



Course : Electrical Machines

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Project Name : Analysis of a DC Shunt Motor

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♦ **Project Goal :**

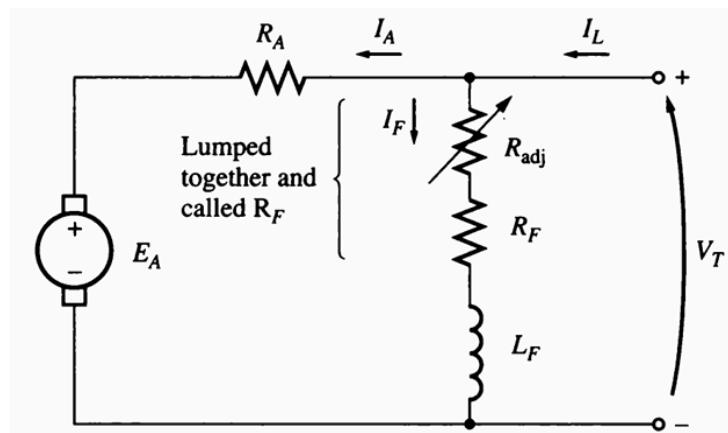
- Efficiency calculation for **Shunt-excited DC** motor using Excel

➤ In the next few slides I will use the given parameters to find the efficiency , then i will explain everything about the excel sheet.

♦ **The given parameters :**

Shunt-excited DC motor: $R_f = 240 \Omega$, $L_{af} = 1.8 H$, $R_a = 0.6 \Omega$, $L_f = 120 H$, $L_a = 12 mH$, $V_a = 240 V$,
5 hp, rated speed 1220 rpm, rated torque 29.2 N.m, $B_m = 0$, $J_m = 1 kg.m^2$

♦ **The equivalent circuit of a shunt dc motor + information about it :**



- A shunt DC motor is a type of DC motor in which the field winding is connected in parallel with the armature winding. This parallel configuration ensures that the field winding receives a constant voltage supply, resulting in a relatively stable magnetic field. Because of this, shunt DC motors are well known for their ability to maintain nearly constant speed under varying load conditions.

- The shunt DC motor consists of two primary windings:
 - a) Armature winding: Located on the rotor, this winding carries the main current responsible for torque production.
 - b) Field (shunt) winding: Located on the stator, this winding produces the magnetic field required for motor operation.

➤ **Important note :**

At steady state, inductors behave like short circuits for DC. That means:

$$V_L = L \frac{di}{dt} = 0$$

$$\frac{di}{dt} = 0$$

And because the current $i(t)$ is constant $\frac{di}{dt} = 0$

→ so we should not use the values of L_a , L_f , L_{af}

➤ **Steps for calculations 😊**

$$I_f = \frac{V}{R_f}$$

- V = supply voltage (V)
- I_f = field current (A)
- R_f = the field resistance (Ω)

- From the given parameters = $V_a = 240$ V, $R_f = 240$ Ω

$$\text{So } \rightarrow I_f = V_a / R_f = 240 / 240 = 1 \text{ A}$$

$$\omega = \frac{2\pi N}{60}$$

- ω = Angular speed (rad/s)
- N = Rotational speed (rpm)

- From the given parameters = $N = 1220$ rpm

$$\text{So } \rightarrow \omega = (2\pi * 1220) / 60 = 127.75810 \text{ rad/sec}$$

$$P_{\text{out}} = T \cdot \omega$$

- T = torque (N.m)
 - ω = Angular speed (rad/s)
 - Output Power is mechanical
- From the given parameters $T = 29.2$ N.m , $\omega = 127.75$ rad/sec

So → $P_{\text{out}} = 29.2 * 127.75 = 3730.53$ watt

$$V = E_a + I_a R_a$$

$$P_{\text{mech}} = E_a \cdot I_a$$

- E = EMF (V)
 - R_a = armature resistance (Ω)
 - I_a = armature current (A)
 - V_a = armature voltage (volt)
 - $P_{\text{mech}} = P_{\text{out}}$ (watt)
- By using substitution to find the value of I_a

$$I_a = \frac{V \pm \sqrt{V^2 - 4R_a P_{\text{mech}}}}{2R_a}$$

So → using the given and the calculated values to find it , $I_a = 16.2$ A

$$P_{\text{in}} = V \cdot I_{\text{total}} = V \cdot (I_a + I_f)$$

- Using the values above to find the P_{in} (electrical input power)

So → $P_{\text{in}} = 240 * (1 + 16.2) = 4128.001$ watt

$$\text{Efficiency}(\eta) = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

So → Efficiency = $(3730.53 / 4128.001) * 100 = 90.3715$ %

➤ The losses in the shunt DC motor :

- Copper losses:
 - Armature: $I_a^2 R_a$
 - Field: $I_f^2 R_f$

So → the armature loss = $16.2^2 + 0.6 = 157.4640$ watt , field loss = $1^2 + 240 = 240$ watt

- The total loss is = $P_{\text{input}} - \text{Output} \rightarrow 4128.001 - 3730.53 = 397.471$ watt
 - And also using armature loss + field loss = $157.4640 + 240 = 397.464$ watt
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In the Excel Sheet

♦ My project goal :

Study how a DC shunt motor behaves under different conditions.

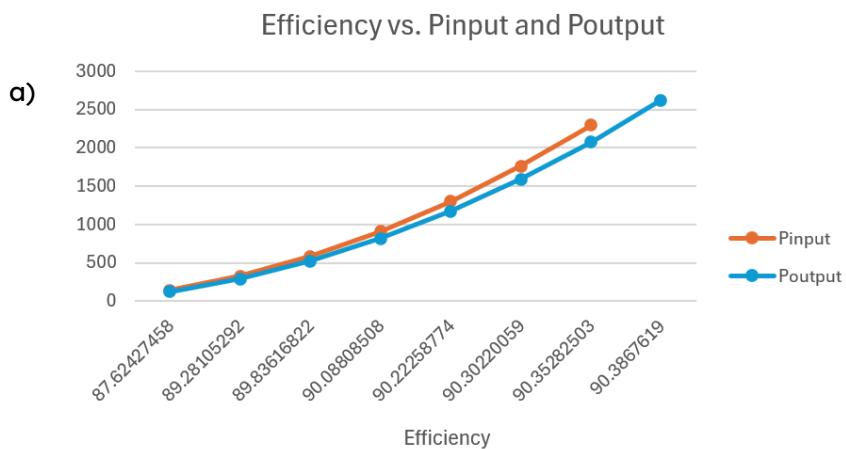
♦ What i Did :

In this experiment, I changed the armature voltage while keeping the field resistance constant, which caused the field current to vary. I also changed the torque and angular speed, which affected the output power. As a result of these changes, the armature current changed, leading to a change in the input power. Since both input power and output power changed, the efficiency of the motor also changed.

♦ What i Found :

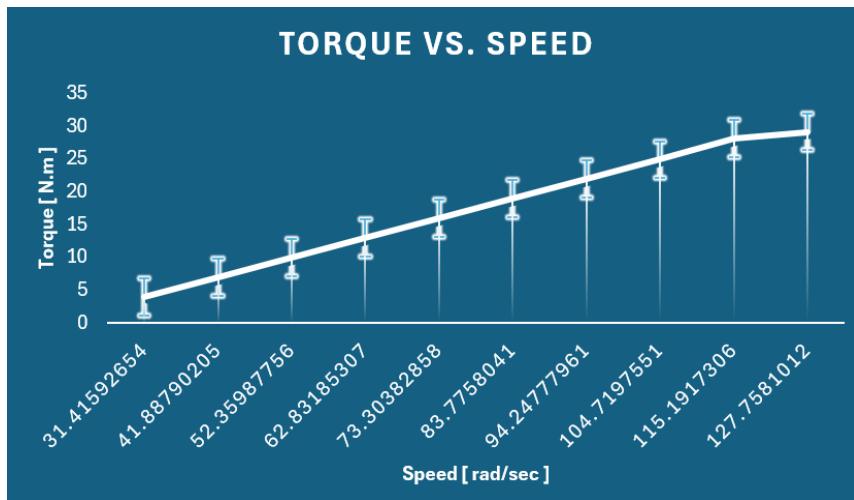
- Efficiency : The motor became more efficient as voltage and power increased. It reached over 90% at higher loads.
- Output Power : Output power increased as input voltage increased.
- Torque and Speed : Torque increased with speed.
- Power Losses : Losses (especially from the armature winding) also increased with voltage and current.

♦ Plots and Results :



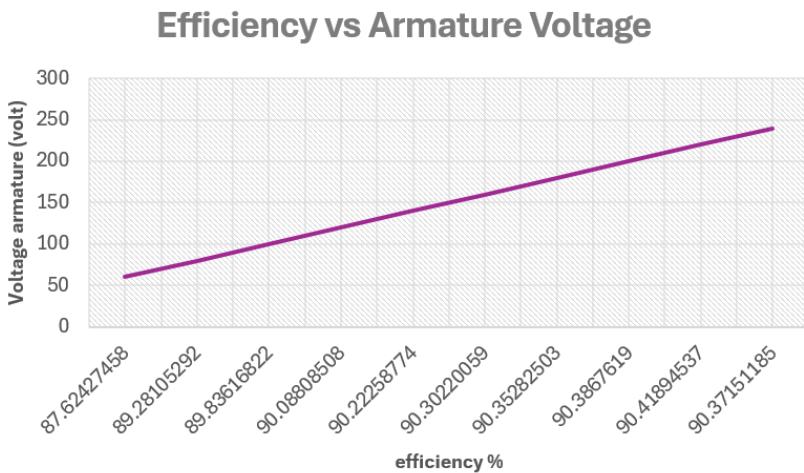
- Both Pinput and Poutput increase as efficiency increases, which is expected.
- The gap between Pinput and Poutput reflects losses — and that gap gets slightly bigger at higher power levels, also expected.

b)



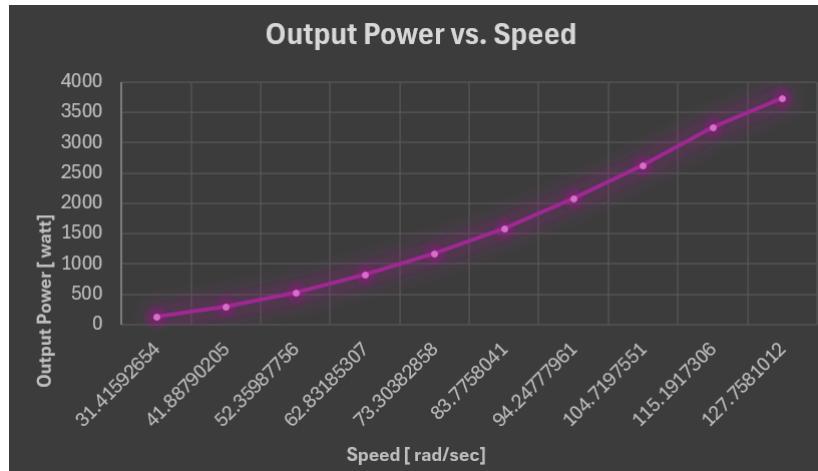
- The motor showed steady torque behavior as speed increased, as expected for a shunt motor

c)



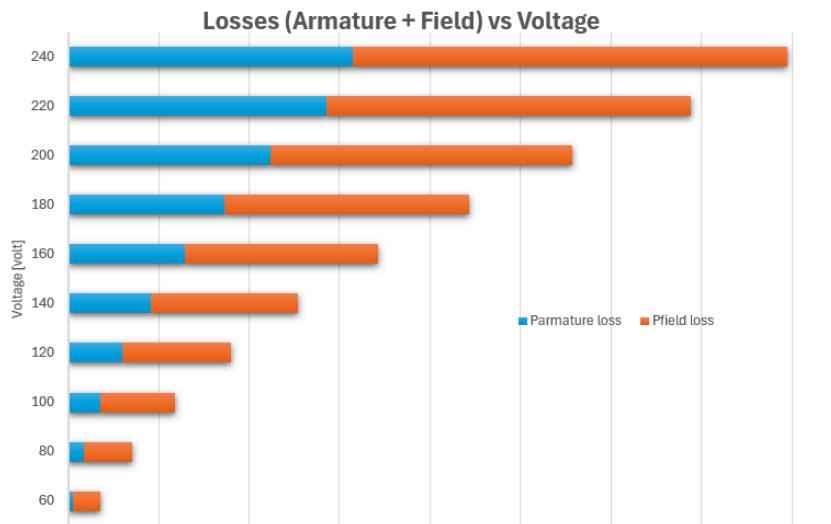
- Efficiency increases as the armature voltage increases.
- At lower voltages, the efficiency is lower because more power is lost in the motor (mostly due to copper losses).

d)



- As the speed increases, the output power also increases.

e)



- This stacked bar chart shows how total copper losses (field and armature) increase with voltage