ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY
AUTONOMOUS INSTITUTION
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VII Semester

AU3008 Sensors and Actuators

UNIT – 3 - Variable and Other Special Sensors

3.4 Magneto strictive Transducer

3.4.1 Principle of magneto strictive Transducer:

- A device that is used to change the energy from mechanical to magnetic energy is known as a magneto strictive transducer.
- The **magneto strictive transducer working principle** uses a type of magnetic material where an applied oscillating magnetic field will squeeze the atoms of the material, creates a periodic change within the material length & produces a mechanical vibration with high frequency.
- These types of transducers are mainly used in the lower frequency ranges & these are very common in ultrasonic machining & ultrasonic cleaner applications.
- **Magnetostriction** is a property of ferromagnetic materials that causes them to change their shape when subjected to a magnetic field.
- Certain ferromagnetic materials are considerably affected in their magnetic properties when they are mechanically stressed. This phenomenon is known as "magnetostriction" (**Villari effect**) and is particularly significant in nickel and nickel- iron alloys.

Magnetostrictive Transducer

- Ferromagnetic materials like iron, nickel, 68 permalloy etc., change their magnetic permeability under mechanical stress. This is known as **Villari effect**.
- The permeability can increase or decrease depending upon the material, the type of stress, (compression, tension or torsion) and the magnetic flux density in the sample.
- **Magnetostrictive Materials:**

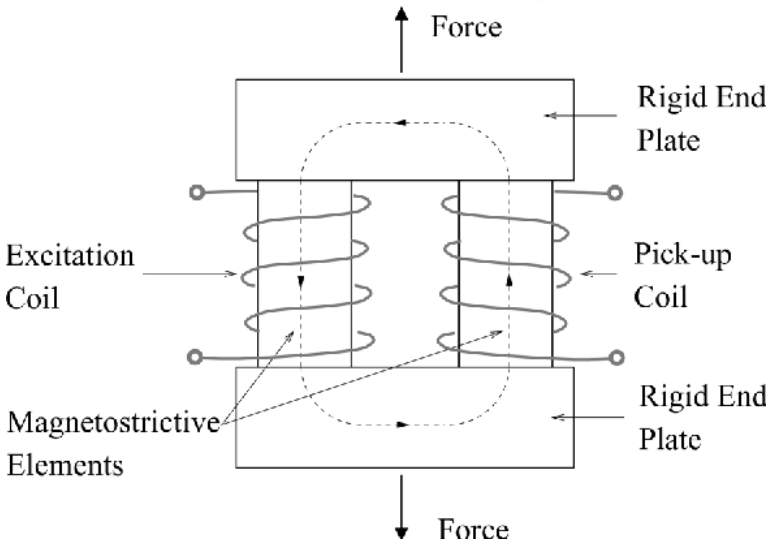
  Some of the magneto strictive materials are
  - Nickel
  - Permalloy - (nickel alloy with 68% nickel)
  - Ferroxcube B

3.4.2 Construction of Magneto strictive Transducer:

A magneto strictive transducer typically consists of the following components:

1. **Ferromagnetic Core:** This is the heart of the transducer and is usually made of a material like nickel, iron, or a nickel-iron alloy. It exhibits the magnetostrictive effect, changing length in response to a magnetic field.

2. **Coils:** These are wound around the core and carry an alternating current (AC). The magnetic field produced by the current interacts with the core, causing it to expand and contract.



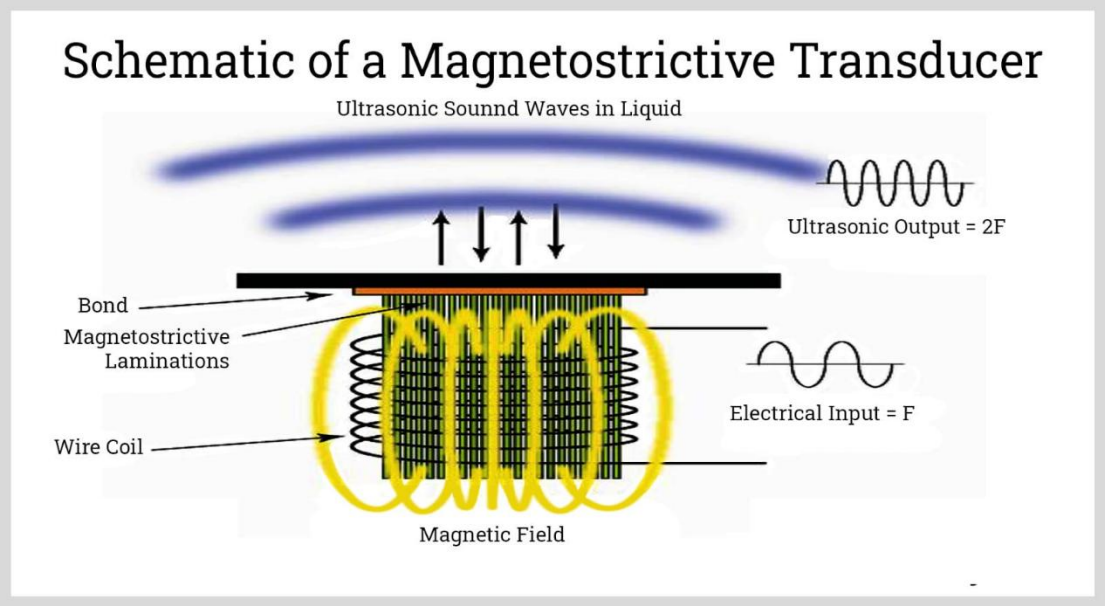
3. **Magnetostrictive Elements**: Materials that change shape or dimension in response to a magnetic field. These are responsible for converting magnetic

energy into mechanical force or displacement.

4. **Pick-up Coil**: Monitors changes in the magnetic field or provides feedback for controlling the actuator's operation.
5. **Rigid End Plates**: These are used to transmit the mechanical force or displacement generated by the magnetostrictive elements.
6. **Force**: The mechanical output (typically linear force or motion) resulting from the magnetostrictive material's deformation.

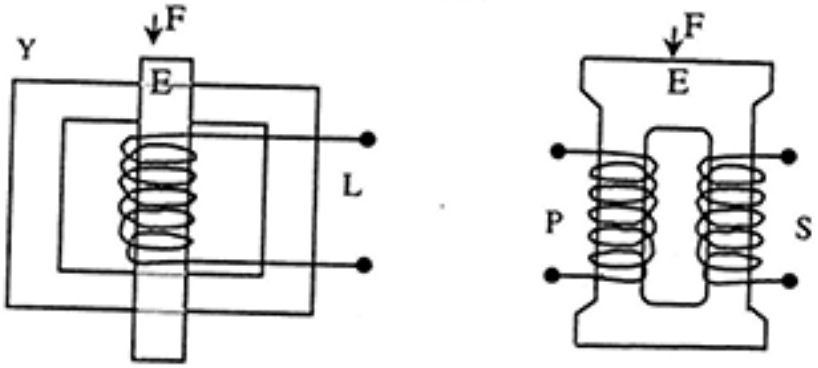
Working of Magnetostrictive Transducer:

i. **Force Application:** When a force is applied to the sensor, it is transmitted to the magnetostrictive elements.
ii. **Magnetostriction:** The applied force causes the magnetostrictive elements to strain, which in turn changes their magnetic properties.
iii. **Magnetic Field Change:** The change in magnetic properties induces a voltage in the pick-up coil.
iv. **Signal Processing:** The voltage signal from the pick-up coil is amplified and processed to determine the magnitude of the applied force.



3.3.4 Magetostrictive Load Cell:

- Load cells can be designed using magneto strictive element as a basic sensor.
- Depending upon the cross-sectional area of the probe, forces from several grams up to several tons can be measured directly.
- The displacement at the input of the transducer is very small-of the order of micro meters.



Core Components:

- **Magnetostrictive Element (E):** This is the central component, made of a material that exhibits magnetostriction, meaning it changes shape in response to a magnetic field.
- **Excitation Coil (L):** This coil applies an alternating current (AC) to the magnetostrictive element, creating a time-varying magnetic field.
- **Pick-up Coil (P):** This coil senses the changes in the magnetic field caused by the strain in the magnetostrictive element. These changes are proportional to the applied force.

Working:

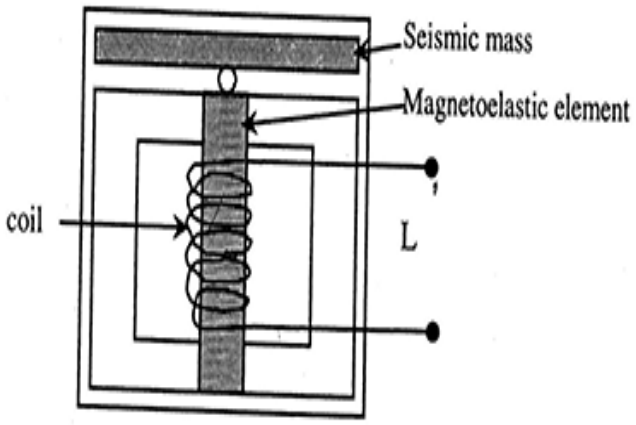
i. **Magnetic Field:** A constant magnetic field is established within a ferromagnetic rod.
ii. **Deformation:** When a load is applied to the rod, it deforms, causing a change in its length.
iii. **Magnetic Field Change:** The deformation alters the magnetic field within

the rod.

iv. **Voltage Induction:** A coil wrapped around the rod detects the change in magnetic field and generates a corresponding voltage.

v. **Measurement:** The voltage is proportional to the deformation, which is directly related to the applied load.

3.3.5 Magnetostrictive Accelerometer :



Components:

- **Seismic Mass:** This is a heavy mass suspended on a spring or other flexible support. Its movement relative to the sensor housing is indicative of applied acceleration.
- **Magnetostrictive Element (Magnetoelastic Element):** This is a material that changes its shape (strain) in response to a magnetic field.
- **Excitation Coil (L):** This coil applies an alternating current (AC) to the magnetostrictive element, creating a time-varying magnetic field.
- **Pick-up Coil:** This coil senses the changes in the magnetic field caused by the strain in the magnetostrictive element. These changes are proportional to the applied acceleration.

Working:

❒ **Acceleration:** When the transducer experiences acceleration, the seismic mass moves relative to the housing.

- **Magnetostriction:** The movement of the seismic mass is transmitted to the magnetostrictive element, causing it to strain. This strain changes the magnetic properties of the element.
- **Magnetic Field Change:** The change in magnetic properties induces a voltage in the pick-up coil.
- **Signal Processing:** The voltage signal from the pick-up coil is amplified and processed to determine the magnitude of the acceleration.

Advantages:

- High sensitivity and precision.
- Robust and durable, capable of operating in harsh environments.
- Wide frequency range.
- No need for external power (self-generating signal in some designs).

Applications:

- Vibration monitoring.
- Structural health monitoring.
- Aerospace and automotive systems.
- Industrial machinery.

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