Low-Cost DIY Vane Anemometer based on LabVIEW interface for Arduino

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Abstract. An anemometer from low-cost materials in a DIY (Do it yourself) for the fabrication process was composed of a rotating vane (modified from cooler CPU) with speed sensor installed on it. The vane was connected to Arduino and controlled by LabVIEW program. This anemometer was called "Vane Anemometer based on LabVIEW interface for Arduino (VALA) model". The VALA was calibrated and compared with a hand-held standard anemometer (TECPEL model of AVM-702) for measurement of wind velocity of 0.6-4.7 m/s. The efficiency of the VALA was confirmed by the slope was 0.0052 which the blade was calculated to be 4.96 cm with the error of 0.8%. The VALA was low cost, thus it could become an easy-to-use fabricated DIY for application in Physics education lab in high schools.

1. Introduction

Wind speed measuring device is an important instrument to identify wind or gas properties. An anemometer is an ordinary weather station instrument for that purpose. The word is derived from the Greek word Anemos, meaning "wind". An anemometer was described for the first time around 1450 by Leon Battista Alberti. It has a variety of models; for example, cap anemometer, windmill anemometer, hot-wire anemometer, laser Doppler anemometer, sonic anemometer and vane anemometer [1,2]. In the present, the vane anemometers are normally used to measure velocity of air or gas substances at room temperature and determine the volume flow rate in various applications, such as mining ventilation systems, air or gas control systems in factories, smart farm system and meteorological measurement [1,2]. The sensing element is a vane rotor, of which the rotational speed is proportional to the velocity of the flowing air stream. It is different from other models and designed to be easy to use and carry. It can be used in physics classroom and laboratory (e.g. Bernoulli's. principle demonstration) to create understandable experiments that involve measuring the velocity of wind.

In this paper, an easy simple DIY fabrication [3] is described to demonstrate fabrication methods for a simple set of anemometer called Vane Anemometer based on LabVIEW interface for Arduino [4,5] (VALA) model. The VALA is suitable for teachers and students in high schools as it allows them to DIY the device by themselves to study Physics lab experiments regarding wind's nature. With this kind of activity-based learning (ABL) to create the VALA, it is aimed to help students to understand the Bernoulli's principle of the wind by self-experimentation.

2. Experimental setup and procedures

In figure 1, the VALA was composed of the rotating vane which was modified from the cooler CPU with the speed sensor (LM393 Comparator Speed Sensor Module or a FC-03 Infrared RPM) installed on it by DIY process. And, it was connected with Arduino board and controlled by LabVIEW program. Then, the VALA was calibrated and compared with a hand-held standard anemometer to measure the velocity of wind at 0.6-4.7 m/s which corresponds to the distance of 0.2-1.4 m from the wind source.

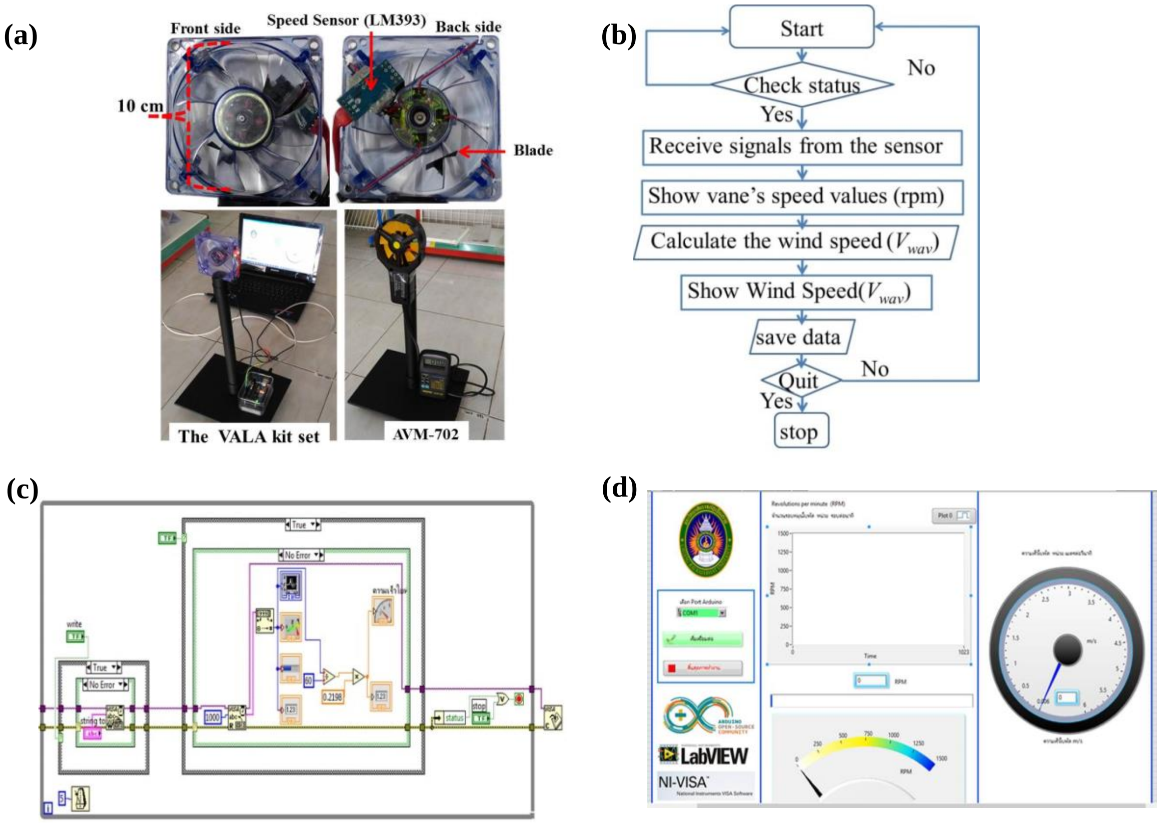

Figure 1. The rotating vane has front and back sides equipped with the speed sensor (LM393) and the blade on it. (a) Comparison between the VALA and AVM-702, (b) the flowchart in LABVIEW programming was designed to measure wind velocity (c) block diagram and (d) front panel.

3. Theoretical Background

The Disk actuator theory was explained by Rankine (1865) and Froude (1885) to provide an analytical means for evaluating ship propellers. It can explain how wind acts on the wind vane and how to calculate wind speed from rotation of the wind vane or idealized windmill. Based on the assumption, the infinitely thin vane offers no resistance to air passing through it, therefore the analysis is purely 1-D which thrust loading and velocity is uninformed on the vane, and far upstream and far downstream pressure is the freestream static pressure, viscous effects are not considered and incompressible. From the conservation of mass [6-9]

$$\rho A V_{w1} = \rho A V_{wav} = \rho A V_{w2} \tag{1}$$

where ρ is the fluid density, A is the area, V_{w1}, V_{wav} and V_{w2} are wind speed at the front, the middle and the back of the vane, respectively, we can write the angular momentum in term of pressure (P) and the pressure at the vane (P_V).

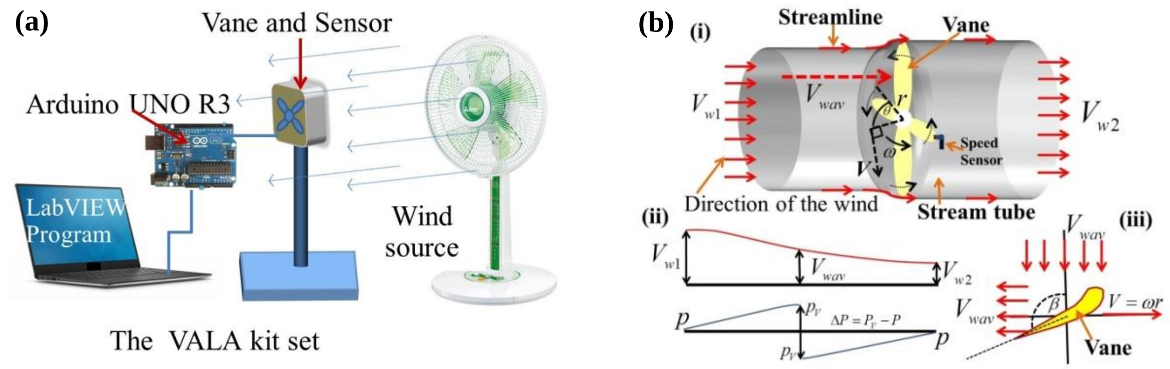

Figure 2. (a) Experimental set up of the VALA and (b) diagram of the direction that the controlled volume of the wind was percolated through the vane.

This leads to the assumption of equal wind speed and rotating blade speed. The rotating vane is modified from the cooler CPU and is designed to provide fast venting, so the wind speed of the rotating blades is close to the speed of the wind that flows through the vane. The vane has a twisting angle (β) at about 110-135 degrees to get wind. The direction of the wind speed (V_{wav}) is controlled by the twisting vane in the opposite direction to the velocity ($V = \omega r$) [10] as shown in figure 2 (b (iii)). So, we can find the wind speed equation,

$$V_{wav} \approx V = \omega r = \frac{2\pi}{T} r \tag{2}$$

where the blade rotates to pass the speed sensor (LM 393), and the angular velocity of sensor can be written as:

$$\omega = RPM \frac{2\pi}{60} \tag{3}$$

then,

$$V_{wav} = RPM \frac{2\pi}{60} r \tag{4}$$

4. Experimental results

The values of wind speed measured by the VALA were lower than those of AVM-702 anemometer, as shown in figure 3(a) that it was typically affected by many factors such as friction torque of CPU motor. To reduce the error of measurement, the VALA was calibrated in comparison with AVM-702 anemometer. The calibration curve of wind speed was shown in figure 3(b). After data correction of the wind speed of the VALA was added into the program, the efficiency of the VALA was confirmed by equation 4 to verify the relation between the wind speed and the revolution of motor (RPM). In figure 3(c), the slope was 0.0052 which was equal to $2\pi r / 60$. Then, the radius of the blade was calculated to be 4.96 cm with the error of 0.8%. It was equal to the radius of the actual rotor, so it could be a do-it-yourself craft for a standard wind gauge.

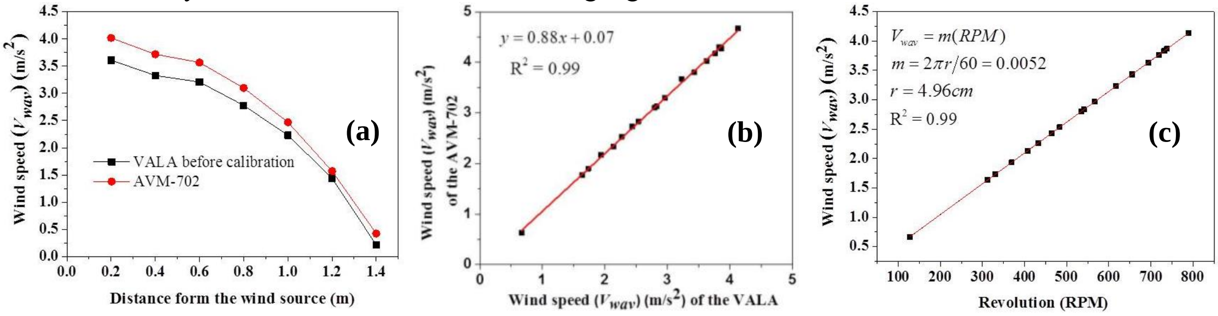

Figure 3. Graph showing wind speed in relation to distance from the wind source of VALA before calibration in comparison with AVM-702 (a). Values from standard anemometer (AVM-702) were calibrated and compared with values from constructed anemometer (the VALA) (b). Graph of wind speed and revolution confirmed by equation (4) (c).

5. Conclusions

Low-Cost DIY Vane Anemometer based on LabVIEW interface for Arduino was fabricated to provide simplicity as a key to an activity-based learning (ABL) lesson for both teachers and students despite of lacking expensive equipment in learning about the nature of wind in everyday life. From these VALA kits, a few experiments were carried out to demonstrate how these principles could be realized in the field. Further advanced experiments utilizing these kinds of VALA kits for meteorology applications could also be a challenge for them.

Acknowledgement

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