Rheology and Processing of Paints, Plastic and Elastomer based Composites
Prof. Santanu Chattopadhyay
Rubber Technology Centre
Indian Institute of Technology Kharagpur

Lecture 19
Practical demonstration on Brookfield viscometer and Oswald viscometer

Welcome back to NPTEL online certification courses on rheology and processing of paints, plastics and elastomer based composites. And today we will be discussing about Oswald Viscometer as well as Brookfield Viscometer. So these are the basic viscometers. So while calculating the viscosity of a polymer, we need the polymer as well as the solvent in which we will be dissolving the polymer. So in this case we have taken toluene as a solvent and we have three different concentration of the polymers. As you can see the 0% that is only the solvent, the 0.5% of the polymer and 1% solution of the polymer. So we have taken PMMA and we have made a solution in toluene and we will be using this Oswald Viscometer which can be seen. We have placed the Oswald Viscometer over here. So we will draw the liquid from this volumetric flux and we will measure the viscosity using the Oswald Viscometer.

So, viscosity is a flow which is a function of time. So you can see this is very low viscous material and it is flowing easily. But if you are taking a high viscous material, then it takes time to flow. It is flowing but it is flowing very slowly. So it is a function of time.

So utilizing that particular phenomena what we will do is we will now use the same principle and we will use the Oswald Viscometer. So first we should understand how we will calculate the viscosity. Now we will first calculate the relative viscosity which is the ratio of the viscosity of the solution and the viscosity of the solvent. And this relative viscosity is also can be deduced by time taken by the solution to flow and time taken by the solvent to flow. A particular fixed volume of the solvent as well as the solution is made to flow through orifice and the time is calculated.

So this ratio of time can also be correlated with the relative viscosity. Now relative viscosity if it is divided as you can see from the formula we call it as the specific viscosity. Now the specific viscosity can also be deduced and can be also be written using this equation 3. Now reduced specific viscosity is specific viscosity by the concentration. Now you can see if we can plot a graph of reduced specific viscosity versus concentration we get a straight line and the cut in the y axis is directly correlated with the viscosity of the polymer which is called the intrinsic viscosity.

This intrinsic viscosity and molecular weight of the polymer is denoted by using or can be correlated by using the Mark-Howink equation which is the viscosity is equal to K M to the power alpha, where K and alpha are particular constant which is different for the solvent, polymer and temperature. And this constants can be found from a handbook of polymer which we specially refer to Bandrup. We will fill this second bulb up to the mark. You can see the solution is filled to the second mark and we will start the stopwatch as soon as we release the pressure from upside and we will continue to run the stopwatch until the fluid comes and strikes this lower end, lower mark. So this will be our fixed volume for each and every solvent.

So we will start the stopwatch. We should make sure that while the experiment is going on, the viscometer should be straight, should be kept straight. So we have stopped the stopwatch. It is coming as 42 seconds. So we will note down, it is at 42 seconds.

So we will repeat this particular experiment 3 to 5 times and we will take the average of that. So now we will take the second solution which is 5% solution of the polymer and we will fill it in the Oswald viscometer. So now we are filling 0.5% solution of the polymer into the Oswald viscometer in the similar way as we did for the only solvent. In the same way, we will be doing for our polymer.

So we will pull the sample up in the second bulb. We will adjust the meniscus and we will start the stopwatch. So we have stopped the stopwatch and it is coming as 45 seconds. So you can see that there is an increase in the time. In the same way, we are going for 1% polymer solution.

It is always advised to go from the lower concentration to the higher concentration Oswald viscometer and after each and every experiment, the viscometer should be thoroughly cleaned with the solvent. So we will reset our stopwatch and we will do the same exercise again. We will pull the liquid up into the second bulb until it reaches the mark. We will adjust the meniscus and we will start the experiment. We will do the same exercise again.

So it is coming at 48 seconds. So taking all those values, we have plotted the graph which you can see on the screen and we have also calculated the viscosity. We have also calculated the molecular weight using the Mark-Houwink equation which is displayed on the screen as you can see. So next we will move on to the Brookfield viscometer. So now we will give a short demonstration on the Brookfield viscometer.

So as you can see, this is the Brookfield viscometer and this is the very basics of a rheometer. So rheometers have all evolved from a viscometer. So viscometer is something which will have a fixed rpm and it will measure the viscosity at a constant rpm. So that is why it is a viscometer. In case of a rheometer, you can change the rpm, you can keep the rpm constant, you can change the temperature.

So there are many modes in which you can perform various viscosity measurement experiments. So that is why it is a rheometer. So in case of a Brookfield viscometer, we have a display, we have various spindles and we have a cup. So the spindle is attached with the machine over here and we can put the required polymer solution or whatever we want to measure. But we must make sure that the solution or the polymer melt or whatever we are using should not contain any bubbles inside it.

So we will slowly insert this. We will lock the attachment. We can also use a beaker in which you can keep the polymer solution and we can also use paints and different types of adhesives for this particular measurements. So now we will set the program. So it is CC 25, constant cylinder.

We will fix the rpm. So it is like 200 rpm and the time is 60 seconds. So we will give a rough ID, AA or something like maybe test, so test 1 as T1, press okay and we will start the experiment. So you can see that the spindle is rotating and now if you focus on the display, you can see that the percentage which is coming is above 100%. So we should discard this result. We will wait for the completion of the experiment.

So the percentage should be above 10 and below 100. So accordingly we have to change either the spindle or the rpm of the experiment. So presently we do not have a provision to change the spindle. So we will change the rpm and we will check at what rpm, it is below 100 and at particular that rpm what is the viscosity of the oil. We have used a silicon oil over here.

The experiment has terminated and we will again go back. We will re-run the experiment with a lower rpm, maybe 150. So it is all trial and error. We will give as T2. We will start the experiment or we should say it as a spindle.

See at 150 rpm, it is around 84%. So we can take this result. We will wait for 60 seconds and the machine will be calculating the average, will be averaging out the total viscosity in the duration of 60 seconds. So you can see the experiment is completed and eta which is viscosity is 494.

24 milli Pascal second. So similarly you can do any type of liquid. You can perform the experiment on any type of polymeric sample, paints, lacquers, varnishes, any resins. So

we can have this viscosity at a constant temperature, at a constant rpm using Brookfield viscometer.