ISSN:0971-1260
Vol-22-Issue-16-August-2019

Investigation of The Effect of Armature-Resistance Control and Field-Resistance Control on The Efficiency of A Dc Shunt Motor For The Same Change In Speed At No-Load

ISHAN LUTHRA

School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab, India

ishan.luthra@lpu.co.in

Abstract: In this paper attempt has been made towards verification of the fact presented in many books that armature-resistance control method of speed control leads to heavy power loss in the controlling rheostat which causes large decline in the efficiency of a DC Shunt Wound Motor. Experiments have been performed on a 3 H.P., 220V DC Shunt Motor at no-load condition. Speed of the motor is first obtained without any additional resistance. Speed is then changed by 200 r.p.m. in steps of 50 r.p.m. using Armature-Resistance Control and Field-Resistance Control methods. Efficiency of the motor is calculated at different speeds using each method. It has been observed that there is approximately same decrease in the efficiency using each method, for the same change in speed. Though the experimental results contradict with the facts stated in the books, but this work can be considered as a preliminary attempt towards the verification of those facts by further investigating the cause(s) of contradiction which will be a part of the future work.

Keywords: DC Motors, DC Shunt Motor, Speed Control, Armature Control, Field Control

1. INTRODUCTION

Speed control of a motor refers to intentional change caused in the speed of the motor. When it comes to DC motors, speed is governed by the relation

$$N \propto E_b/\varphi \qquad (1)$$

whereE_b is the backemf induced in the armature while φ is the magnetic flux at each pole. The relationship for back emf is as under

$$E_b = V - I_a R_a \quad (2)$$

Where V refers to applied voltage, $I_a$refers to armature current and R_a refers to armature resistance. Thus, equation (1) can rewritten as

$$N \propto V - I_a R_a / \varphi \qquad (3)$$

From equation (3) it can be deduced that speed of DC motor can be varied by varying either or all of the following:

Copyright © 2019Authors

ISSN:0971-1260
Vol-22-Issue-16-August-2019

1. Magnetic flux per pole, φ, which refers to field control
2. Armature voltage drop, I_aR_a, which refers to armature control
3. Applied voltage, V, which refers to voltage control

According to several authors [1-4], armature-resistance method of controlling the speed which is one among different types of armature control methods used in DC shunt motors causes heavy power loss in the controlling rheostat. Since more power will be lost in the rheostat therefore output power in the armature will significantly reduce causing a large decline in the efficiency of the DC shunt wound motor.

The present work attempts to verify the above statement by comparing the change in efficiency of a DC shunt wound motor caused by armature-resistance controlling technique with that caused by field-resistance controlling technique which is a type of field control method.

2. METHODOLOGY

Figure 1 shows the connection of a DC shunt motor. Power supplied to the motor is given as

$$P_i=VI_L \text{ watt} \tag{4}$$

where I_L is the total current supplied to the motor

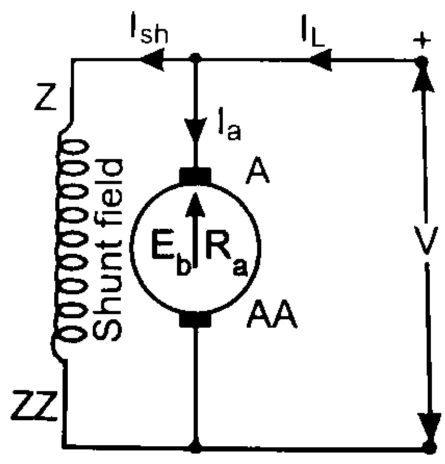

Figure 1. DC Shunt Wound Motor

Power developed in the armature is given as

$$P_o=E_bI_a \tag{5}$$

2.1 ARMATURE RESISTANCE CONTROL

Figure 2 shows the connection of a DC shunt wound motor with armature resistance controlling technique. It consists of a resistor,R, which is variable and is in series with the armature. The back emf under this condition is given as

$$E_b=V-I_a(R_a+R) \tag{6}$$

 Copyright © 2019Authors

ISSN:0971-1260
Vol-22-Issue-16-August-2019

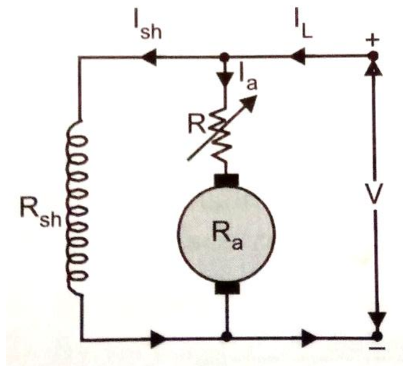

Figure 2. DC Shunt Wound Motor with Armature-Resistance Control

Hence power developed in the armature will be given as

$$P_{o\text{-}arc}=I_a(V-I_a(R_a+R)) \quad (7)$$

2.2 FIELD RESISTANCE CONTROL

Figure 3 shows the connection of a DC shunt wound motor with field resistance controlling technique. It consists of aresistor,R which is variable and connected in series with the field winding. Under this condition the back emf is given as

$$E_b=V-I_aR_a \quad (8)$$

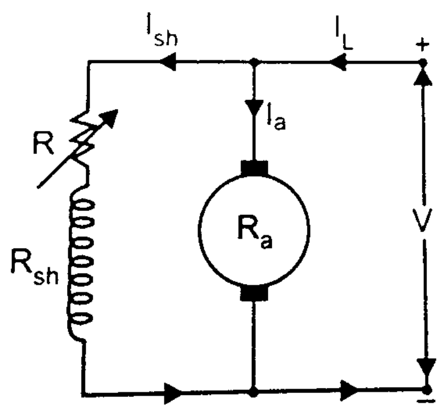

Figure 3. Field-Resistance Controlled DC Shunt Motor

Hence power developed in the armature will be given as

$$P_{o\text{-}frc}=I_a(V-I_aR_a) \quad (9)$$

3. EXPERIMENTAL SET-UP

Experiments were conducted on a 3-H.P., 220V DC shunt wound motor, as shown in Figure 4. Resistance of the armature, R_a, is found to be 5Ω.

Copyright © 2019Authors

ISSN:0971-1260
Vol-22-Issue-16-August-2019

Figure 4. 3-H.P., 220V DC Shunt Wound Motor used in Experiment

Figure 5 shows the experimental setup in which a variable resistor was connected in series initially with the armature and then with the field winding.

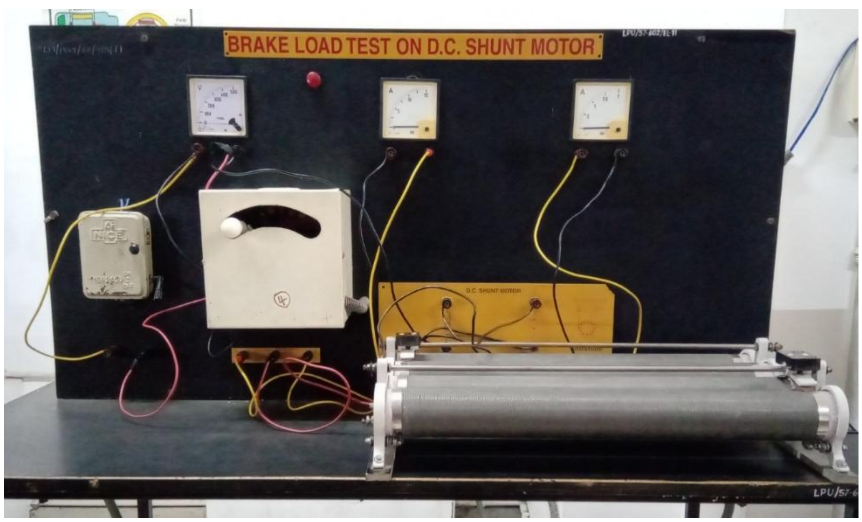

Figure 5. Experimental Set-up

Resistance which is variable and connected in the armature circuit was first increased in steps to cause a change of 50 r.p.m. in armature speed at each step. In this case the resistance which is variable and connected with field winding in series was kept null. Then keeping the variable resistance in armature circuit null, the variable resistance in the field winding was increased in steps to cause a change of 50 r.p.m. in the speed of armature at each step.

4. RESULTS

The speed of the motor was first measured at no-load condition by keeping the variable resistors at null value. This no load speed was found to be 1400 r.p.m. Then for each 50 r.p.m. change in speed caused by

Copyright © 2019Authors

ISSN:0971-1260
Vol-22-Issue-16-August-2019

armature-resistance method, value of resistance which is variable and added in series with the armature is measured along with calculating the input power and output power of the motor as shown in Table 1.

Table 1. Experimental Parameters Measured in Armature-Resistance Control Method

Change in Speed (r.p.m.)	Resistance added in series with Armature, R (Ω)	Power Supplied, VI_L (W)	Power Developed in Armature, E_bI_a (W)
0	0	262.5	134.38
50	18	252	117.72
100	32	252	112.68
150	48	252	106.92
200	63	252	101.52

Similarly, for each 50 r.p.m. change in speed caused by field-resistance method, value of resistance which is variable and connected with the field in series is measured along with calculating the input power and output power of the motor as shown in Table 2.

Table 2. Experimental Parameters Measured in Field-Resistance Control Method

Change in Speed (r.p.m.)	Resistance added in series with Field Winding, R (Ω)	Power Supplied, VI_L (W)	Power Developed in Armature, E_bI_a (W)
0	0	262.5	134.38
50	55	210	93.48
100	90	189	83.2
150	125	182.7	77.01
200	155	177.32	72.88

Table 3 compares the efficiency of the motor for each 50 r.p.m. change in speed caused by each of the two methods.

Table 3. Comparison of the Efficiency of the Motor using each speed control method for same change in speed

Change in Speed (r.p.m.)	Efficiency with Armature-Resistance Control (%)	Efficiency with Field-Resistance Control (%)
0	51.1	51.1
50	46.7	44.5
100	44.7	44.02
150	42.4	42.14
200	40.28	41.1

Copyright © 2019Authors

ISSN:0971-1260
Vol-22-Issue-16-August-2019

Figure 6 is a graphical comparison of the change in efficiency of the motor for the same change in speed obtained using armature-resistance controllingtechnique and field-resistance controlling technique.

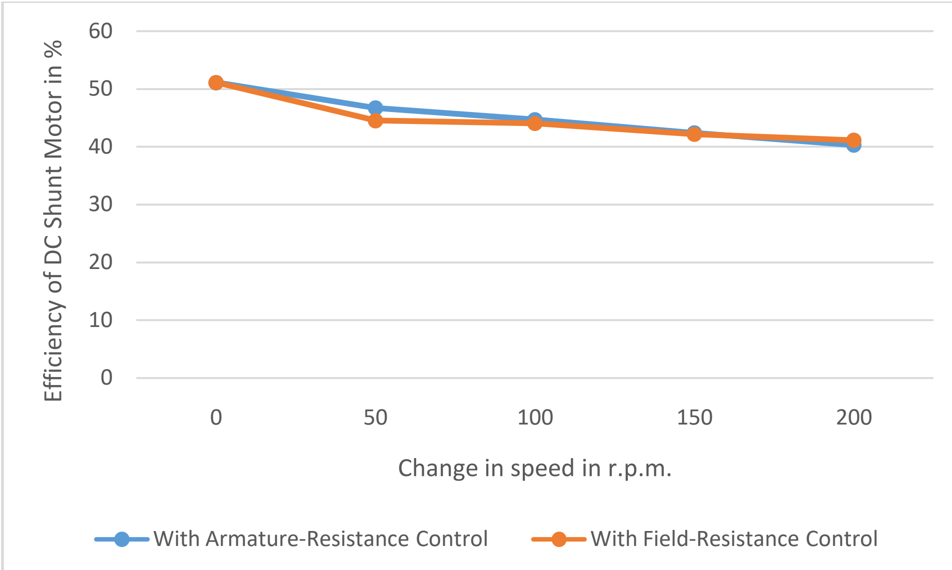

Figure 6. Change in efficiency of the DC Shunt Motor for the same change in speed using different methods

It can be seen that efficiency of the motor decreases 10.82% when speed changes by 200 r.p.m. using armature-resistance control and it decreases 10% when speed changes by 200 r.p.m. using field-resistance control.

5. CONCLUSION

The present work attempted to verify the fact laid down in several books that armature-resistance control method of controlling the speed leads to heavy power loss in the controlling rheostat thereby causing significant decrease in the efficiency of a DC Shunt wound Motor. For verification, the armature-resistance controllingtechnique was compared with field-resistance controllingtechnique for achieving the same change in speed, at no-load condition. It was observed that fall in the efficiency of the motor was nearly the same in each case. Although the results do not show agreement with the statement given in many books on electrical machines, they open a way for further investigation in this direction to find out the cause(s) behind the disagreement. Further investigation in this direction will be a part of the future work. Investigating the effects of these methods on the efficiency at on-load condition will also be covered in the future.

REFERENCES

1. Electrical Machines, S.K. Sahdev, Cambridge University Press, pp. 328
2. Electric Machines, DP Kothari and IJ Nagrath, Tata Mc-Graw Hill Education, pp. 342
3. Electrical Machinery, PS Bimbhra, Khanna Publishers, pp. 246
4. Theory and Performance of Electrical Machines, JB Gupta, SK Kataria and Sons, pp. 289

Copyright © 2019Authors