EHDA closed loop control system based on real time non-visual spray mode classification

Relatório de Atividades 3
Projeto Final de Curso

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1 Summary

Electrohydrodynamic Atomization (EHDA), also known as Electrospray (ES), is a way to disintegrate a liquid into droplets by exposing it to a strong electric field. EHDA surveys have contributed as an important tool for the development of water technology (thermal desalination and metal recovery), material sciences (nanofibers and nano spheres fabrication, metal recovery, selective membranes, and batteries), and biomedical application (droplet encapsulation). Besides that, the project is merged with the Energy Transition strategy and Innovation Agenda Agriculture, Water, and Food, Key Enabling Technologies (KETs). Although, there are EHDA applications in industry, stabilizing the cone-jet spray mode is done empirically and based on mean current measurements.

The electric current flowing transported by the spray reveals characteristic shapes for different spray modes. Those shapes cannot simply be summarized by its mean value. In figure one we can see an example of cone-jet mode electrospray.
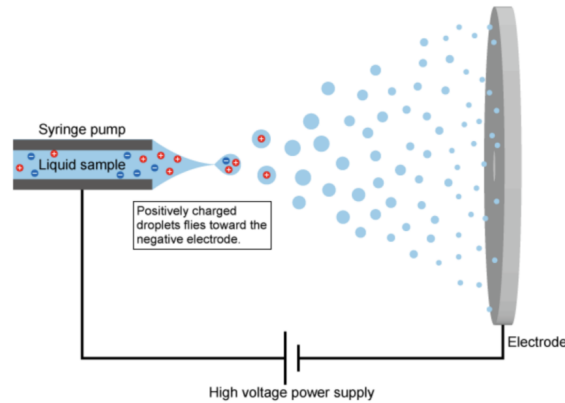
Figure 1: EHDA

Signal processing techniques can allow a non-visual classification of the spray mode based on the electric current shape. The spray process imposes noise and random sequences on the measured signal making its classification not a trivial task.

Industrial applications demand automated stabilization of a spray mode. This can be achieved by a closed-loop control system. Automated classification of the spray mode is a crucial part of a control system same as the development of an appropriate control algorithm. Signal processing implementations of previous projects of the NHL Stenden Water Technology group are showing good classification results. Further research is necessary to improve the classification accuracy and research and implementation of a suitable classification algorithm. Because of that, the work will be done by the Water Technology Group at NHL Stenden University of Applied Sciences and in combination with Dutch companies to match analysis possibilities with knowledge and infrastructure availability.

The setup used for this project can be seen in the Figure 2. To run the experiment automatically it is used a computational processing machine to integrate the peripherals and run their routines, system sensors such as the oscilloscope and the high speed camera and also the system actuators which is represented by the high voltage power supply and the syringe pump.
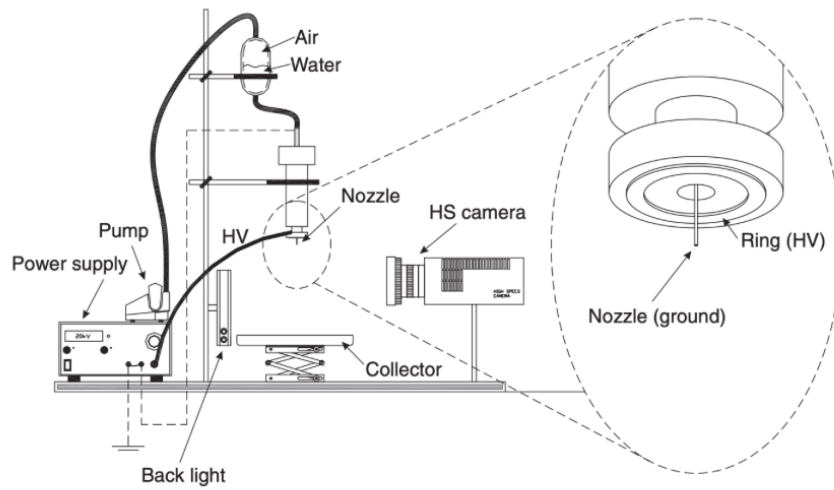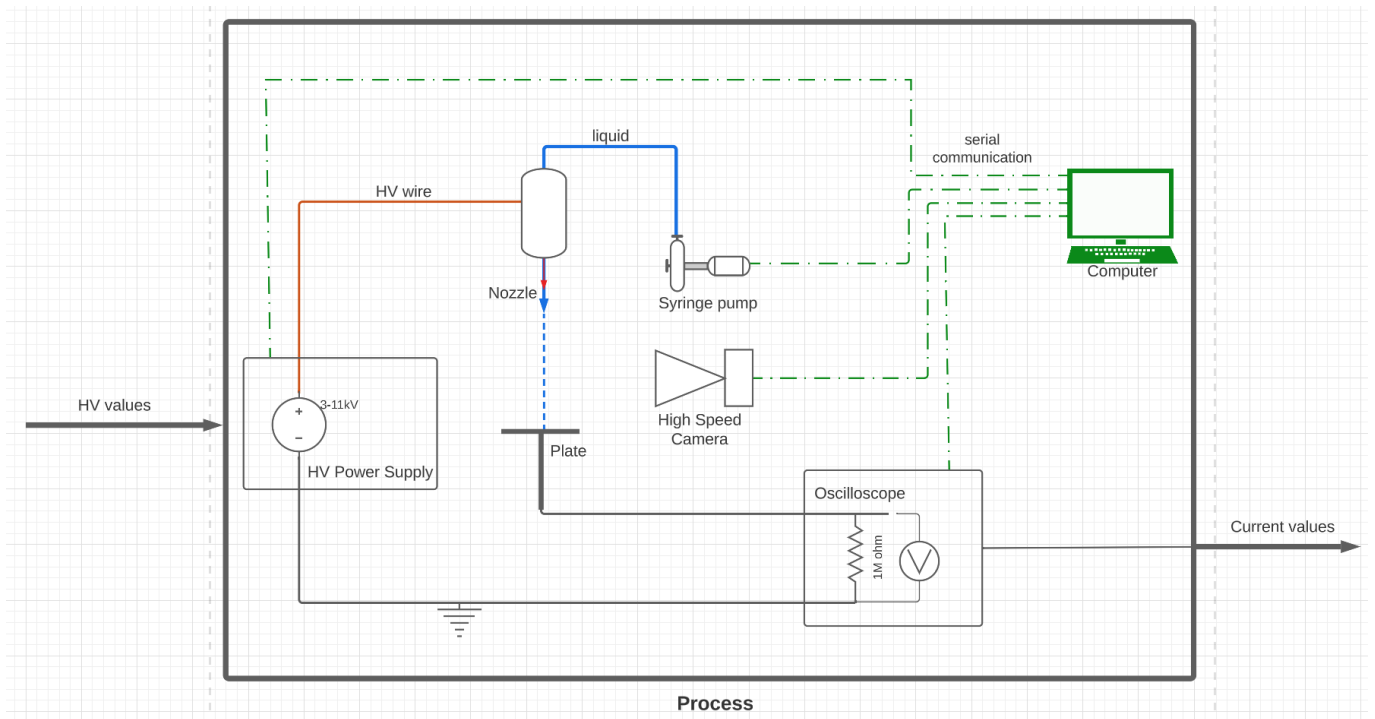
Figure 2: System Architecture
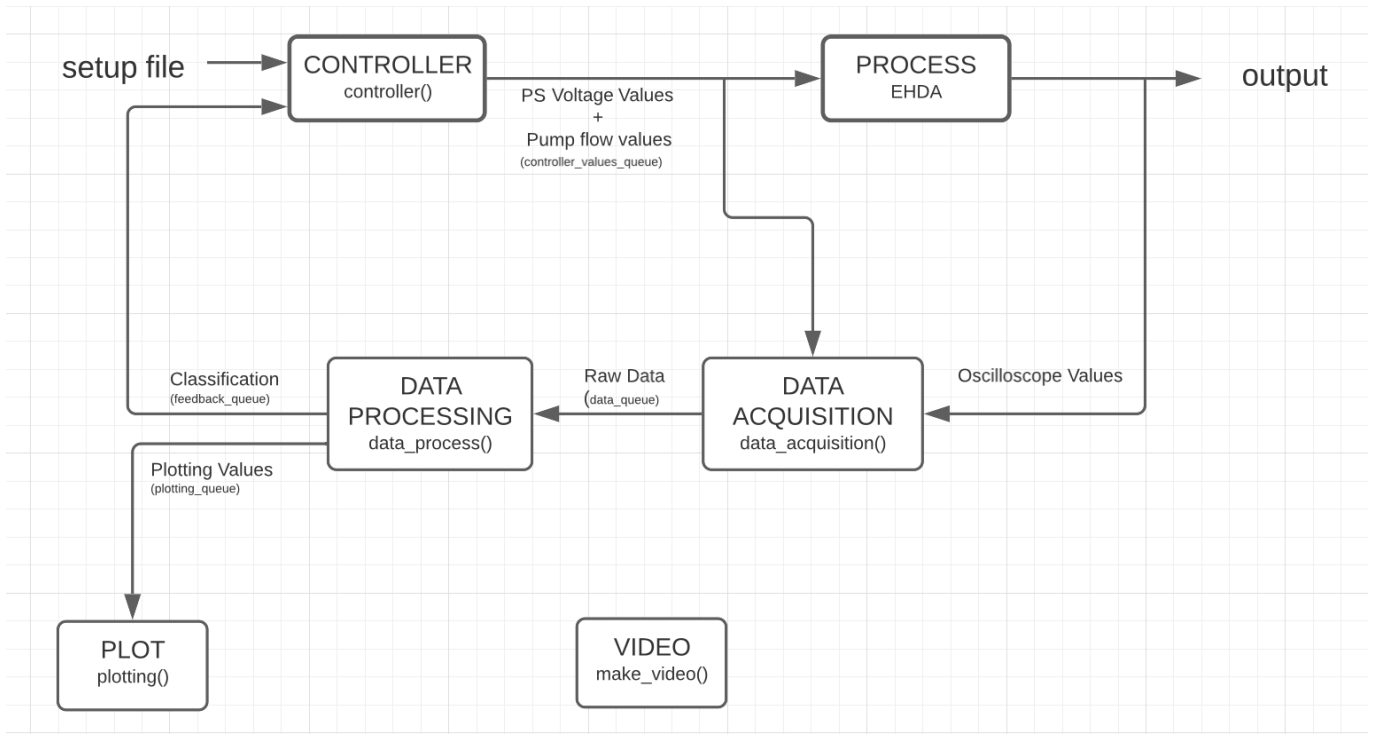

Figure 3: System Design

Figure 4: Software Design

2 Metodology and Results

3.1 Pump Integration

The pump integration in the automation algorithm bring us a new controllable variable, the Flowrate. Now we can control the spraying mode with the two main variables that afect the system. It will bring more complexity for the system since now we are dealing with multivariable control. Fortunatelly those two variables are uncuppled (* be certain of that first *) which means that actuating in one of them will not interfere in the other one. Controlling also the flowrate gives to this project a new dimension in the system giving us freedom to explore the flowrate properties.

The pump integration was developed using also python language. As I could not find a good library for this pump I developed an quick and easy interface for sending the pump commands to be integrated with the main automation routine. The communication with the pump was made using the serial interface and the commands list were found in the pump user manual.
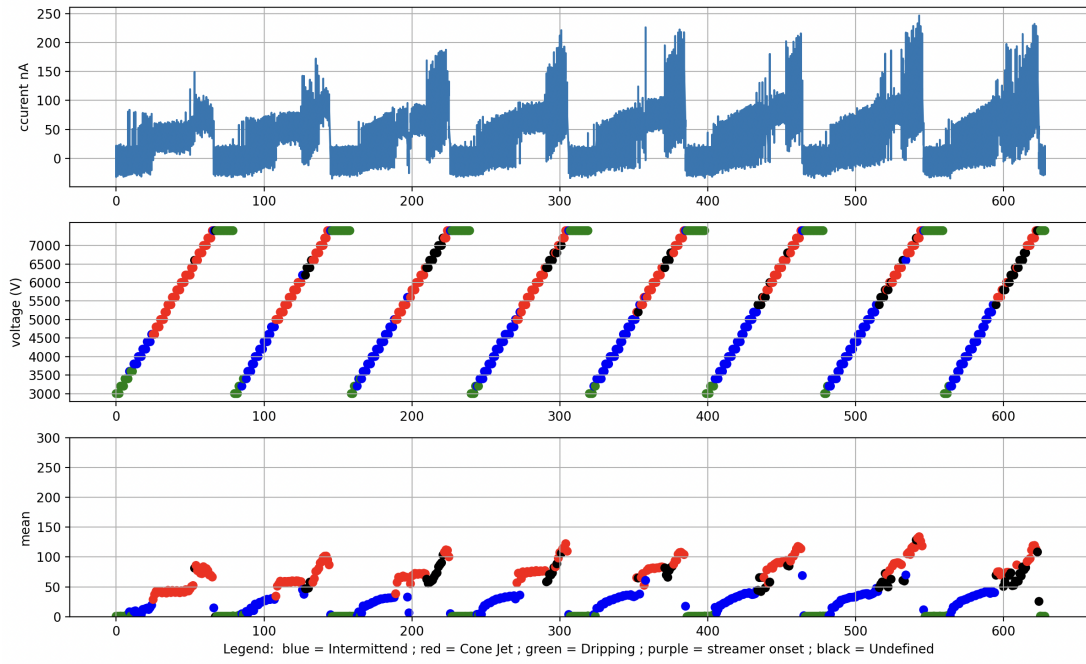
3.2 First mapping Experiments
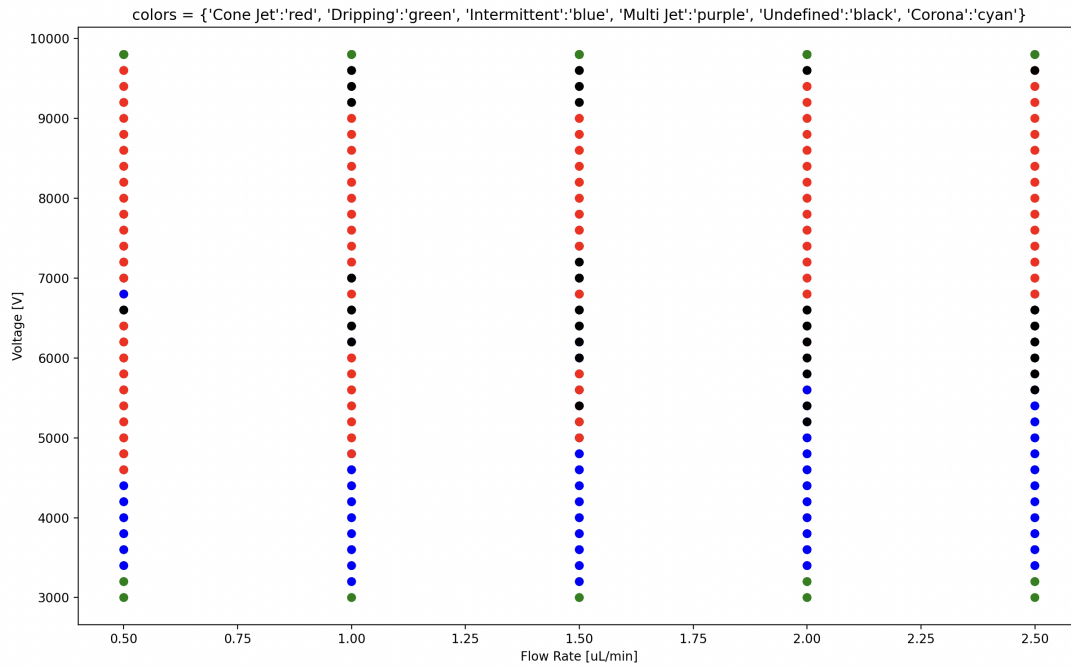

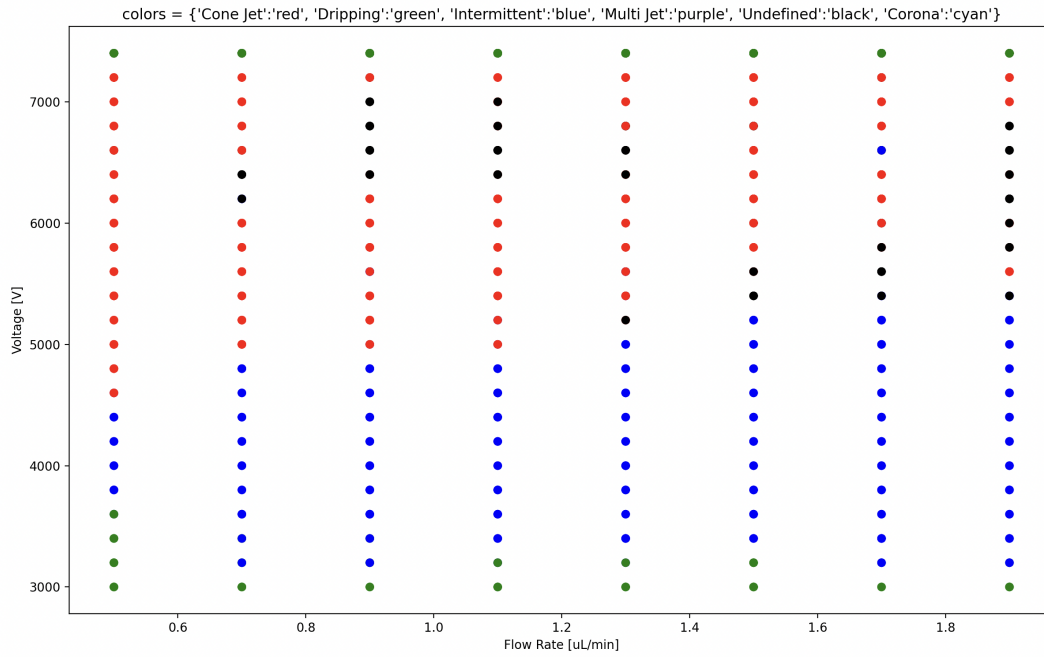Figure 5: Mapping Experiment data

Figure 6: First mapping trial

Figure 7: Second mapping trial

It was noticed that the motor of the pump in certains speed generate a noise caused by the stepping from the stepper motor. This noise from the motor was being acquired by the current data and was interfering in the classification method. Because of that the firsts results of the map have a lot of undefined or incorrect classifications. This can be reduced inserting a bubble in the syringe to atenuate mechanical noises.
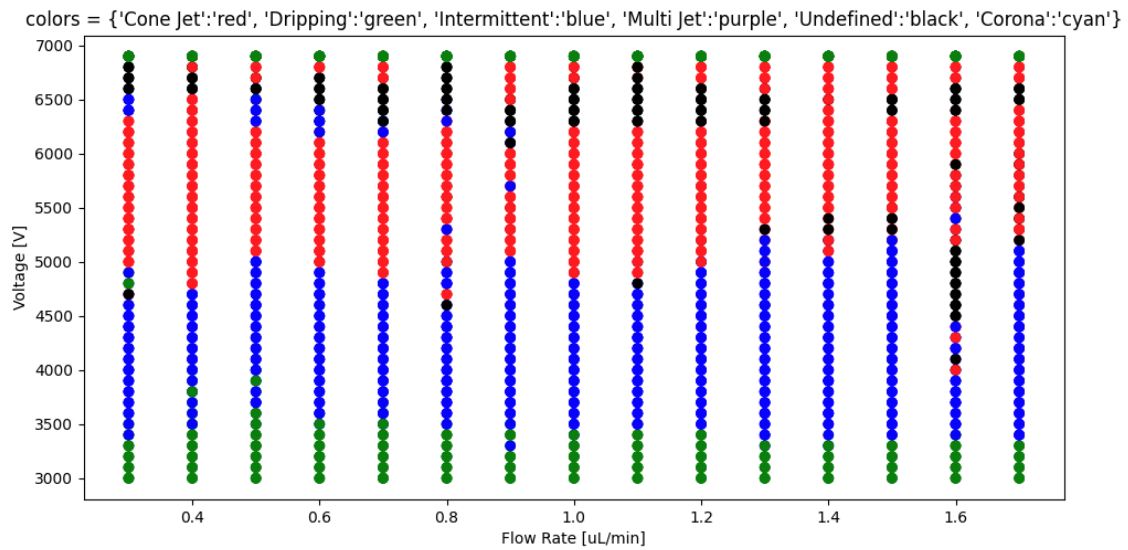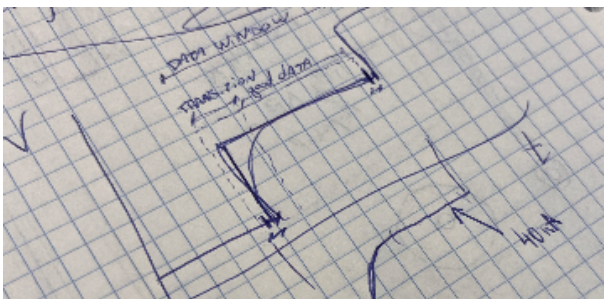

Figure 8: map3

3.3 Capacitance of the system in step response

We were discussing if the voltage step implies in a transient state in the current acquired. If yes, the data acquired in this transient should not be used in the classification step. Since we want to analise the spraying in a constant dynamics.

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For that I reproccessed all raw data acquired cutting the head of the data window. The new classification map is showed in the figure 10.
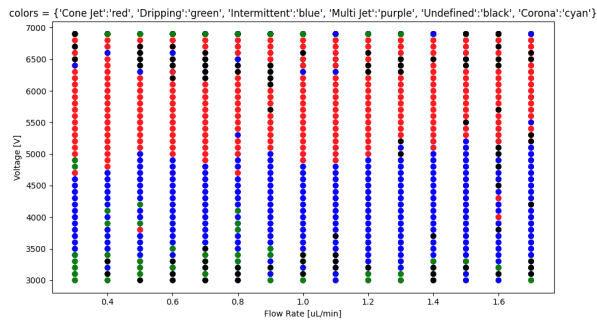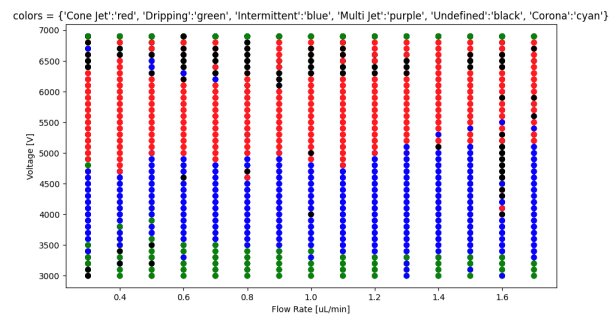

Figure 11: map reproccessed data tail
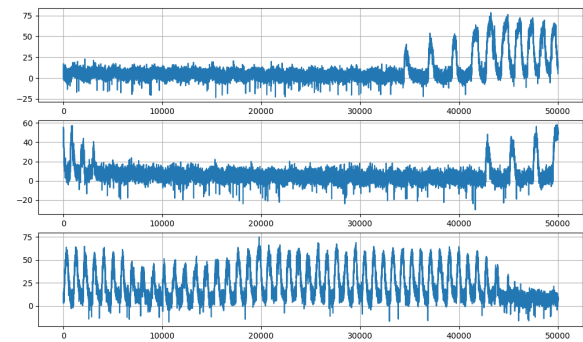

Figure 10: map3 reproccessed data head

Figure 12: USE ANOTHER IMAGE WITH STABLE SAMPLES OR DELETE THIS ONE

Also tested cutting the tail of the data window to see if have improvements in the classification.

TRY TO PUT STEP RESPONSE OF THE POWER SUPPLY HERE

CONCLUSION: Does not made much difference. For steps under 250V the system does not show a transition dynamic. With steps above 250V the capacitance of the system reacts with a capacitance curve.

3.4 Manual x Automatic Cone Jet stability island maps
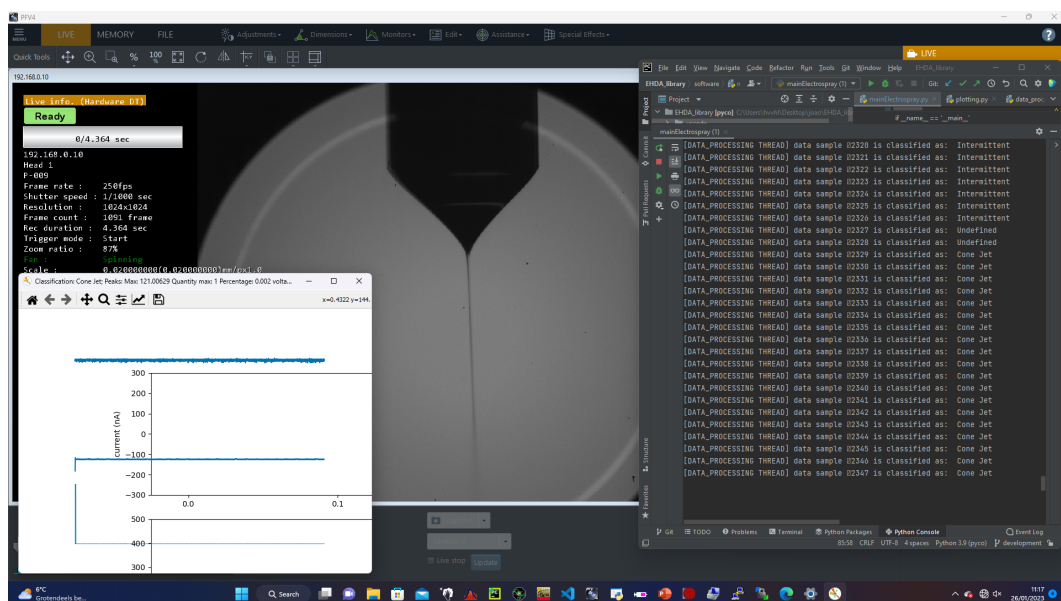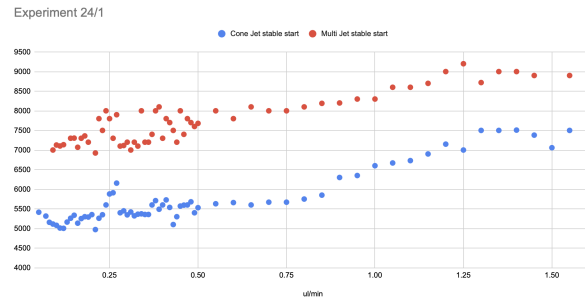
Metodology

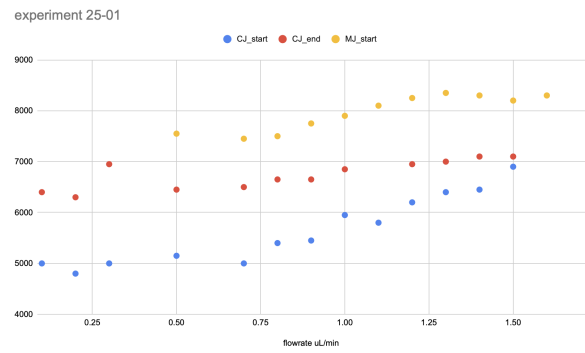

Figure 13: exp 24
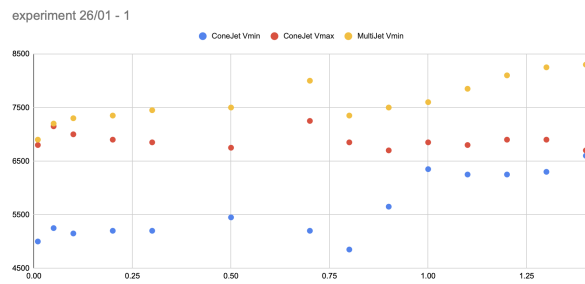
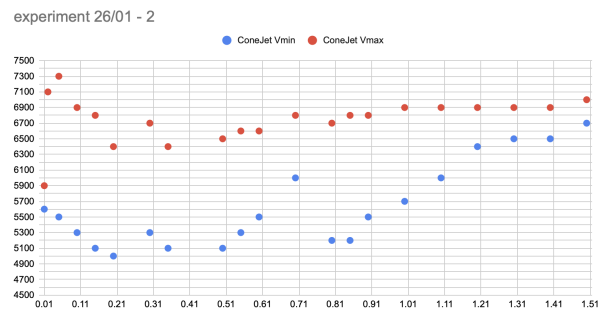Figure 14: exp 24

Figure 15: exp25-01-1

Figure 16: exp-26-01-1

Figure 17: exp-26-01-2

3.5 Temperature and Humidity influences

- Started collecting temperature and humidity values for each sample using arduino and DHT11 sensor from adafruit. - Closed the system and sprayed pure oxygen O2 to decrease the humidity of the system.

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3 Conclusion

Sjaak[1]

References

[1] S. Verdoold et al. "A generic electrospray classification". In: *Journal of Aerosol Science* 67 (2014), pp. 87–103. ISSN: 18791964. DOI: 10.1016/j.jaerosci.2013.09.008. URL: http://dx.doi.org/10.1016/j.jaerosci.2013.09.008.