes or not or if any step has been incorrectly applied, then that also can be established through the subsequent characterization. We also need to have the not just information about the process or procedural steps which have been used, but also need to know the process parameters.

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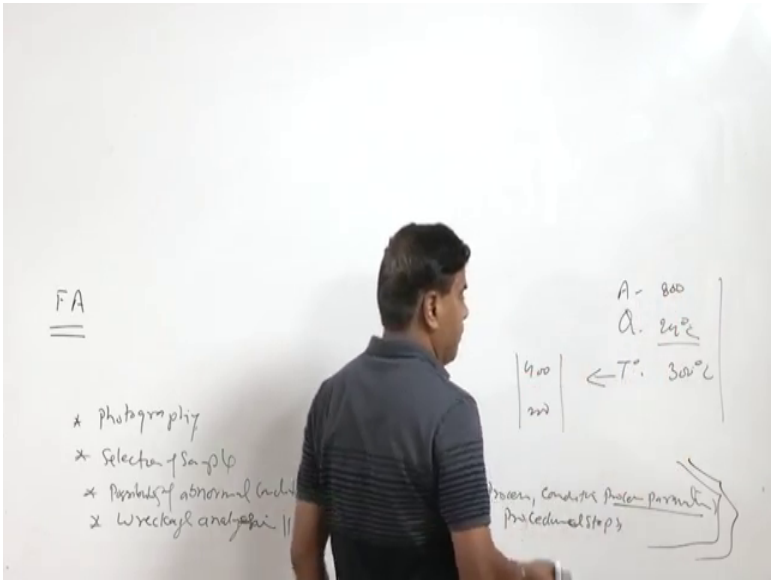

Say if the heat treatment should have been done like 7 like say astonishing at 800 degree centigrade followed by quenching at 24 degree centigrade, and then tempering at like say 300 degree centigrade. So, we need to have the information about this according to these steps and the conditions, the material will have you a particular kind of the structure and properties. If environmentally it is being subjected to the 400 or 200 degree centigrade, then it will have product will have altogether different kind of the structure and properties, and which may lead to which may encourage or which may discourage the fracture. So, we need to see that we have the detailed information about the process parameters which were used for that manufacturing purpose. Apart from that service conditions for which component has been exposed is also important.

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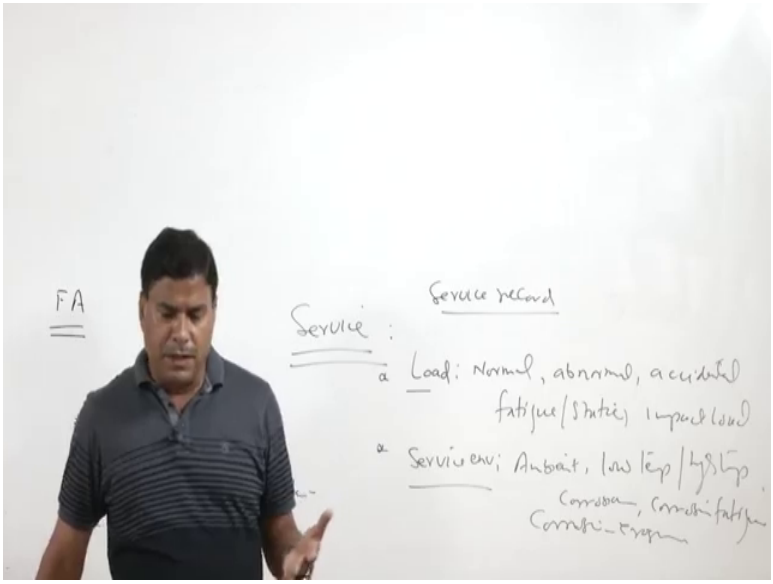

So, service conditions, what will be the service conditions? like each critical component, the history of service of each com critical component is usually maintained in all big industries.

Because they will be governing that they will be affecting the continuity of the service. So, if it is so that that we that the proper service record of particular component which has failed is maintained, then it makes the job of the failure an analyst very easier in the sense that it he will be able to have the idea about the kind of service conditions for which it has been exposed, and these may be in terms of the load. Load whether there has been only the possibility of the normal load there is a possibility of the abnormal loading or there is a possibility for the sudden accidental loading, and the load is the fatigue kind or it is static or there is a possibility of the impact loading.

So, according to the kind of the load which can be there, whether the material of the component is having the requisite properties or not that is what can be checked through the subsequent analysis. So, this is one the loading type than the service environment. Service environment means it has the like it if it is ambient conditions, normal atmosphere or it is the low temperature or the high temperature conditions, or it is like some corrosive environment exposure under the corrosive environment, now it is under the corrosion fatigue, the fluctuate thing load under the corrosive environment or there is a combination of the corrosion and erosion there can be variety of the conditions.

Like, the components which are used in the sea they are subjected to both corrosion and erosion like number of components which are used in the hydropower plants they are subjected to the arrows on end of the cavitation. So, depending upon the kind of the product, which is being considered there can be different. Apart from this not just the temperature values the temperature gradient which can which is for which the component is being exposed also needs to be considered.

So, if these details are available, we can anticipate the behaviour of the component under the service conditions; whether a given product should fail in a car under these conditions or not. And if it is failing then it will have it is own effect on the fracture surfaces, which subsequently which through subsequent analysis can be identified.

If really the fracture has been caused due to the deficiency in the material or improper service conditions. apart from that of course, if the history of the service record is not available then the job of the failure analyst becomes difficult in the sense that he will have to reduce the information based on the service conditions. And the that also will depend upon the experience of the failure analyst if the incorrect estimation of the service conditions is done, then that can be completely misleading. So, we need to be very careful when information is deduced based on the information about the service conditions. So, next step is the photography here. Like, if the failure has taken place we need to take the proper photographs of the seen where the failure has taken place.

So, that so, that proper record can we maintained what was the seen immediately after the failure. Something which will appears is to be the casual and the normal one, subsequent analysis may indicate that there has been tampering and there has been intentionally the things have been manipulated to cause the failure so, there can be legal implications. So, to deal with those aspects, it is important that proper record of the photographs of the failed component is obtained. So, that and this of course, should be a representative representative of the situation. Of course, we need to take the photograph in such a way that it helps to show us the situation immediately after the failure in order to also indicate the possibility.

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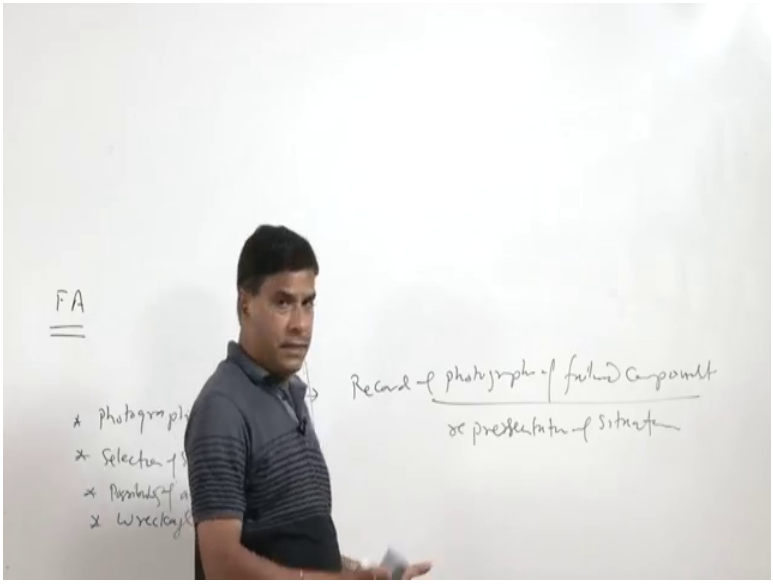

So, this will help that if the subsequent analysis indicates that there has been some tampering or intentionally something wrong has been done with the product, and then that can have the legal implications and to deal with those things it is important that the proper photographic record of the failed component is maintained. Another thing is about the selection of sample. Like in the in the site of the failure wherever failure has taken place it the seen may be very bad.

Like, the blast in the boilers take place was in the accident site the situation may be very bad, wherein lot of the damaged machines and the people would have died. So, in that situation it is important that, now we need to see where from the samples can be collected in order to, in order to go through for the future or the further analysis. So, this of course, likes the photographic record.

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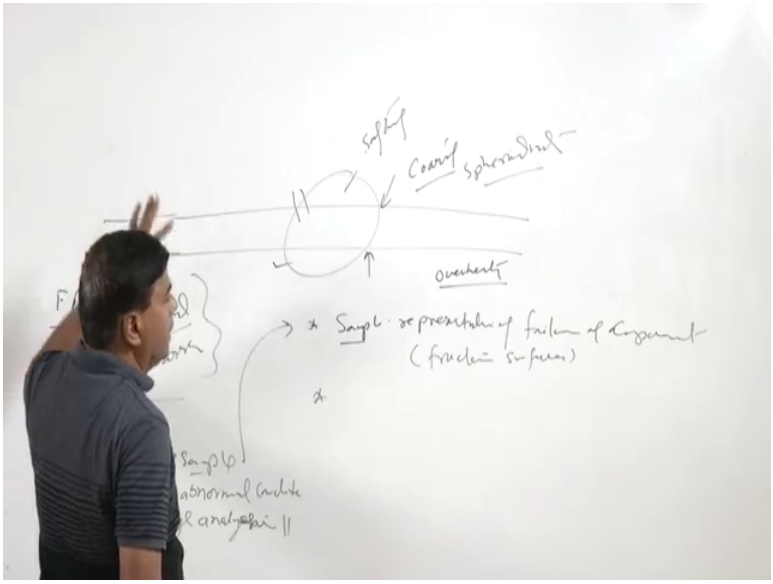

The whatever the samples samples are there they should be representative of the failure of component. So, of course, these are these need to be taken from the near fracture. Fracture surface basically fracture surfaces and near fracture surfaces, this is one thing. Sometimes, it is important that sample is also collected from some other location. Like, in a tube in a boiler if the busting of the tube has taken place from this location, then of course, we need to collect the sample from this location where our fracture has taken place. But at the same time we also need to collect the sample from some other location where really the failure has not occurred.

So, this kind of the sample collection actually helps us to see, really if this particular location has experienced a unique kind of the service conditions as compared to the other location, where failure has not taken place or the failure has occurred due to the manufacturing problem. Say, for example, in the boiler tubes normally failure occurs due to the overheating.

So, the one location which has been overheated will be experiencing the coarsening of the grain. And exploitation of the exploitation of the steel so, exploitation and coarsening both will be leading to the softening of the steel. And which under the pressure can lead to the bursting. So, to establish this if this is if this particular location has failed due to the overheating or improper heat treatment.

Then for that we need to see that the structure of this location is compared with the other location where failure has not taken place. So, we will be taking this sample location from other sample also. And if it shows that the structure is normal noise faradization, then it will suggest that this particular location has been subjected to the overheating. And because of that only the coarsening and exploitation has taken place and which has caused the failure but if this location also shows that this location is all.

So, having the (Refer Time: 22:37) structure very coarse, grains, then it is indicating that this is having the faulty heat treatment. Instead of the normalizing it has been given prolonged normalizing which has led to the coarsening of the grain structure. So, the improper heat treatment would be the cause of the failure instead of the overheating.

So, this kind of thing can be established only through the proper systematic analysis of the failed sample, and comparing it with the new one or something or the structure of some other location which has not failed. So, comparison with other location so, we need to collect the sample for that purpose.

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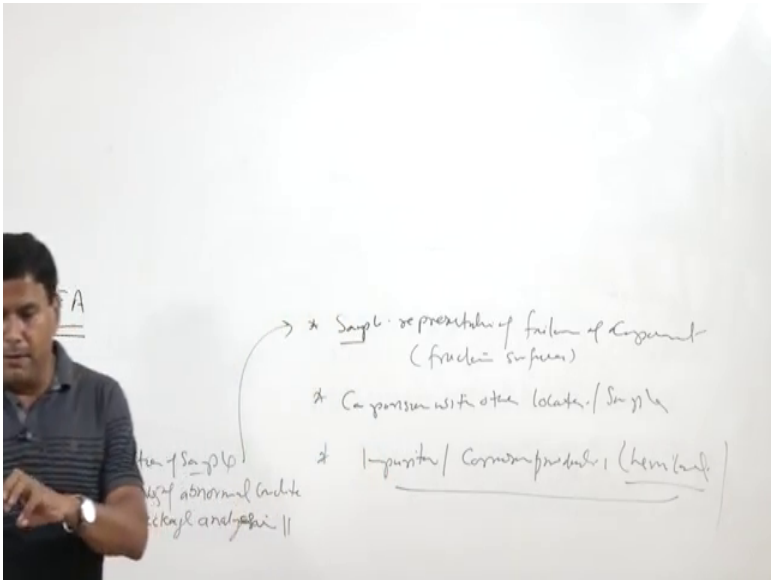

In addition to this we also need to see that there whatever if if there is some like impurities or corrosion products, corrosion products chemicals if these are present on the surface all these need to be collected so, that these can be used as an evidence to see, if the failure has been contributed by the formation of such kind of the products on to the

fracture surface formation of the irregularities and impurities on the surface which have triggered the failure.

So, samples we need to collect considering the various aspects like the sample is representative to the failure of the component sample for comparison purpose or the products or the components which are failed by the corrosion or the or the or the related factors then accordingly we need to see whatever products, and the things are present on the surface that is collected properly. Like say, if the if particular gear in an engine has failed due to the lack of the lubrication, that also need to be collected to see right like if there is a black oxide debris is present on the surface instead of the lubricant that will be suggestive of the absence of the lubricant. So, that blackness needs to be is to be collected.

So, that it can support the finding that the lubricant was not there, and rather the wear of the gear teeth surfaces have taken place due to the direct metal to metal contact beer which has led to the production of that the black oxide powder on the fro on the wear surface of the gear teeth. So, whatever is present on the fracture surface has to be collected properly. So, that it can be analysed subsequently for the analysis purpose the possibility of the abnormal load conditions.

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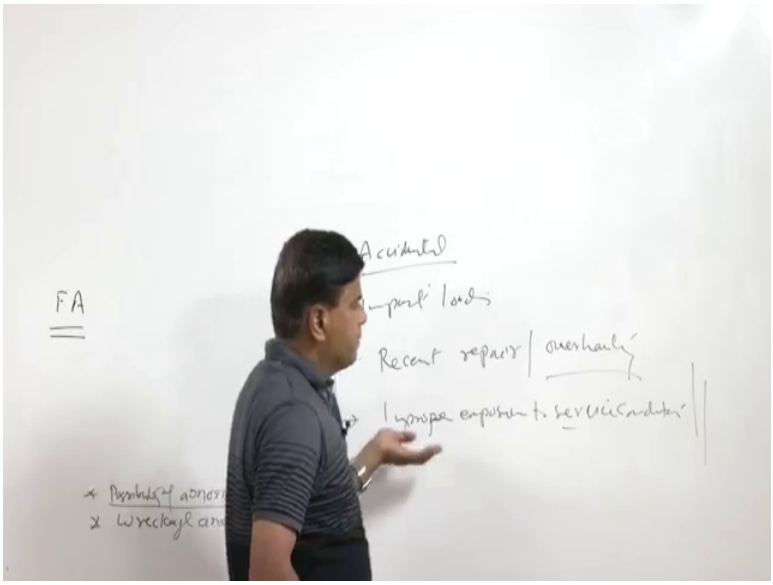

So, possibility of the abnormal load conditions like there is a possibility of the accidental load. If the accidently some additional load can come on to the surface, and there is a

possibility of the impact load. And there is a passive a possibility of the if abnormal thing like recent repair or overhauling was carried out.

Sometimes in inappropriate overhauling and repair can also lead to the ex-sudden failure of the system, and then there is like improper exposure to the service conditions which were not expected or intended. So, like suddenly it has been exposed to the corrosive conditions suddenly it has been exposed to the very low temperature and normally the, if the component is expected to work under the ambient condition. But suddenly if it is exposed to the minus 20 and minus 30 degree centigrade, then it will not perform as intended. And so, these are the some abnormal conditions which can happen with the product these are normal exposure to the service conditions may be in terms of temperature corrosion or some kind of chemical in which component may not behave as expected.

So, a list a of such kind of the possibilities with regard to the abnormal service conditions should be identified so that their possible contribution on the failure of the component can be explored and investigated, then the wreckage analysis is the another step related to the preliminary sorry background collection information, a collection of the background information. So, wreckage analysis there are 3 important aspect related wreckage analysis. The number one is to find the position of the different fractured component.

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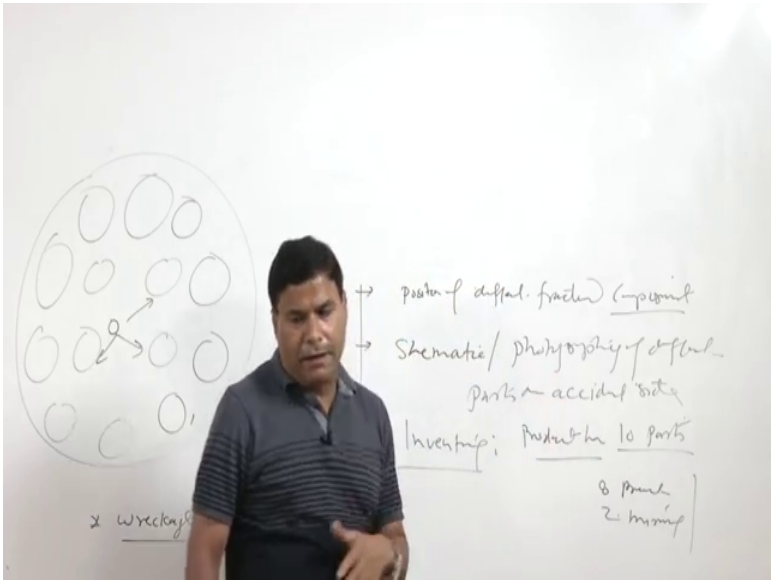

This helps us to see the intensity under which the intensity of the load or the failure which has led to the scattering of the different parts or a small area or over a large area.

Like, we must have seen that the intensity of the blast is checked through the through the distance up to which the broken pieces were found away from this site of the blast, or the distance up to which the glass windows were broken away from the site of the site of the blast. Like say, if this is the site of the blast so the effect is there up to this zone or it is up to this zone. So, that will be indicating the intensity of the blast. So, similar situation is here position of the different fracture component. Where, what was found immediately after the accident, and then there is about the schematic or photographing of the different parts on accident site.

It is possible that a in one photograph each and everything may not be covered. So, what will happen if the accident site is so large, then we need to use the askew metrics. Like, if this is the area of affected by the ex accident or the why the failure. So, and this is the actual site of the accident. So, in one photograph it may not be possible to cover the entire area. So, in that case, we need to make the schematic, and schematic of location one location to location 3. And sequentially we need to take the photograph to show what is there at what location with regard to the distance and each can be levelled with and then accordingly we can take the photograph of each of the location to show, where what was present and this can be marked.

So, it can be on the scale or without a scale just to show that what was the area affected and where what was found with regard to the different parts of the fractured component. Then there is inventory, inventory of the field component. This is very important aspect because we need to see really like if a product has 10 parts. So, after the after the failure all those different parts need to be collected, and they need to be assembled to see really after the fracture after the failure how many parts were found. And if we find that after the failure only 8 were present and 2 are missing 2 parts are missing.

Then this will suggest that some manipulation has been done some intentionally something wrong has been done with the product because the 2 things are missing and while 8 are present. So, this can be established only if the proper inventory of the fracture site the failed component is maintained. Like normally, we see that in the

railway train accidents people try to find that whether the rail was the, their throughout the length or not in that accident site different fish plates were present or not.

And if it is found that fish plates were missing then that can be activated as one of the possible cause that something tampering some kind of tampering has been done because of which fish plates are missing or the that the rail was cut over a particular length that is why absence of rail has led to the now the accident of the train. So, those kinds of things can be established only through the subsequent analysis subsequent collection of the different failed parts and through the inventories. So, for the inventory is an important part, because it helps to identify what was actually left after the, what was found after the accident.

Now I will summarize this presentation. In this presentation basically, I have talked about what are the different the points under which information we need to collect. So, that we are familiar with the component which has failed and based on this we can try to make the possible sequence of events of the failure so that we can really device the procedural steps which should be followed in the failure analysis.

Thank you for your attention.