A

Seminar report

On

Transducers

Submitted in partial fulfillment of the requirement for the award of degree
Of Bachelor of Technology in Mechanical

SUBMITTED TO:
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Preface

I have made this report file on the topic **Transducers;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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1. Abstract

Transducers are electric or electronic devices that transform energy from one manifestation into another. Most people, when they think of transducers, think specifically of devices that perform this transformation in order to gather or transfer information, but really, anything that converts energy can be considered a transducer.

Transducers that detect or transmit information include common items such as microphones, Geiger meters, potentiometers, pressure sensors, thermometers, and antennae. A microphone, for example, converts sound waves that strike its diaphragm into an analogous electrical signal that can be transmitted over wires. A pressure sensor turns the physical force being exerted on the sensing apparatus into an analog reading that can be easily represented. While many people think of transducers as being some sort of technical device, once you start looking for them, you will find transducers everywhere in your everyday life.

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1. INTRODUCTION

There are two methods of measurement of any physical quantity

1) The direct method and

2) The indirect method.

In the direct method any physical quantity like length, mass, etc are measured directly by some instruments like the measuring tape, weighing scale etc. In the indirect method of measurements some transducing devise, called transducer, is used, which is coupled to a chain of the connecting apparatus that forms the part of the measuring system. In this system the quantity which is to be measured (input) is converted into some other measurable quantity (output) by the transducer.

Definition:-

Transducers are the mechanical, electrical, electronic, or electromechanical devices that convert one form of the energy or the property that cannot be measured directly into the other form of energy or property that can be measured easily. The signal given to the transducers is called as input , this is the parameter that is to be measured but cannot be measured directly. The signal obtained from the transducer is called as output, which can be measured easily.

The transducer selected for the measuring system is such that the output obtained is proportional to the input. Since the output can be measured easily by the available instruments, the scale can be calibrated between the values of the output and the input. From this calibration, for all the values of the output the input value i.e. the parameter or physical quantity to be measured can be obtained easily.

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2. What are Electrical Transducers?

The transducers that convert the mechanical input signals of the physical quantity into electrical output signals are called as electrical transducers. The input given to the electrical transducers can be in the form of the displacement, strain, velocity, temperature, flow etc and the output obtained from them can be in the form of current, voltage and change in resistance, inductance and capacitance. The output can be measured easily and it is calibrated against the input, thus enabling the measurement of the value of the input.

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3. Types of Electrical transducers

1) Primary transducer: changes “real world” parameter into electrical signal.

2) Secondary transducer: converts electrical signal into analog or digital values**.**

4. Examples of Electrical Transducers

Here are some of commonly used electrical transducers:

1) Potentiometers: They convert the change in displacement into change in the resistance, which can be measured easily.

2) Bridge circuits: These convert the physical quantity to be measured into the voltage.

3) Wheatstone bridge: It converts the displacement produced by the physical quantity to the current in the circuit.

4) Capacitive sensors or Variable Capacitance Transducers: These comprise of the two parallel plates between which there is dielectric material like air. The change in distance between the two plates produced by the displacement results in change in capacitance, which can be easily measured.

5) Resistive sensors or Variable Resistance Transducers: There is change in the resistance of these sensors when certain physical quantity is applied to it. It is most commonly used in resistance thermometers or thermistors for measurement of temperature.

6) Magnetic sensors: The input given to these sensors is in the form of displacement and the output obtained is in the form of change in inductance or reluctance and production of the eddy currents.

7) Piezoelectric transducers: When force is applied to these transducers, they produce voltage that can be measured easily. They are used for measurement of pressure, acceleration and force.

8) Strain gauges: When strain gauges are strained or stretched there is change in their resistance. They consist of the long wire and are able to detect very small displacements produced by the applied force or pressure.

9) Photo electric transducers: When the light is applied to these transducers they produce voltage.

10) Linear variable differential transformer (LVDT): LVDT is the transformer consisting of the primary and the secondary coil. It converts the displacement into the change in resistance.

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11) Ultrasonic Transducers: These transducers use the ultrasonic or ultrasound waves to measure parameters like fluid level, flow rate etc.

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5. How does a Transducer Work?

There are two operation taking place in transducers:-

1) It changes the “real world” parameter into electrical signal.

2) It converts electrical signal into analog or digital values.

There are numerous types of transducers and they have different types of applications. Let us see the example of use of transducer for different applications.

5.1 Thermometer

In our day-to-day life we have to measure the temperature many times and the most common devise used for this purpose is the thermometer. The temperature of the surroundings or body cannot be measured directly, so we need a device which can measure the temperature of the surrounding. Thermometer is the device that measures the surroundings temperature.

5.1.1 Principle

We know that liquids tend to get expand when heated and contracts when cooled. This property of the liquids is used to measure the temperature in thermometers, which is type of transducer.

5.1.2 Working

In thermometers there is thin capillary tubing and small bulb at the bottom, which is filled with highly temperature sensitive liquid called mercury. When the temperature of the bulb of the thermometer increases, the mercury tends to expand and fill the capillary tube to certain level depending on the temperature. The thermal expansion of mercury is proportional to the temperature of the mercury, so more is the bulb temperature more is expansion of the fluid. Thus if the bulb temperature is higher, mercury will expand to higher levels in the capillary and if its temperature is lesser, the rise in level will also be lesser.

Now, outside the capillary tubing, the scale is marked that indicates the temperature of the body. This scale is marked from the standard scale obtained by considering the extent of expansion of mercury at various temperatures. Thus the level of the mercury in the capillary indicates the temperature of the body.

5.2 Strain Gauge

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A strain gauge is a device used to measure the strain of an object. When external forces are applied to a stationary object, stress and strain are the result. Stress is defined as the object's internal resisting forces, and strain is defined as the displacement and deformation that occur. For a uniform distribution of internal resisting forces, stress can be calculated by dividing the force (F) applied by the unit area (A)

5.2.1 Principle

The majority of strain gauges are foil types, available in a wide choice of shapes and sizes to suit a variety of applications. They consist of a pattern of resistive foil which is mounted on a backing material. They operate on the principle that as the foil is subjected to stress, the resistance of the foil changes in a defined way.

5.2.2 Working

A strain gauge takes advantage of the physical property of electrical conductance and its dependence on not merely the electrical conductivity of a conductor, which is a property of its material, but also the conductor's geometry. When an electrical conductor is stretched within the limits of its elasticity such that it does not break or permanently deform, it will become narrower and longer, changes that increase its electrical resistance end-to-end. Conversely, when a conductor is compressed such that it does not buckle, it will broaden and shorten changes that decrease its electrical resistance end-to-end. From the measured electrical resistance of the strain gauge, the amount of applied stress may be inferred. A typical strain gauge arranges a long, thin conductive strip in a zig-zag pattern of parallel lines such that a small amount of stress in the direction of the orientation of the parallel lines results in a multiplicatively larger strain over the effective length of the conductor—and hence a multiplicatively larger change in resistance—than would be observed with a single straight-line conductive wire.

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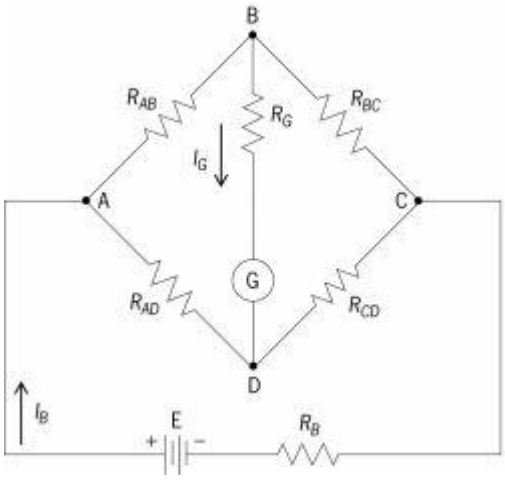
5.3 Wheatstone bridge

A Wheatstone bridge is used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. Its operation is similar to the original potentiometer. The Wheatstone bridge is a circuit that consists of a power source connected across four components that are resistive. The

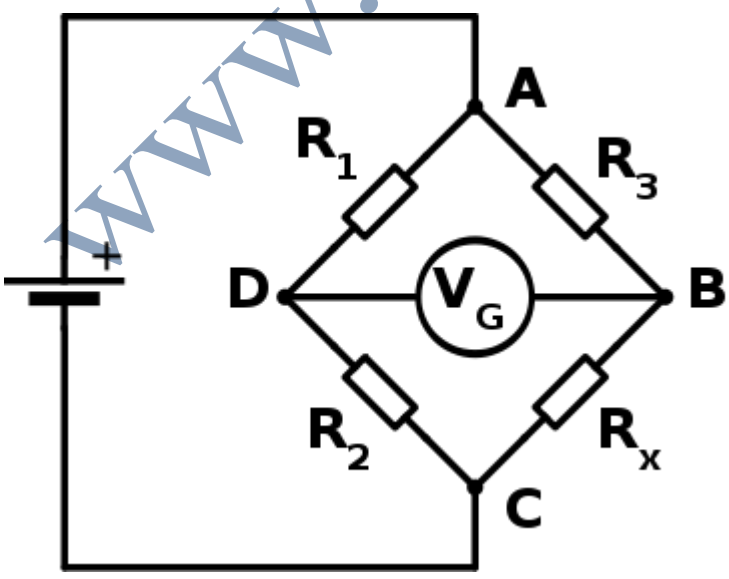
Wheatstone bridge is commonly shown is a shape of a diamond. Typical Wheatstone bridge is shown in the fig.



5.3.1 Principle

The bridge network has two terminals from which an output is taken. When there is no voltage difference between the output terminals, the bridge is balanced. Hence Wheatstone bridge works on the principle that when the resistance ratio between the series resistors at the left & right branches of the bridge is equal then the bridge is said to be balanced.

5.3.2 Working



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R_x is the unknown resistance to be measured; R_1, R_2 and R_3 are resistors of known resistance and the resistance of R_2 is adjustable. If the ratio of the two resistances in the known leg(R_2 / R_1) is equal to the ratio of the two in the unknown leg (R_x / R_3), then the voltage between the two midpoints (B and D) will be zero and no current will flow through the galvanometer V_g. R_2 is varied until this condition is reached. The direction of the current indicates whether R_2 is too high or too low.

Detecting zero current can be done to extremely high accuracy (see galvanometer). Therefore, if R_1, R_2 and R_3 are known to high precision, then R_x can be measured to high precision. Very small changes in R_x disrupt the balance and are readily detected. At the point of balance, the ratio of R_2 / R_1 = R_x / R_3

Therefore, $R_x = (R_2/R_1) \cdot R_3$

Alternatively, if R_1, R_2, and R_3 are known, but R_2 is not adjustable, the voltage difference across or current flow through the meter can be used to calculate the value of R_x, using Kirchhoff's circuit laws (also known as Kirchhoff's rules).

5.4 LVDT(Linear Variable Differential Transformer)

The linear variable differential transformer (LVDT) is a type of electrical transformer used for measuring linear displacement. The 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 secondaries. A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube.

5.4.1 Principle

The LVDT is composed of three coils whose cross section is shown in Fig. The central emitter coil, driven with a sinusoidal signal at a frequency between 10 and 20kHz, mounted between two larger receiver coils; the two receiver coils are identical, counter-wound and connected either in series or in parallel. The emitter is mounted on the IP table while the two receivers are attached on a reference structure; when the emitter is exactly in the mid point between the twin receiver coils, no net signal is induced. When the table movements move the emitter coil in a direction, a sinusoidal signal appears on the receiver coils. This signal has amplitude roughly proportional to the displacement from the center position. If the coil is moved in the opposite direction, the sign of the induced sinusoid is changed

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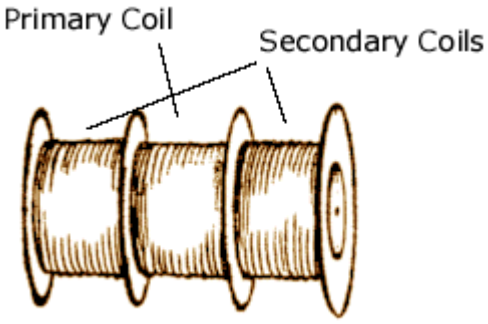

Inside a Transformer

5.4.2 Working

An alternating current is driven through the primary, causing a voltage to be induced in each secondary proportional to its mutual inductance with the primary. The frequency is usually in the range 1 to 10 kHz. As the core moves, these mutual inductances change, causing the voltages induced in the secondaries to change. The coils are connected in reverse series, so that the output voltage is the difference (hence "differential") between the two secondary voltages. When the core is in its central position, equidistant between the two secondaries, equal but opposite voltages are induced in these two coils, so the output voltage is zero. When the core is displaced in one direction, the voltage in one coil increases as the other decreases, causing the output voltage to increase from zero to a maximum. This voltage is in phase with the primary voltage. When the core moves in the other direction, the output voltage also increases from zero to a maximum, but its phase is opposite to that of the primary. The magnitude of the output voltage is proportional to the distance moved by the core (up to its limit of travel), which is why the device is described as "linear". The phase of the voltage indicates the direction of the displacement. Because the sliding core does not touch the inside of the tube, it can move without friction, making the LVDT a highly reliable device.

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6. Advantages of an electrical transducer

1) The signal can be converted into digital form and can be stored for further reference.
2) Display of the data is possible on a CRO.
3) Reading of analog data with the help of electrical transducers has less loss involved as compared to the mechanical transducers.

4) The biggest advantage of the LVDT is that the output obtained from it is proportional to the displacement of the mechanical member whose displacement is being measured.

5) LVDT cannot be overloaded mechanically since the core is completely separated from the other parts of the device.

6) Another important advantage of LVDT is that the output obtained from it is fairly high and it can be measured easily without requiring the need of the intermediate amplification.

7) LVDT is insensitive to the temperature and the changes in the temperature.

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7. Application:-

There are numerous types of transducers and they have different types of applications. The transducers are used for various applications for the measurement of the physical quantities like temperature, pressure, flow etc.

1) Experimental stress analysis.
2) Diagnosis on machines and failure analysis.

3) Multi axial stress fatigue testing, proof testing
4) Residual stress
5) Vibration measurement
6) Torque measurement
7) Bending and deflection measurement
8) Compression and tension measurement
9) Strain measurement
10) Used to generate diagnostics of passive filters
11) LVDTs are commonly used for position feedback in servomechanisms
12) Automated measurement in machine tools

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8. Conclusion:-

Measuring any physical quantity with a electrical transducer is very easy and convenient. The Electrical transducer illustrates the concept of a measurement of any physical quantity, which can be extremely accurate. By means of a transducer, a complex electrical quantity, such as watts, can be measured at a convenient location For remote indication of watts or vars, a transducer can reduce the number of signal wires to be laid

between source and indicator from as many as nine to two. Hence it can reduce the cost of a project to a large extent.

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