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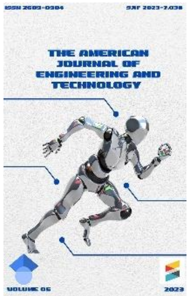

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Research Article

USING MODELS OF ELECTRIC ACTUATORS IN THE FACTORY

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Alijonov Xabibullo Avazbek O'g'li
Andijan Machine Building Institute, Andijan, Uzbekistan

ABSTRACT

There are many drives, gearboxes and mechanisms used in production today, and they are used in various industries. Friction is almost always present in drives and mechanisms used in mechatronic systems. By effectively using these mechanisms, we increase the production capacity and ensure the long service life of the mechanisms

KEYWORDS

Actuators, DC Motors, AC Motors, conductor, magnetic field

INTRODUCTION

In mechatronic systems electric motors are often used as actuators. They are mostly used in position and/or speed control systems. Electric motors are of two types:

- DC Motors (mostly used in modern control systems)
- AC Motors

DC Motors

Basic Principle

The basic principle of operation of a motor can be explained with the help of Fig. 3.29.

1. A force is exerted on a current carrying conductor placed in a magnetic field (Lorentz's law). This force, called Lorentz force is given as

$$F = BI\,L \quad (1.1)$$

where B is the magnetic field strength, I is current through conductor, and L is

length of conductor.

2. When a conductor moves in a magnetic field then an electromotive force (e.m.f.) is induced across it. The

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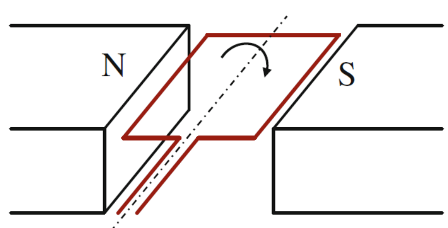
induced emf is equal to the rate at which the magnetic flux φ swept through by the conductor changes (Faraday's law)

$$e = -\frac{d\phi}{dt} (1.2)$$

The negative sign is because the emf is in such a direction as to oppose the change producing it (Lenz's Law), i.e. direction of induced emf is such that it produces the current. The current sets up magnetic fields which tend to neutralize the change in magnetic flux linked by the coil and which was responsible for the emf. That is why, the induced potential is called as back emf. Figure 2 shows the schematic arrangement of permanent magnet and one loop of rotor coil. Here for rotation to continue, when the coil passes through the vertical position, the current direction through the coil has to be reversed. If the current direction is not reversed then the moment generated by the Lorentz forces after passing the vertical position would

Models of Actuators

Fig.1.1 Basics of DC motor



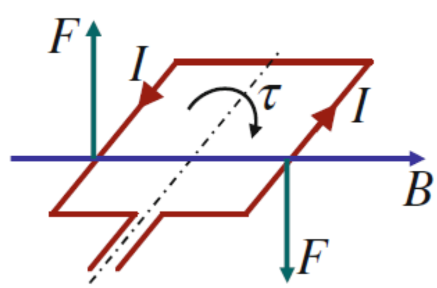
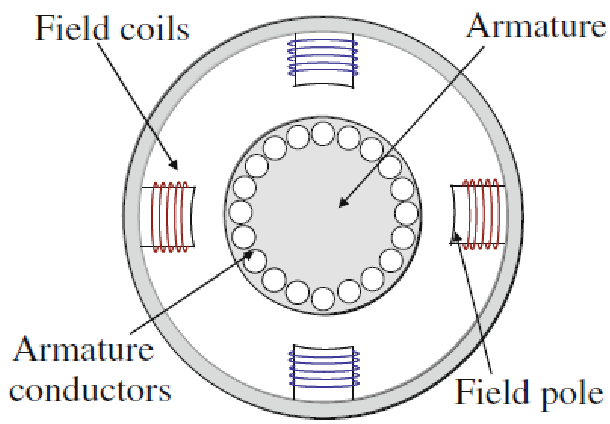


Fig1.2 Field magnet DC motor



Permanent Magnet DC Motor

The torque generated by a DC motor can be explained with help of Fig. 1.1, Force at right angle to conductor is given as $F = IBL$. With N such conductors, the net force becomes $F = NBIL$. Because the conductor bars are arranged in such a way that counter current flows at the exact opposite side, these forces result in a torque T about the coil axis given by $T = Fb$ where b is the width or mean diameter of the coil. The torque generated can be written as

$T = NBILb$(1.3)

If we take $Kt = NBLb$, then

$T = K_t\, I$(1.4)

Here Kt is the torque constant. Since armature is rotating in a magnetic field, electromagnetic induction occurs and back emf is induced. The back emf V_b is directly proportional to the rate in which flux linked by the coil changes. For a constant magnetic field (say, due to a permanent magnet), the back emf is directly

Modeling of Actuators, Sensors, and Electronic Circuits

Fig. 1.3. Equivalent circuit of DC motor

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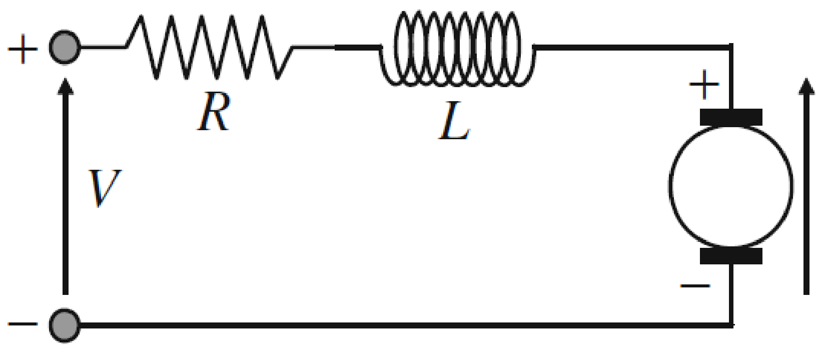

If field coil is in series with armature coil, it is called a series wound DC motor.

Figure 1.3 shows the series wound DC motor. Following are the characteristics of

series wound DC motor.

1. Motor has higher starting torque and higher no load speed.

2. Reversing the polarity of supply has no effect on the direction of rotation of

motor. It will rotate in the same direction since both field and armature currents

are reversed.

Figure 1.4 shows the bond graph model of series wound DC motor. The armature inductance is L_A and the effective field inductance is L_F = L_m + L_S, where

L_m and L_S are the mutual and stator inductances, respectively. The electromechanical transformation is modeled as a modulated gyrator (MGY) with its modulus defined as

$K_t\ (i_F) = L_m i_F\ N_A/N_S$ (1.5)

where i_F is the field current (here, i_F = i_A), and N_A and N_S are the number of

turns in the armature and the stator, respectively. If the field is externally energized

or constant (as in permanent magnet motor) then Kt becomes a constant

Fig. 1.4 Bond graph model of series wound DC motor

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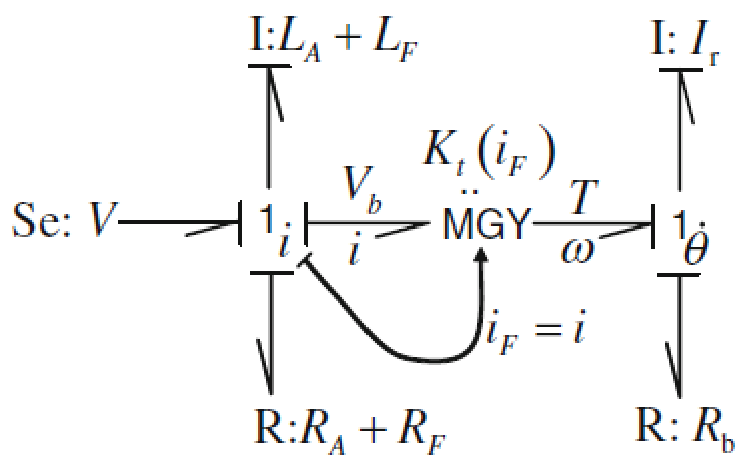

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