Interfacial Engineering

Dr Manigandan S.

Department Chemical Engineering

Indian Institute of Technology, Ropar

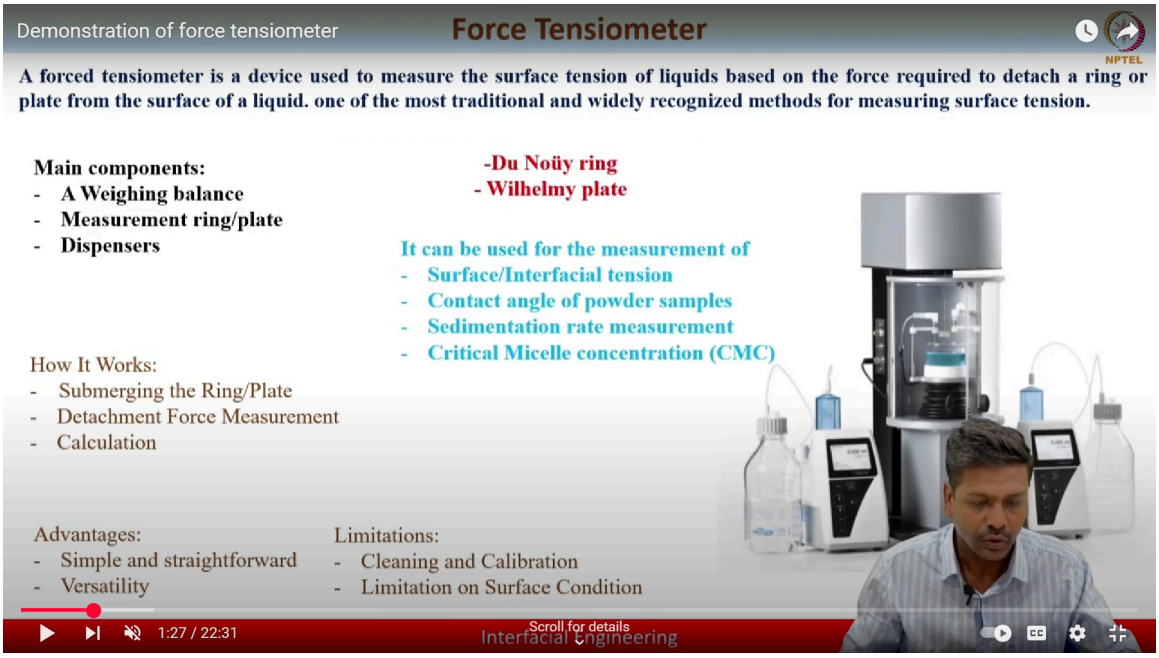
Lecture-14

Demonstration of force tensiometer

Force tensiometer; Surface Tension

Welcome back. In today's video lecture, we will examine the demonstration of a force tensiometer. We have been discussing various measurement techniques, but in today's lecture, we will examine the working principle and the demonstration part of the force tensiometer. This particular lecture will be divided into two parts. First, I will give you an overview of the device. After that, one of my PhD students will be taking you on a tour of the laboratory, you know, the research laboratory where he can show you a demonstration of the force tensiometer, right? Right. Right. So, first, let me explain and give you an overview of the force tensiometer. Let's begin.

Timestamp: 1:27mins



Yes So, a force tensiometer is, you know, one of the devices used to measure the interfacial tension of liquids, right? If you want to measure the interfacial tension of, let's say, various fluids, you will need a device like a force tensiometer. If you can remember, we have looked at various measurement techniques, such as using the pendant drop method, right? Also, one can measure the surface tension or interfacial tension. So, there is a device called an optical tensiometer. What we are looking at today is a force tensiometer. Whereas in the optical tensiometer, also known as a goniometer, you will be able to use the pendant drop technique to measure the interfacial tension.

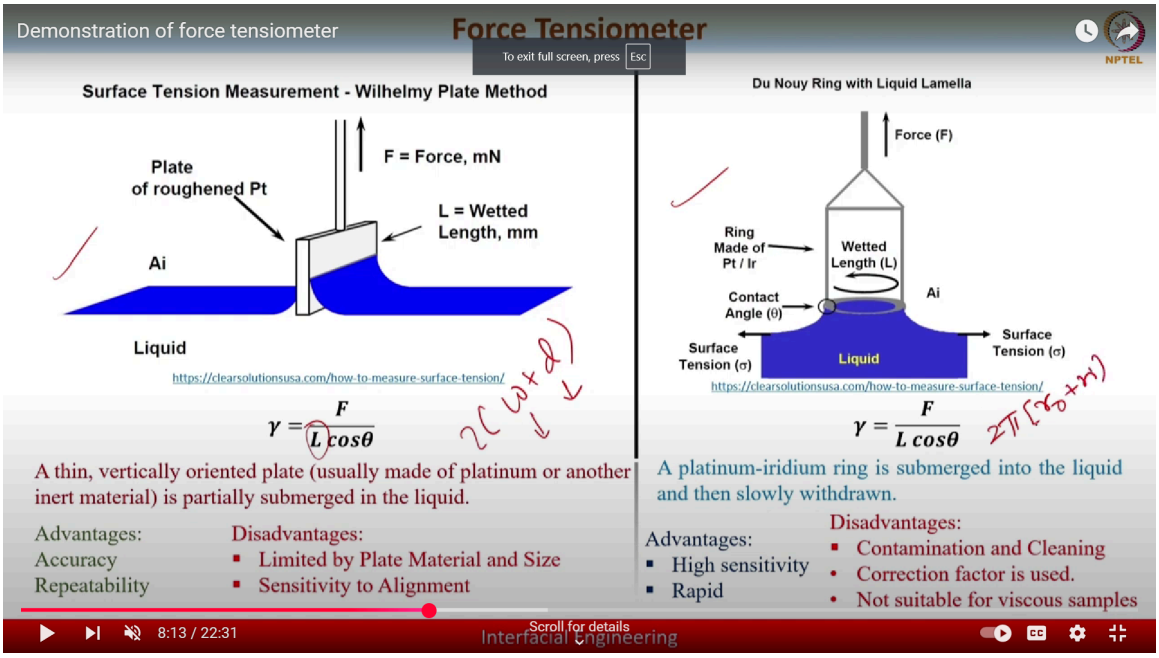
So, by using the image analysis, we will examine the force tensiometer. So, it has several components in it. So, use a weighing balance, measurement ring, or plate. The force tensiometer uses both the Du Noüy ring method and the Wilhelmy plate method. Often, these two methods are used whenever you want to measure the interfacial tension of various liquids It consists of three important key components: a weighing balance, a measurement ring or plate, and a dispenser. By using the force tensiometer, you will be able to perform several measurements. Right So, you can measure the surface tension or interfacial tension and the contact angle of powder samples. So, if you want to measure the three-phase contact angle of powder samples using the Washburn equation, you can perform this analysis using a force tensiometer. You can also perform sedimentation rate analysis using this device. Last but not least, the critical micelle concentration of any given surfactant can be determined using the force tensiometer. So, this particular aspect we will be covering is the critical micellar concentration in Module 3, right? We will look at it in more detail when we deal with module 3. So, how it works: we have already seen

the working principle of the Wilhelmy plate method. So, you have a plate or a ring, okay? You will place this plate or ring at the surface of the liquid of your interest. The moment this plate is brought down to the liquid surface and just touches it, the affinity between the liquid and the plate or ring will come into play. There will be a meniscus, and the weight of the meniscus will act on the plate or ring. This can be directly measured using a weighing balance. One can calculate the surface tension by knowing the weight of the liquid acting on the plate or ring. That's why you can measure and calculate the surface tension of a given liquid. There are some advantages to these techniques.

The force method is a straightforward method, unlike the optical tensiometer, where errors can occur due to imaging. When you perform the imaging and averaging, it is possible to generate errors in a device like the optical tensiometer. In contrast, the force tensiometer employs a simple technique. Because it is based on force balance, the measurement we obtain is quite accurate. The sentence is grammatically correct as it is.

However, there are some limitations.You have to be worried about the cleaning and calibration at all times. That is the key. To achieve a result with good accuracy, you have to deal with tasks such as cleaning and calibration, right? Another limitation is the surface condition. So, the surface should not deteriorate over time.

Timestamp: 6.47 mins



So, one always has to monitor the condition of the surface, right? The schematic of the

Wilhelmy plate method and the Du Noüy ring method is shown here. So, as you know, the working principles of these two methods are similar. What is different is the geometry. The Wilhelmy plate method uses a rectangular plate. The geometry is different from the Du Noüy ring, as the Du Noüy ring uses a ring-type device to measure surface tension.

Therefore, what will be different is the wetted perimeter that comes along with the geometry. In the case of the Wilhelmy plate method, the wetted parameter will simply be two times. You know that two times w plus d means that w is the width and d is the thickness.

Wetted parameter for Wilhelmy plate, $L = 2 (w + d)$

Wetted parameter for Du Noüy ring, $L = 2 \pi (r_o + r_i)$

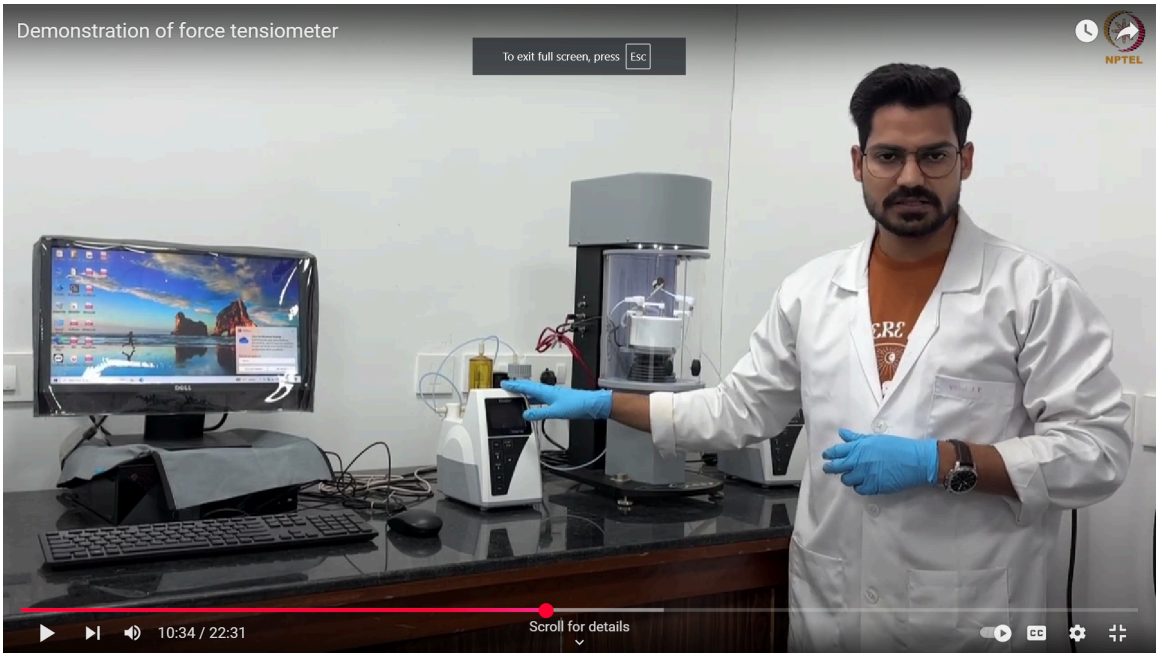
In the case of the Du Noüy ring, it will be two pi times the inner radius plus the outer radius. What makes the difference is the perimeter, right? Okay. So, because we often use platinum metal or a special metal alloy to deal with theta, the contact angle, we must remember that the contact angle is also a variable. So, when we use platinum or the special alloyed metal, the theta it establishes with the water is usually zero. Not only water but also most organic liquids, have negligibly small amounts.

So one can get away with this cosine theta component. So, in this case, cos zero will be one. So what you need to worry about is the perimeter, always, right? So that is exactly what you have to do. Sometimes, the Du Noüy ring uses the correction factor. If the ring that is employed is too finite, then one would have to use the correction factor.

One of the disadvantages in the case of the Du Noüy ring could be that. Otherwise, both methods are complementary to each other. Both can complement one another. Both methods are widely used. So, depending on the sample volume, if you want to perform dynamic measurements quickly, you can use the Du Noüy ring, right? And if your sample volume is too small, then you may have to use a Du Noüy ring, right? Depending on the requirement, one can choose the geometry appropriately.Now we will move on to the demonstration. I will stop here for the demonstration of the equipment. It will be shown by one of my PhD students.

Thank you. Yes.

Timestamp: 10.24mins



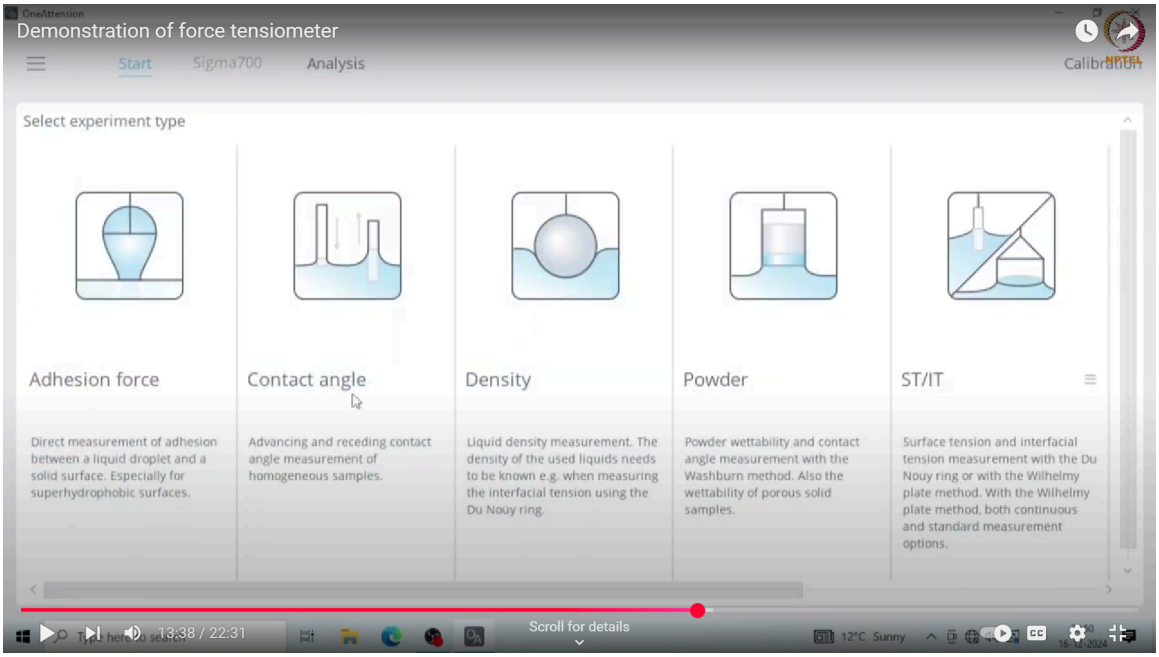
Welcome back. Let's see the demonstration of the force tensiometer. So I'm using this system made up of Biolin, and the model is attention. Here, as you can see in the system, we have two dispensers. One is this one, and the other is that one.
That can be used for the CNC measurement of the sample attached to the needle. One will take the sample, and one will remove the sample. This is a special vessel. Here, we need to fill our samples, or you can use another type of small vessel that can fit inside. Alternatively, you can fill your sample air directly in this vessel, which is connected to the thermostat that will manage the temperature using the bath system.

Additionally, you can see here that this is the balance where you need to hang your plate. Your ring-type plate, or whatever type of plate you want to use, must be hung very carefully. If someone wants to move the stage or the sample stage, it can be adjusted using these switches. As you can see here, our stage is moving upward, and now it is moving downward. This movement is used to adjust the interface of the ring-type plate, Wilhelmy plate, or whatever you choose to use. Also, you can turn the system off or on during the experiment. Now, I will show you how to measure the surface tension of an air-water system using a Wilhelmy plate and a ring-type plate. First, let me show you how the Wilhelmy plate and the ring-type plate look. Now, this is our Wilhelmy plate made of titanium. As you can see here, we have a separate cleaning procedure for this, which I'll explain later. We can hang this Wilhelmy plate like this. Now let me show you the Du Noüy ring, also known as a ring-type plate. This is our ring-type plate, as you can see here. This is Du Noüy ring plate used for the measurement geometry. You can see that it has a perfect ring shape. This one is also made of platinum. It will hang in the system for measuring surface and interfacial tension, along with the CNC and other parameters.

This is our sample vessel. As I told you, one can use this vessel directly, which is available with the instrument. If you want to change the temperature or maintain specific conditions, you can use this vessel, too.

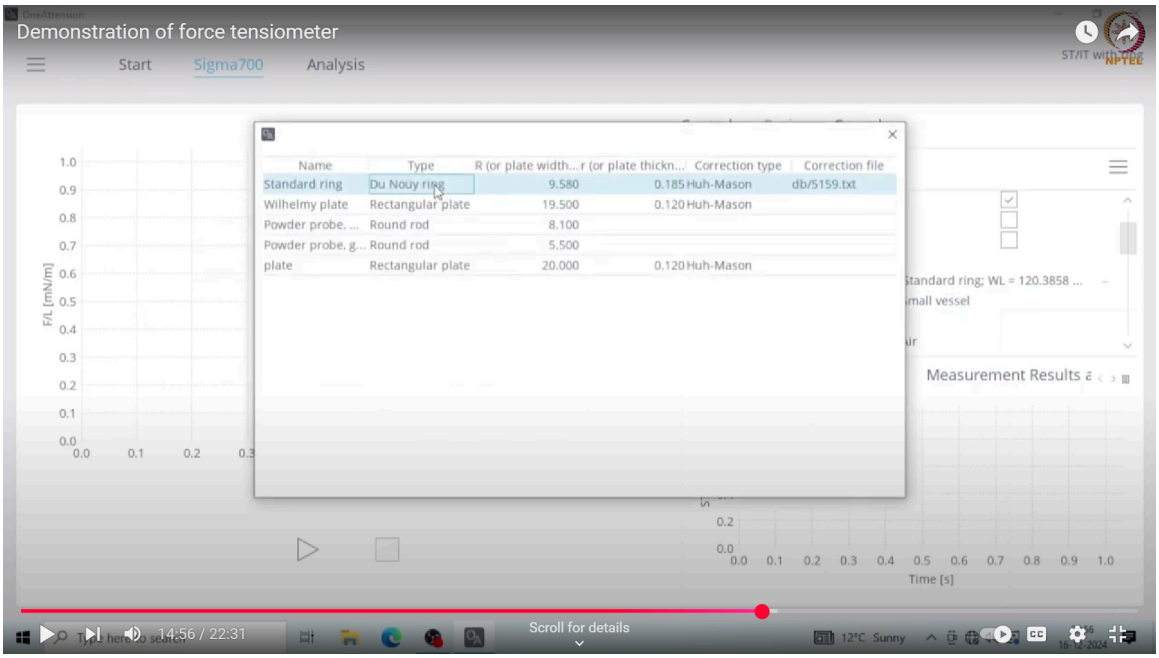
For easy handling, you can use a 50 ml or 100 ml sample vial, which can be placed inside the system like this. Both volumes are available for use. Now, let us move on to the software interface. This is our software window.

Timestamp: 10.37 mins



The software is named One Attention. After opening, you will find several applications. For instance, one can measure adhesion force using a hook-type needle, contact angle using a plate-type needle, and density using a ball. These are separate geometries for measuring surface tension and interfacial tension. You can use either the Du Noüy ring or Wilhelmy plate for these measurements. Additionally, you can determine CMC using either of these two plates. Sedimentation measurements can also be performed depending on the application. Today, I will demonstrate to you the measurement of surface and interfacial tension using the Du Noüy ring. Upon selecting the desired measurement in the software, a window will appear that allows you to choose the specific geometry. Whether it's a ring or Wilhelmy plate for surface or interfacial tension. I will use the Du Noüy ring for this demonstration.This interface allows you to create a recipe for the experiment. Here, you can name your experiments. If you want to use autosave, enable the autosave feature. If you want your experiment to be private, select the private save mode. You also need to specify the type of symmetry that you will use here.

Timestamp: 14.56 mins



Since I am using a Du Noüy Ring, I will select it now. Next, specify the type of vessel you are going to use, as there are different versions available. I am going to use the small vessel. Additionally, choose a material you would like, such as the phase or heavy phase. For demonstration, I'm using air and water you can also select this from the directories. You can see it here. A large number of samples is provided for both cases, and you can choose them chronologically. If you want to add something, you can do that as well. Next, adjust the parameters. If you are conducting a specific test and the settings depend on the variability and type of test, you can set the zero balance automatically.

The system will take care of the zero balance. A zero balance is crucial because, during interfacial tension or surface tension measurement, the ring or plate touches the interface at that point. You need to ensure that the zero balance is performed. Automatic surface detection can also be enabled. If you are using a system with viscosity that changes concerning temperature or operating conditions and you want continuous stirring, you can select the stirring option here. Set the stirring speed as a percentage, such as 100%, or customize it manually. This is the raw graph, and this one is the surface tension graph. You can choose either option based on your requirements. The console provides details about the ongoing operations. In the control section, you can perform a zero balance on the position after adjusting it near the ring or plate. The sample vessel is ready, and I will now place it inside the container.As I mentioned earlier, I am using the Du Noüy ring. This thing must be cleaned properly. Always ensure that if you are using a plate or ring for any geometry in the force tensiometer, it is thoroughly cleaned. If the geometry is not clean or contains contaminants, the measurement will vary. Let's see how to clean. For

the cleaning procedure, we will first clean using DI water. Then you will rinse it with ethanol for thorough cleaning. Cleaning is a critical step in this experiment, especially for the tensiometer, whether it is an optical tensiometer or a force tensiometer. After this, you will use butane gas or apply a flame to remove any biological contaminants. Continue cleaning until it looks clearer. Now our system is cleaned properly, and the ring is ready for measurement.

Timestamp: 18.21 mins

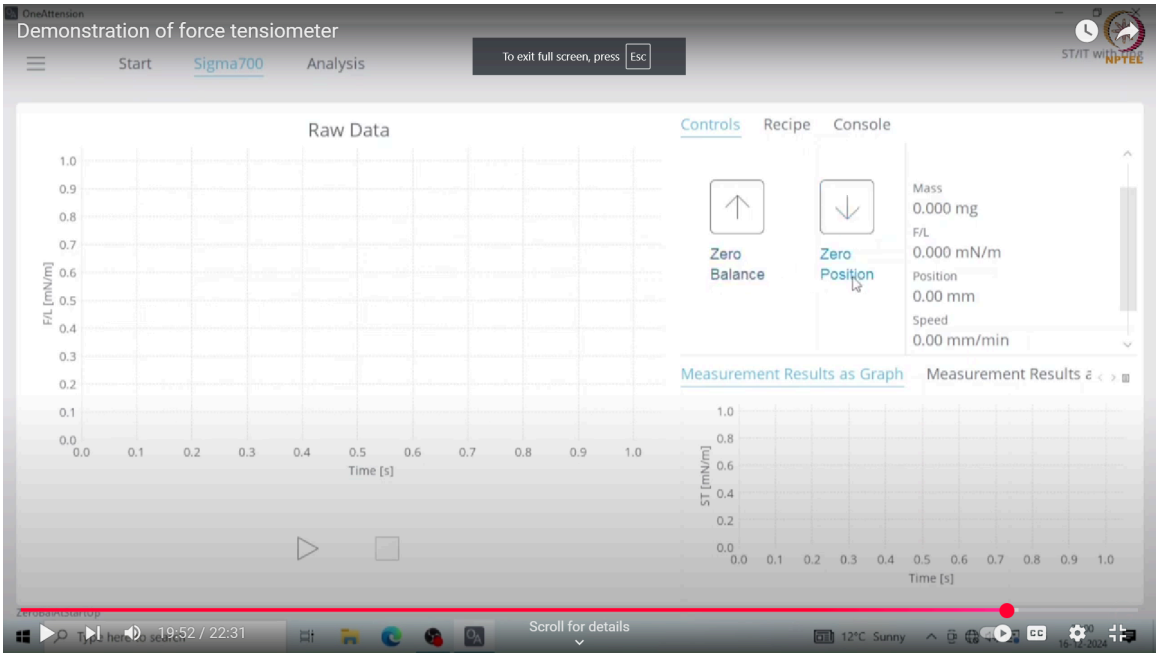
As of now, we have completed the cleaning process. Let us carefully place our rings on the balance. Remember, this step will not cause much movement in the system. Now let's close the system. You can see here that our Du Nuoy ring is ready for measurement. Notice the significant difference between the Du Nuoy ring and the sample.

Now we need to lift the stage so that the ring is nearer the surface. You can observe as I move the stage, you will need to determine manually if the system is close enough to the surface. Once the position is set near the surface it will become zero and the balance of the Du Noüy ring attached to the weighing system will also be zero. This zeroing process is performed using software which you will handle shortly.

Timestamp: 19.06 mins

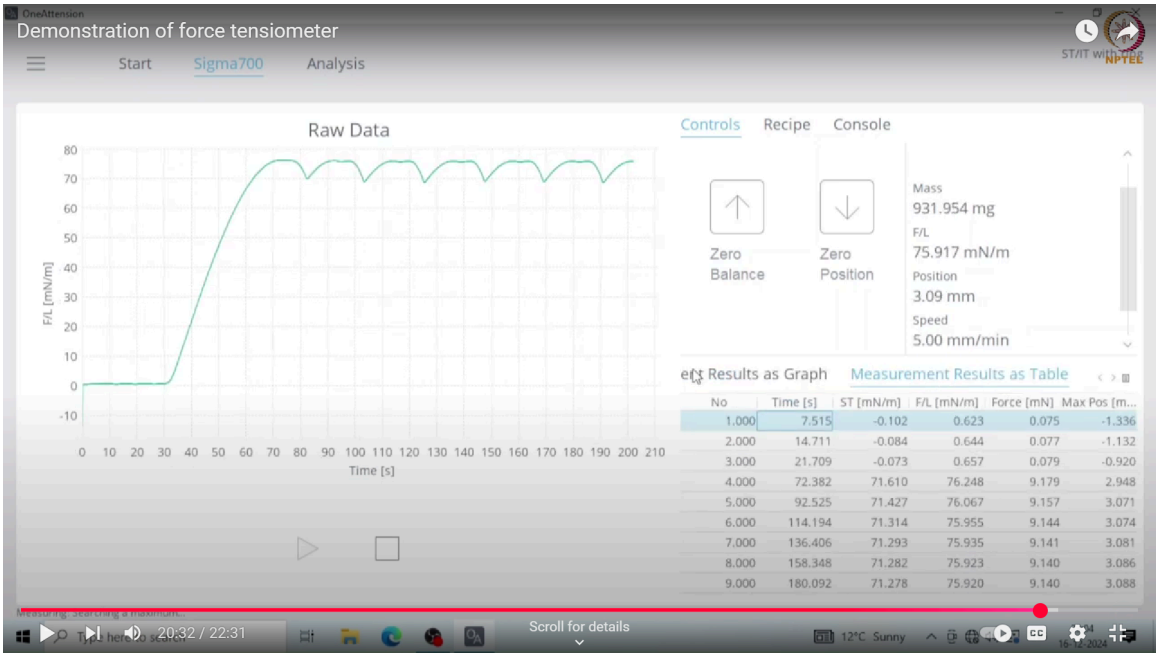
Let us now move the stage closer to the surface. As you can see, we are approaching the interface. The Du Noüy ring is at the interface and we can proceed to perform the zero balance. After positioning the stage and ensuring the balance is at zero, the mass and position values system will also become zero. The stage can be operated using the controls. The upward arrow moves the stage up while the downward arrow moves the down.

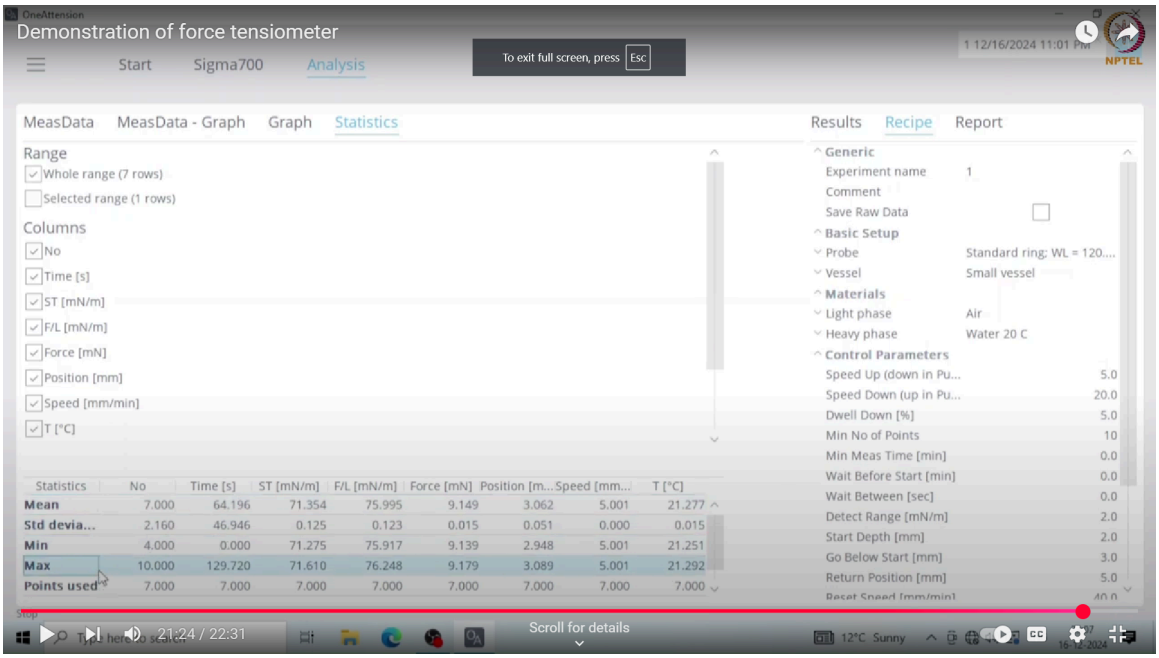
Timestamp: 19:56 mins



We have already positioned the stage manually so I will now perform the zero balance. As you see the mass is almost set to zero and the position is also set to zero. Now we are near to the interface. As I mentioned earlier, we have prepared the recipe. With the recipe ready I will now start the measurement click on the measurement to begin this process will take some time you will notice a change in the mass you will notice a change in the mass and the position values indicating that the measurement is in the process the system will measure the surface tension of the air-water interface once the measurement is complete you can proceed to the analysis section once the measurement is complete open the measurement sample in the analysis mode to review your data here you can see the raw data displayed as a graph between the time and surface tension data per cycle as well as the raw data in the tabulated form you can export this data in the desired format.

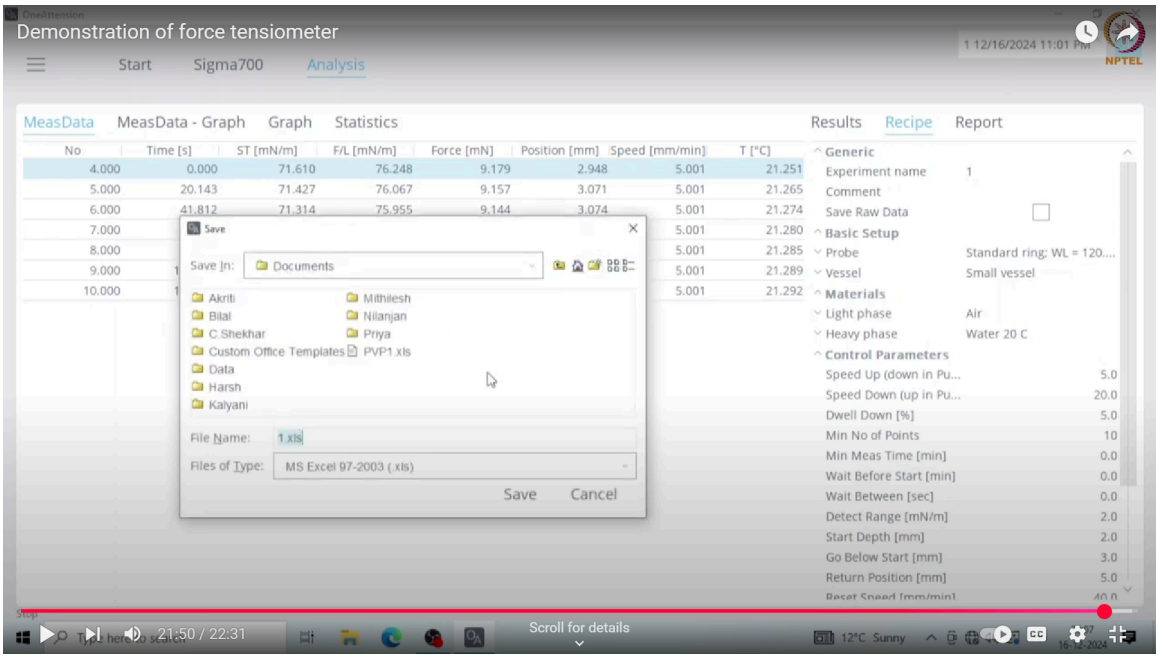
Timestamp : 20.32 min





Additionally software calculates the mean which is the mean or average value for surface tension in the standard deviation as well and the minimum and the maximum values as well for our measurement of the surface tension at the air-water interface is 71.354 which is good agreement with the standard 72.8 this demonstration shows how surface tension can be measured using your force tensiometer.

Timestamp: 21.50min



If you wish to save the data click on the export all and select the desired location for savings once the experiment is complete we will lower the stage manually you can also use the software to lower the stage but I prefer doing it manually.After the stage is in the home position, carefully remove the ring without causing any disturbance. Finally, follow the cleaning procedure again to ensure this step is ready for future use.

Thank you for joining us.