Experimental Stress Analysis - An Overview

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Lecture - 4.2
Introduction to Coherent Gradient Sensor

We have been discussing about, various experimental techniques. What is the physical principle behind the experimental technique? What are it is main features? And also in which class of problems these techniques could be ideally used? And we have discussed the method of caustics in the last class. And you know when you look at each of the techniques; there are pioneers who have made significant contribution into the development of these techniques.

Professor Calthorpe from Germany, was a person who as worked on caustics, and made it to its perfection. And they have been contribution from Theocharis and also from Rosaceous and his groups at Calicut. So, many scientists have contributed to development of each of the techniques, if you look at any technique if we look at strain gauges, if we look at holography, these all are not developed by a single individual. Someone identifies physics behind it. And the idea is initiated then people carry on and many scientists contribute to it.

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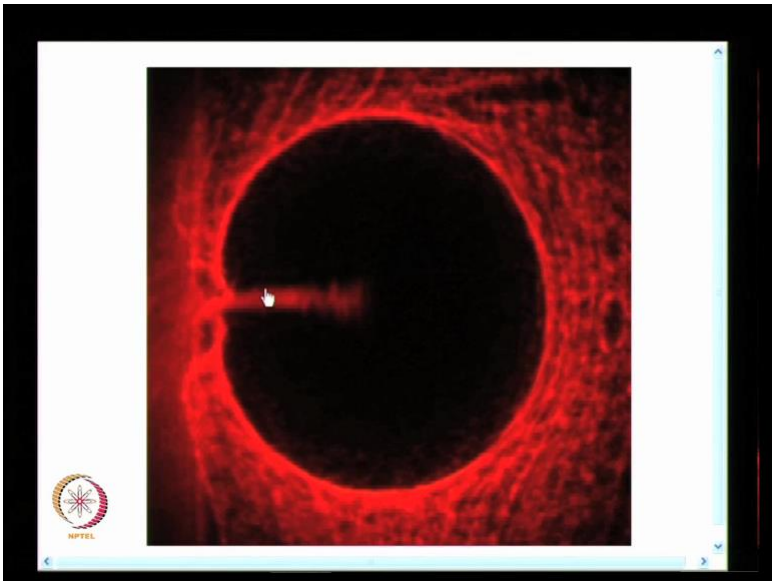

What we saw in the last class was, we had seen at the tip of a crack, you have a nice caustic shadow obtained. We explain how this shadow is formed, and we also looked at that the silver line what you have is the caustics. And in actual experimentation, you just measure this diameter. You measure this diameter, and then you have equation which will help you to find out what is the parameter associated with this problem.

In this case you will be able to find out the stress intensity factor, by measuring the diameter. And I said caustic is not a general purpose experimental tool. It is only a high stress variant problems you get information from this. And what you find here? You do not have any information in the shadow region. So, this prompted researcher to find out how to fill in information even in this zone. If you really look at the method of coherent gradient sensor, that is what we are going to discuss next. That has originated from this aspect in mind and what you have here is, It is a double grating lateral shearing interferometer providing whole field fringes in real time.

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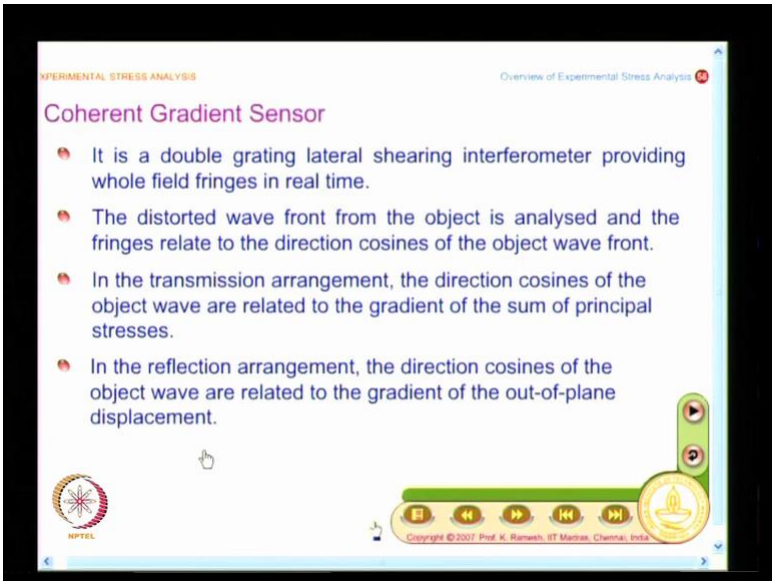

So, we have emphasize some of these concepts, we have said whenever you look at on optical technique you have to find out whether you get information in real time. If you get information in real time, it makes your life lot simpler. And we have seen any technique which involves double exposure you need to do post processing and only then you see the fringes in real time. Whereas, techniques like Photoelasticity, Moiré you do see fringes in real time.

On similar lines, you also find coherent gradient sensor, gives you fringes in real time. And here the optics is little involved and also the principle is also the mathematics is quite involved. So, what we will do is we will have a bird's eye view of what this technique is, and what you find here is, you have a light, if it is opaque model it gets reflected from the surface. If it is a transparent model it get transmitted, and you are really looking at the distorted wave front. And you look at the distorted wave front and you find out the direction cosines of the object wave front. This is what we essentially in the optics, and this as different meanings when I do a transmission arrangement, or when I do a reflection arrangement.

So, what you find here is, in a transmission arrangement. I relate these to the gradient of the sum of principal stresses. So, this is what I had said, for each of the techniques what

you find here is there is, physics is exploited and that physics dictates; what is the information you get from interpreting the fringe patterns. And here what happens? You are able to get those direction cosines related to the gradient of the sum of principal stresses.

This is what happens in the transmission arrangement, and when I go to reflection arrangement. What I get this I relate this to the gradient of the out of plane displacement. So, we have seen very similar parallel information, when we are looking at a holography. What we said was, I can find out essentially out of plane displacement. In fact, when I want to combine Photoelasticity and Holography, I exploit the feature of holography to measure the change in thickness because of Poisson ratio. That is related to sums of principal stresses that we had a looked at it.

So, they go together when I have out of plane displacement and also it is relation to in plane problems, it could be related to sigma 1 plus sigma 2. So, what we find here is I can apply coherent gradient sensor in transmission arrangement as well as reflection arrangement. In transmission arrangement I get the gradient of the sum of principal stresses and in reflection arrangement I get the gradient of the out of plane displacement. I get only a gradient. I do not get actual values, I get only the slope.

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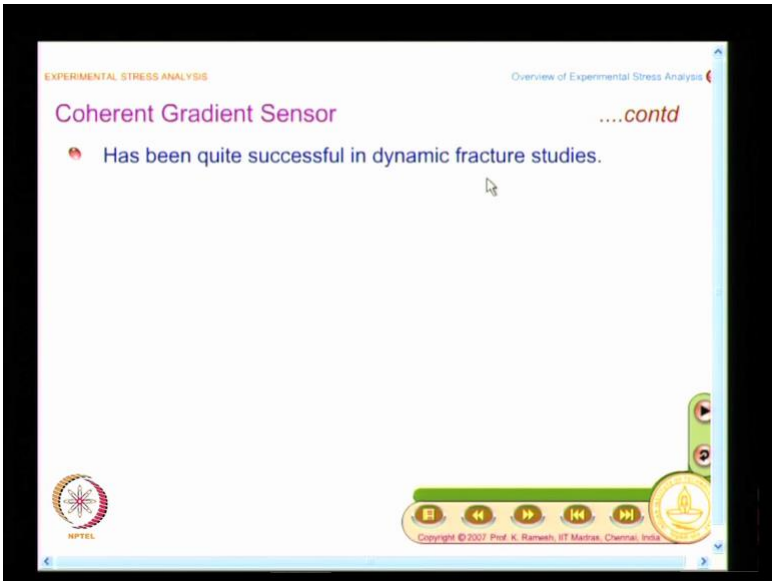

What you find here is this has found wide application in dynamic studies. So, if you look at a dynamic fracture, Professor Rosa KS and his group and Harish Tippur, they have developed this technique. They have found it useful for, dynamic fracture studies. So, what you find is in the caustic shadow, you loose information caustics are not a general purpose experimental tool.

On the other hand coherent gradient sensor because it gives the information on the entire region, this has been used for finding out curvature. That is what we had seen in few classes earlier we had also looked at the shearing interferometer can be used for finding out slope and curvature. And in a sense, it complements the data that is given by caustics. If there are also experimentalist who have combined method of caustics and method of coherent gradient sensor, to be recorded in one optical arrangement; see I have been saying, if we have a problem on hand you may not be able to solve all the quantities that you want by using one experimental technique.

You may have to use multiple experimental techniques in a generic sense. I have shown that people have combined strain gauges and brittle coatings. So, that they could do and solve industrial problems very quickly. And we have also seen if I want to find out a separation of stresses interferometer technique and Photoelasticity could be combined. On the other hand, people also thought of recording this information simultaneously; such equipments also have come.

One is use and performs experiment separately, then processes the information. And once you decide that these are the two information I want, people also device new equipments. Where in they could, either simultaneously record or record one after another with the same optical arrangement with modification of what you want to insert. Such a development has also been seen in combining method of caustics and coherent gradient sensor.

So, such information available in the literature in this class we have started with a brief look at what caustics were. Then I said in the caustic shadow you do not get information. So, you have coherent gradient sensor, which provides information in that shadow.