Electric Motors

Electrical Engineering

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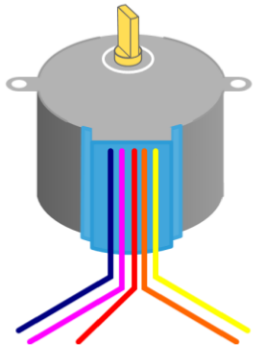
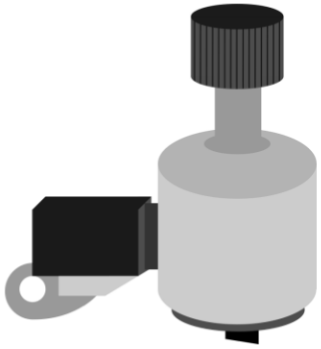
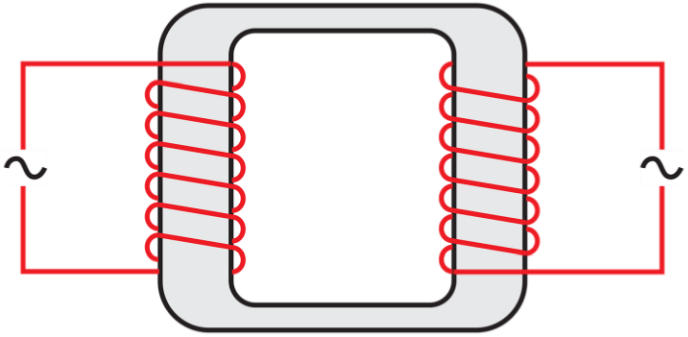
Electric Motors (1)

- Electric Machines
  - Motors
    - Convert electricity to mechanical power.
  - Generators
    - Convert mechanical power to electricity.
  - Transformers
    - Transfer electric energy from one electric circuit to another.





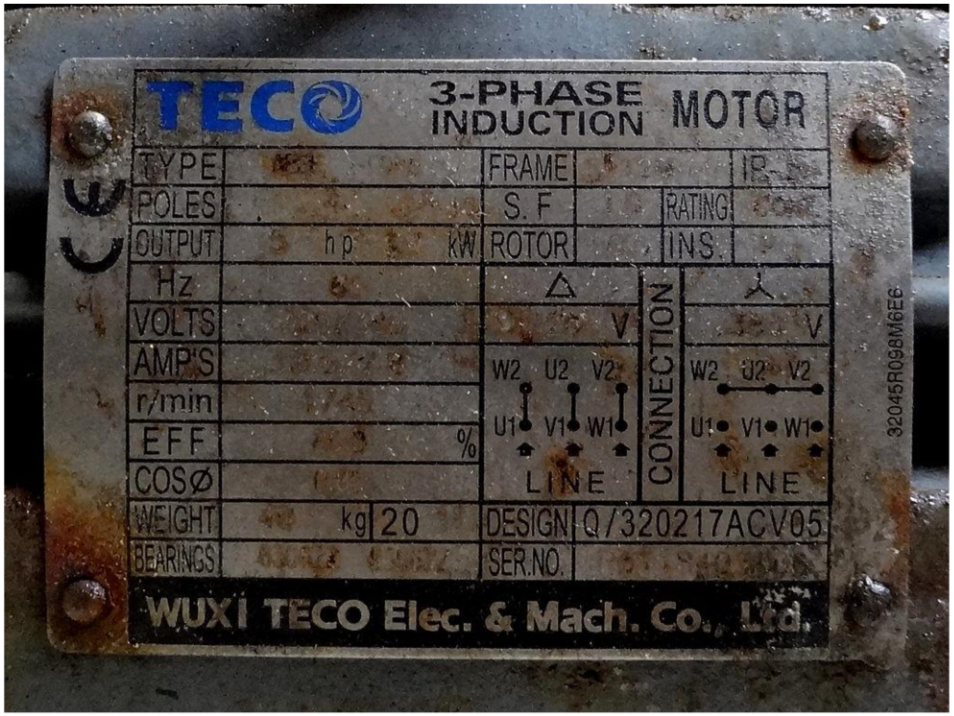


Electric Motors (2)

- Kinds of Motors
  - DC motors
    - Are powered by a direct current source.
  - AC motors
    - Are powered by an alternating current source.
  - Stepper motor
    - Driven by a rotating magnetic field.
    - Powered by a special stepper motor driver.
    - Does not turn continuously but step-by-step.

Electric Motors (3)

- Characteristics of Motors
  - Voltage
  - Nominal current
  - Nominal power
  - Power factor
  - RPM (revolutions per sec.)
  - Direction (of rotation)
  - Torque
  - Efficiency

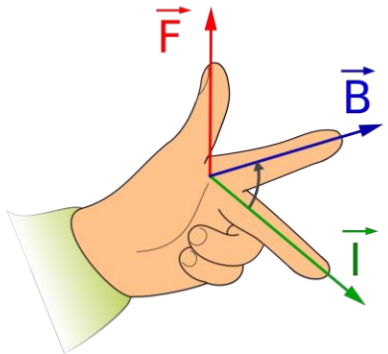


Electric Motors (5)

- Force Produced by Motors
  - It depends on:
    - Magnetic flux density (B)
    - Electric current (I)
    - Number of wires (z)
    - Length of wire (l)
  - The Fleming's left-hand rule shows its direction.

$$F = B \cdot I \cdot l \cdot z$$

[B] = T, [I] = A, [l] = m



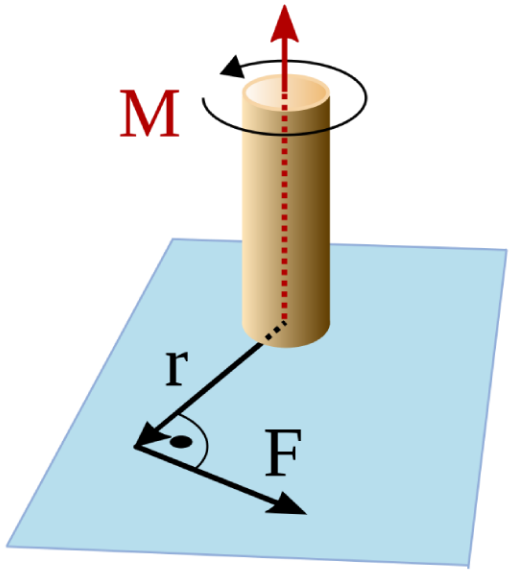
Electric Motors (6)

- Torque Produced by Motors
  - Force of a lever arm
    - M: torque in Nm.
    - r: length of lever arm.

$$M = F \cdot r$$

  - Torque on a shaft
    - P: Power in W.
    - n: Revolutions per second.

$$M = \frac{P}{2 \cdot \pi \cdot n}$$



Electric Motors (7)

- Efficiency of a Electric Motors
  - The electric power consumed can not be used totally.
  - There are losses.

$$P_{in} = P_{out} + P_{loss}$$

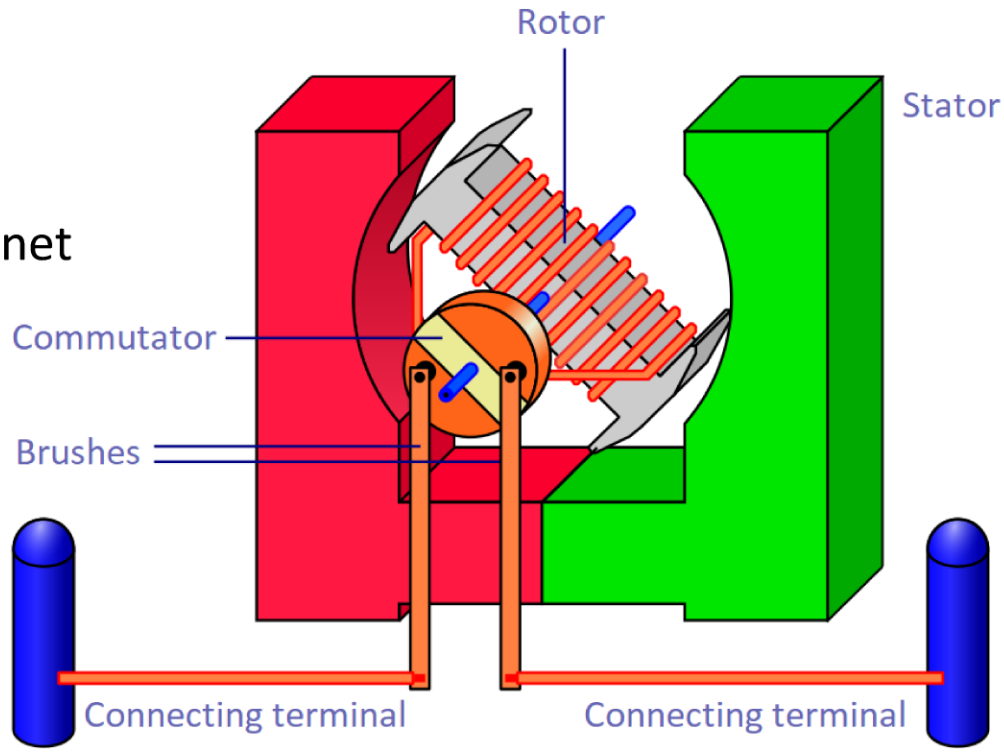
  - The efficiency is calculated by:

$$\eta = \frac{P_{out}}{P_{in}}$$

  - Efficiency is always less than 1 (100%).

DC Motors (1)

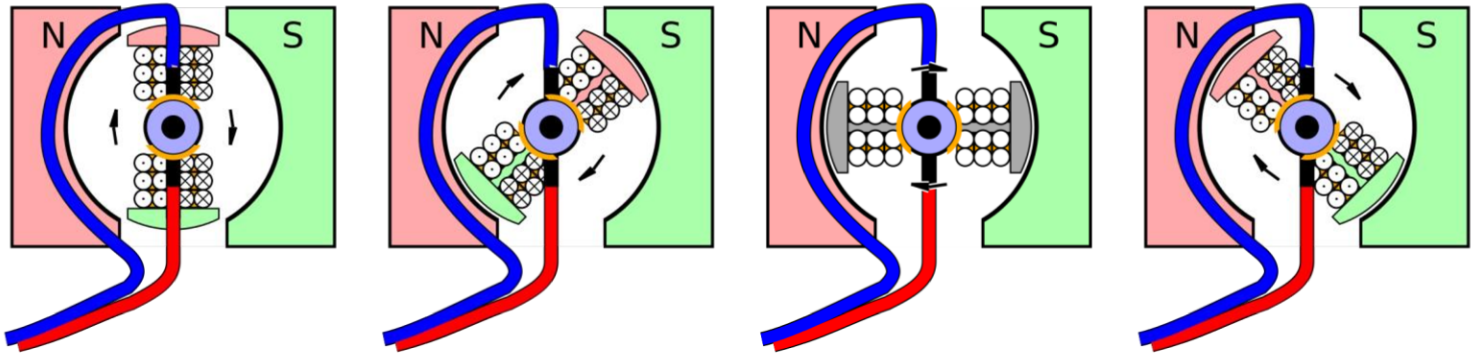
- Components
  - Stator
    - Stationary
    - Permanent magnet
  - Rotor
    - Moving
    - Electromagnet
  - Commutator
    - Pole changer
    - Brushes



Quelle: https://commons.wikimedia.org/wiki/File:Gleichstrommaschine.svg

DC Motors (2)

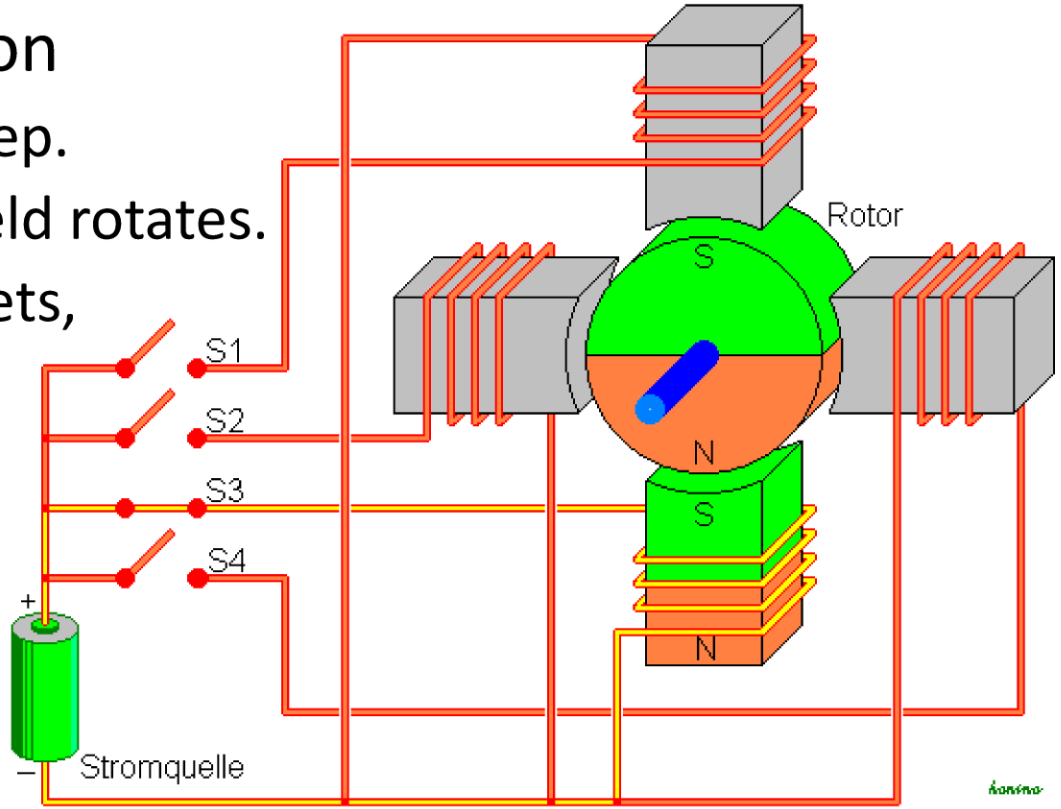
- Mode of Operation
  - Poles attract and repulse.
  - At the dead point current is interrupted.
  - After the dead point the poles are changed.



Quelle: https://commons.wikimedia.org/wiki/File:Animation_einer_Gleichstrommaschine_(Variante).gif

Stepper Motor (1)

- Mode of Operation
  - Turns step-by-step.
  - The magnetic field rotates.
  - The more magnets, the smaller the steps.



Quelle: https://commons.wikimedia.org/wiki/File:Schrittmotor.PNG

Stepper Motor (2)

- Stepper Motor Drivers
  - The control of stepper motors is complex.
  - It is common to use a special driver.
  - Commands: step, direction, enable, reset.