Optical Droplet Volume Detection

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In a range of industries, including the printing industry, there is an interest in measuring the volume of dosed fluids quickly, precisely and inexpensively. In this project, a method for quickly measuring the volume of high velocity, micro-liter sized droplets using an optical technique was explored. By monitoring the power of a laser beam after passing through the measurement field, the eclipsing effect of droplets in flight through the beam was measured.

Motivation

The current techniques used to characterize droplets generally employ a digital camera combined with a high speed flash to capture images of droplets in flight. Image processing algorithms then determine characteristics of the droplet, including volume. This technique works well, however the camera chip's read frequency is limited, with very high speed cameras quickly becoming prohibitively expensive. Additionally, the magnifying optics used in droplet cameras limit their field of view to a small window in space. These limitations significantly reduce the droplet rate and the number of simultaneous droplet sources which can be measured.
In this project the eclipsing effect of droplets passing through a laser beam was measured in conjunction with a measurement of the velocity of the droplet, removing several of the disadvantages of the camera based technique.

Goal

The goal of this project was the realization of a detector to amplify and measure changes in laser intensity, as well as the design of a digital system to acquire the measurements and use them to calculate droplet velocity and volume.

Realization

In the course of the project work new detector hardware was designed which included two photodiodes to measure the variations in light intensity. The two photodiodes are spatially separated allowing for the calculation of droplet velocity, used for the determination of droplet volume. The detector includes a dual channel 20 MSPS analog to digital converter to digitize the signal. The detector hardware was then coupled to a ZedBoard FPGA evaluation platform so that a digital system could be constructed to perform the necessary signal processing.
On the ZedBoard the acquired data was used to calculate droplet velocity using a cross correlation technique to find the time shift between the two signals. Finally, a simple geometric technique assuming rotational symmetry of the droplets allowed their volume to be calculated.

Results

The signals captured from the new detector hardware and digital system show qualitative geometric agreement with high speed video data. Droplet volumes calculated with the system also show strong correlation with values measured using other techniques.
The detector system has already been used successfully to measure droplet characteristics to determine the performance of fluid dosing micro-valves for an industry partner.

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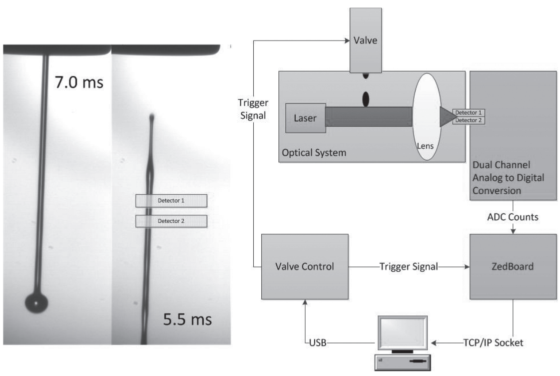
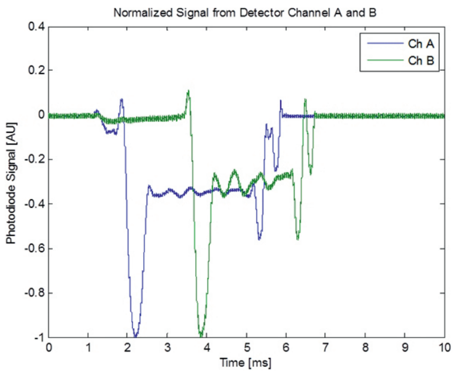


Right: The measurement system concept.
Left: Example images of a droplet in flight.



Detected data, acquired using the new system, from the droplet in the first image.