University Of Technology- Iraq
Department of Materials Engineering
General Materials Branch
Fourth class

Smart Materials

Lecture 8 : Manufacturing and Application of Magnetoretictve Alloys

Class Code on Google Classroom :2shhens

Powder Metallurgy Used for a Giant Magnetostrictive Material

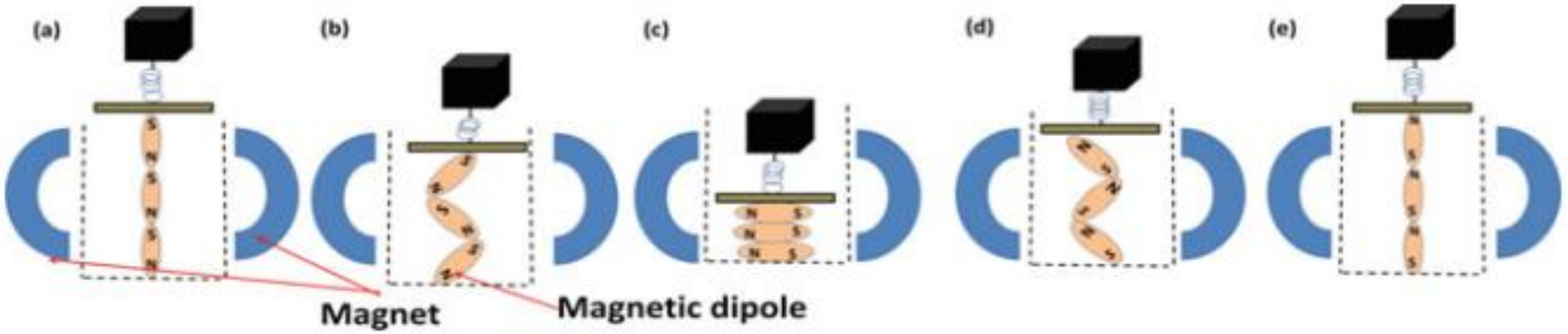
- Magnetostrictive materials for actuator devices have used ferrite and nickel materials in the past, however, the amount of displacement of those materials has been only 30 ppm while piezoelectric materials whose amount of displacement is 800 ppm has been used for actuator devices.
- By changing the process of manufacture for GMM from the conventional Bridgman method to a powder-metallurgical method, we have developed the GMMs at a low cost and with a high amount of displacement

Features of Powder Metallurgical GMM

- Anisotropic GMM made by the powder metallurgical method has been processed similar to a process used to produce rare-earth magnets, and has been formed into cylindrical and C-forms by a near-net shape technique.
- Magnetostrictive characteristics are directly influenced by forming the anisotropic material in a magnetic fi eld with a powder metallurgical method, and the anisotropic orientation characteristic is important.

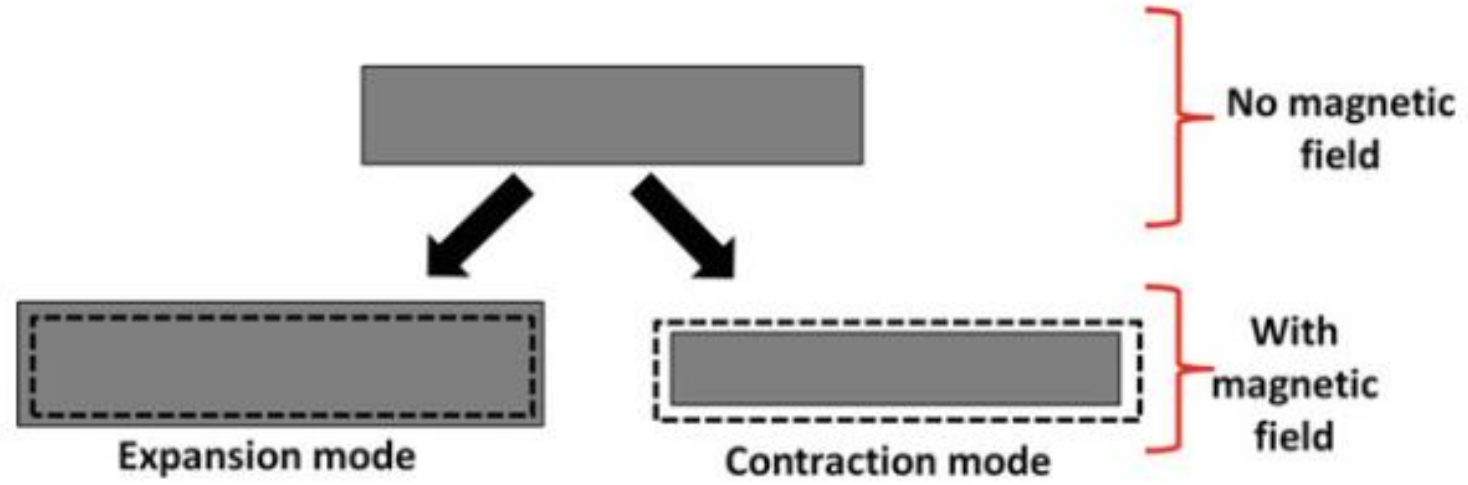
Magnetostriction in Mechanical Industries

- Magnetostrictive transducers for lifting: Magnetostrictive transducers are used to convert mechanical energy into magnetic energy and vice versa. Due to bidirectional coupling between magnetic state and mechanical state of the material, the transducers can be utilized for sensor and actuator



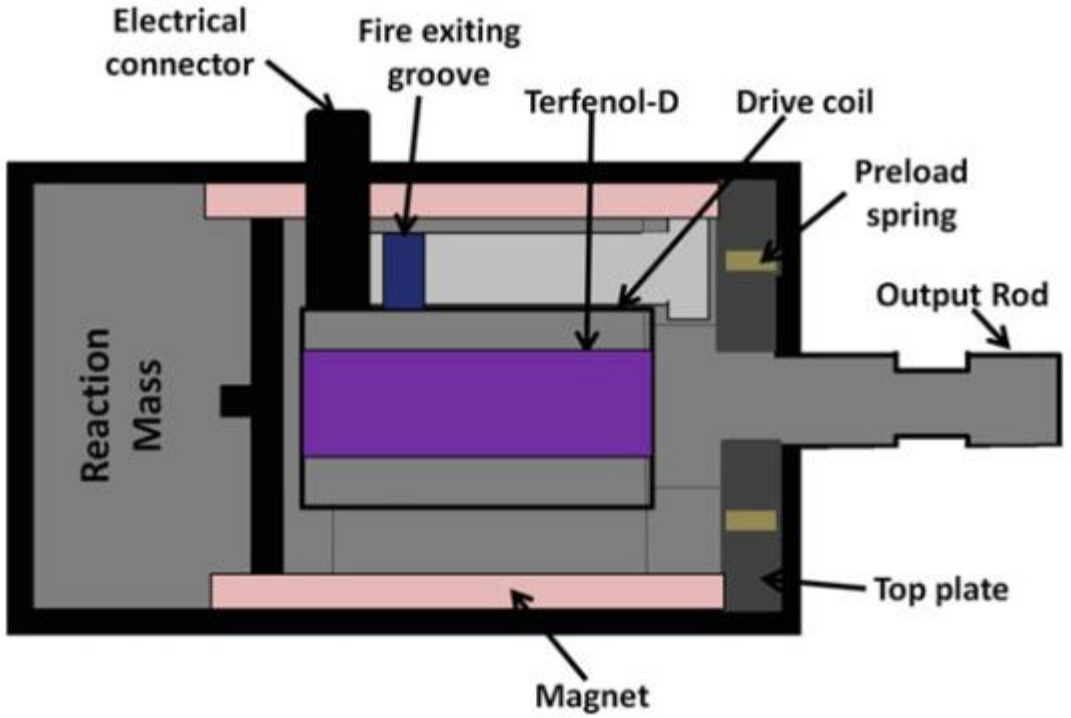
Magnetostriction in Mechanical Industries

- Ultrasonic transducers: The magnetostrictive material changes its volume when subjected to magnetism as domain alignment takes place under the influence of the magnetic field. The volume change may increase or decrease depending upon the material



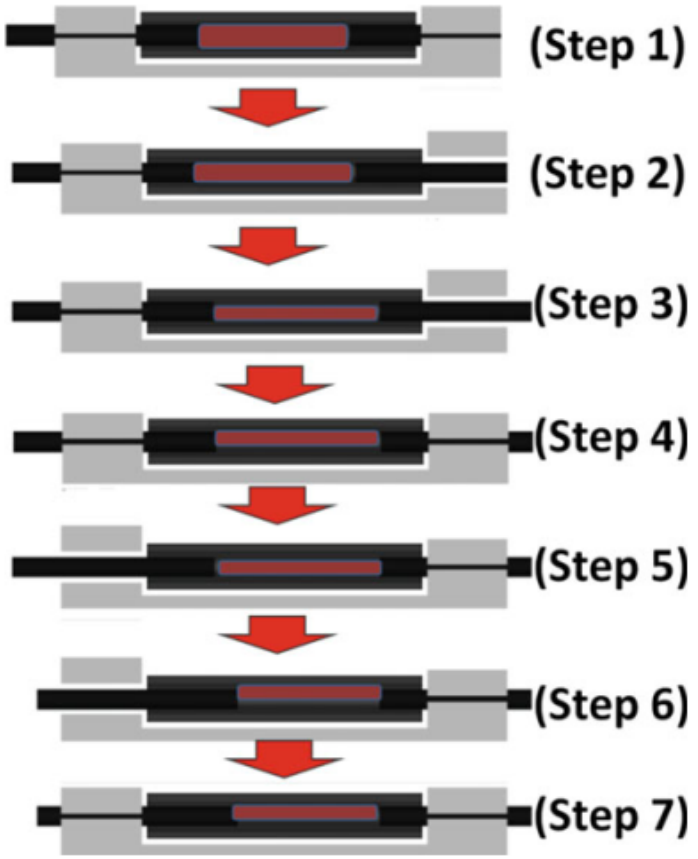
Magnetostriction in Mechanical Industries

- Reaction mass unit: Etrema has designed, built, and validated an actuator that is capable of generating useful forces, although it can operate over a wide range of frequencies.



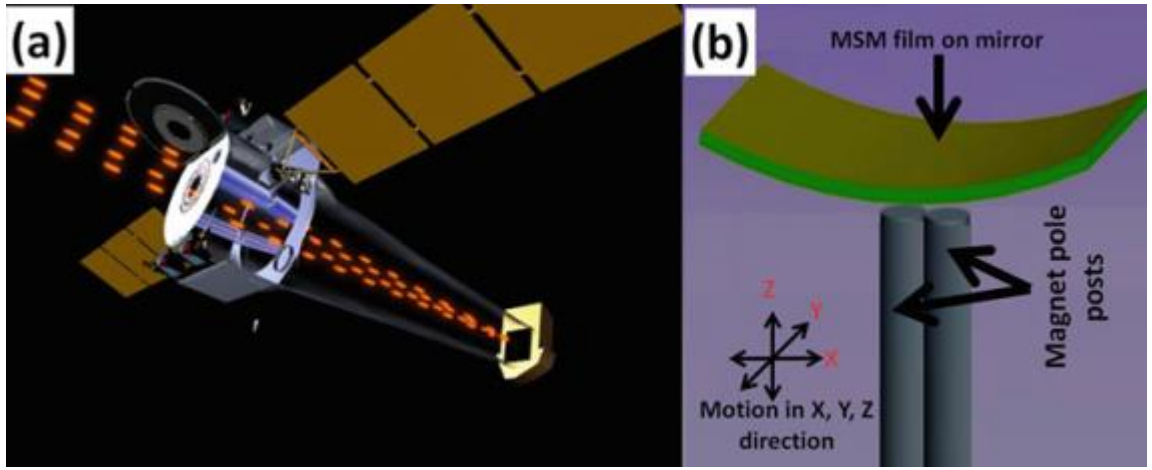
Magnetostriction in Mechanical Industries

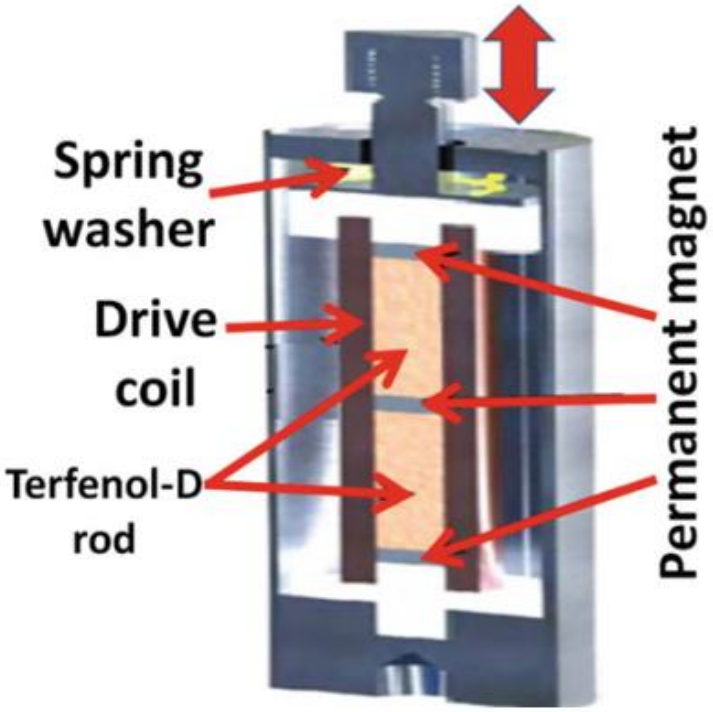
- Linear motor based on Terfenol-D: Energen Inc. designed and manufactured a compact linear motor based on the intelligent Terfenol-D material. The central feature of this linear motor is the Terphenol-D rod surrounded by an electric coil which, when switched on, causes the rod to elongate.



Magnetostriction in Aero-Industries

- Application of magnetostrictive films in astronomical X-ray telescopes
- Magnetostrictive materials for morphing aircraft
- Aerocraft wing pivot (Gulfstream III aircraft)

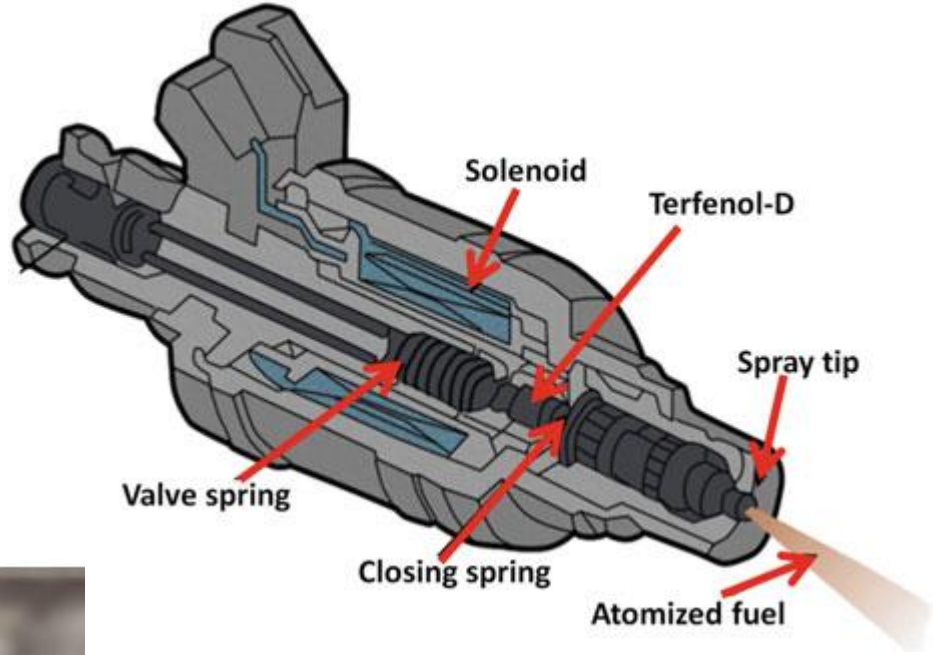




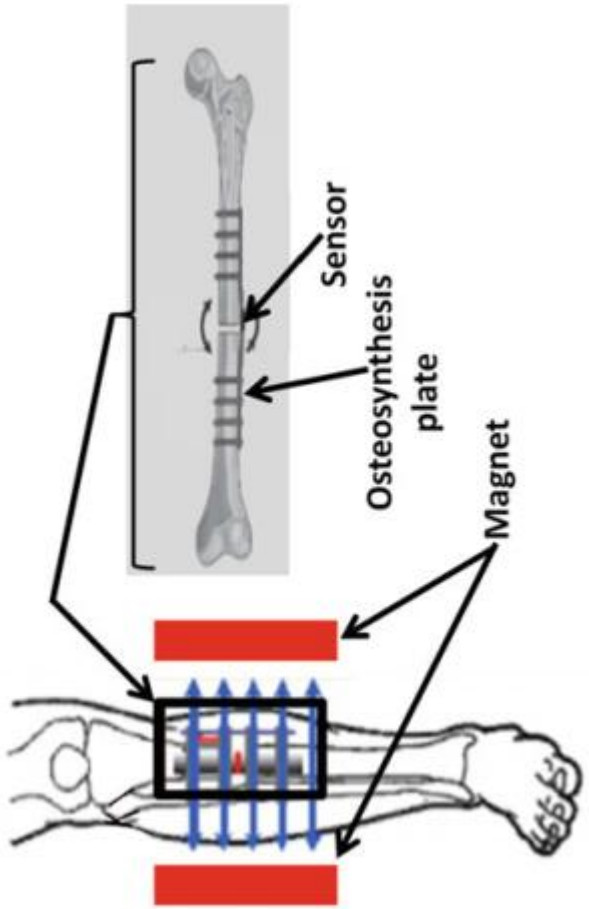
Magnetostriction in Automotive Industries

1. Auto-drive magnetic guidance system:

2. Magnetostrictive brake:
3. Fuel injector design concept
4. Hydraulic lifts



Magnetostriction in Biomedical Industries



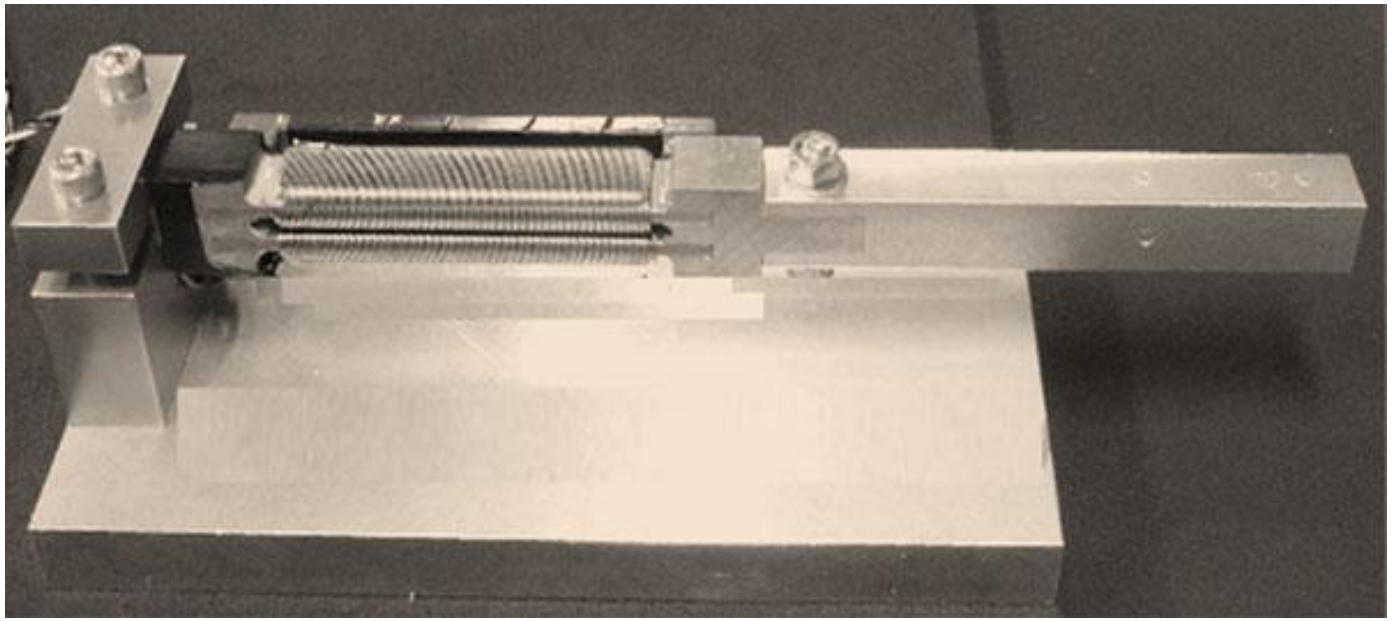
- A contactless device operation mechanism is very much required in biomedical application, where agnetostrictive materials play a big role.
- For example, a copper coil coupled with a microscale Galfenol-silicon film is used to track the bone fracture healing. The load fracture decreases gradually from the osteosynthesis plate to the bone tissue as the bone healing process starts which generally creates stress on thin Galfenol film.
- Figure showing the osteosynthesis plate with the Galfenol-based strain sensor and the geometry of the galfenol strain sensor.

Magnetostriction in Construction Industries

1. Suspender cables on bridges
2. Lift bridges
3. Liquid-level sensor

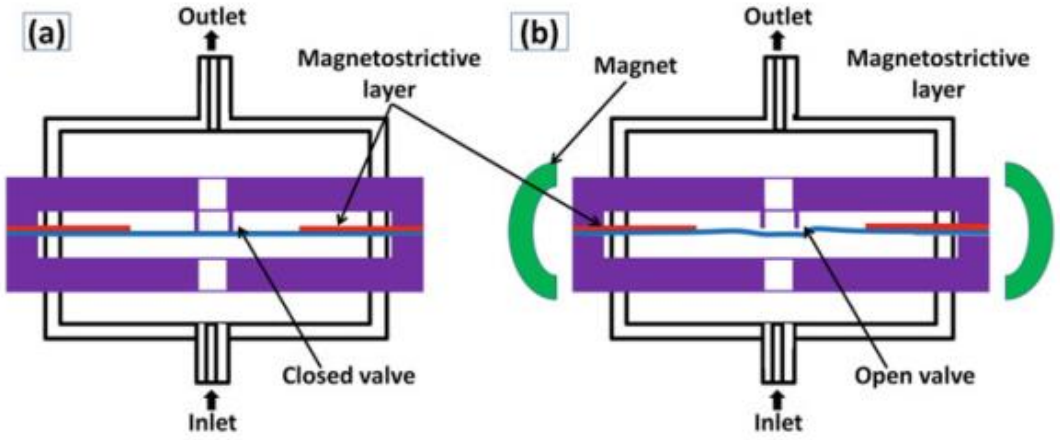
Magnetostriction in Energy Harvesting Materials

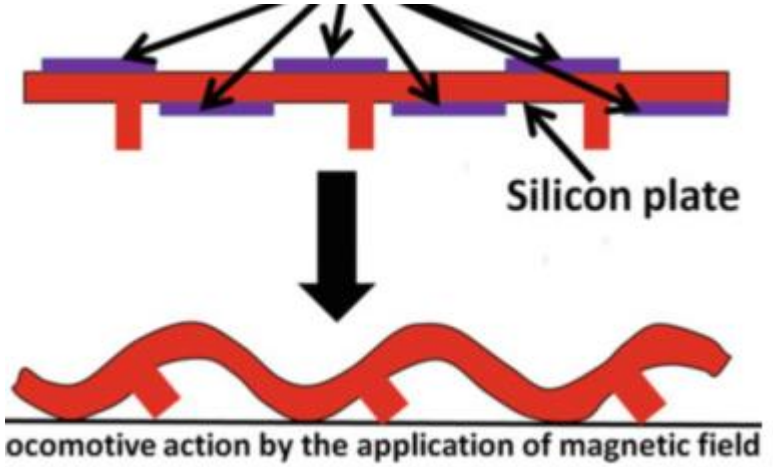
1. Stirling thermoacoustic power converter and magnetostrictive alternator
2. Vibration-driven generator



Magnetostrictive Materials in Other Industries

1. Wireless thin film micro motor
2. Thin-film valve
3. Magnetic contact torque sensors: In these applications, Wideman, Villari, ΔE, and Matteucci effects are used to detect changes in magnetic quantities, providing numerical information on stress, force, or torque

- 



Advantages of MS Materials

1. Noncontact easy installation: Due to the involvement of magnetic setup, there is no need for additional actuation circuit connection (electric set up). Exterior magnet is enough to operate the materials.
2. 2. High reliability: The magnetostrictive is based on the waveguide theory and without mechanical parts, so it has no friction and wears. The entire transducer was placed in a stainless steel tube without contact with the measuring medium. Therefore, it is reliable and durable.
3. 3. More stability: The magnetostrictive structure has more stability, multi-output mode, and has overvoltage/highfrequency interference prevention.

Advantage of MS Materials

- 4. No insulation and maintenance: No regular insulation and maintenance that requires an input power protection function that is available with opposite polarity.
- 5. High accuracy: The magnetostrictive fluid meter is based on a waveguide pulse, it measures the replacement time of the start and end pulses, so its accuracy is very high.
- 6. Better resolution: Resolution better than 0.01% full scale, higher than the resolution of other sensors.

Advantages of MS Materials

- 7. Safety: The function is satisfactory without any precaution. In addition, with internally safe explosion protection the function of the magnetostrictive liquid meter is satisfactory.
- 8. Suitable for system automation: The output signal of the magnetostrictive measuring device (e.g., liquid meter) is standard, so the microcomputer is very suitable for information processing and easy entry into the network, which improves the automation of the measuring system.
- 9. Can be operated with low impedance amplifiers: The advantage of magnetostrictive sensors over other types of transducers is that they can be operated with conventional low impedance amplifiers, especially at frequencies well below resonance.

Disadvantages of MS Materials

- 1. Eddy currents formation: at high frequency, there is a chance of eddy currents formation in the material that prevents the excitation of the core of the material. Such problems can be eliminated by using laminated materials.
- 2. Current leakage and demagnetization: Some of the challenges associated with the use of magnetostrictive materials are related to the effects of current leakage and demagnetization, which require the efficient design of the sensor’s magnetic circuit.

Disadvantages of MS Materials

- 3. Higher product cost: The production of advanced magnetostrictive joints is expensive because the conductors of advanced crystal converters must be fabricated using crystal growth techniques that provide directional hardening along the drive axis, combined with precision lamination, end diameter, and parallel machining of cut pieces.
- 4. Significant nonlinearity and hysteresis: In terms of device implementation, magnetostrictive materials have significant nonlinearity and hysteresis to the same extent as other intelligent materials, such as electrostrictive materials, in the case of a magnetostrictive fluid-level sensor