ME 222: Kinematics of Machines and Mechanisms

[L9] Practical Considerations II

Outline

- Some practical considerations

Some practical considerations

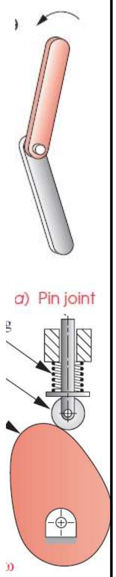
- Linkages versus Cams
- Selection of Motors and Drivers

Practical considerations

- Many factors need to be considered to create good-quality designs
- Not all of them are contained within the applicable theories
- A great deal of art based on experience is involved in design as well.

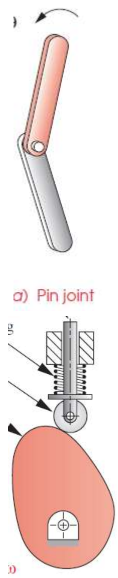
Linkages versus Cams

- Pin-jointed linkage has all the advantages of revolute joints
- Cam-follower has all the problems associated with the half joint.
- Pin-jointed linkage with good bearings is a potentially superior design, and should be the first explored
- Linkages have relatively large size compared to the output displacement in comparison to Cam.
- Linkages are relatively difficult to synthesize, and cams are relatively easy to design.
- Dwells are easy to get with cams, and difficult with linkages.



Linkages versus Cams: Comparison

- Linkages can survive hostile environments, with poor lubrication, whereas cams cannot
- Linkages have better high-speed dynamic behavior than cams.
- Linkages are less sensitive to manufacturing errors, and can handle very high loads.
- Cams can match specified motions better.
- So the answer is far from clear-cut. It is another *design trade-off situation*.



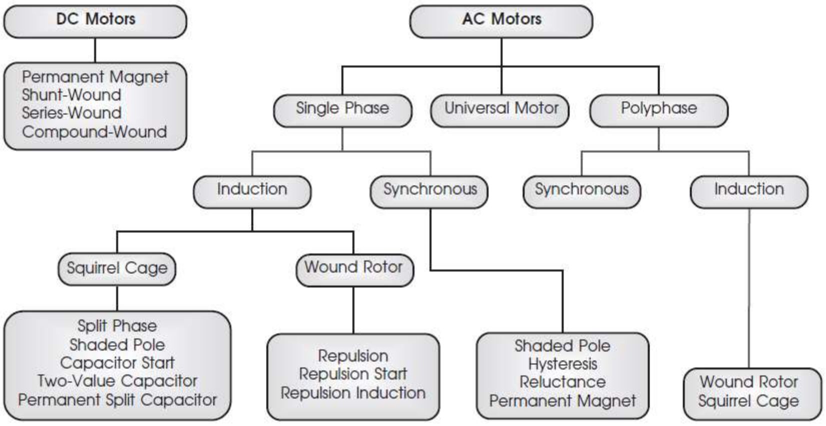
Motors and drivers

- Need of driver to provide the input motion and energy.
- Continuous rotary input: Motor is the logical choice.
- Motors come in a wide variety of types.
  - Most common energy source for a motor is electricity
  - Air and hydraulic motors

Electric motors

- Motors provide continuous rotary output.
- Stalled momentarily against a load
- It can not tolerate a full-current, zero-velocity stall for more than a few minutes without overheating.
- Electric motors are classified by
  - Electrical configuration
  - Function or application
  - Rated power

Electrical configuration



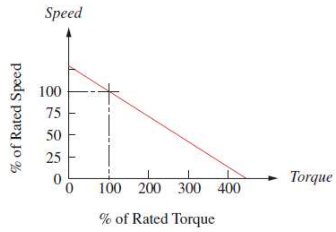
- Functional classifications
  - Gear motors
  - Servomotors
  - Stepping motors
- Rated power
  - Subfractional (> 1/20 HP)
  - Fractional (1/20 - 1 HP)
  - Integral (> 1 HP)

DC motors

- Have electrical configurations: *permanent magnet, shunt-wound, series-wound, and compound-wound*
- Rotating armature coils connected to the stationary field coils—
  - in parallel (shunt), in series, or in combined series-parallel (compound)
- Permanent magnets replace the field coils in a PM motor.
- Each configuration provides different *torque-speed* characteristics.
- T*orque-speed* curve describes how motor will respond to an applied load

Permanent Magnet DC Motors

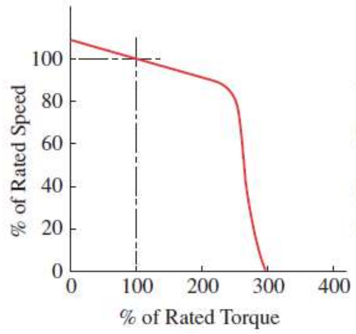
- Torque varies greatly with speed
- *power* = *torque* x *angular velocity*.
- Torque is maximum at stall (zero velocity)
- This is an advantage when starting heavy loads (unlike IC engine)



(a) Speed–torque characteristic of a PM electric motor

Shunt-wound DC Motors

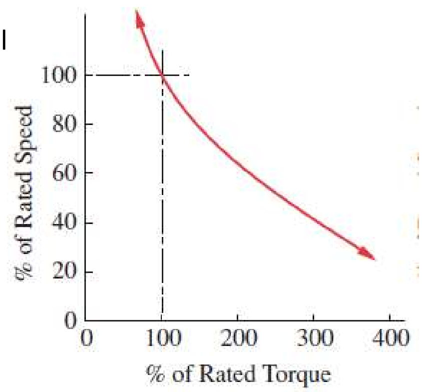
- Flatter slope around the rated torque
- Less speed-sensitive to load variation
- It stalls very quickly
- Typically used on fans and blowers.



(a) Shunt wound

Series-wound DC Motors

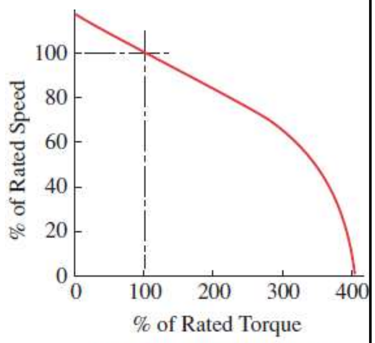
- More speed-sensitive (large slope)
- Starting torque as high as 800% of full load
- No theoretical maximum no-load speed
- Run away if the load is removed. (Maximum speed 30,000 rpm.)
- Gives a “soft-start”
- Sewing machines and portable grinders



(b) Series wound

Compound-wound DC Motors

- Combination of shunt-wound and series-wound
- Speed sensitivity is greater than a shunt-wound but less than a series-wound
- It will not run away when unloaded.
- Has high starting torque and soft-start capability
- Good choice for cranes and hoists that experience high inertial loads and can suddenly lose the load due to cable failure



(c) Compound wound

Speed control DC motors

- Controller increases and decreases the current against changing load to maintain speed.
- Speed-controlled (typically PM) DC motors will run from an AC source.
- Cost of such motor is high.

AC motors

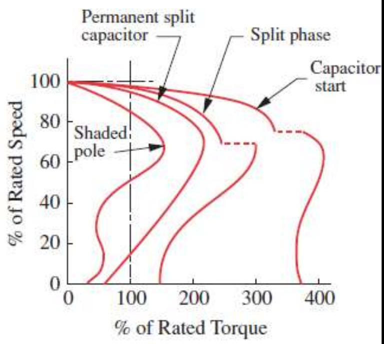
- Least expensive way to get rotary motion.
- Synchronous motors "lock on" to the AC line frequency and run exactly at synchronous speed.
- Nonsynchronous motors have a small amount of slip and lag the line frequency by about 3 to 10%.
- The synchronous motor speed $ns = 120f/p$.

AC Motor Speeds

Poles	Sync rpm	Async rpm
2	3600	3450
4	1800	1725
6	1200	1140
8	900	850
10	720	690
12	600	575

Single-phase motors

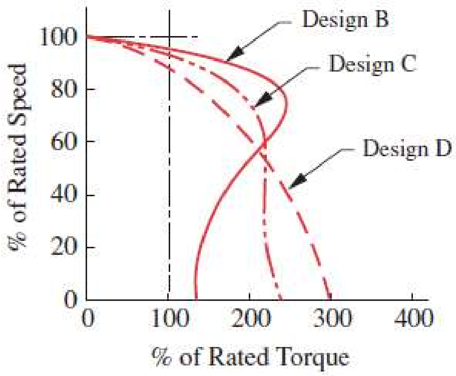
- Shaded pole and permanent split capacitor: starting torque lower than their full-load torque.
- Split-phase and capacitor-start motors: boost the start torque



(a) Single phase

Three-phase motors

Differ mainly in their starting torque and speed sensitivity near full-load point.



(b) Three phase

Gearmotors

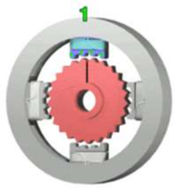
- Motor's output shaft is connected by gearbox
- Gearmotor with integral gearbox is available
- Available in variety of output speeds and power ratings.

Servomotors

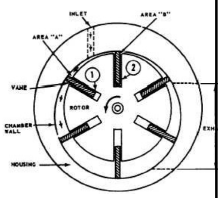
- Servomotors are made in both AC and DC configurations
- **Closed-loop**-controlled (*sensors for position/velocity feedback)*
- Precise positioning of the output device
- Capable of holding a fixed position against a load.
- Have fast-response
- Aircraft and guided missiles, numerically controlled machine, robots

Stepper Motors

- Brushless permanent magnet motors.
- Intermittent motion devices (no continuous rotary motion)
- They run open loop, without *feedback*
- Resolution depends on the number of magnetic strips.
- Relatively small and have low drive torque capacity
- Have high holding torque.
- Expensive and require special controllers



Air and Hydraulic motors



- Require a compressed air or hydraulic source.
- Less energy efficient due conversion of the energy.
- Air motors used factories where compressed air is available.
- Cost of all the ancillary equipment is high.
- Hydraulic motors are found cranes, aircraft, and ships.

Air and Hydraulic Cylinders

- These are linear actuators (piston in cylinder)
- Provide a limited stroke, straight-line output
- Input of either compressed air or hydraulic fluid
- Share the high cost, low efficiency
- Farm and construction equipment

Solenoids

- Electromechanical (AC or DC) linear actuators
- Share some of the limitations of air cylinders
- *Energy inefficient*
- Very short strokes (about 2 to 3 cm) length
- Develop a force that varies exponentially over the stroke
- Inexpensive, reliable, and have very rapid response times.
- They cannot handle much power.
- Used in camera shutters, electric door or trunk locking systems in automobiles

Thank you

Next Class: Dimensional Synthesis