Experimental Stress Analysis – An Overview
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Lecture – 3.6
Introduction to Double Exposure
Hologram Interferometry

In the last lecture, we have looked at Hologram Interferometry.

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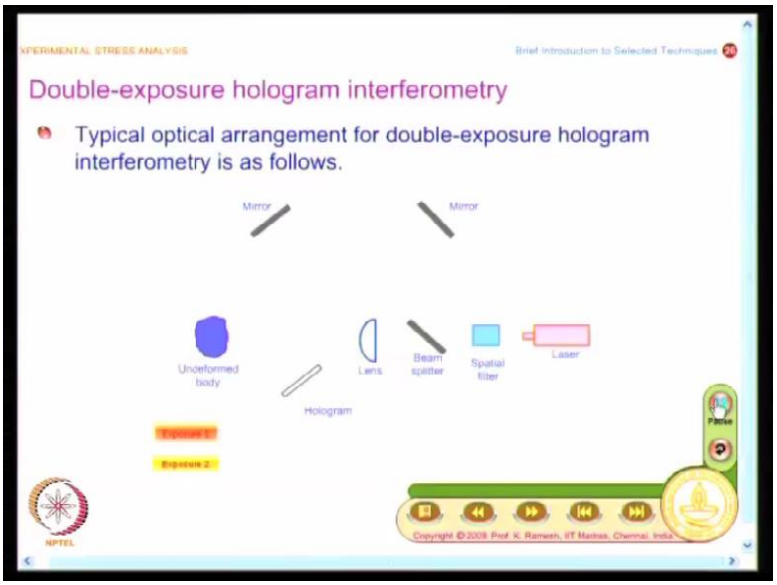

By using a suitable optical arrangement we can get the some of principles stresses that is; sigma 1 plus sigma 2, which are known as Isopachics. If we use this technique in conjunction with photoelasticity, then we can get the individual principle stresses.

Now, we will look at what are the steps in it, Double Exposure Hologram Interferometry. Because, I said vibration isolation is very very important and when you say vibration isolation is very important you will have to know; what are all the components in a general holographic recording and we will have a look at it, we will also have enlarged portion of it.

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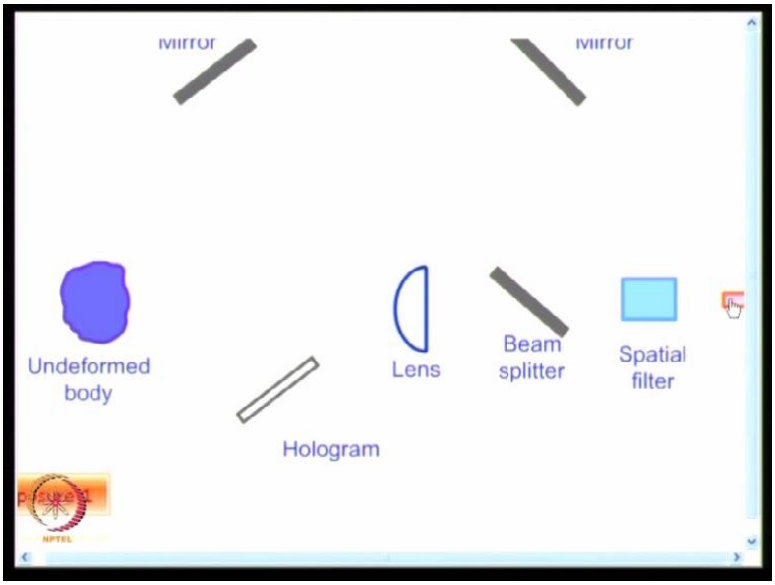

So, what I have here is, I have a light source, I have a next component as spatial filter; this spatial filter has a pin hole and also a lens. Then I have a beam splitter, then I have a another lens, I have two mirrors and I have a object to be recorded for the hologram and I have a holographic plate, you need to sketch this and we will see the optical diagram, what we will do is, I will have to do two exposures; I will make exposure one, I will also show exposure two. So, you need to have a decent sketch of it, it will take you few minutes for you to do it, take your time because this is important and I am going to show this in a slow motion, in the sense you know light travels at a very high speed.

So, I am going to draw the diagram and then I am going to show as if light moves, but it is at a very very slow movement and what I will do is, I will make an exposure part; just look at what happens. Light comes, hits the beam splitter and goes the mirror arrangement and comes to the hologram and this is a reference beam and from the beam splitter another set of rays go and eliminate the body and this also comes to the hologram and both happens simultaneously. For the purpose of understanding, I have shown how the reference beam falls on the hologram and how the light reflect from the object, falls on the holographic plate, after you develop the holographic plate it becomes a hologram, you can see the hologram.

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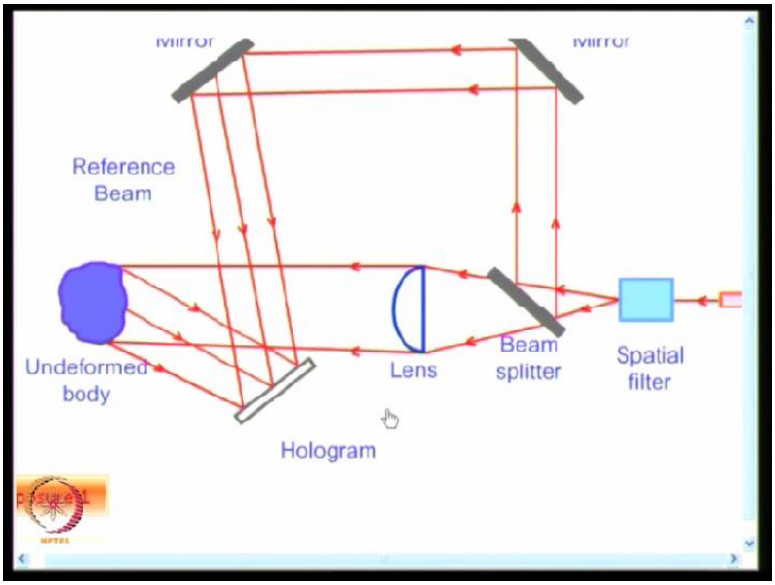

So, what you have here is, you have a laser light source, you have a spatial filter, you have a beam splitter. So, beam splitter sends one set of beam to the holographic plate directly, you call that as a reference beam and the necessity of a reference beam brings in the restriction of vibration isolation. If I do not require a reference beam, then I do not have to worry about vibration isolation because of the reference beam, I need to conduct experiment as carefully as possible, see one of the requirement is, even a normal running AC can alter the vibration characteristics, so people keep the also AC, away from the holographic table they do not keep it near it, so you have to take care of that.

I will repeat the exposure one; you can just have a look at it how the whole exposure takes place. So, you have a reference beam and you also have a beam reflected from the undeformed body. So, these two ways interfere and then I get this pattern, so if I see this pattern; What I will see? I will see this three-dimensional object. If I record this as a hologram, developed it and then reconstruct it, I will see the three-dimensional object and here I am not interested in knowing the metrology of the three-dimensional object, I am not interested in the depth measurement or shape measurement of that object. I am interested because of loads applied, what is the deformation introduced in the model; that is what my interest, so that is why you need a double exposure.

So, what I do is, in the first exposure you capture this, now what I do is let me see whether I can do the second exposure. I have a button below I will carefully press it. So when I do a second exposure; you would have noticed, I have not changed the reference beam, the body is deformed and the deformation how I obtained, I have not shown it in the figure. I have only shown that this is a deformed body, so you have the light reflector on the deformed body is also recorded in the same holographic plate.

Now, when I develop this plate, I will be able to get the fringe which is representative of complete deformation of the three-dimensional objects that is the advantage of holography, because you record so much information, interpretation becomes involved. Once you find it is involved, there are enough number of research students and research scientists across the world who try to crack this problem, so that work is going on, their large extend we have achieved. In certain issues you have to have certain complicated calculation that is fine, and let us now repeat the exposure two, and then we will see the entire animation again.

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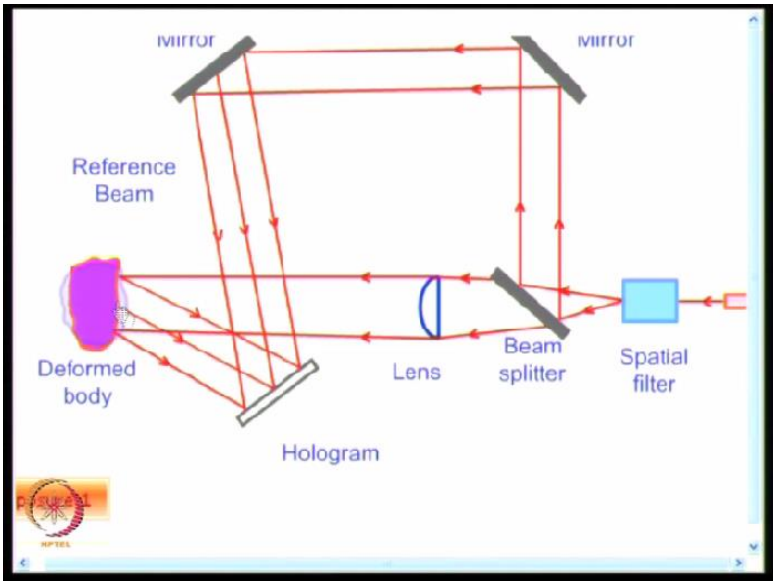

So, in the exposure two, I have a reference beam that is not altered, I deformed the body and I record another set of light rays on the holographic plate and if we go in the sequence, we will see the exposure one. So, only during exposure I have a reference

beam which falls on the holographic plate that is not disturbed when I go for the exposure two. So, in between the exposure, I have to deform the body. There are certain aspects that you will have to note down, how do you deform and what is it that you need to practice; all that we will see. Right now you look at the optical diagram and find out, how the whole aspect is done.

So, this illustrates that you have a reference beam and you have undeformed body and then you have this second exposure; second exposure is done where I have this light rays come from the deformed body.

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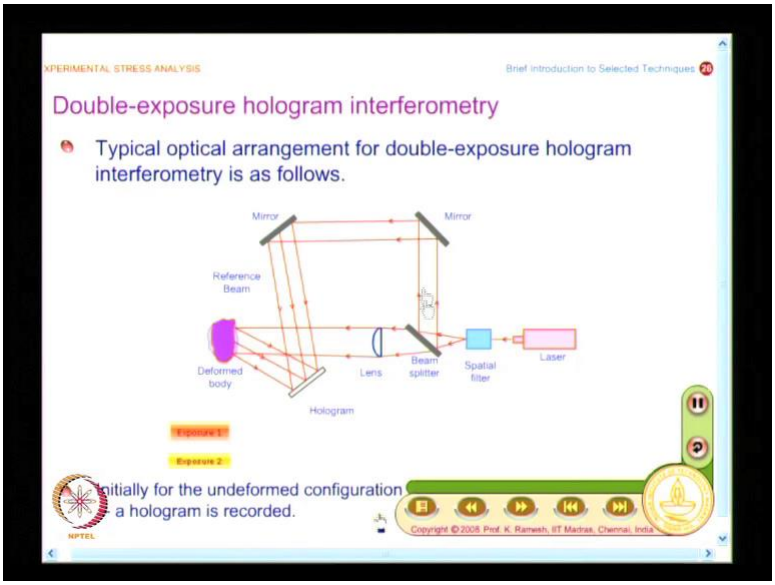

Now, we will look at what are all the restrictions that you will have to look at when you are loading the model. See the specimen is loaded and the second exposure is made, that you have well understood and this is to be done what, this is to be done in darkness; total darkness and you have to ensure nothing of the optical arrangement can be disturbed between the exposures. So, it is not that you simply move your hand and then I mean disturb the alignment of any of the optical elements; this has to be done very carefully.

So, that is what I always been saying, experiments are planned and executed it is not that you go quickly make some measurement and come and interpret the way you do it.

Experiments have to be carefully planned also you anticipate what is a type of result approximately, there may be error in judgment, but still you would not know the range, that is how you want to do the experiment. So, you cannot disturb optical arrangement and what are the other final points, the object has to be mounted suitably so that it can be loaded without disturbing the optical setup and loading has to be done in dark, even this you can practice.

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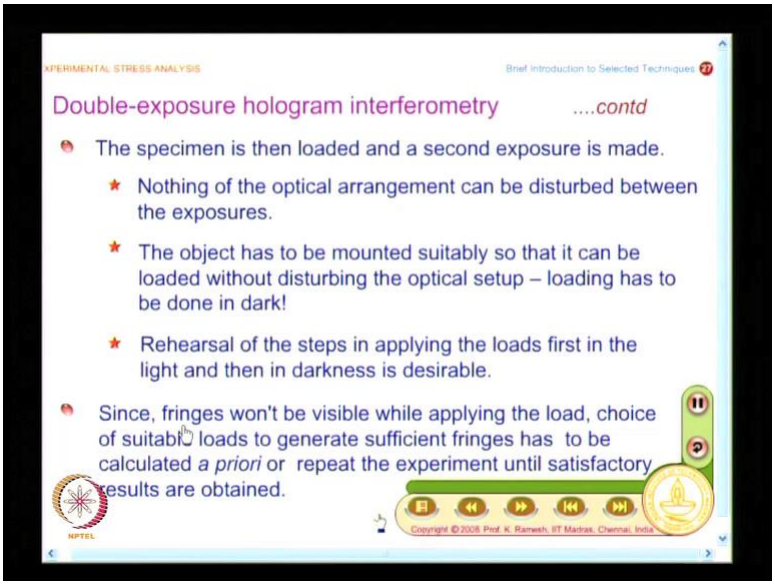

The other difficult point here is, since you do not know a priori how the fringes are formed. You will have to have appropriate calculation to find out, what is the extent of load that you should apply and what is advised is, you have to do rehearsal of the steps in applying the loads first in the light and then in darkness is desirable, so you have to do some practice.

So, when you want to record a hologram, you have to do this practice and from loading point of view; since fringes would not be visible while applying the load, choice of suitable loads to generate sufficient fringes has to be calculated a priori or repeat the experiment until satisfactory results are obtained. So, you understand experiments are not that easy it is back breaking, that is why people want to minimize the number of experiments that they want to do. The numerical simulation have to be looked at more in

the light of reduce in the number of experiments because experiment is truth, ultimately any design that you want to release for the public; where any design deficiency can have serious consequences. You have to testify the results verified by experimental measurement, but experiments have to be done systematically, it takes time until you get satisfactory results you may have to get it.

This is where people found that why do you have to go and do this kind of double exposure with advancements in computer technology, people are able to solve and address this issues reasonably well and even now; though there are restrictions digital holography is also catching up and what are the other things that you will have to look at.

Because I said, you are recording more information; reliable quantitative interpretation of holographic fringes is still difficult. There is no general method, but for specific applications interpretation is possible, see one of the emphasis on many of this optical methods is people would like to minimize human intervention, what they want is they want to press the button and then finally, say that this is the displacement, deformation so on and so forth. In fact, I do not subscribe to that kind of a view, you need to use computers more for doing the routine job, but intelligence; human intelligence has to be used. Replacing human intelligence totally by any of the automated methods can result in observed answers many times and also the effort involved is quite high.

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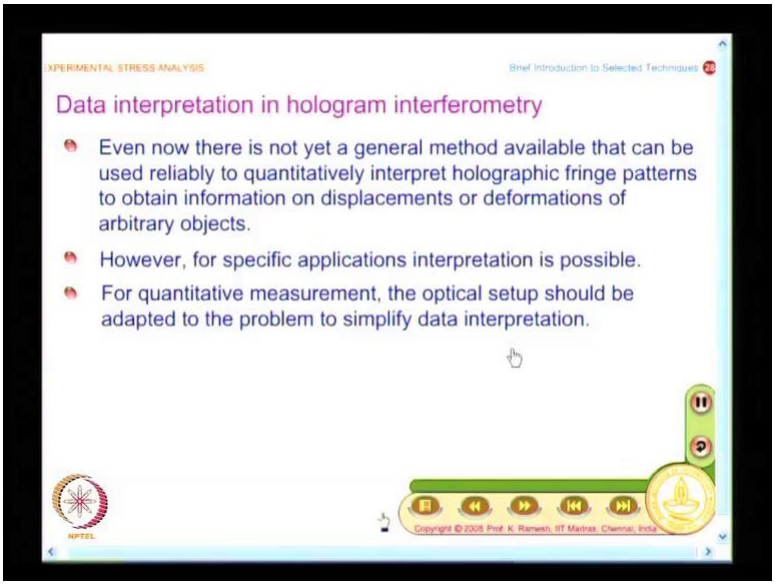

So, what we find here is; data interpretation is an issue and what we will have to do is, when I want to do for specific applications, I said already the specific application is determining isopachics. The optical setup should be adapted to the problem to simplify data interpretation.

So, finally, what you come down to; planar surfaces are easier at to handle, so though you start with three-dimensional surfaces, three-dimensional displacement, I can record the information, but interpretation becomes difficult, but I will also say when I have three-dimensional information is very rich and we will also see a separate lecture on how to extract as much information as possible by looking at fringe patterns alone. We will have a lecture on that, but once you come to any one of these experimental methods, the optical setup should be adapted to the problem to simplify data interpretation. A generic approach is still a loosely when difficult, specific applications are possible and you adapt the optical arrangement to simplify data interpretation.

In this lecture, we have looked at the basic experimental arrangement in double exposure hologram interferometry, we have also looked at several restrictions while performing the experiment. Finally, we have discussed briefly the Data Interpretation in double exposure hologram interferometry.

Thank you.