Optical Methods for Solid and Fluid Mechanics
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Lecture - 28
How is a DIC Experiment Set Up

(Video starts: 00:02)

Hello and welcome everyone to this tutorial session for a solids part of this course. So, in last few lectures we have seen theories for digital Image correlation. We have seen how to correlate two images what correlation coefficient is what all assumption goes in while correlating two images why do we need speckle patterns. So, all this Theory needs to have a good image set before analyzing. So, that is what today's session will be all about.

So, I will show you how to take good images and what all considerations we have to take care while taking images. So, for experimental aspects I will focus on first setting up the camera and all problems that we face while setting up the camera. Then second I will show you how to impose a good speaker patterns. And how to decide the scale of speaker patterns when we need a proper resolution of the results.

And third I will show you how we have to take care of lighting when we take images at high speed. So, for demonstration purpose I am going to show you two configurations first will be experimental setup for DIC using a high speed camera. So, we need such a configuration when we have to take images of deformation at very large strain rate so, which is very commonly encountered in practice.

And the second configuration will be a very simple configuration which you can try at your home using a phone camera.

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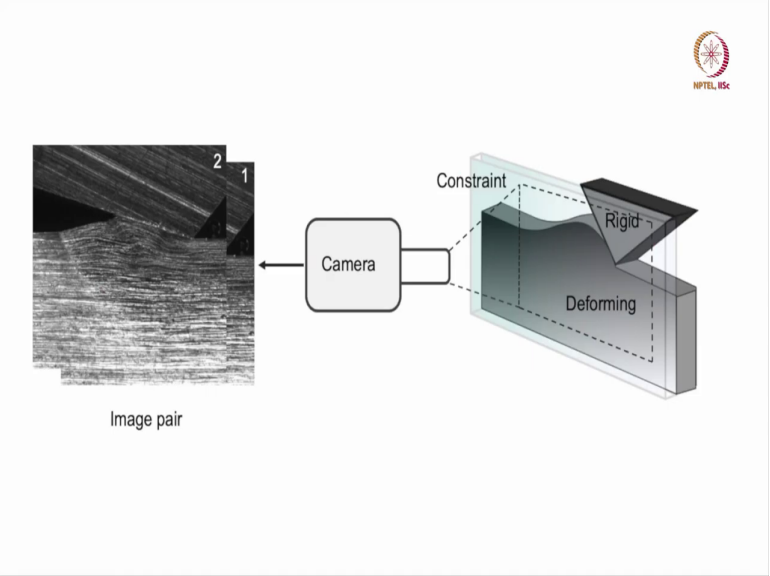

So, let us look at the basic components which goes into a DIC experiment we have a work piece which is deforming and to ensure that there is no out of plane deformation we have this glass plate pressed against the work piece. Perpendicular to this workpiece we have our camera which is focusing on the region of Interest and will get a image pair while Imaging this region of Interest. So, let us look at how we set up this experiment in lab.

So, first step is to prepare the specimen. So, this is the specimen that we are going to deform today. So, this is the phase which will be imaging through the camera. So, you can see that face doesn't have any pattern as of now. So, we are going to take this specimen and use memory paper to operate this specimen. So, this memory paper is going to create random patterns on the surface of the specimen.

And will we have to decide the grid of the memory paper based on what scale of resolution we require in our results. So, using this memory paper will upgrade the service and will create a random pattern but the scale of the resolution will be based on what grid size we are using for this abrasion. So, right now I am using 180 grit Emery paper. But if let us say we have to go on much finer scales in our result we have to use more final grid Emery sizes.

So, another way of introducing the pattern is using a paint is press away I have this spray bottle and I am just going to spray paint on this specimen. So, again based on the speaker sizes that we have introduced we are going to get different scale of resolution in the final results. So, if we need very fine Speckles. So, we have to use air gun for spraying this paint but just for demonstrating purpose I am using a simple spray bottle.

So, let us look at the components of this experimental setup first thing is a specimen we have a aluminum specimen here. So, on this specimen I have created speaker patterns using memory paper as I shown you now this is specimen is moving against this stationary tool. So, as a result of this movement this specimen will deform. And will result in a chip formation and we call this process as a machining process now.

So, this will be the region of Interest. So, we are trying to observe now how this deformation happens. So, we have to make sure that while imaging our whole region of Interest is there in the images. So, let us look at what do we need to do to ensure that this region of interest is in the field of view. So, this length system is mounted such that this is exactly perpendicular to the region of Interest.

So, and this lens system is attached to a high speed camera since we are using a high speed camera we need to ensure that we have a good light source. So, this is a light source a fiber optic light source I have two light sources here one is this and one is this. So, I am using two light sources just to ensure that the whole region of interest is eliminated properly. And we have to make sure that light is diffused.

And not focusing directly on the region of interest because what happens if we focus light directly on the region of Interest some part of the region will be over illuminated while some parts will be under eliminated another thing to note here is that we have to choose our lens system such that the region of Interest will be there in the field of view because let us say I take this higher magnify magnification lens the field of view will be less.

So, we have to decide magnification of the lens based on the size of field of view. So, the next important part of the experiment is deciding the frame rate. So, our schematic is something like this. So, we have a tool and this will be a work piece. So, this is our workpiece this is the tool and the motion of the workpiece is in this direction. So, and this dotted region here is the region of Interest now the velocity of the workpiece is approximately 500 mm per minute based on what lens system we use.

So, right now the scale of my lens system will is such that one pixel of an image corresponds to two microns. So, that will be like 2 microns per pixel. So, let us just convert this into

microns per second so we have 500 into 10 power 3 by 60 microns per second now we have to decide the frame rate for Imaging that will be like f. So, this is f frames per second. So, we need to determine the frame rate that will be in frames per second.

So, right now we have the Velocity in terms of microns per second and we have the scale as microns per pixels but from the correlation from the analysis what we get is a pixels per frame quantity that is a displacement in between two frames. So, it is the combination of this we have to determine the displacement in between two frames. So, we can set based on how good our algorithm is and what is the displacement we require in between two frames we can set a limit of this displacement.

So, let us say our displacement limit is 6 pixels per frame that means we do not want displacement more than 6 pixels in between two frames. So, let us see we have 5 into 10 to the power 4 by 6 microns per second into one by two pixels per microns into we have 1 by F second per frame. Now if you see this whole quantity on multiplication is going to give us we will have pixels per frame.

So, that is 5 into 10 power 4 divided by 12 f is equals to our displacement limit that we have decided is 6 pixels per frame. So, this number on solving is going to give us approximately 700 FPS. So, that is how we have to decide FPS while imaging. So, here on the screen I'm showing you the output of the camera. So, this is the tool which is stationary and this is the work piece which is moving and which is mounted against the glass.

So, which ensures that the deformation is in plane strain now another thing to note here is that we have this random pattern on this specimen surface that we have created using emery. Now this scale of pattern can be reduced by using final grid size of the emery paper. Another important thing here is that we can observe that the whole surface as well as the chip is in proper illumination. We can see there are no bright spots anywhere on this deforming workpiece and chip.

So, here the velocity of the work piece is approximately 500 mm per minute. So, according to the calculation we have seen that we need minimum of 700 fps to ensure 6 pixels of displacement in between two frames. So, I have. So, I have chosen the frame rate which is bit larger than 700 FPS that is 750 FPS I hope first configuration was clear now the next

configuration that is a simple configuration that I am going to show you is using this stretchable rubber sheet.

So, we are going to image using a phone camera and will keep a transparent plate on this rubber sheet while stretching to maintain plane strain and this configuration is a simple and easy to track configuration that you can try at your home. So, let us do one very simple experiment. So, we have a stretchable sheet of rubber as I shown you and on the top of this sheet we have put one constraint that can be a glass plate or it can be anything which is transparent now we are stretching this stretchable sheet and we are we have to image this.

So, we will put a camera which can be a phone camera just perpendicular on the top of this plate. So, this will be a region of interest that will be Imaging as I shown you in the schematic this is the setup we have a stretchable rubber sheet that we are stretching using hand and on the top of this is stretchable sheet we have put a glass and we are Imaging from the top perpendicular to this setup and we have created this pickle using a marker.

So, in this lab tutorial we have shown you two configurations first was with a high speed camera and second watch using a phone camera I hope this configurations were clear and you were able to get an idea of how to set up an experiment to perform a DIC. Now we have covered so, many experimental aspects of DIC in this tutorial but few very important considerations. Before setting up experiments or for example first we have to make sure that we have proper scale of speckle patterns.

Deciding this scale is important to make sure that our results have proper resolution because this is going to decide the subset size that you use for correlation. Second thing we have to keep in mind is that our specimen should be properly eliminated. In case if you do not have proper illumination on the specimen you are going to get bad correlation between the frames and thus at the end you are going to get bad results.

Third thing that we have to make sure that our specimen should be deformed in a plane strain manner because otherwise the deformation will be out of plane and the play the 2D deformation images that you are taking is not the correct representation of what is happening in the process. Then we have to make sure that we recite proper frame rate because if you

have improper frame rate what will happen that your displacement between two frames will be either very small or very large.

In case if it is very small you have to analyze lot of frames or if it is very large you are not going to get good correlation above some particular limit then the next consideration that you have to keep in mind is that you have to choose proper lens system for Imaging because we have to make sure that our full region of interest is in the field of view. So, that was I think all about taking good images.

So, we have seen all these aspects in this lab session but we have not discussed how to analyze the images. So, in the next tutorial we are going to show you how you can analyze your image set using open source software. So, see you in the next session.

(Video Ends: 15:20)