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Application of humidity sensors and an interactive device

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Abstract

In many applications, sensors (e.g., temperature, humidity and chemical composition) are used downstream of passive interactive devices to determine their transient response. In this arrangement, the sensors alter the apparent response of the device. As a practical example, the transient characteristics of a humidity sensor are investigated during a step change in humidity with no change in temperature. This response of the humidity sensor is measured for a step change in the humidity and the data are correlated with exponential functions with two time constants of about 3 and 100–300 s. When the same humidity sensor is used downstream of an interactive passive moisture transfer device (e.g., a regenerative wheel for transferring water vapour), the measured humidity is found to correlate with exponential functions with longer time constants than the sensor itself. In this case, the measured response of the sensor includes the combined effects of the device and sensor. An analysis is presented to determine only the transient moisture transfer characteristics of the unknown device using the measured responses of the sensor alone and the response of sensor with the device upstream. The time constants of the interactive device may have errors as large as 20% when the transient response of the humidity sensor is neglected for the application studied in this paper.

Keywords: Humidity sensor; Transient response; Moisture transfer; Adsorption; Desorption

1. Introduction

Many research papers have been published on the transient characteristics of sensors (e.g., for humidity [1–4] and temperature [5], which have been calibrated at equilibrium conditions. The calibration of electronic humidity sensors [6,7] at steady-state equilibrium conditions is a well known procedure. Often a chilled mirror sensor and/or saturated salt solutions are used as transfer standards to determine the bias uncertainty of humidity sensors. Calibration over a range of relative humidity gives the steady-state bias uncertainty of the sensors. This equilibrium bias uncertainty of many electronic humidity sensors can often be reduced to less than ±2%RH (ASME PTC 19.1-1998) uncertainty in the relative humidity range of 5–95%. When transient changes in humidity or temperature occur for such a sensor, the time response characteristics of the sensor must be determined by separate tests.

This paper investigates this transient humidity step change characteristics for a humidity sensor during isothermal conditions because changes in air temperature alter these characteristics. In this research, an experimental facility is constructed to investigate the transient response of humidity sensors and in separate tests the same sensors are used with an upstream interactive device that absorbs or desorbs water vapour. The passive interactive device studied in this paper is the porous matrix of an energy wheel, which transfers heat and water vapour and is made of aluminium foil coated with a molecular sieve desiccant and has significant moisture storage capacity [8]. An initially steady-state inlet condition followed by a transient step change in operating conditions is used to determine the relative humidity response for both the sensor by itself and an interactive device upstream from the sensor. This paper presents a new analysis to predict the transient response of the device alone. This analysis, presented for humidity sensors downstream of a passive interactive device, is expected to be applicable to temperature sensors and chemical composition sensors downstream of interactive devices. In addition, over damped sensors such as some pressure and electrical signal sensors may behave in the same manner when downstream of an interactive passive device, so a similar analysis will apply.

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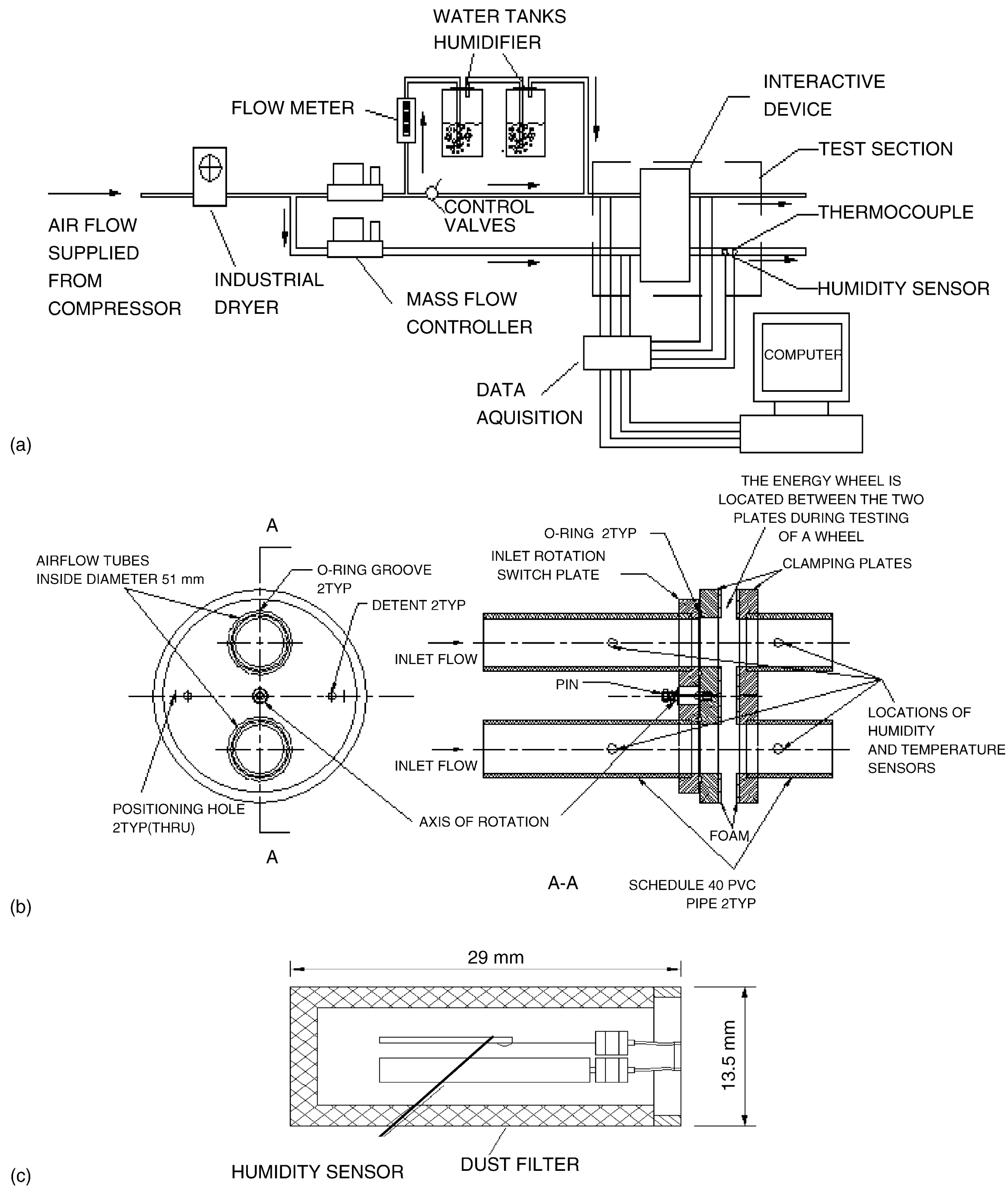

Fig. 1. Schematic showing (a) air flow lines, instrumentation and test interactive device, (b) the test section with its rapid rotation switch plate for the two inlet flow tubes, and (c) humidity sensor cross-section.

2. Test facility

The test facility is shown schematically in Fig. 1(a). This test facility is designed to first obtain the transient response characteristics of the sensor and then to measure the transient response characteristics of the interactive device using the sensor downstream of the device. To facilitate a step change of humidity, a special device is designed and constructed which permits the rapid interchange of the location of the inlet flow tubes as shown in Fig. 1(b). At the time or instant of the step change, the two inlet tubes are rapidly interchanged by means of the 180° rotation of a switch plate shown in Fig. 1(b) and photographed in Fig. 2. Figs. 1(b) and 2 show the testing of the humidity sensors and Fig. 1(a) shows the testing of the interactive device (i.e., energy wheel) located upstream of the outlet humidity sensor. The Vaisala Type HMP230 capacitance humidity sensor used is shown in cross-section in Fig. 1(c).

Air supply for the experiment is provided by an air compressor with a large storage tank. Compressed air is passed through an industrial dryer, which reduces the inlet air relative humidity