LVDT Based Absorption Hygrometer

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Abstract— It works on principle of moisture measurement, when it subjected to environment the hair like hydroscopic materials absorbs the moisture present in air and contracts, by the contraction of hydroscopic material the mechanical linkage provided reciprocates LVDT transducer such that the linear displacement of soft core of LVDT varies in voltage, this induced voltage is collaborated as readings on digital indicating guage such that water vapour present in the air is measured.

Key words: LVDT, Hygrometer

I. INTRODUCTION

An hygrometer is an instrument used for measuring the water vapor in the atmosphere. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. By calibration and calculation, these measured quantities can lead to a measurement of humidity. Modern electronic devices use temperature of condensation (the dew point), or changes in electrical capacitance or resistance to measure humidity differences.

Generally hygrometers are classified in two types

1) Mechanical humidity sensing absorbtion hygrometer
2) Electrical humidity sensing absorbtion hygrometer.

The Operating principle of mechanical hygrometer involves the change of linear dimensions of some hydroscopic material like wood, paper, human hiar, animal skin, etc., when they absorb moisture from atmosphere. This varaiation in linear dimensions is used to measure the humidity present in atmosphere.

Coming to electrical absorption hygrometer it consists of two electrodes coated with hugroscopic salt. It is lithium chloride conductor and as acts as humidity sesing element .The leads of two electrodes are connected in one arm of balanced wheatstone bridge circuit. when electrodes placed in atmosphere the lithum chloride absorbes moisture and resistance of lithium chloride conductor changes by this value is indicated on indicating guage.

Basing on this two types of hygrometers to increase effective working and reduce frictional losses in mechanical hygrometer, LVDT based absorption hygrometer is developed with maximum accuracy and precision.

II. PROBLEM IDENTIFICATION

1) Frictional lossess in mechanical hygrometer
2) To increase accuracy of hygrometer
3) Increase rate of response

A. Solution to the problem

1) In this LVDT based hygrometer the rate of time response is high.
2) The problem of friction is reduced.
3) Accuracy is increased.
4) Independent of environmental conditions.

III. WHAT IS LVDT?

The name linear variable differential transformer (LVDT) is also called as, linear variable differential transducer, It is a type of electrical transformer used for measuring linear displacement (position).

LVDTs are robust, absolute linear displacement transducers; inherently frictionless, they have a virtually infinite cycle life when properly used. As AC operated LVDTs do not contain any electronics, they can be designed to operate at cryogenic temperatures or up to 1200 °F (650 °C), in harsh environments, under high vibration and shock levels. LVDTs have been widely used in power turbines, hydraulics, automation, aircraft, satellites, nuclear reactors, and many others. These transducers have low hysteresis and excellent repeatability,

The LVDT converts a position or linear displacement from a mechanical reference (zero, or null position) into a proportional electrical signal containing phase (for direction) and amplitude (for distance) information. The LVDT operation does not require an electrical contact between the moving part (probe or core assembly) and the coil assembly, but instead relies on electromagnetic coupling.

A. General review of LVDT based hygrometer

The invention related to absorption type hygrometer as particular application of measurement of water vapour in the air, this hygrometer consists of mechanical and electrical linkage in this hygrometer the hair like hydroscopic material is placed for absorption of moisture or water vapour present in the air. when it absobs the moisture it tends to contract by which the mechanical linkage moves or reciprocates the arm, to regain the position a tension spring is placed between pivoted arm and linkage of the LVDT soft core.

When the hydroscopic material absorb moisture then the mechanically pivoted arm linkage reciprocates linearly such that LVDT soft core is pulled from null position between primary and secondary coils depending upon voltage induced the readings are taken on indicating guage.

IV. THE PARTS USED IN LVDT ABSORPTION HYGROMETER

1) Humidity senosor(hair)
2) Pivoted arm
3) Steel thin connecting link
4) Tesion spring
5) Linear variable diffential transformer
6) Digital indicating guage

A. Description of Important Parts

1) Humidity Sensing Element (Hair):

The sensing element (hair) works on the principle of Hygroscopy. It is the phenomenon of attracting and holding water molecules from the surroundings, which is usually at normal or room temperature. This is achieved through either absorption or adsorption with the absorbing or adsorbing substance becoming physically changed somewhat. This could be an increase in volume, boiling point, viscosity, or other physical characteristic or property of the substance, as water molecules can become suspended between the substance's molecules in the process.

Hygroscopic substances include cellulose fibers such as (paper), sugar, caramel, honey, glycerol, ethanol, wood, methanol, sulfuric acid, many fertilizer chemicals, many salts (including sodium chloride), and a wide variety of other substances

Zinc chloride and calcium chloride, as well as potassium hydroxide and sodium hydroxide (and many different salts), are so hygroscopic that they readily dissolve in the water they absorb: this property is called deliquescence. Not only is sulfuric acid hygroscopic in concentrated form but its solutions are hygroscopic down to concentrations of 10% v/v or below. A hygroscopic material will tend to become damp and cakey when exposed to moist air (such as the salt inside salt shakers during humid weather).

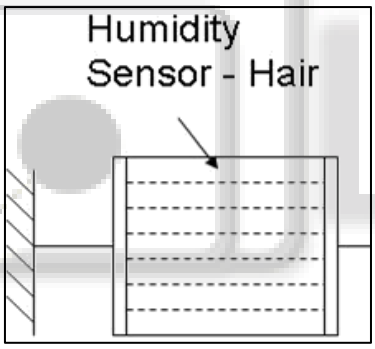


Fig. 4.2.1: humidity sensor (hair)

This humidity sensor is fixed at one end and linked pivot arm at another end.

2) Pivoted ARM:

Pivoted arm a short shaft or pin supporting something that turns fulcrum, the end of a shaft or arbor that terminates in a bearing.

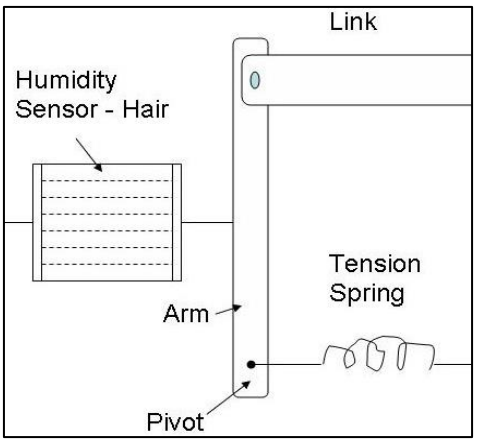


Fig. 4.2.2: pivoted arm

This arm pivoted at its one end and usually supports to connect the linkage between humidity sensor and LVDT soft core with attachment of tension spring at bottom of arm to regain its orginal position after humidity sensor expands.

3) Tension Spring:

Tension springs are tightly wound coils that are designed to operate with tension. The spring stretches to a specific length as the load/force is applied to it. In an unloaded position, the loops of the spring are touching, with either a loop or hook attached at one end, and it is when this attachment is directed with force that the spring stretches. When these components are pulled apart, usually from either side, the spring tries to hold itself together, causing the springing action, until the force is stopped and it can return to its original form.

As long as not stretched or compressed beyond their elastic limit, most springs obey Hooke's law, which states that the force with which the spring pushes back is linearly proportional to the distance from its equilibrium length.

$$F = -kx,$$

Where

x is the displacement vector – the distance and direction the spring is deformed from its equilibrium length.

F is the resulting force vector – the magnitude and direction of the restoring force the spring exerts.

k is the rate, spring constant or force constant of the spring, a constant that depends on the spring's material and construction. The negative sign indicates that the force the spring exerts is in the opposite direction from its displacement

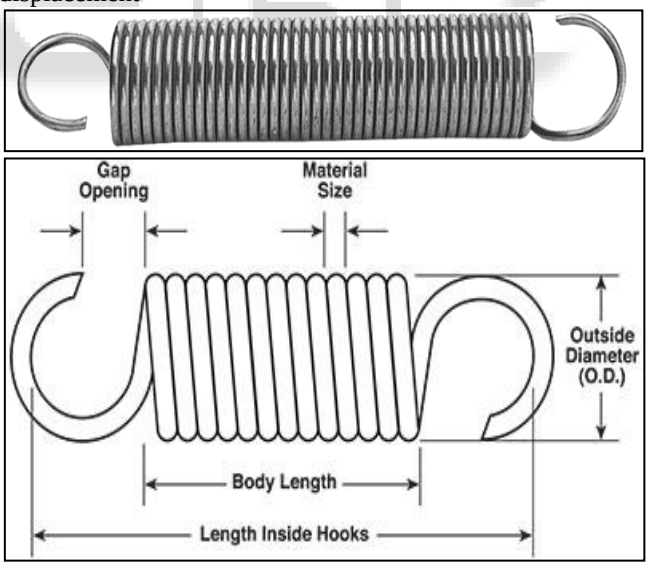


Fig. 4.2.3: Tension spring

Body length=25mm

Outer diameter=3mm

Material size= .125mm

The use of tension spring in hygromter is to regain pivoted arm orginal position after expansion of humidity sensor/.

4) Steel Thin Connecting Link:

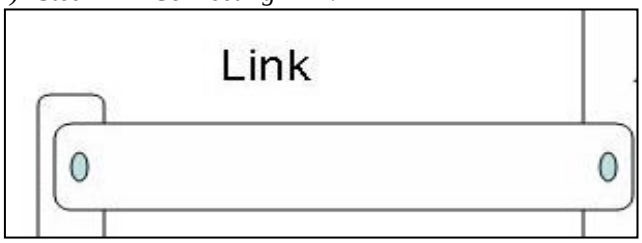


Fig. 4.2.4: steel thin connecting link

This link connects the pivoted arm top edge and LVDT soft core, such that when humidty sensor by absorbing moisture it contracts and pulls the pivoted arm by this connected link moves forward which makes linear displacement in LVDT soft core circuit.

5) Linear Variable Differential Transformer (LVDT):

The linear variable differential transformer has three solenoidal coils placed end-to-end around a tube. The center coil is the primary, and the two outer coils are the top and bottom secondaries. A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube. An alternating current drives the primary and causes a voltage to be induced in each secondary proportional to the length of the core linking to the secondary. The frequency is usually in the range 1 to 10 KHZ

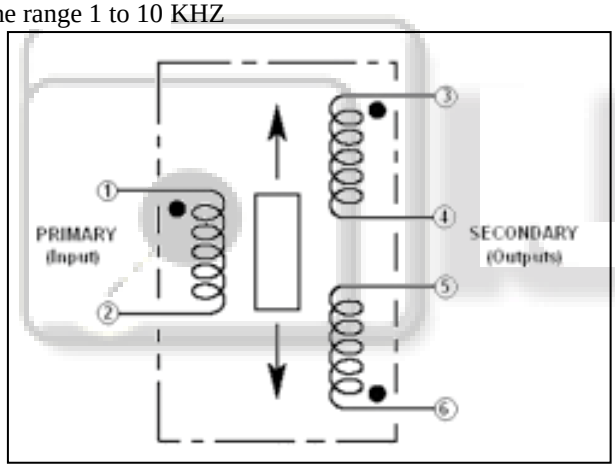
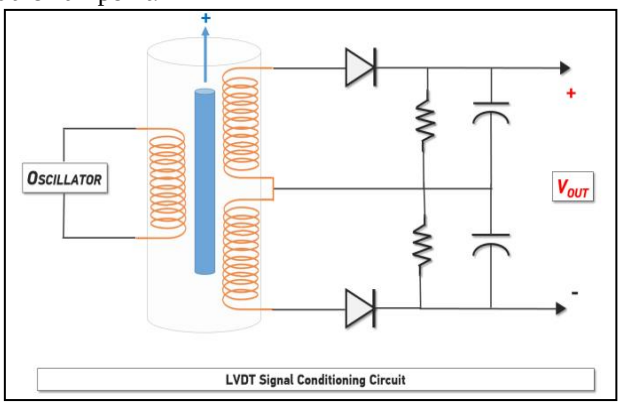


Fig. 4.2.5: Linear variable transformer

As the core moves, the primary's linkage to the two secondary coils changes and causes the induced voltages to change. The coils are connected so that the output voltage is the difference (hence "differential") between the top secondary voltage and the bottom secondary voltage. When the core is in its central position, equidistant between the two secondaries, equal voltages are induced in the two secondary coils, but the two signals cancel, so the output voltage is theoretically zero. In practice minor variations in the way in which the primary is coupled to each secondary means that a small voltage is output when the core is central.

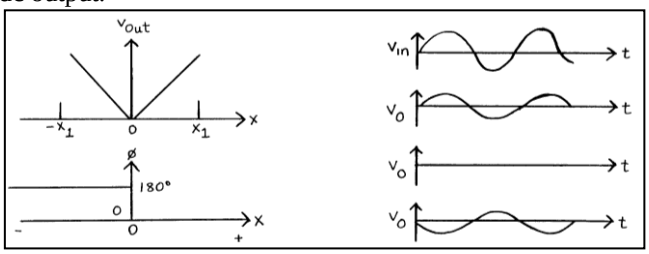
This small residual voltage is due to phase shift and is often called quadrature error. It is a nuisance in closed loop control systems as it can result in oscillation about the null point, and may be unacceptable in simple measurement applications too. It is a consequence of using synchronous demodulation, with direct subtraction of the secondary voltages at AC. Modern systems, particularly those involving safety, require fault detection of the LVDT, and the normal method is to demodulate each secondary separately, using precision half wave or full wave rectifiers, based on op-amps, and compute the difference by subtracting the DC signals. Because, for constant excitation voltage, the sum of the two secondary voltages is almost constant throughout the operating stroke of the LDVT, its value remains within a small window and can be monitored such that any internal failures of the LVDT will cause the sum voltage to deviate from its limits and be rapidly detected, causing a fault to be indicated. There is no quadrature error with this scheme, and the position-dependent difference voltage passes smoothly through zero at the null point.



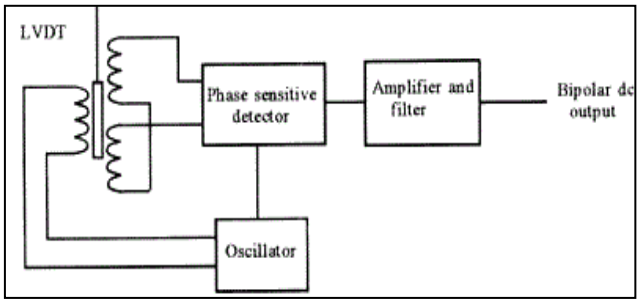
Where digital processing in the form of a microprocessor or FPGA is available in the system, it is customary for the processing device to carry out the fault detection, and possibly ratiometric processing to improve accuracy, by dividing the difference in secondary voltages by the sum of the secondary voltages, to make the measurement independent of the exact amplitude of the excitation signal. If sufficient digital processing capacity is available, it is becoming commonplace to use this to generate the sinusoidal excitation via a DAC and possibly also perform the secondary demodulation via a multiplexed ADC.

When the core is displaced toward the top, the voltage in the top secondary coil increases as the voltage in the bottom decreases. The resulting output voltage increases from zero. This voltage is in phase with the primary voltage. When the core moves in the other direction, the output voltage also increases from zero, but its phase is opposite to that of the primary. The phase of the output voltage determines the direction of the displacement (up or down) and amplitude indicates the amount of displacement. A synchronous detector can determine a signed output voltage that relates to the displacement.

The displacement noted in the form of Core at centre, core at right, core at left has it is calculated by phase sensistive detector then it is amplified and filtered as bipolar dc output.



LVDT Output signal



LVDT signaling block diagram

6) Digital Indicating Guage:

It is a digital voltage measuring instrument in which voltage is collaborated into values i.e water vapour present in air.

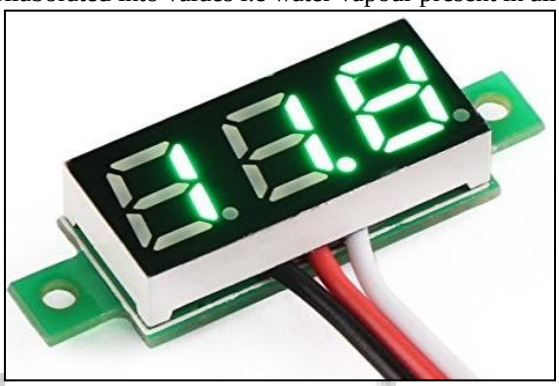


Fig. 4.2.6: indicating guage

The output voltage from LVDT amplifier is filtered as bipolar dc and this dc volatage is measured by digital indicating guage which is then collaborated as moisture value present in the air.

V. BLOCK DIAGRAM OF WORKING MODEL

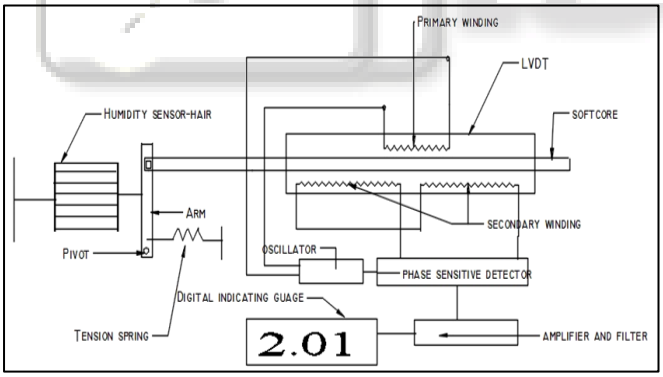


Fig. 5.1: block diagram of LVDT based absorbtion hygrometer

A. Advantages

1) High degree of accuracy.
2) Simple in construction.
3) Frictional losses is less.
4) Rate of response is high.

B. Disadvantages

1) Required electricity for operation.
2) Initial cost is high.

VI. CONCLUSION OF PAPER

In this rapid growing world need of technology development and increase in accuracy of adopted technology. Thus LVDT based hygrometer measures the moisture in the air accurately and rate of response of this device is high such that it gives exact results which is most important in measurement of water vapour in air.

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