Ecole Polytechnique Fédérale de Lausanne

Experimental Methods in Engineering Mechanics

ME-412

Determination of the glycerol concentration in the lab bottle

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1 Introduction

During the Module 3, of the Experimental methods in Engineering Mechanics course, we work with a glycerol solution. At the beginning we consider this solution to be compose 100% of glycerol. However, this solution is in a bottle which has been opened 1 year ago. Glycerol has the characteristic to be hygroscopic, that means that it absorbs water of the environment. So the dynamic viscosity is not the one of an 100% glycerol solution, that's why in this contribution we are going to determine the actual concentration of glycerol/water in the bottle. Thanks to that the calculations to do the right dynamic viscosity should be more accurate.

2 Comparison between theoretical and experimental viscosities, with 100% glycerol solution

The idea of this module is to make a glycerol/water mixture that has a group specific viscosity and make some tests on it. For us, for example, we need to have a kinematic viscosity of $4cSt$. So we calculate the online calculator [1], the volumetric fraction of glycerol and of water to have approximately 4cSt. So it suppose to be 60% of water and 40% of glycerol at 22.2°C to obtain the good kinematic viscosity. After that, we have found interisting to see the evolution of the viscosity in function of the temperature. So we filled in a table the theoretical viscosities for different temperatures.
For the experimental method, we have made the mixture with these water fraction and glycerol fraction, and then we use the rheometer (Figure 1), then we get value of our mixture's dynamic viscosity in function of the temperature. We plot the experimental method curve and the theoretical one. We observe that curves do not fit together (Figure 2). The explication is

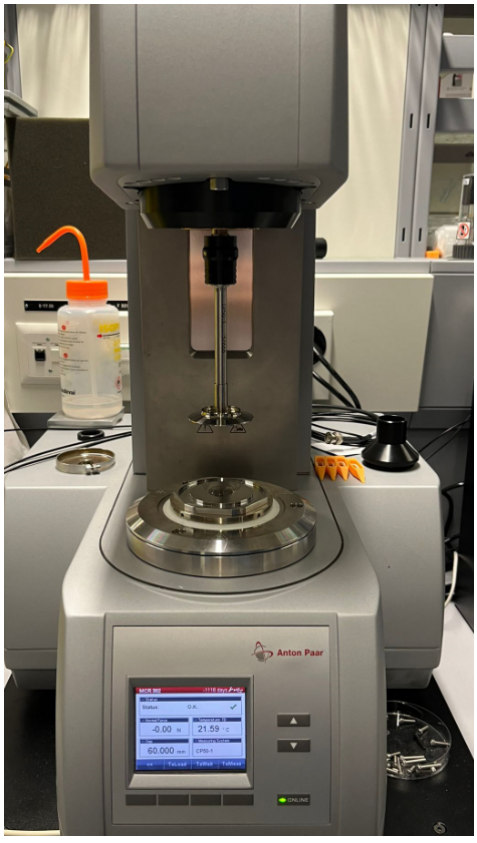

Figure 1. Rheometer used for the measurements

chemical, indeed we can see that consider the glycerol bottle to be compose of 100% glycerol

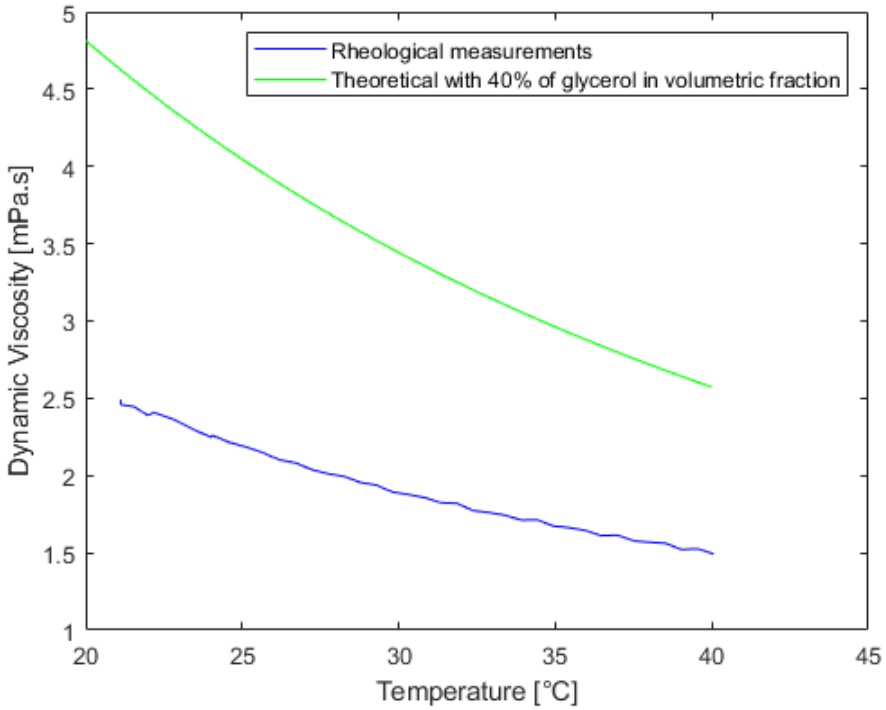

Figure 2. Comparison between theoretical dynamic viscosities for 40% glycerol volumetric fraction in the mixture, and rheological values of dynamic viscosities in function of the temperature. We observe that there is a big difference between both. So the volumetric fractions in our mixture should not be good to fit with theoretical values. So we need to consider hygroscopic characteristic of the glycerol.

solution is not true. Glycerol is hygroscopic [2], as the bottle has been opened few years ago, it is now compose of water also. So the interest is to determine the new composition of glycerol in the bottle.

3 Determination of the glycerol composition in the bottle

To determine the glycerol volumetric fraction, we use the online calculator precedently used, we take the value at 21.1°C determined by the rheometer and try to find the value of glycerol volumetric fraction which corresponds. We find that the total mixture has 73.2% of water (W_{new}) and 26.8% of glycerol. We fill a table and plot it to compare if the curve corresponds approximately to the rheometer's one. We see that the two curves fit each other (Figure 3). The maximum relative error is equal to 2.9% so we can admit that these mixture fractions are accurate. Now, we want to calculate in the bottle the volumetric fraction of glycerol.

$$\begin{aligned} W_{\text{new}} - W_{old} &= \Delta W \\ \Delta W &= 0.142 \end{aligned} \tag{1}$$

$$\frac{G_{\text{new}}}{G_{\text{new}} + \Delta W} = 0.654 \tag{2}$$

So now, we know that the glycerol solution in the bottle has a glycerol volumetric fraction equals to 65.4% and a water volumetric fraction equals to 34.6%.

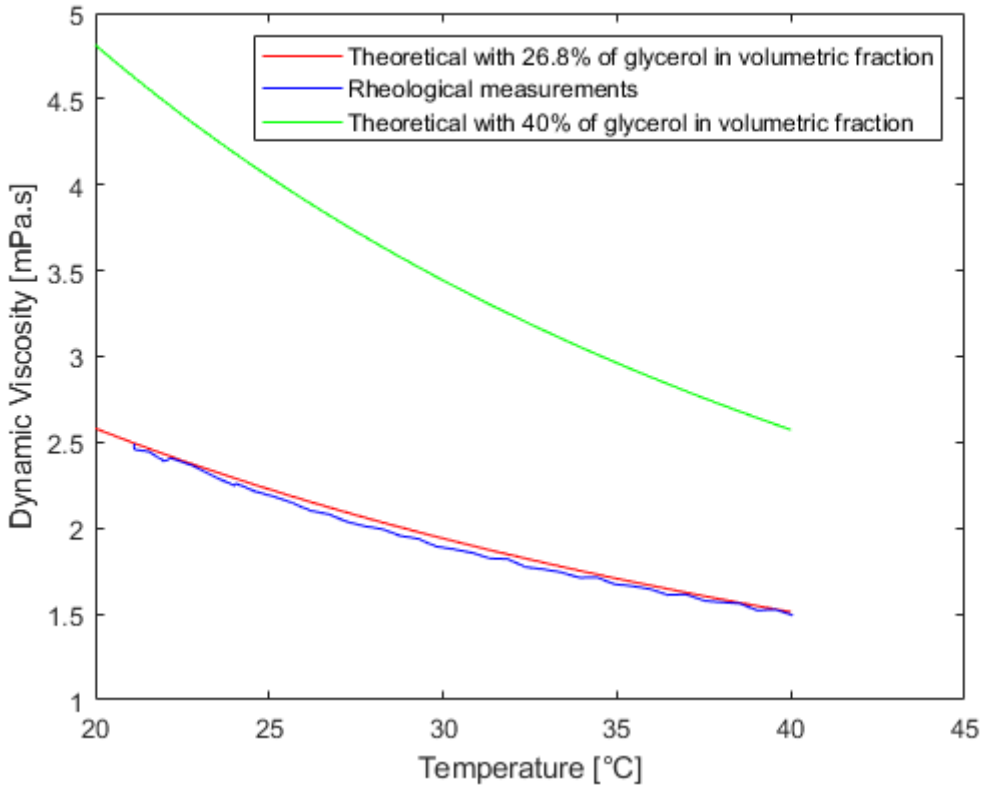

Figure 3. Comparison between theoretical dynamic viscosities for 40% glycerol volumetric fraction in the mixture, rheological values of dynamic viscosities and theoretical dynamic viscosities for 26.8% glycerol volumetric fraction in the mixture in function of the temperature. We observe that rheological measurements fit well with the theoretical values calculated with a glycerol volumetric fraction equals to 26.8%)

4 Conclusion

In this contribution, we have determined the real glycerol volumetric fraction present in the glycerol bottle (65.4%), and thanks to that we will be able to compare theoretical, rheological and processing results for the viscosity in function of the temperatures.

References

[1] "Online viscosity glycerol/water calculator." (), [Online]. Available: http://www.met.reading.ac.uk/~sws04cdw/viscosity_calc.html. 4 April 2018.

[2] "Hygroscopy." (), [Online]. Available: https://en.wikipedia.org/wiki/Hygroscopy. 10 December 2022.