Objectives:

- To determine the speed variation in loaded and unloaded DC series wond motor using armature voltage control.
- To determine torque and efficiency characteristics.
- To find out how to reverse the direction of rotation.

Introduction: DC-Series Motor has relatively few field turns connected in series with armature as shown in the equivalent circuit below:

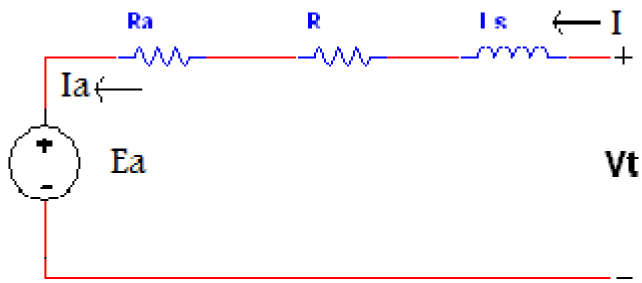


Figure1: The equivalent circuit of DC-series motor.

the speed torque relationship is much different than that of a chunt motor, as the torque increases the speed decays as in the equation:

$$n=(V_t/K_E.\ \tau\ .VK_\varphi/K_M)-(R/K_\varphi.\ K_E)$$

* three ways to control the speed of this motor:

- Alternating the terminal voltage.
- Inserting a resistor in parallel with the field coil, causing the field flux to change
- Inserting a resistor in parallel with armature, to change the armature current

The flux in DC-series motor directly proportion to the armature current, and compared with other DC motors this delivers more torque per ampere than others, so in high torque application it will be the best choice.
A deep look on the speed-torque equation above, when the torque is zero (no load) the speed of the machine goes up to infinity. Never disconnect the load while the motor operates.

Some useful formulas for describing the DC-series motor:

$V_t = I_a.(R_a + R_f) + Ea$, $\tau = K_M . \Phi . I_a = K_M . K_f . I_a^2$

$\Phi = K_f . I_a$

Procedure:

A) Measuring some characteristics of DC Shunt motor:

Im(A)	Vt(V) Cons.	Pin (W)	N(rpm)	τ(N.m)	Pout (W)	η%
4	220	880	3420	1.75	626.47	71.22%
5	220	1100	3030	2.46	780.56	70.95%
6	220	1320	2800	3.18	932.42	70.64%
7	220	1540	2600	3.86	1051	68.25%
7.3	220	1606	2550	4.08	1089.5	67.84%

W=2.pi.n/60 , Pin=Im.Vt , Pout=w. τ , η %=(P_o/P_i).100

Calculations:

Pout=(2π/60) . 3420 . 1.75=626.74 η %=626.74/880=71.22%

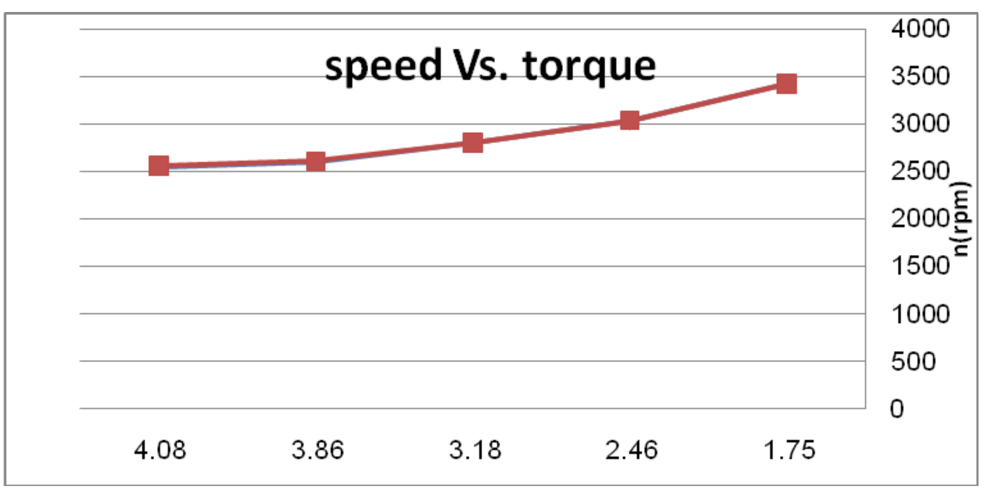
Pout=(2π/60) . 3030 . 2.46=780.55 η %=780.55/1100=70.95%

Pout=(2π/60) . 2800 . 3.18=932.42 η %=932.42/1320=70.64%

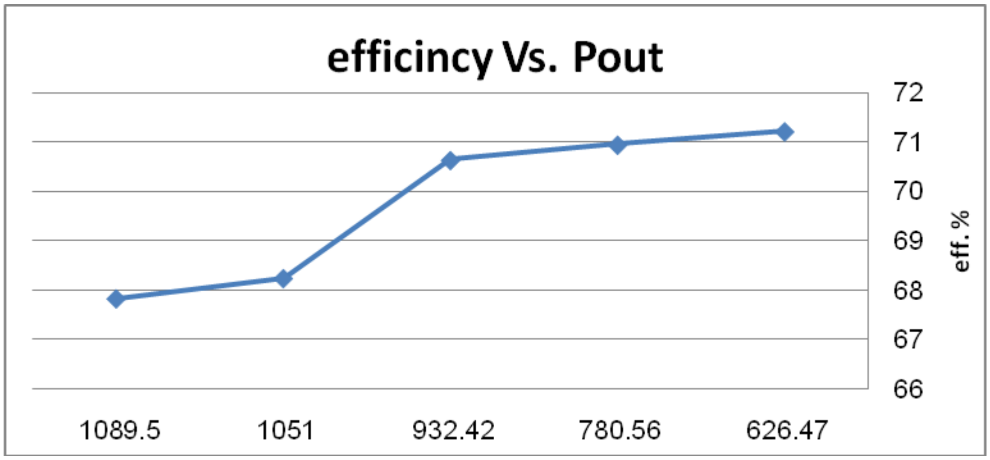
Pout=(2π/60) . 2600 . 3.86=1051 η %=1051/1540=68.25%

Pout=(2π/60) . 2550 . 4.08=1089.5 η %=1089.5/1606=67.84%

Q1: plot speed versus torque curve.



Q2: plot eff. Versus output power.



Q3:Explane the nature of the curves above?

Both curves (speed Vs. toque) and (eff. Vs. Pout) ere inversely relation proportion, from the equation:

$n=(V_t/K_E.\ \tau\ .VK_\varphi/K_M)-(R/K_\varphi.\ K_E)$ as the torque increases the speed must decreases.

for (efficiency Vs. Pot) curve, the increase in power comes from the increase in the current, and then the losses will increases.

B) Speed control of a DC series motor:

By alternating terminal voltage.

Im(A)	Vt(V)	Pin(W)	N(rpm)	τ (N.m)	Pout(w)	η%
7.25	200	1450	2240	4.03	945.32	65.2%
7.03	150	1054.5	1560	3.91	648.55	61.5%
6.08	100	608	970	3.27	323.16	53.15%
4.22	50	211	450	1.98	93.3	44.2%
0.24	0	0	0	0.03	0	0

Pout=(2π/60) . 2240 . 4.03=945.32 η %=945.32 /1450=65.2%

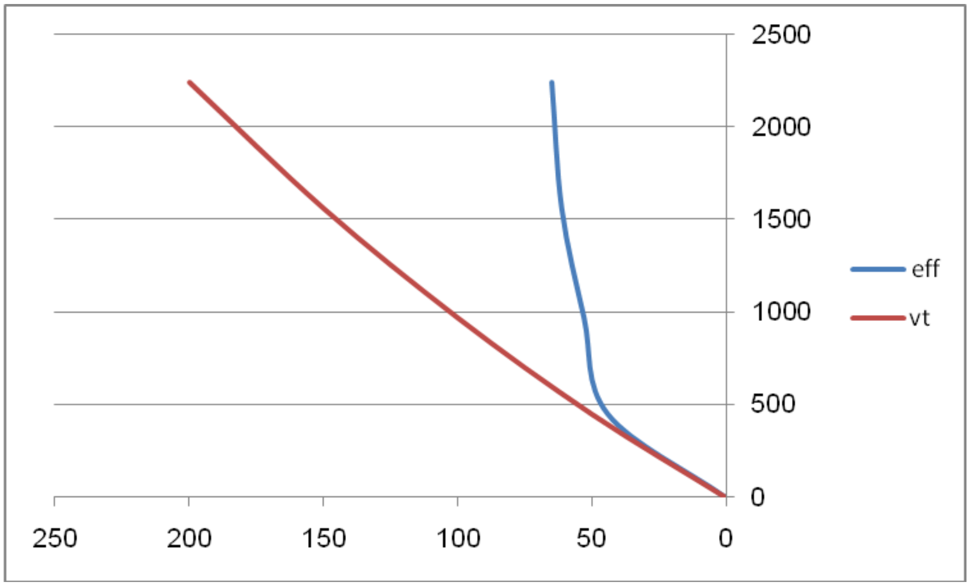
Pout=(2π/60) . 1560 . 3.91=648.55 η %=648.55/1054.5=61.5%

Pout=(2π/60) . 970 . 3.27=323.16 η %=323.16 /608=53.15%

Pout=(2π/60) . 450 . 1.98=93.3 η %=93.3/211=44.2%

Pout=0 η %=0

Q1:plot speed versus Vt and versus efficiency in the same graph.



C) Reversing the direction of rotation of DC shunt motor:

Q1) if the direction of the current through the field is changed, what will happen?

If the direction of the field current changed, then the direction of rotation will reverse because the flux has changed.

Q2 if the direction of the current through the armature is changed, what will happen?

If the armature current is changed, then the direction of rotation will change.

Q3 if the direction of the current through both the armature and field is changed what will happen, explain why?

As changing the direction of one of the tow current cause the direction of rotation to change, when the two currents are changed, the direction of rotation changed twice, that means it remains the same

Conclusion:

two ways to change the direction of rotation; by changing the direction of armature current or field current, not both and not Vt.

The torque and speed are inversely proportion in DC-series motor.

Compared with other Dc motors, series motor delivers more torque per ampere.

We should not turn on this motor without any load, doing this will be dangerous.

This motor is not efficient for high load applications, because the efficiency is inversely proportion to the output power