X-Ray Crystallography
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Lecture - 40
Tutorial 11
Residual stress measurements by X-Rays

The final application; I would like to show you is a stress measurements. Stress measurement is another very important area in the in terms of engineering components and it has got more elements in industry and we will discuss the basic principle behind measuring the stress in a component by X-Ray diffraction.

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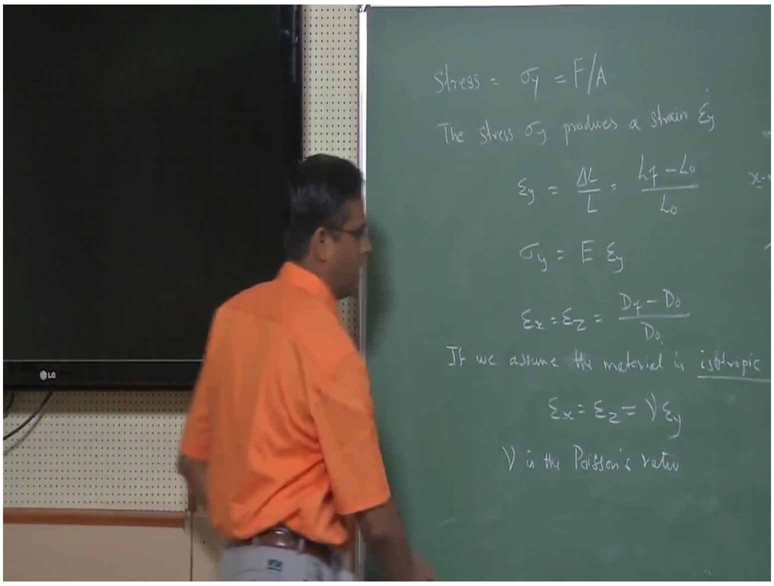

So, we will just draw some few schematic quickly and then we will take it from there. So, this is the coordinate axis towards the perpendicular to the black board this is zee and this is y and suppose you assume that this is a X-Ray which comes and we are trying to identify assume that; this is a cylindrical sample which is being pulled in the uni-axial direction and you have the dimensions of D and L and this is the X-Ray which comes and impinges on the surface of the sample and then it get diffracted.

So, how are we going to use this geometry for identifying the relation? So, we will write a basic expression for stress is equal to sigma y here because it is a y direction. So, we write like this force by area in the y direction and you assume that there is no force in the x and zee direction. So, for this, we can write some relation the stress sigma y produces say strain epsilon y and which is given by epsilon y delta L by L which is nothing, but L final minus L initial divided by L naught this is a original length this is after you stretch it and then you get the strain and this strain is related to the stress by this. This is very famous Hooke's law. So, the stress is related by strain by this relation and we can also relate this epsilon x and epsilon y or z zee is equal to D final minus D initial divided by D naught.

So, this is the strain in the x direction strain; in the z direction is measuring by this change D final minus D initial by D naught which is a diameter of the sample also can be represented by this if the if we assume that material is if we assumed that the material is isotropic; isotropic then we can write epsilon x is equal to epsilon zee is equal to mu times epsilon y this is also true where mu you see Poisson's ratio.

So, now how these relations are related to our X-Ray diffraction that is the idea I have to write one more schematic quickly?

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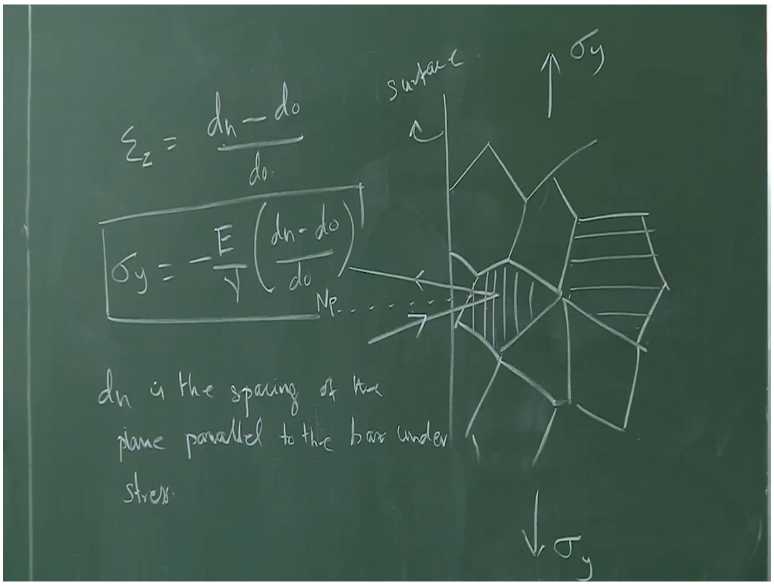

Now putting direction; the D spacing as a smaller compared to the a planes which are perpendicular to the loading axes you can see that the distance is different because of the stress. So, this is the bottom line this is the bottom line for using the X-Ray diffraction. So, we can quickly look at epsilon zee is equal to D and minus D naught divided by D naught. So, this is your initial D spacing this is normal the after the; a stress then what is the D spacing.

So, that is a difference. So, we can write sigma y is equal to minus E divided by mu where dm minus D naught by D naught. So, this is this is the relation which is forms the basis for this using X-Ray diffraction you find the D spacing and I will write the details d n is the spacing of the plane parallel under stress. So, d n is under stress and D naught is without stress. So, you see that difference and I think this is the basic idea behind the measurement of a stress you see X-Ray diffraction you will be able to identify the D spacing and you have to remember that you have to have the plane always perpendicular to the; this is a normal plane where [noise] P is the X-Ray diffraction takes place where the plane which are perpendicular to this incidence

So, you have you have to make sure that this kind of information are always obtained only from the plane which are parallel to this load or perpendicular to this load axis or I would say parallel to the X-Ray diffraction and so on. So, you have to keep that in mind and in fact, this is what; I am talking about here a simple case actual case is a bi-axial and tri-axial stretches are measured with the with an elaborate procedures involved and people calculate the residual stress which is a very important component in an a engineering application and we can readily quantify this stresses using X-Ray diffraction similar based on the fundamental principles like this.

Se we will not get into the details because each one will combined a special course in itself, but a as a beginner you should know what is a basis of X-Ray diffraction in in applying for all this parameters like you know crystal structure determination phase identification stress measurements and so on.

So, in the next class I will take you to the lab and then show actual how we measure this in a material in a polycrystalline material how do we obtain an X-Ray data and then how do we analyze with the interface software today and everything is automated. So, you just get the final result in your desktop, but you have to understand unless you get into these fundamentals here then only you will be able to appreciate what the software is doing in your interface. So, that is the intension of this particular I mean illustrations what we have shown today’s class the equipment which is going to show you is another very important X-Ray machine.

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Which measures the residual stresses in an; or a stress measurement system is which is industrially important; you can see that this is the equipment typical equipment.

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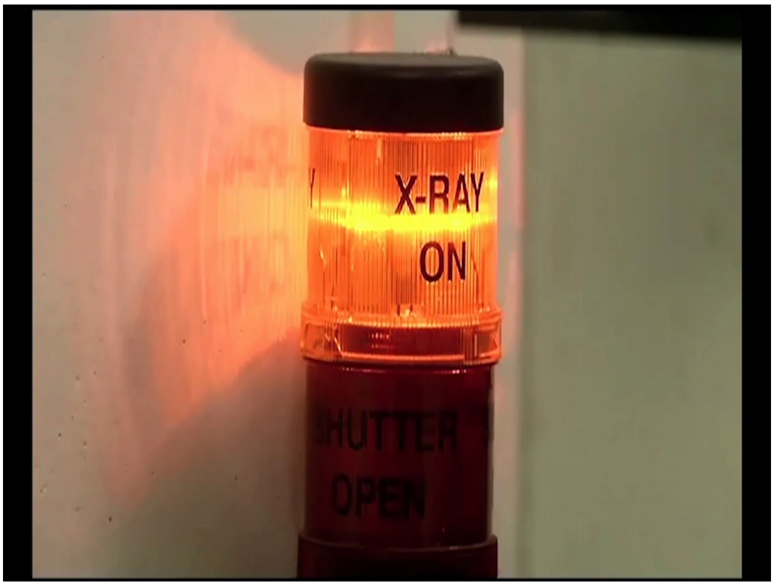

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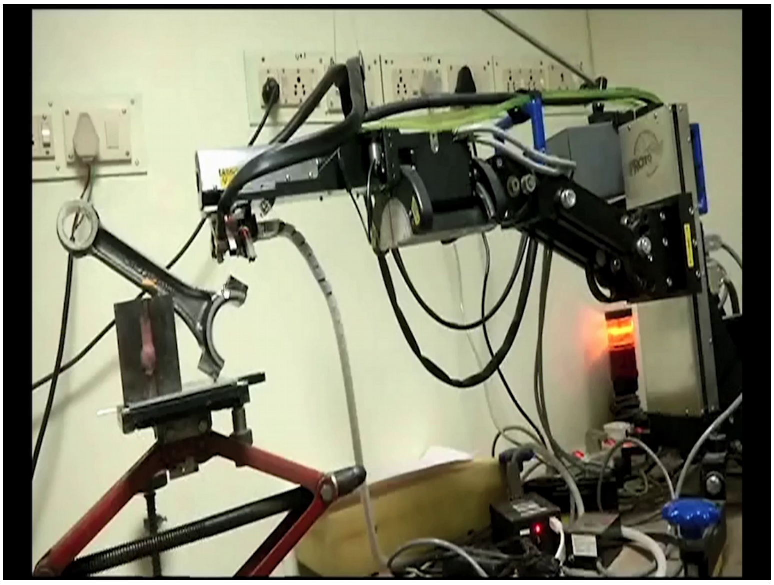

You have a look at it and then we will discuss about the functionality of this equipment. So, this is an extended arm where you have this. I will probably I will stop here and unlike the Bragg Brentano geometry what we have just witnessed before which is maintained here and here this is an X-Ray source X-Ray source are here it is not a diverge beam here it is a parallel beam parallel beam and the X-Ray source straight away comes there and then you see that there is a typical connecting road which is being measured which is clamped through a stand here and the X-Ray beams are simply falling on this connecting rod and the you have the 2 detectors besides this. In fact, the; you are looking at the side view.

So, the detector will move on this the curved half; half circle stage like this. So, the X-Rays will come straight on the sample and then get diffracted into the 2 that I mean detectors which is kept side by side to this source. So, the difference between the previous diffractometer and this is here the X-Rays are a parallel beam and you have the direct collection of the diffracted beam and then you try to analyze the X-Ray data. So, now, you can have a close look at this arrangement.

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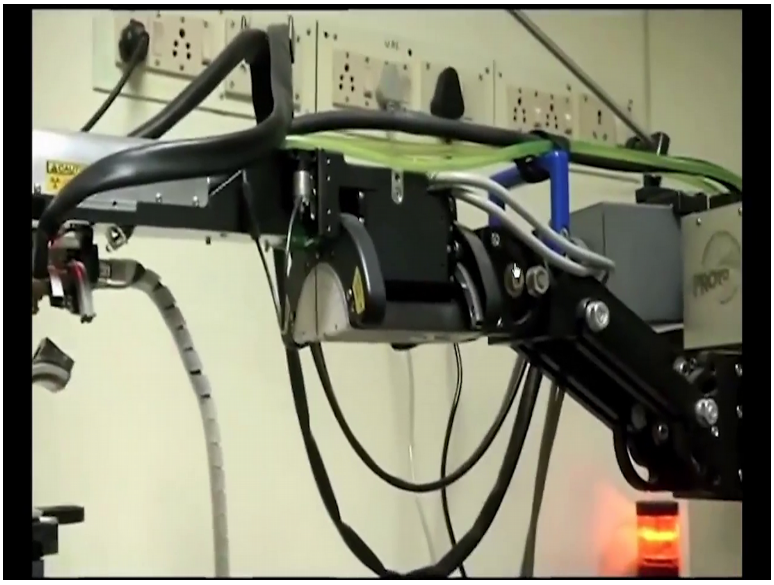

So, this is one of the unique facility of this our laboratory a stress measurements using X-Ray diffraction you have now better clarity here yes the source which I am talking about is this X-Ray source and the 2 detectors are kept side by side. The one advantage with this kind of setup is you do not have any restriction on the specimen a size any specimen which can be a fixed into the stage; can be broad; you can see that. Now how the scanning is done? The X-Ray source can rotate and that half circle and then you can see that this is a source now very clearly source and the detectors are side by side the source in the centre and 2 detectors. Now it scans for all the 2 theta measurements here.

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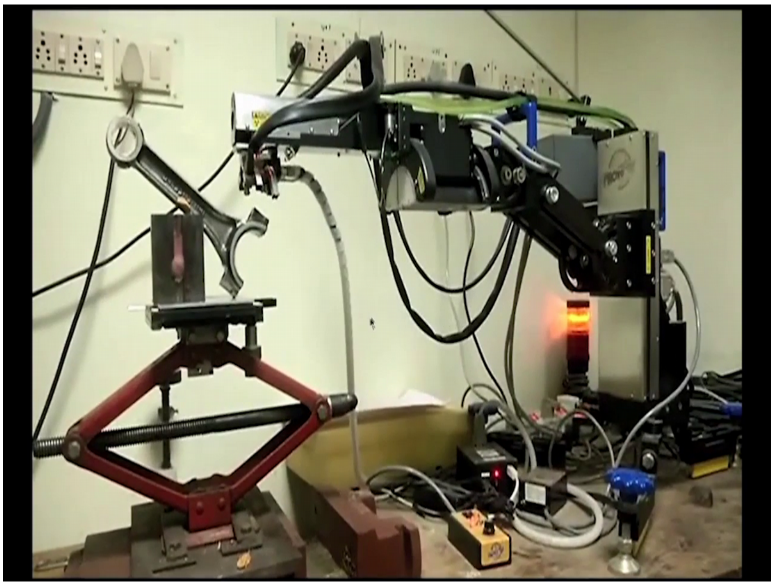

So, that is an advantage of this particular machine of any component; big component can be scanned and then you will get the data.