Factors in Choosing the Right Wind Sensor for your Application

WEATHER MONITORING

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The measurement of wind is one of the most important factors in weather prediction. Wind is the movement of air caused by uneven heating of the earth's surface. It occurs in light breezes that are locally generated due to heating of an immediate landmass, to winds on a grand scale spanning continents caused by solar heating. Besides being used as part of a weather monitoring station there are many other situations where knowledge of the wind condition helps in decision-making such as pollution control, safety of tall structures, control of wind turbines, studies on the effects of wind on crops, manovering of ships and aircraft landing systems. Wind speed is measured with an anemometer; the word anemometer comes from the Greek anemos meaning wind, plus meter.

Measurement Systems

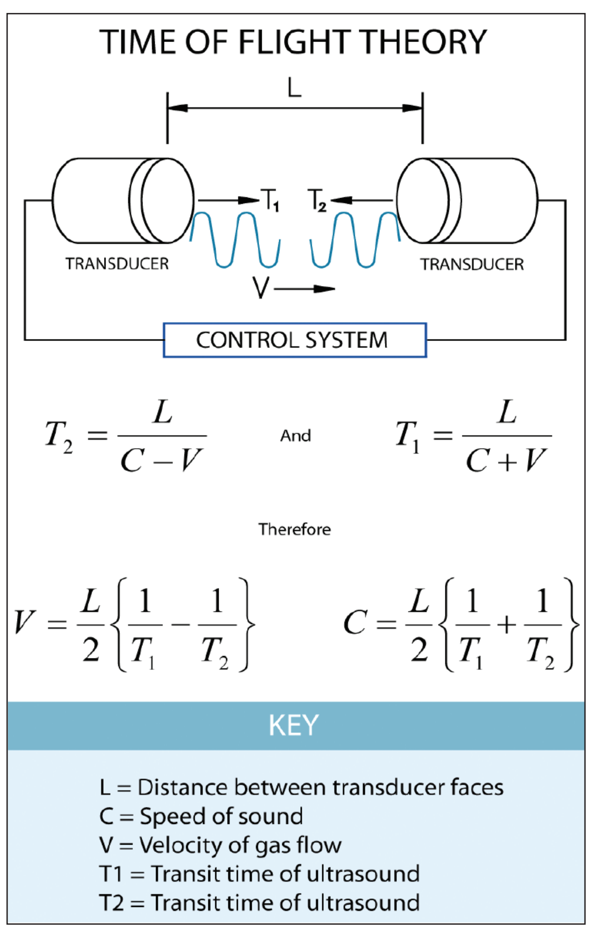
For many years mechanical cup and vane anemometers have been used to measure wind speed and direction. These are normally simple but effective tools with the cup measuring the speed and the vane the direction. Variants of the mechanical design also use a small propeller to measure the wind speed and both types of instruments are relatively inexpensive. However there are alternative technologies worthy of consideration. Over the last fifteen years ultrasonic and other solid-state techniques have come on onto the market. Of these the use of ultrasonics is dominant.

Ultrasonic anemometers have the advantage of having no moving parts and therefore they do not suffer bearing wear unlike mechanical devices. With reliable modern day electronics Ultrasonic anemometers are virtually fit and forget. Another advantage is that they have no initial friction to overcome before providing data. Ultrasonic anemometers are available in single axis, two axis and three axis variants. Single axis units will only measure the component of wind speed along the axis in which they are placed, two axis units measure the horizontal wind speed and direction, and three axis units measure three dimensional real time turbulence profiles.

Two axis ultrasonic anemometer.
Picture courtesy of Gill Instruments.

Ultrasonic technology relies on the measurement of sound waves between fixed transducers. A typical two-axis anemometer measures the times taken for an ultrasonic pulse of sound to travel from the North transducer to the South transducer, and compares it with the time for a pulse to travel from S to N transducer. Likewise times are compared between West and East, and E and W transducer. If for example, a North wind is blowing, then the time taken for the pulse to travel from N to S will be faster than from S to N, whereas the W to E, and E to W times will be the same. The wind speed and direction can then be calculated from the differences in the times of flight on each axis. This calculation is independent of factors such as temperature. Some ultrasonic anemometers also provide Speed of Sound and Sonic temperature outputs, these parameters are important in some research applications.

Another important factor in the use of the ultrasonic technique is that the instruments can provide inherent diagnostic capability. With a mechanical anemometer you do not know if it is not working or if there is no wind if zero wind is reported. With ultrasonic instruments you can provide a health check as part of the output stream.



When first introduced to the market Ultrasonic anemometers were relatively expensive and were used primarily by the research community or where high reliability was critical. However there are a number of two axis instruments available on the market that are comparable in price to professional quality cup and vane /propeller units, and ultrasonic anemometers are rapidly becoming the instrument of choice for all professional measurements. Electronic outputs from both mechanical and ultrasonic anemometers are available in a number of analogue and digital formats and so data can be sent to a wide range of recording instruments such as data loggers, digital displays, chart recorders or directly to a PC for viewing and archiving. Software is available from a number of manufacturers to achieve this. However anemometers will only measure wind speed and direction at the precise point where they are positioned. In some instances it is necessary to make wind measurements higher up in the atmosphere. This can be achieved in a number of ways but traditionally this involved the use of weather balloons and wind finding radar. There are also remote sensing systems now on the market that do not require the use of balloons. These instruments are known as SODARS (SOnic Detection And Ranging). Sodar systems are like radar (radio detection and ranging) systems except that sound waves rather than radio waves are used for detection. Sodar systems operate by sending an acoustic pulse and then analysing the return signals intensity and Doppler (frequency) shift as a function of time (and therefore altitude) to determine the wind speed, wind direction and turbulent character of the atmosphere. Sodar systems typically have maximum ranges varying from a few hundred metres up to several hundred metres or higher. Maximum range is typically achieved at locations that have low ambient noise and moderate to high relative humidity.

Anemometer Applications

There are many different anemometer models on the market and selecting the correct one for your application can be difficult. It is therefore essential to fully understand the environment that exists where you intend to make the measurements. The instrument may need to measure and survive high wind speeds and so needs to be mechanically robust. They may also need to operate in very cold and icy conditions and to achieve this heated variants are available. Corrosion resistance may also be important in offshore and certain industrial applications. There are also instances in potentially hazardous environments such as on oilrigs or within refineries where instruments certified as Intrinsically Safe in accordance with the ATEX directive are required; these instruments are available from certain manufacturers. As well as their use as part of a weather station anemometers are also used to make air flow measurements to control ventilation in buildings and road tunnels.

One application has been responsible for an increasing demand for reliable wind speed and direction measuring instruments. With the drive to reduce greenhouse gas emissions from burning fossil fuels thousands of wind turbines have been erected. These are large structures and to produce enough electricity many turbines are placed in close proximity on wind farms. These are intrusive on the local environment and are therefore often placed in fairly remote locations and even offshore. However before erecting a wind farm it is important that the right site is selected. These sites are invariably financed on the basis of a return on investment, and this calculation requires extensive information on how much wind will be available all year round. Errors in this prediction can have an enormous effect on the amount of electricity produced and the viability of the investment. For this reason the potential sites are surveyed for long periods to assess the amount of wind available. Large towers are erected with many anemometers mounted at varying heights to collect data. Consequently selecting the right instrument is paramount, it would be very unfortunate if the wrong instrument was selected and a large amount of data was lost.

Typical array of two axis and three axis anemometers.
Picture curtsey of Gill Instruments.

Once the site has been selected the anemometers then have another important application. The wind turbines need to be steered into the wind and the blades controlled according to the wind strength. To achieve this task anemometers are placed at the very top of the turbine. In this situation reliability is key, consequently anemometers need to be chosen with the least amount of maintenance necessary.

Earlier in the article it was mentioned that three axis anemometers were available for measuring wind turbulence. This information needs to be available in a number of situations such as airport landing systems, monitoring around building structures and long bridges. However a little known requirement except among the scientific community relies on the measurement of minute levels of wind turbulence. The measurement of weather not only relies on measurements at particular points but also researchers need to know how these conditions arose. Various techniques used to assist in these studies rely on the measurement of surface fluxes of heat momentum, carbon dioxide and water vapour. The most common technique to measure these fluxes is the Eddy Correlation technique. To make these measurements you need at least an infa-red gas analyser and an anemometer capable of monitoring wind in the vertical and horizontal axis, with a fast response above 20 Hz. Three axis anemometers are available with data rates up to 100Hz,and extensive networks have been set up world wide to study important ecosystems which contribute to the carbon cycle.

These systems are controlled by specially written software that calculates the surface fluxes of momentum, sensible and latent heat and carbon dioxide.

Conclusion

Selecting the correct anemometer for an application is vital if data is not to be lost. Ensure that you discuss your application with the manufacturer. He can guide you to the correct instrument. What might seem the cheapest instrument may not be the correct choice. Professional/industrial wind speed and direction instruments start from several hundred dollars, rugged versions are more expensive, but a trip to a site in a remote location to fix a problem will far exceed the initial cost. Also think about the through life cost of ownership. Regular calibration and maintenance can also cost more that the initial purchase price, especially if you intend to keep the instrument for up to 10 years.

Typical Eddy Correlation site.
Picture courtesy of ADC BioScientific.

Ian Bywaters has been involved in the environmental measurement and control industry for the last 25 years. He has a wide experience in engineering design, product specification and sales. He is employed by Gill Instruments as their Sales Manager, responsible for the sales department. Gill Instruments are the world leaders in Ultrasonic anemometers, which they sell world wide through their extensive sales and distribution network

New SPN1 Sunshine Pyranometer

The new Sunshine Pyranometer type SPN1 measures sunshine duration, plus global (total) and diffuse radiation – all in one instrument! It is easy to use, works at any latitude and needs no routine adjustment or polar alignment.

The SPN1 is a meteorological class instrument designed for long-term outdoor exposure, and is an affordable alternative to traditional shade-ring pyranometers, the Campbell-Stokes and other sunshine recorders. It also provides some of the functionality of expensive pyrheliometers but without the complications of shadow bands and motorised tracking.

The Sunshine Pyranometer uses a patented array of thermopile sensors and a computer-generated shading pattern to measure the direct and diffuse components of incident solar radiation. The shading pattern and thermopiles are arranged so that at least one thermopile is always fully exposed to the solar beam, and at least one is fully shaded from it, regardless of the position of the sun in the sky. A microprocessor derives the global and diffuse radiation values, which allows an estimate of the direct beam, and hence sunshine hours, to be calculated.

The Sunshine Pyranometer is protected by patents EP 1012633 & US 6417500. The Sunshine Pyranometer provides 2 voltage outputs for global and diffuse energy, and a digital output of sunshine state for data logging. Delta-T's low cost logging solution for the SPN1 is the GP1 Data Logger. The WMO defines the sunshine threshold as 120 W.m-2 in the direct beam. The SPN1 estimates sun hours to within a few percent of the WMO standard. Researchers working in countries that have adopted different sunshine threshold levels should contact **Delta-T** (UK) with details of their requirements. The SPN1 has a precision ground glass dome and uses wideband thermopile sensors; it achieves a near ideal spectral and cosine response. The internal heater keeps the Sunshine Pyranometer clear of dew, ice and snow down to –20°C, ensuring reliable readings in difficult climatic conditions. The Sunshine Pyranometer is a high performance instrument offering a unique combination of solar radiation measurements in a single, low maintenance device.
The SPN1 will be released this summer.

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New Radiation Shield From Environmental Measurements

The new NFS1 from **Environmental Measurements** (UK) is a combined fan and naturally aspirated radiation sensor shield for use with temperature humidity probes. The design of the NFS1 is based on the highly successful SS1 radiation sensor shield and is of a similar multi-plate construction. The plate profiles are shaped to allow the minimum restriction of airflow while providing the necessary shielding from solar radiation and precipitation. The NFS1 shield also has a fan fitted between the top plates to assist with air flow when wind speed is low. The fan may be powered continuously or, when used as part of a weather station fitted with an anemometer, can be turned on at low wind speeds to assist the natural flow of air through the shield and thereby reduce any temperature errors. At higher wind speeds the fan can be turned off and the shield used in naturally aspirated mode thereby saving power. The larger top plates also provide extra protection against temperature rise from direct solar radiation and ensure the exhaust airflow is dispersed away from the inflow.

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