High Precision and Advanced Actuators

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This Lecture Contains

- High Precision Actuators
- Ball and Screw Linear Actuator
- Linear Stepper Motor
- Piezoelectric Actuators
- Thermal Actuator
Introduction

• In the last lecture, we have talked about traditional actuators which are generally used for low precision and high power actuation.

• In this lecture we will talk about low power high precision actuators. The figure below shows a thermal actuator that belongs to this category.
How many a ways a Precise Positioning System could be built?
Ball-Screw Driven Linear Actuator

A ball screw driven table is a highly efficient low friction linear drive system. The ball screw transmits torque to the nut through one or more recirculating ball bearing tracks. Since this involves rolling contact rather than sliding friction, this actuator is highly efficient (about 90%).

One potential problem with a ball screw driven positioning table is the occurrence of backlash, which produces poor results in bi-directional applications. Due to axial play inherent to a recirculating ball system, this is bound to occur.
Voice-Coil Actuator

Voice coil actuators are versatile direct drive, hysteresis-free, non-commuted limited motion servo motors with linear control characteristics.

They are virtually ideal servo devices. It is based on a permanent magnet field assembly in conjunction with a coil winding to produce a force proportional to the current applied to the coil.

These two-terminal, non-commutated electromagnetic devices are used in linear and rotary motion applications requiring high acceleration, high frequency actuation, and flat force vs. displacement output.
Linear Stepper Motor

Linear step motor is basically an unrolled variable reluctance step motor. The technique used to produce motion is very similar. The rotor and stator of the rotary motor are replaced by the platen and forcer of the linear step motor.

In the schematic, a current flows through the coil on the left. This causes the teeth to attract the teeth of the platen at point 1, and repel at point 2. By applying a current to the left coil, the teeth shift a quarter of the tooth pitch, in order to align the teeth at point three. Now by reversing the current on the left, they shift another quarter and so on, until they have moved a full tooth or four steps.
Advanced Actuators
Piezoelectric Inchworm Devices

- Such devices are used to develop small-scale walking systems, micromanipulators and patch-clamping.
- In a simple form, it involves three piezo-actuators – (two clamps and one lateral system)
- There are six-steps in the actuation process. Depending on fixity – this may either result in worm-like movement or linear motor action. Brisbane (1964) achieved a speed of about 50mm/second using this actuator.
Unimorph-Thunder

• One of the popular devices that is used for high precision linear and bending actuation is known as Thunder [Thin Layer Composite Uniform Ferroelectric Driver]

• It is an unimorph made of PZT at the core and bonded with one/two metallic layers at high temperature.

• The bonding agent is a special high strength thermo-plastic LaRc. At high temperature, this gets melt inside the system and then slowly cooled to develop pre-stress.
A Thermal Actuator for space application

Surface micromachined Guckel thermal actuator consists of a blade connected to electrical contact pads by two thin beams. A potential difference is applied to the electrical contact pads and current flows through the thin beam & blade, the difference in conductivity causes bending.

Specifications:

Area 700 µm × 700 µm, fabricated using MEMS technology, compatible with the standard IC process. Movement up to 1 µm, driving voltage: 3 V with 3 mW power consumption. Its mechanical frequency of 7 kHz is high enough to support high bandwidth servo control systems.
Special References for this lecture

- Micro-mechatronics by Uchino & Giniewicz, Marcel, Dekker
- Modelling and Dynamic Simulation of Vibration driven Robots, Becker et al, 2011
- A Piezoelectric driven inchworm locomotion device, Lobonitu et al, 2001