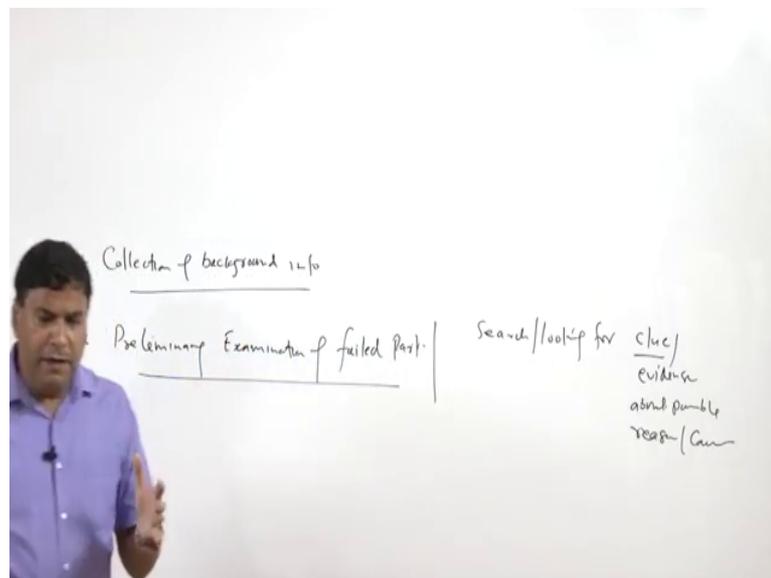


Failure Analysis & Prevention
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Lecture – 20
General Procedure of Failure Analysis: Preliminary Examination

Hello, I welcome you all in this presentation related with the subject failure analysis and prevention. And now we are talking about the general procedure for the failure analysis, and under this general procedure for the failure analysis, we have talked about the first and important point collection of the background information.

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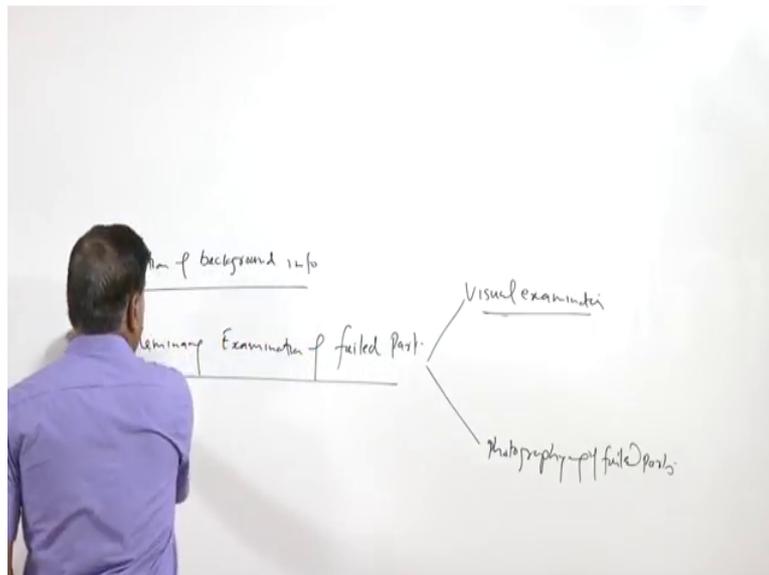
This helps us to understand the various aspects related with the failed component, which may be in form of like say that design the manufacturing methods which have been used for making that component, the service conditions under which it has been exposed.

And the kind of after that the failure what are the different items related with the failed component have been collected. So, under the wreckage analysis, and also it helps to identify if identify the possibilities of abnormal service conditions like recent repair or recent overall or sub abnormal load or accidental load possibilities or change of the service condition. So, all that information about the failed components collected under the first point that the collection of the background information. In connection with the

general procedure for the failure analysis the second point is about the preliminary examination preliminarily examination of failed part of the failed parts.

So, we know that the failure of a component is about the inability to perform the desired functions. So, the main objective is to search or looking for the clues or evidences about the possible reason or cause of the failure. So, we need to see the failed component itself which can indicate the possibility of the reason because of which the failure has occurred. So, this is the main objective we are trying to basically look for the clues evidences so that the possible reasons or the cause for the failure can be identified. And for this purpose, basically the 2 approaches are used. One is the visual examination of the failed part.

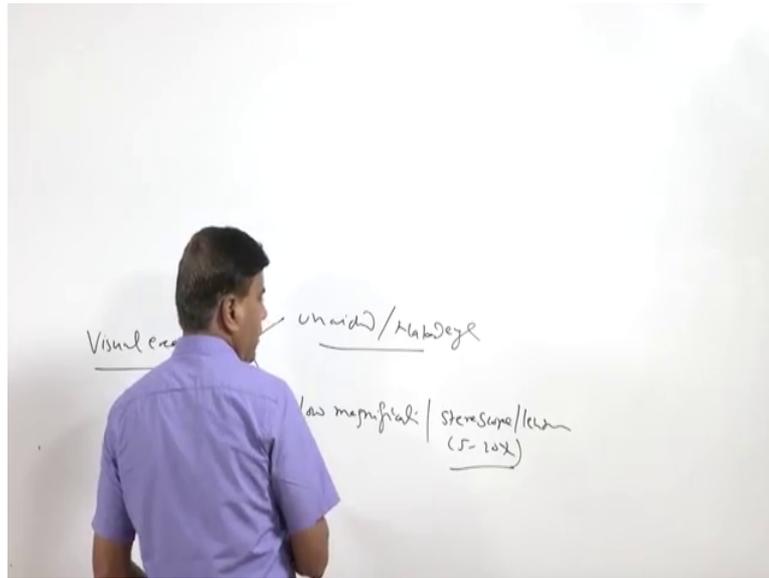
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And the second one is about the photo graphing of the graphing of the failed part.

So, of course, the first row of all the visual examination is conducted and thereafter we will be undertaking the photographing of the failed part. So, what are the things which need to be taken up under the visual examination and how it is conducted?

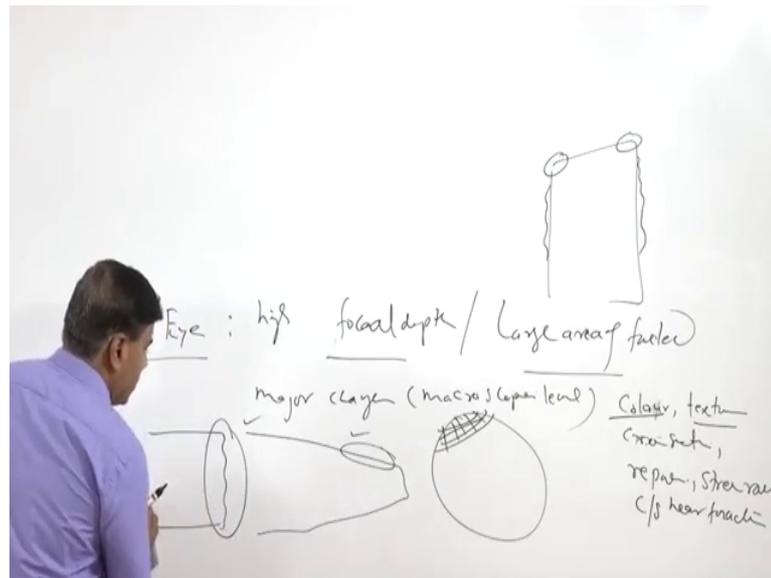
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So, basically the 2 types of the tools are used for the visual examination of the failed part. One is like unaided or just naked eye is used for the observation purpose. And the second is we can say the low magnification stereoscope or the lenses is stereoscope or the lenses can be used for the visual examination. So, normally this range is like say 5 to the 20 x magnification, or one is the unaided eye or the naked eye.

So, advantage so, as per the need the suitable technique is applied for the visual examination. So, when we use the unaided eye means use unaided eye for the preliminary examination of the field part offers the one main advantage over the other techniques is that, it has got very high length or very high we can say the focal depth or ability to focus over a wide range of the depth, and it can cover the large area of the failed part.

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So, because of these 2 advantages it helps us to see the major changes which are taking place in the failed component or on the fracture surface. So, major changes basically at the macro scope level, a inform of like say the change of colour, change of colour change of texture, cross section, change of like say the cross section or presence of any kind of the repair near the fracture zone or any other kind of the stress raiser if it is present. So, all these things we can simply see by the naked eye, or if any kind of the change in cross section, near the fracture has taken places.

So, basically if this is the sample sizes, it can fill simply in abrupt manner or it can fill the company lot of elongation prior to the fracture. So, this is the Mac this kind of the microscopic change in the cross section of the failed component can only be observed through the naked eye, which will suggest the kind of mod of the fracture or the kind of fracture which has taken place.

Say, a particular region has been overheated then the change of colour will be their different means if this is the region which has been overheated, then this will have the different colour as compared to the other areas. Similarly, if we take up this fracture zone, and if we see it high magnification means even if see this fracture surface using naked eye, we have found that we will refined that one area is of the different shade different texture in colour as compared to the other areas. So, this change in colour or texture indicates that either the component has been exposed to the different kind of

service conditions in terms of temperature corrosion or the fracture mechanism is different.

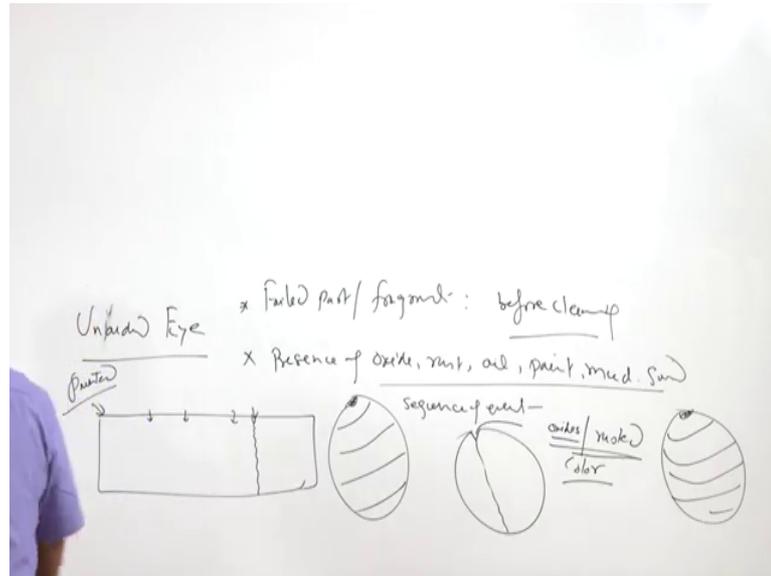
So, this area if it is of the different colour and texture as compared to the remaining area, then it will indicate that this area has experienced one type of the fracture mechanism as compared to the other areas. Similarly, we can say in case of the failed components when like say of the piston, and this portion has subject has been subjected to say extension here, and this portion has been subjected to some kind of the metallic failure, then since the piston is in very is large size, and in any change if you have to observe then basically the naked eye will help us to see the locations the extent of the wear which has taken place one particular area and the kind of fracture which has taken place where it has taken place and what is the extent of that damage.

So many things can be checked with the help of the unaided eye itself, and the those changes which have taken place can be judged in terms of the change of colour texture roughness cross section any kind of his stress raiser in form affiliate or the keyway or hole repair recent repair or so.

Likewise, so many things on the failed components can only be observed through the naked eye. That is why the naked eye observations become very useful in the failure analysis. And intention of this observation is primarily to find out the some of the reasons or the causes or the evidences because of which failure has taken place.

So, there are some specific things which are checked through the visual examination, and I will be writing specifically those things.

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Like, what are the failed parts and its fragments, and how the fragments are related with the failed part, that is what is efforts are made to correlate with that the the relationship of the fragments with the main failed component, efforts are made to establish this. And of course, all these things are done before cleaning, no cleaning, just in as just after the failure just after the accident the things are assessed to see where what was present, and how the different parts of the failed component can be related with the main system or the component which has a failed.

Then we need to see if any presence of, presence of like say oxides rust, oil, paint, or like say mud or soil, anything which is there on the fractures surface than efforts are made to notice that. This can be useful in establishing the sequence of events also. For example, like this was the shaft which has been used for long and it was like say painted about 6 months before. So, when whenever paint is applied, then the paint will try to seep into the Jones vacancies or the post or the cracks if they are there. And say in the shaft if this crack was present then the paint will get seep into this crack.

And after say 6 months or one year if the shaft fails in, then failure from this location will show the presence of the paint over this particular area. So, this will suggest that actually the painting was done about 6 months or one year before, and the crack was present since then, and they are after the crack has grown gradually. So, it will indicate that the crack has been crack was present since long and it has grown gradually, under

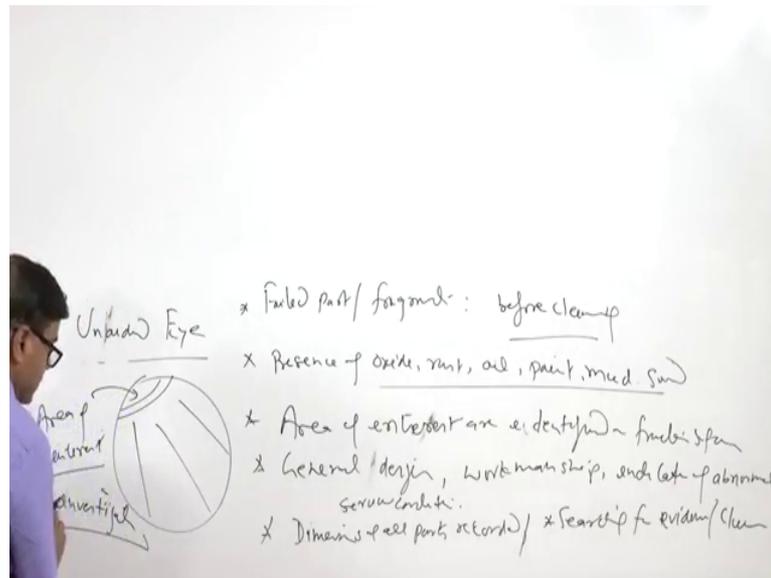
the service conditions. In addition to this there is one more way of relating these things with the failure, that is about like if the steel component which was exposed in the normal ambient condition.

And if it has it had either discontinuity like in form of pores or the cracks, then the surface which is exposed will get oxidized. I will have the oxides or it will get rusted so, that will of course, will have that different colour. So, when the failure occurs failure will be metallurgical one and it will be showing the bright and the different colour and the texture as compared to the oxide area or the zone which has was subjected to the oxidation or the rusting. So, the presence of these rusts and oxides also indicate that this crack was present since long and it has grown gradually under the external load conditions and subsequently the sudden fracture has taken place.

So, it is important to observe the presence of such kind of such kind of the impurities or undesirable things of for an material in form of oxides or oil paint mud soil etcetera. Even like the presence of the corrosion products can also indicate that the component for a while has been exposed for in the corrosive environment and which might have triggered the nucleation and the growth of crack.

So, the second point is about identification or looking for the presence of these kind of impurities and if they are observed we they need to be recorded and noted down. And then the third is like on the fracture surface if this is the fracture surface. So, of course, one area will be of the different shade and different colour different texture which will indicate that this zone is different from the remaining zone.

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So, the remaining zone might have failed by one way, but it has it will suggest that this is this area this location is different, and which might be different due to the presence of discontinuities or stress raisers or stress concentration, or something else some presence of discontinuities poor mechanical properties or something else.

So, it will be leading to the identification of the area which is unique and present on the fracture surface. So, this area becomes the area of the interest area of interest and such kind of area of areas of the interest should be like say it needs more systematic investigation to see what is uniqueness in this area and which is different from other zone, which may be suggestive of the presence of some cause of the failure.

So, such kind of the areas, areas of interest, interest are identified are identified on the fracture surface. So, this is the second third point. Then whenever the failed component is observed what will be able to see, that what is I it will give the general observation by the naked eye or unaided eye, will also give us the idea about the general design of the product or the field component weather. So, if it is huge discrepancy in terms of the design that can be identified easily through the general observation. So, general idea about the design or the workmanship can also be seen.

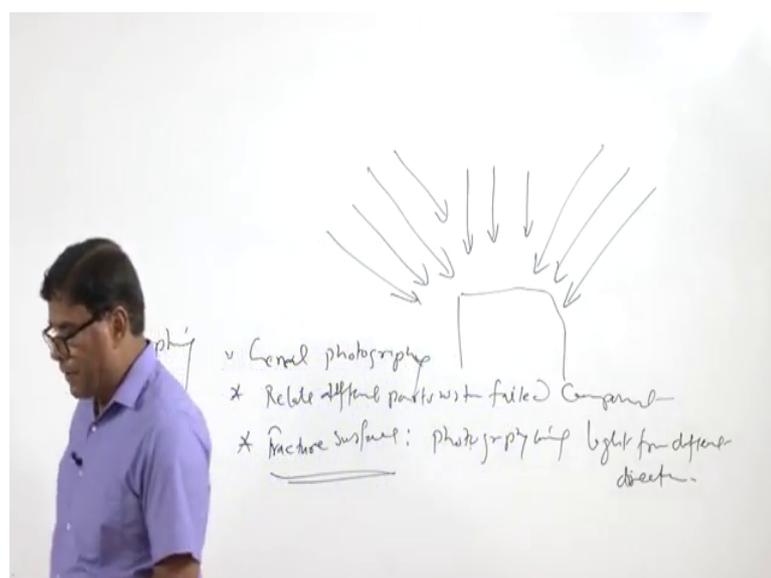
How properly and meticulously the things have been designed and the manufactured, or if there is a casualness during the manufacturing that also can be seen and apart from the general design, and the workmanship these there can also be the possibility for the

indications of abnormal service conditions, abnormal service conditions. So, if it is expected that component will be working in this particular kind of environment as per the design, and accidentally or inadvertently if the component has been exposed to the conditions for which it was not designed. So, the circumstantial conditions it may say may indicate that the component has been subjected to the abnormal service condition so, that is what also can be identified through the unaided eye.

And like say that whatever has been collected and observed the dimensions of all parts need to be recorded. And the way by which they are related with each other also be established. And the next point is basically we need to keep on looking for searching for the evidences, clues, at the site of the failure so that, if these clues are present they are they are not lost due to the carelessness of the failure analysts. So, analysts so, it is important that properly checks and the search is the site of the failure properly in order to find such kind of the possibilities possible evidences and clues which can be indicate you of the possible cause of the failure or the reason for the failure.

Another aspect is the photographing, photo graphing. So, a photographing is an important aspect because before the things are disturbed after the failure we need to capture the location of each and every component either with the help of photograph or by making by taking the bird's eye view of the entire seen, or by using the number of sketches to show the location of the different parts.

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So, one thing is that first of all we will be doing the general photography to show where what is present in what size general photography.

And then second is efforts are made to then efforts are basically made to relate to the relate different parts with the failed component. So, this is this is the second aspect. So, with the help of the photographs efforts are made to relate the different fragments and the field components with the main components. So, so how the fractured parts are related to the main component that? For that is what is efforts are made to relate, and then if there is a fracture surface. So, fracture surface need more careful treatment with regard to the photography.

For that, we may use the different photographing fracture surface needs the photography using light from the different directions. So, so there are 3 approaches which are used like say if this is the failed component. So, we can through the light perpendicular roughly perpendicular to the surface or normal to the surface. Second one we can through light at certain angle from the left side or right side or from the left side. So, the direction of the light when the light is directed from the different directions it helps to reveal the features present on the fracture surfaces.

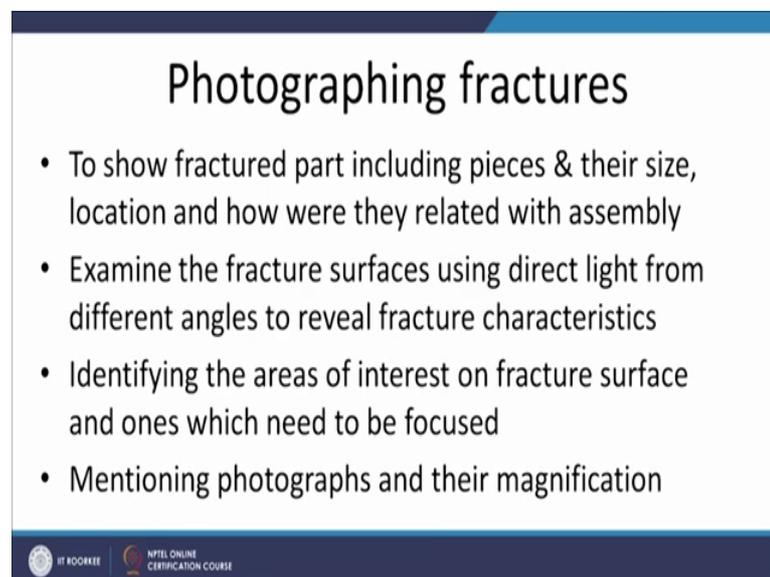
So, if the light is directed on the surface, in a correct way, then it will be able to reveal or expose the features that are of the interest and that can help in relating with the possible source where from failure has been initiated and the direction, in which it has grown or the possibility for the presence of discontinuity, if it is there on the failed components. So, we may direct the light from the different directions primarily to reveal the unique surface features so that the fracture initiation side direction of the crack growth and the presence of discontinuities if any can be identified. So, for this purpose I have one photograph that is this one like.

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What it shows that use of the photographing of the fractures, surfaces to show the fracture part including pieces and their sizes locations, where how and how the different parts were related with the assembly?

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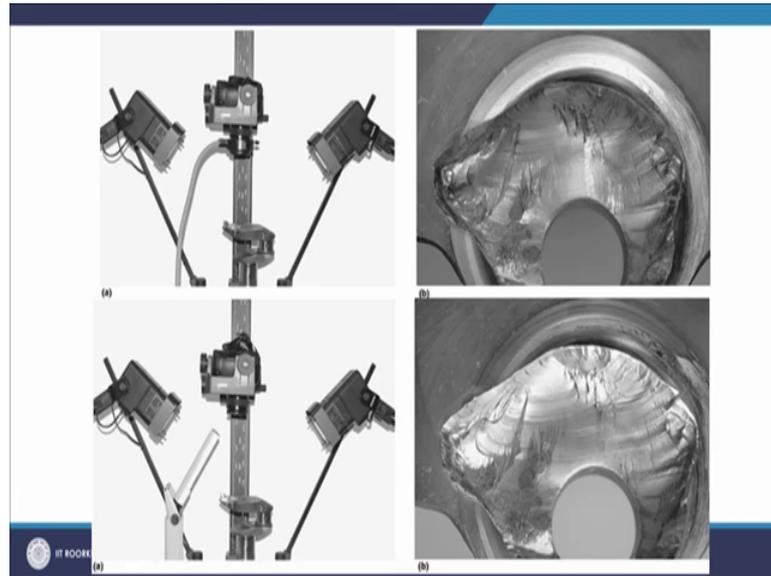
Examine the fracture surface using the direct light it is normal one from the different to direct the light from the different angles to reveal the fracture characteristics and identifying the areas of interest on the fracture surface, and the one which needs to be focused. So, once the fracture surface features are revealed by directing the light from

the different directions, it will help us to identify the areas or the zones of the fracture surface that should be investigated and focused to identify the possible causes of the failure. So, and thereafter once the complete photographing is over we need to mention that which photograph corresponds to which location, and how it is related with the faint main field component at the same time it is magnification is also mentioned.

So, like say here what we can see this is the kind of the system which is used for for photographing the samples using lighting systems at a different angle. So, what we can see here, like this is the same component, how does it look like when the light is directed from the different directions. So, here what we can see this picture a means this picture shows the shows the, this picture shows the sample photograph, when the light is directed from this particular angle. What it shows that some of the fracture surface features are revealed in this particular way but when this when the same component is subjected to the light from the different directions, what we can see if the light is directed from this direction.

We can see that this zone is completely different from the other zones. And here this particular area also shows the different kind of surface features as compared to the other areas. So, this may be unique with regard to the initiation or crack nucleation or the fracture initiation point of view. I meant say, when the light is directed on the fracture surface from the different directions; it helps to reveal us the features in different ways. So, which kind of the feature is suggestive more about the cause of the failure cause of the fracture and that is taken up and that area of the interest is also identified so, that that can be investigated further for the failure analysis? This is the, another kind of the sample when the light is directed in different ways, in the 2 cases.

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So, in one case we can see the certain kind of the features are revealed while in another case the different kind of the features are revealed. So, basically the intensity and the pattern of the different features which can be revealed by the lighting through the different directions that will vary and we need to really study and do the photographing systematically.

So, that the light is directed properly and it is able to reveal the desired surface features. Now here I will conclude this presentation. In this presentation basically, I have talked about what are the important things we need to look for at the time of a preliminary examination of the failed components. And there are 2 techniques, one is the visual examination and another is a photographing, which will help us in the preliminary examination of the failed component so that some evidences clues and regions for the failure can be identified.

Thank you for your attention.