Experimental Stress Analysis – An Overview

Prof. K. Ramesh
Department of Applied Mechanics
Indian institute of Technology, Madras

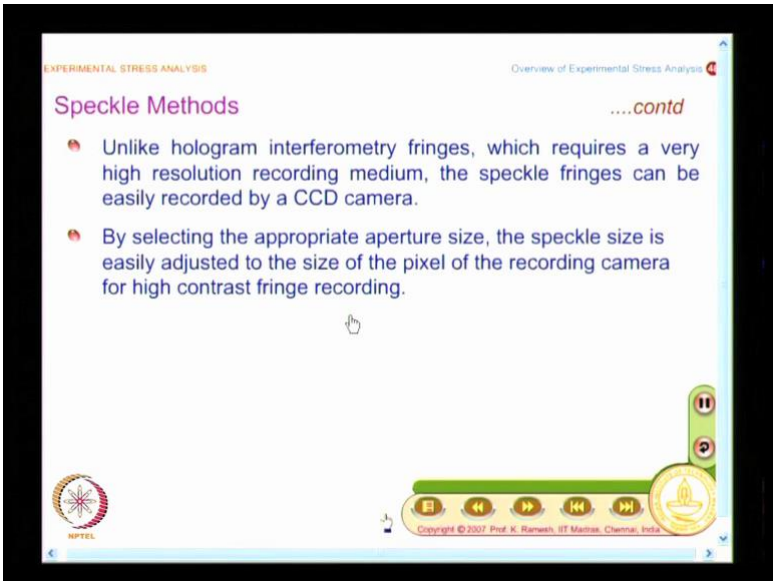
Lecture – 3.8
Introduction to Speckle Interferometry Techniques

In the last class, we had seen how Speckles are formed; we had also looked at what are objective Speckles and what are subjective Speckles. And I said in subjective speckle, you use a lens.

In the case of objective Speckles you do not use a lens, and you normally perceive only subjective speckles, because human eyes have a lens. So, when an object is eliminated by laser, what you perceive is through a lens, so it is always a subjective. You need to take special efforts to record objective speckle. Now what we will do is we will go and see, what is the Speckle methods that we can think of, what are it is key features different from hologram interferometry.

So, for the first thing is unlike hologram interferometry, which requires a very high resolution recording medium, the Speckle fringes can be easily recorded by a CCD camera. It is lot simpler, but here also you need a good camera for you to do it. What is done is by selecting the appropriate aperture size. The Speckle size is easily adjusted, to the size of the pixel of the recording camera, for high contrast fringe recording. So, you have a provision by which you can adjust the optical system until you get good fringes in you are recording media.

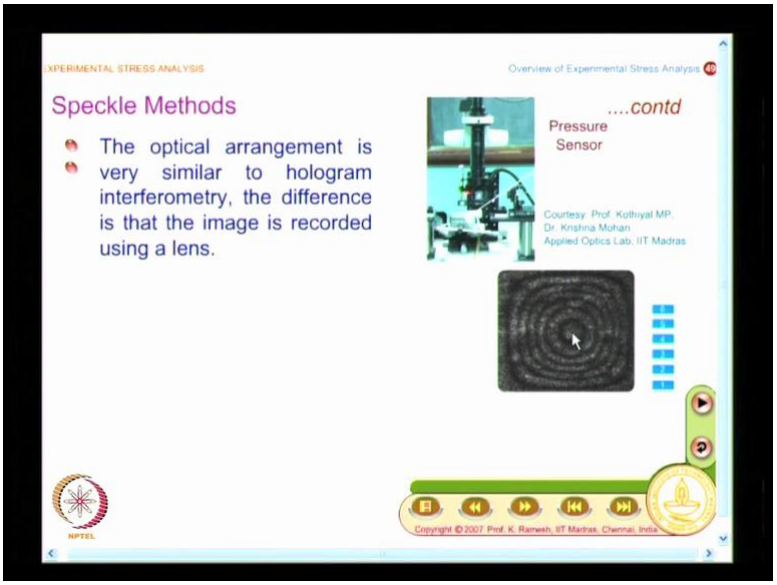
(Refer Slide Time: 01:13)



You have a permission to do that. If you look at Speckle interferometry, it is again same as a hologram interferometry. It is very similar to what is there in hologram interferometry, and we had seen that hologram recording is a lens less photography, once you come to Speckles, we record only subjective Speckles and subjective Speckles are recorded by a lens. So, the difference here is the image is recorded using a lens.

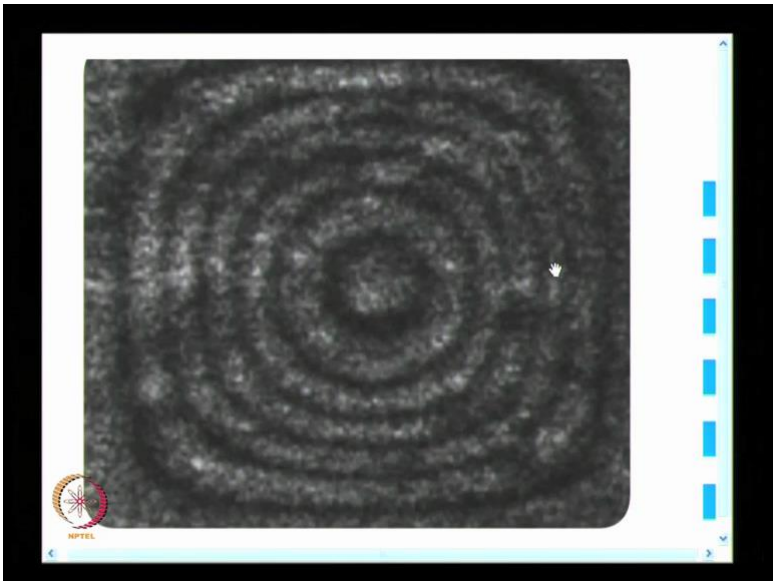
And, you know the example what I have taken here is from a mems application. because we had seen whether it is holography or Speckle interferometry, they are ideally suited for small scale object measurements. What you have here is a pressure sensor.

(Refer Slide Time: 02:08)



I can change the load here and you can see the fringes, and first impression you get is they have very low contrast. They are not as smooth as what you get in photoelasticity. They have specular, you will see dots every where and you have collection of dots. So, you have quite a difficult for you to extract information. So, in all these specular interferometric methods, people spend lot of effort on filtering. Filtering is a very important step in speckle interferometry.

(Refer Slide Time: 03:00)

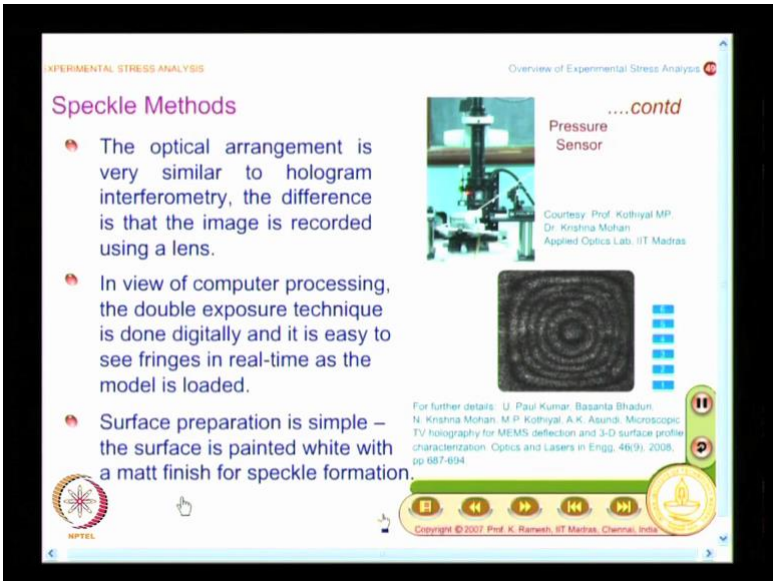


And what you have here is, in all these modern techniques they employee computers. Because of computer processing the double exposure technique is done digitally. So, initially is stored the initial configuration in a file, and use it for viewing the deformed configuration. It is easy to see fringes in real time as the model is loaded.

So, what you find here is, you are able to see fringes in real time. That is because of your computer processing of data, and you have fast computers to process image information quickly and it gives you a semblance of real time appearance of fringes. You know, when you want to paste a strain gauge you have to have elaborate preparation, same is the case when I go for photoelastic coating application.

Compare to these methods, surface preparation is simple. The surface is painted white, with a mat finish for Speckle formation. You want a specularly reflecting surface. So, you want to have only a simple surface preparation, but even the simple preparation is not simple in the real sense, you need to have some practice on applying your white paint uniformly.

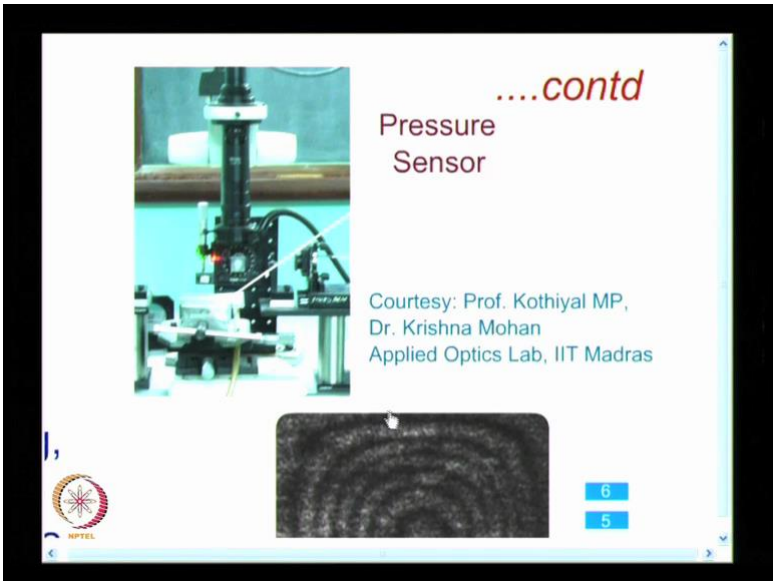
(Refer Slide Time: 04:55)



It should not have smudges on the surface when you come to experiments you need to develop skill. The methodology is discussed in comparison to other techniques, this method is simple. But even a simple technique requires some kind of a skill development, and skill development comes only through practice. You cannot do it on one day. One day you wake up and then you want to go and do specular interferometry, it is not possible. You need to have some training, and perfect the steps involved in this, then you go and make measurement, your measurements will be reliable. So, simple or difficult is a relative term, right?

You have to get a uniform thin coating on the surface. We can also have a look at the close of view of this, and this is actually a micro scope which is used and you have pressure sensor which is very, very small. You see the fringe pattern of this. And this was done in Professor Kothiyal's Lab - Applied Optics Lab, IIT Madras.

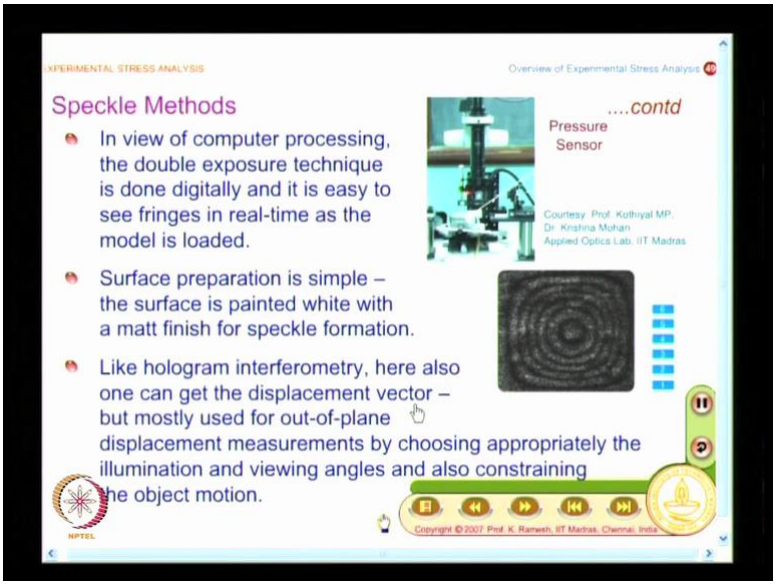
(Refer Slide Time: 06:35)



If you want to have further details you can go to this reference, and you know there is always a discussion in academic circles, whether to label a method as Speckle interferometry or holography. This debate is on they have called it has a T V Holography here, three d surface profile characterization and so on.

So, this debate is always on, and in Speckle interferometry also, you can get the displacement vector. And I had mentioned earlier when you get a displacement vector, interpretation becomes little more complex. You need to have methods and if you go to this literature they will talk of something like sensitivity vector, and how to extract data these are all mathematical details.

(Refer Slide Time: 07:16)



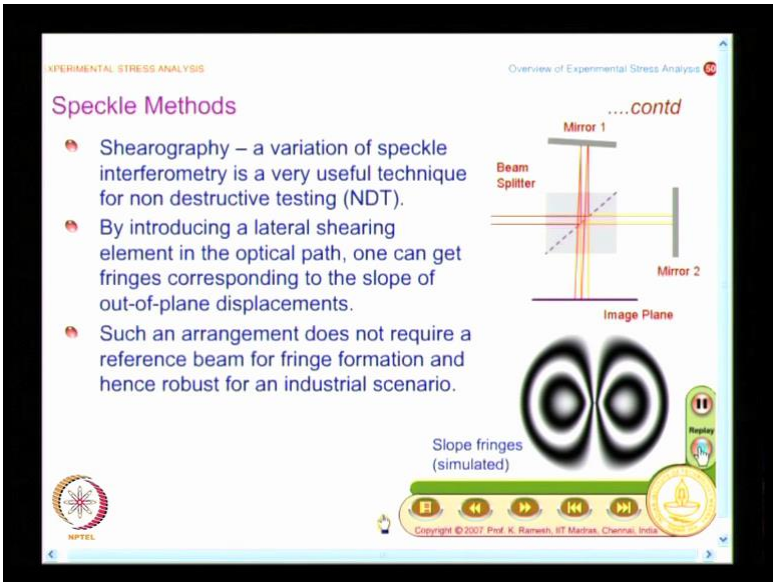
We are not getting in to those mathematical details at this stage. Our focus is mainly to appreciate the principles involved in various techniques, and also look at broadly for which class of problems these techniques are applicable. Also limitations broadly speaking what way this techniques look. How these can be compared? Some kind of information which will aid you to arrive at appropriate technique for the given application. So, what you find here is mostly you will get out of plane displacement measurements, but you can get the displacement vector by choosing appropriately the illumination viewing angels and also constraining the object motion. This is common to both hologram interferometry and Speckle interferometry.

If you want to get u and v displacement, and you have to choose the elimination viewing angels and also constraining the object motion. All these have to be used for finding out specific components of displacements. On the other hand, Moiré by choosing the grating your interpretation become simple. Here it is involved, because you collect more information and. So, you have to be systematic in filtering out, what is that you need.

And another popular version of a speckle interferometry is a Shearography, and this is a very useful technique for non destructive testing. In fact, for honey comb panels, this is the very popular technique, with composites becoming very important structural

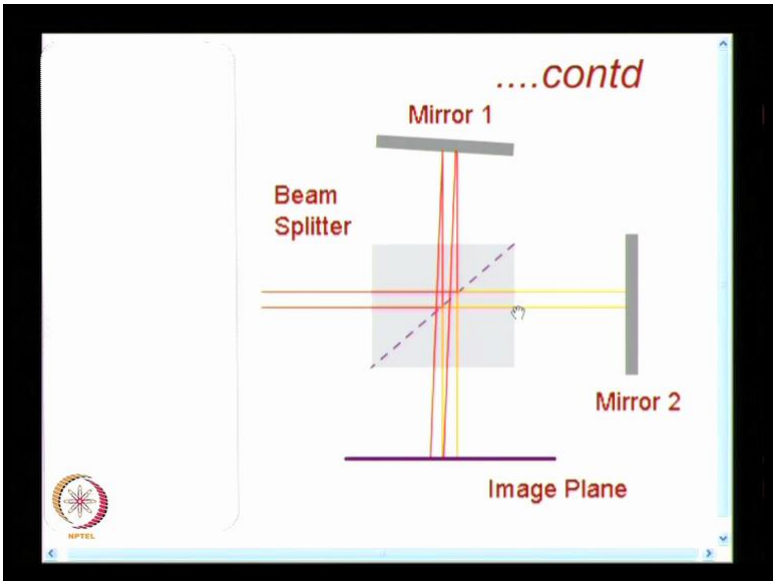
materials, there again you have problem of delimitation techniques like this, go a long way in identifying, and this shows a shearing element we will have a closer look of it.

(Refer Slide Time: 09:11)



So, what I have is I have beam splitter, one ray goes straight and hits this mirror and comes back. The other ray goes there and get sheared and on the image plane you have for one incident ray, two rays are seen. Same thing you can watch it for the second ray. So, I get one ray from the mirror two and I get another ray from mirror one. You make a sketch of it I will repeat the animation again for you to understand how you perceive this. And because of the shearing action you essentially measure the slope. You measure the slope, essentially.

(Refer Slide Time: 09:55)



So, you have the ray goes and hits this mirror, this is kept perpendicular and the mirror one is slightly tilted. So, beam splitter sends one ray to this mirror, and sends other component to this, and whatever comes from this because of the tilt, it gets shifted and this is called; it is also said it is shear to this point. So, for each incident ray you will have two rays impinging on the image plane.

And will just have a look at the animation again, and this is what you see here, I have the ray goes straight and hits this mirror. Another component goes to mirror one and this gets sheared. And in shearography the vibration isolation requirements are less stringent. That is why it is become a very popular technique in industry and many manufacturers are giving out shearography equipment. it is used routinely for non destructive testing of several composite panels, honeycomb panels and so on.

And when you do this what you get? You get essentially slope fringes, and we have also noted that these are butterfly fringes, because of the shape, because on the sharp floor they would like to classify this as butterfly fringes, for easy identification. In fact, it is dou w by dou x contours.

So, what we find here is, by introducing a lateral shearing element in the optical path, one can get fringes corresponding to the slope of out of plane displacements. That is

what you get here, and this there is nothing like one is a reference for the other and the other is the reference for this, and nothing like a single reference beam for fringe formation and hence, robust for an industrial scenario.

So, what is find here is, shearography is a robust technique compared to Speckle interferometry or a hologram interferometry. If you put a shearing element it makes your life lot simpler. And you get only slope information; you get only slope information, you do not get out of plane displacement, so that is the difference. It makes your experiment simpler, at the same time it gives you a different type of information.

So, in this class we continued our discussion on Speckle interferometry, we saw what is Shearography.