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Indirect Measurement of the Airflow Fed to a Flotation Device, through the Measurement of the Voltage Generated by a Photoelectric Cell

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Abstract: Virtual instrumentation for data acquisition through signal processing is a resource used for some years with reliable results, but with high costs. With the advancement of technology, the cost of sensors and software for instrumentation has become more affordable.

In this work, the relationship between the airflow fed through a sphere rotameter and the voltage generated by a photovoltaic cell was established, by capturing a certain beam of light emitted by a light source that passes through the laboratory flotation device in a water-air system, device used in extractive metallurgy for the recovery of mineral particles and where correct measurement of the feed air flow is operationally important. The experimental system was virtually instrumented using the LabViewTM2020® software and a DAQ card was used as an interface to transform the analog and digital signals.

The experimental results show that as the number of bubbles increases with the supplied airflow, due to gas dispersion interference, the photovoltaic cell receives less light intensity, increasing the difference between the supplied airflow and the estimated one through digital signals. From the above, the need to "calibrate" the signal received in the photovoltaic cell to correct the airflow measurements is established. Through the statistical analysis of the experimental data, the correlation equation that includes the manually fed and digitally sensed flows is proposed.

Keywords: Virtual instrumentation, DAQ, LabVIEW®, Flotation Column, Air dispersion.

Introduction

Virtual instrumentation for data acquisition through signal processing is a resource used for some years with reliable results, although expensive. With the advancement of technology, the cost of sensors and computer programs for instrumentation has decreased considerably.

The so-called DAQ cards are electronic systems capable of acquiring and transforming analog and digital signals so that they can be manipulated in a computer. LabView® (Laboratory Virtual Instrument Engineering Workbench),is a computer package for data acquisition through sensors, used by many industries, as well as educational, and research institutions. This program, developed by National Instruments (NI), is used to collect and display data; and offers extensive acquisition, analysis, and presentation capabilities in a single environment [1]; it is used because it has an intuitive and user-friendly environment, as seen in the different applications mainly in the metal-mechanical industry [1, 2, 3, 4, 5].

The common flow measurement methods used are through devices designed with traditional measurement principles: by volume, velocity, or ultrasound. In this particular case, the airflow measurement is done before entering the flotation systems; Due to the mineral and metallic components that interact in the system, this becomes complicated, so the aim is to measure the airflow by relating the voltage generated by a solar photocell, by passing a beam of light through the medium. The use of photovoltaic cells or the use of photon counters offers practical advantages over existing counters, such as compactness, since it is interconnected to the computer motherboard, in addition to low power consumption, high count rate, and ease of interconnection [5].

Based on the above, the objective of this work is to establish the feasibility of measuring the voltage generated in a photocell, by passing a beam of light through a fluid, as a reliable method to measure airflow; for example in a two-phase flotation system.

Experimental Procedure

A flotation cell of 0.1 m diameter and 0.2 m height was used, made of transparent acrylic material, with a cylindrical internal area and flat external walls. A porous stainless steel tube (0.025 m in diameter), with a nominal pore diameter of 5 micrometers (quoted by the manufacturer; Mott Manufacturing) was placed at the bottom of the cell. Compressed air was fed to the device through the disperser. All the experiments were run in triplicate. Figure 1 shows the experimental setup.

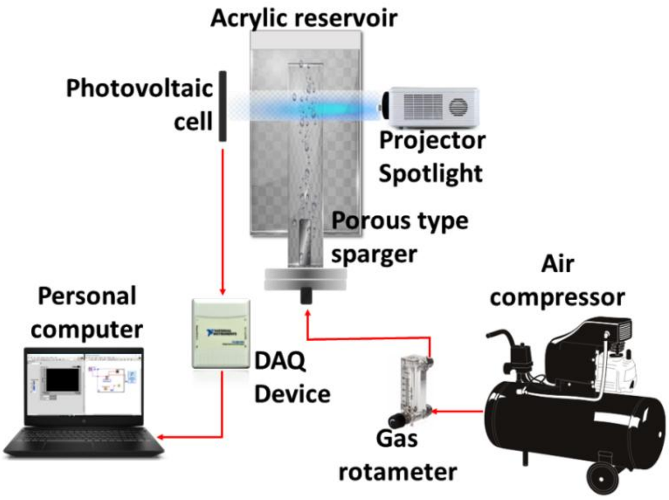

Figure 1 Experimental setup to measure the voltage generated in a photocell, and related to the airflow fed to the flotation device through a cylindrical stainless steel sparger.

To measure the different flow rates, a sphere rotameter was used with a measurement range of 1 to 10 L/min. The light beam was generated using a projector with a 170-watt, 2200-lumen lamp placed on the flat wall of the tank. A solar panel (photovoltaic cell) with dimensions of 0.06 m x 0.10 m, with a generation capacity of 6 volts, was placed on the flat wall at the other end of the tank. For the acquisition and processing of the voltage signal, a NI-USB-6008 card, developed by National Instruments, was used, receiving the signal from the solar panel and sending it to a computer through a USB port; the signal was processed using LabVIEW®; In this package, the routine for acquiring and saving the data in a file in ASCII format was programmed.

Figures 2 and 3 show the graphical interface and the programming panel, built-in LabVIEW®. The computer program was designed to obtain data every half second for 20 seconds, thus obtaining 40 voltage data for each supplied air flow (2, 3, 4, 5, 6, 7, and 8 L/min).

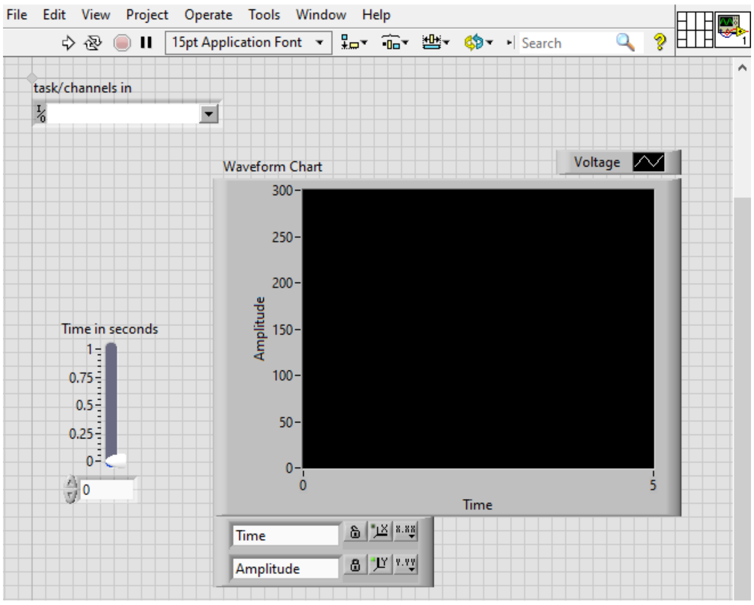

Figure 2 Graphical interface built in LabVIEW®, to monitor and store experimental results during simulations.

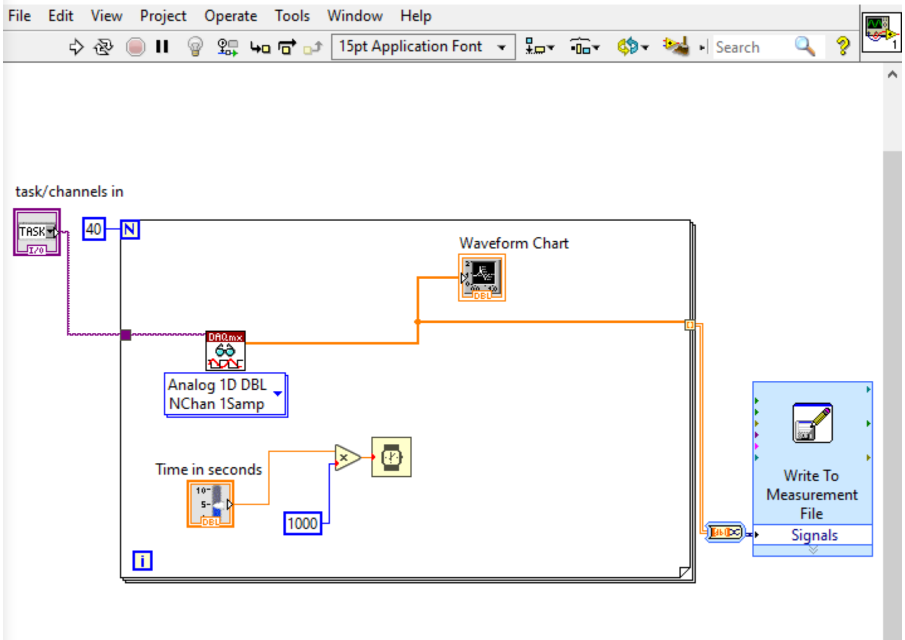

Figure 3 LabVIEW® programming panel with the signal conversion interface.

Results and Discussion

Table 1 shows the average values, as a result of all simulation runs. As can be seen, the voltage converted by the photocell is higher when no air is supplied to the flotation device, and it decreases drastically when the cell does not detect or receive the light beam, since there are interferences due to the amount of bubbles in the system, once the air is supplied.

Table 1 Averages of sensed voltage, with flow variation in clean water, and water mixed with potassium permanganate ($KMnO_4$).

Airflow, L/min	Voltage, mV
2	610
3	548
4	511
5	461
6	440
7	416
8	401

Figure 4 shows the variations of the measured voltage, as the number of bubbles increases due to the airflow fed to the flotation device. It is observed that turbidity in the system affects the actual voltage reading detected by the photocell, incorrectly estimating the fed airflow.

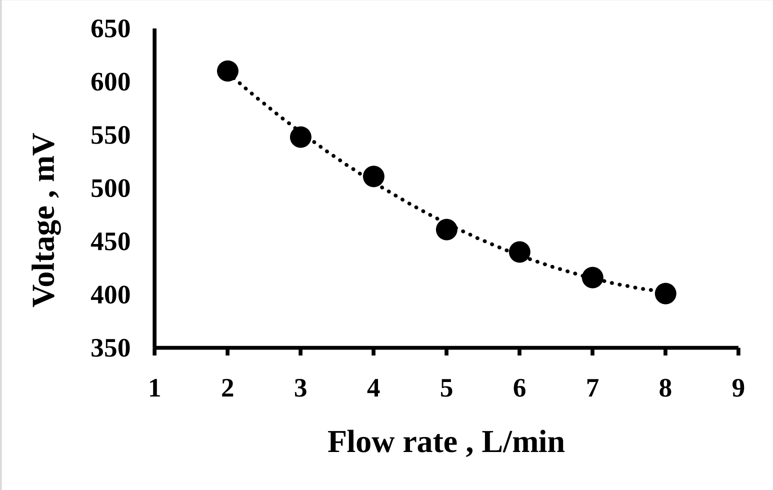

Figure 4 Graphic representation of the voltage signals for the different air flows. Each point is an average of three readings for each airflow value.

From the figure above, the voltage generated is higher in the case of only water, since the working principle of the solar panel is to force the electrons to move towards the opposite side of the material, instead of attaching to it, to produce the difference in potential and electrical tension between the two parts of the material; Therefore, the panel captures only photons of the visible light spectrum, and the darker the medium in which it is transported, it will not capture photons and there will be no voltage generation.

On the other hand, with the previous experimental data, it is possible to establish the relationship between the flow rates measured with the sphere rotameter, and the voltage drop received by the photocell, through the correlation equations shown in Figure 5; with this correlation observing a high correlation index (R^2),the flow value measured in the sphere rotameter is then corrected to obtain the real flow rate fed to the column, regardless of the degree of turbidity in the flotation system.

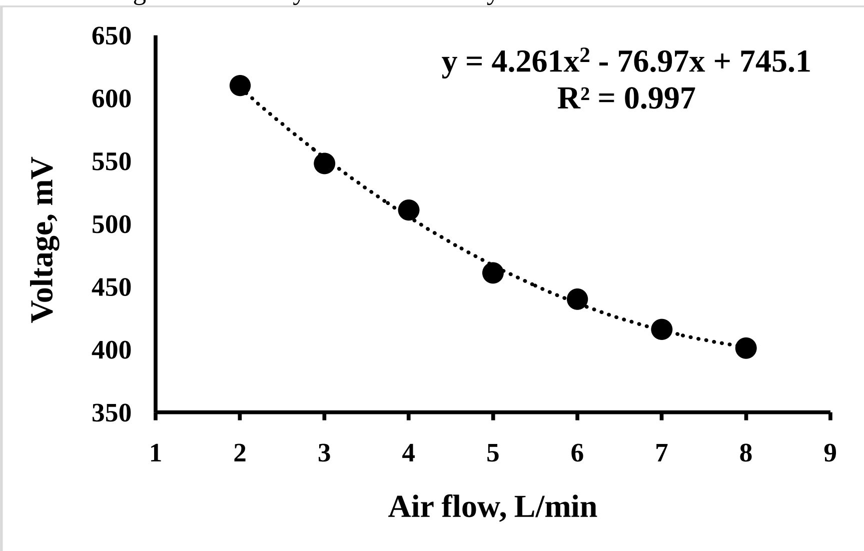

Figure 5 Correlation equation for the clean water-air system, for correction of the airflow fed to the flotation device.

Conclusions

From the experiments carried out to establish the relationship between the airflow fed to an aqueous system and the light beam sensed by a photovoltaic cell, the following conclusions are derived:

Turbidity in the system caused by the flow of bubbles when compressed air is injected into the system affects the actual voltage reading detected by the photocell, incorrectly estimating the fed airflow.

The proposed system to indirectly measure the amount of air fed to the flotation device is feasible, once the photovoltaic cell is “calibrated” for any particular system, such as the one presented in this work.

Acknowledgments

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Conflict of interest

The authors declare that there is no conflict of interest.

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