Universidade Federal de Minas Gerais
Escola de Engenharia
Curso de Graduação em Engenharia de Controle e Automação

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

Relatório de Atividades 3
Projeto Final de Curso

Orientador: Vitor Angelo
Supervisor: Luewton L F Agostinho
Aluno: João Pedro Miranda Marques
Matricula: 2017050495

January 18, 2023

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.

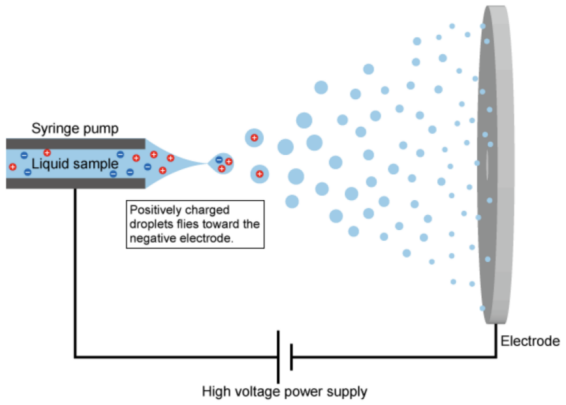

Figure 1: EHDA

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.

2 Metodology and Results

3 Conclusion

In this step of the project the python code was upgraded to optimize the data acquiring, processing and saving. Also started structuring the software to fit our control model. Initial experiments was made in order to evaluate the algorithm performance and intuitivity. With the data collect in those first experiments we can notice that:

- The algorithm is not capable of separating cone jet mode and multi jet mode.
- The algorithm is not capable of sepaating intermittend and dripping.
- It has noise in the current values which are not discovered yet.

As the method proposed by Sjaak[1] classifies each spraying mode using deviation/mean and mean/median relations, we can se in Figure 14 that the colors are well separated by certain deviation/mean range.

For next steps experiments will be done varying the step size and step time of the power supply to get a better undertanding in how the change in dynamics behave. It is already known that it needs an adapting time

to stabilize in a certain spraying mode. The next step will try to measure and understand this time. It is also known that the system has an histeses when changing between spraying modes. This is also another target for further studies.

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.