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DESIGN OF ANGULAR VARIABLE DIFFERENTIAL TRANSDUCER

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Abstract

Many times in an industry the angle needs to be measured of reference disc or button, which is very vital. In order to measure this angle the proposed changes are made to the existing LVDT and with these changes we can measure the change of angle in degrees on electronic display. The name given to the arrangement is Angular Variable Differential Transformer (AVDT).
Keywords: Linear Variable Differential Transducer, Primary Winding, Secondary Winding

1. Introduction

As explained in Fig.1 [1], small shift in the core results in change in voltage induced in two secondary windings. This result into displaying the difference in the voltage induced in secondary windings.
When core moves to right side from the null position then the difference in the voltage is positive and when core is moved to the left side from the null position then the difference in the voltage is negative[2].

2. Theory

As shown in Fig. 4, the rack and pinion gear mechanism is introduced and angular movement of the disc is converted into linear displacement in arm. This results in linear displacement of core. When the disc is rotated clockwise then the arm will move to the right hand side of null position and the difference between voltages induced is positive. When the disc is rotated in anti-clockwise direction then the arm moves to the left hand side of the null position.The display unit will record and display the angle movement. This display is scaled according to the movement of arm and ultimately core to display angle.
Reference Measurement Instrument: Linear Variable Differential Transformer (LVDT)
LVDT stands for Linear Variable Differential Transformer.
It is a common type of electromechanical transducer that can convert the rectilinear motion of an object to which it is coupled mechanically into a corresponding electrical signal.
The transformer's internal structure consists of a primary winding centered between a pair of identically wound secondary windings, symmetrically spaced about the primary. The coils are wound on a one-piece hollow form of thermally stable glass reinforced polymer, encapsulated

against moisture, wrapped in a high permeability magnetic shield, and then secured in cylindrical stainless steel housing. This coil assembly is usually the stationary element of the position sensor.
One of the most important features of an LVDT is its friction-free operation. In normal use, there is no mechanical contact between the LVDT's core and coil assembly, so there is no rubbing, dragging, or other source of friction. This feature is particularly useful in materials testing, vibration displacement measurements, and high resolution dimensional gaging systems. Since an LVDT operates on electromagnetic coupling principles in a friction-free structure, it can measure infinitesimally small changes in core position. This infinite resolution capability is limited only by the noise in an LVDT signal conditioner and the output display's resolution. These same factors also give an LVDT its outstanding repeatability. Because there is normally no contact between the LVDT's core and coil structure, no parts can rub together or wear out. This means that an LVDT features unlimited mechanical life. This factor is especially important in high reliability applications such as aircraft, satellites and space vehicles, and nuclear installations. It is also highly desirable in many industrial process control and factory automation systems. The internal bore of most LVDTs is open at both ends. In the event of unanticipated overtravel, the core is able to pass completely through the sensor coil assembly without causing damage. This invulnerability to position input overload makes an LVDT a suitable sensor for applications like extensometers that are attached to tensile test samples in destructive materials testing apparatus. An LVDT responds to motion of the core along the coil's axis, but is generally insensitive to cross-axis motion of the core or to its radial position. Thus, an LVDT can usually function without adverse effect in applications involving misaligned or floating moving members, and in cases where the core does not travel in a precisely straight line. The materials and construction techniques used in assembling an LVDT result in a rugged, durable sensor that is robust to a variety of environmental conditions. Bonding of the windings is followed by epoxy encapsulation into the case, resulting in superior moisture and humidity resistance, as well as the capability to take substantial shock loads and high vibration levels in all axes. And the internal high-permeability magnetic shield minimizes the effects of external AC fields. Both the case and core are made of corrosion resistant metals, with the case also acting as a supplemental magnetic shield. And for those applications where the sensor must withstand exposure to flammable or corrosive vapors and liquids, or operate in pressurized fluid, the case and coil assembly can be hermetically sealed using a variety of welding processes. Ordinary LVDTs can operate over a very wide temperature range, but, if required, they can be produced to operate down to cryogenic temperatures, or, using special materials, operate at the elevated temperatures and radiation levels found in many nuclear reactors. The location of an LVDT's intrinsic null point is extremely stable and repeatable, even over its very wide operating temperature range. This makes an LVDT perform well as a null position sensor in closed-loop control systems and high-performance servo balance instruments.
The absence of friction during ordinary operation permits an LVDT to respond very fast to changes in core position. The dynamic response of an LVDT sensor itself is limited only by the inertial effects of the core's slight mass. More often, the response of an LVDT sensing system is determined by characteristics of the signal conditioner.
An LVDT is an absolute output device, as opposed to an incremental output device. This means that in the event of loss of power, the position data being sent from the LVDT will not be lost. When the measuring system is restarted, the LVDT's output value will be the same as it was before the power failure occurred. [3]
LVDT is used for measurement of linear displacement ranging from ±100 μm to ±25 cm.

COMPONENTS OF LVDT-
Primary winding- This winding is single in nature.

Secondary winding- There is two windings which are equal and equidistance from primary windings as shown in Fig.1 and Fig.2.
Core- It is connected to the arm. This is soft iron core centrally placed in primary and secondary windings. Core is not in direct contact with the primary or secondary windings.
Arm- Arm is connected to the core which is explained above. Arm is also not in direct touch with the primary and secondary windings.
How LVDT works?
The function of LVDT is more complex, but the results obtained are very simple. As explained in Fig.1 [1], small shift in the core results in change in voltage induced in two secondary windings. This result into displaying the difference in the voltage induced in secondary windings.
When core moves to right side from the null position then the difference in the voltage is positive and when core is moved to the left side from the null position then the difference in the voltage is negative[2].
As shown in Fig.5 the movement of core is shown. Within range the readings are recorded which are very convenient and more reliable.

3. Proposed Work

As shown in FIG. 4, the rack and pinion gear mechanism is introduced and angular movement of the disc is converted into linear displacement in arm. This results in linear displacement of core. When the disc is rotated clockwise then the arm will move to the right hand side of null position and the difference between voltages induced is positive. When the disc is rotated in anti-clockwise direction then the arm moves to the left hand side of the null position.
The display unit will record and display the angle movement. This display is scaled according to the movement of arm and ultimately core to display angle.

4. Components of Proposed Work

1. Disc- Disc is mounted on Pinion.
2. Primary winding- This winding is single in nature.
3. Secondary winding- There are two windings which are equal and equidistance from primary windings as shown in figure 3.
4. Core- It is connected to the arm. This is soft iron core centrally placed in primary and secondary windings. Core is not in direct contact with the primary or secondary windings.
5. Arm- Arm is connected to the core which is explained above. Arm is also not in direct touch with the primary and secondary windings.
6. Rack and pinion Gear arrangement- A rack and pinion gear arrangement is used to convert rotational motion into linear motion.
7. Transparent Disc- The disc is mounted to the rack and pinion gear. When we rotate this disc either in clockwise or anti-clockwise, then the movement of arm is recorded into display with angular reading. The total displacement of arm is πD when the rack and pinion or disc is rotated 360^0 either in clockwise or anti-clockwise direction.
8. Frame- Frame is used to hold the disc and gear as shown in FIGURE 3.
9. Display- To show the display of angle.

CHANGES IN EXISTING LVDT

1. Rack and pinion arrangement should be connected to the CORE of LVDT
2. Disc need to be mounted on pinion
3. Electronic scale should be developed to measure displacement of CORE which is converted into angle in degrees.

DESIGN ATTRIBUTES

If we take distance of rack and pinion gear on one side as πD=200 mm then, Diameter of Disc can be D=63.7 mm. Therefore total length of the gear is 2πD= 400 mm considering both the sides. The disc is mounted on the Pinion. The input voltage is converted into output voltage.

Table.1 Movement of Disc (pinion), Arm, Core and Reading on Scale

Disc Rotation (degree)	Arm movement (mm)	Core movement (mm)	Recording on Display (degree)
0^0 (NULL)	0	0	0^0
90^0	πD/4	πD/4	90^0
180^0	πD/2	πD/2	180^0
270^0	3πD/4	3πD/4	270^0
360^0	πD	πD	360^0

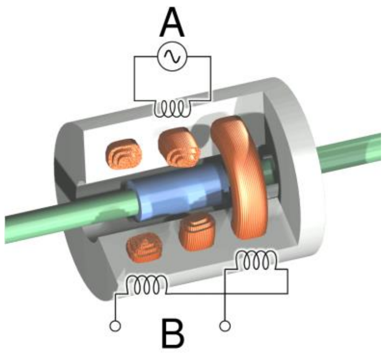

FIGURE 1. BASIC STRUCTURE OF LVDT [1]

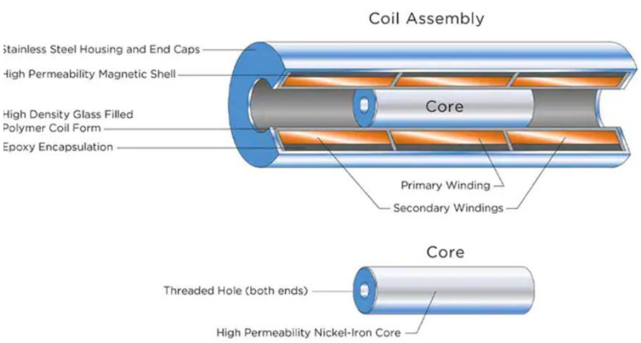

FIGURE 2. DETAIL STRUCTURE OF LVDE [3]

5. Methodology-

1. The center of Disc is coincided with the reference disc for which the angle is to be measured.
2. Coinciding the NULL position
3. Rotating Disc up to the line which is to be measured.
4. Display will show the angle in degrees.

Formula-

The input voltage is converted into output voltage i.e. output voltage is a function of input voltage. The variations are shown in Fig. 7.

$$V_o = f\,(V_{in})$$

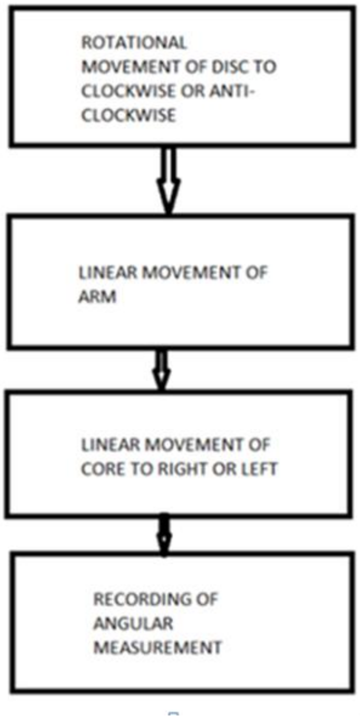

FIGURE 3. BLOCK DIAGRAM

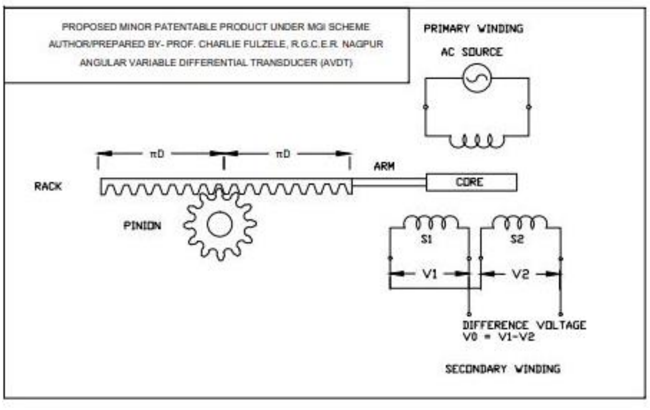

FIGURE 4:- ACTUAL PROPOSED WORK

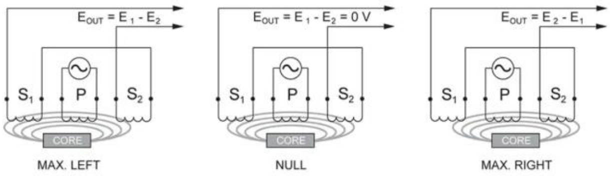

FIGURE 5: MOVEMENT OF CORE W.R.T. WINDINGS [3]

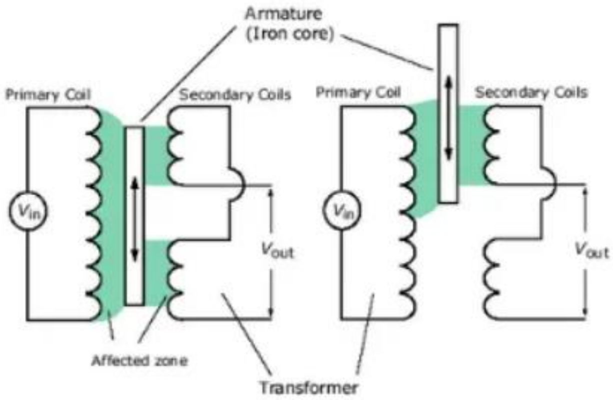

FIGURE 6:- TRANSFORMER ARRANGEMENT

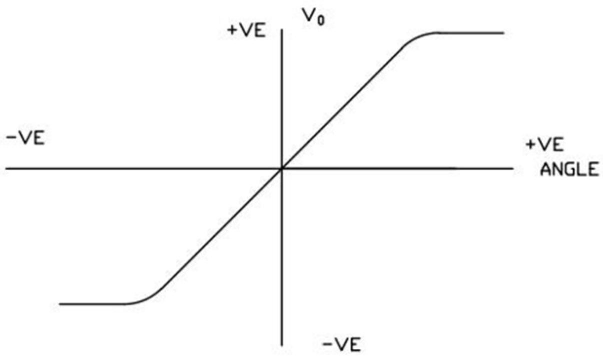

FIGURE 7- GRAPHICAL REPRESENTATION OF OUTPUT VOLTAGE V/S ANGLE

6. Conclusions

Linear Variable Differential Transducer [LVDT] is used to measure the linear variations within specified limit. After making changes in the existing LVDT, we can use the new arrangement called Angular Variable Differential Transducer is used to measure angular changes within some limits. The proposed changes can be implemented in existing design and instrument, for further modification. These changes are well explained above. After implementation in the design we can measure the angle using this device. This could be the patentable idea as no earlier claim is made in the design.

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