



# The Modelling of Properties and Parameters on Variable Resistance with Series Circuit in Micromotor II

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## Abstract

The model of variable resistance and micromotor is established and it is found that the acceleration will attain the  $40\text{mm/s}^2$  at  $5\text{A}$  and  $U=18\text{V}$ ,  $R_m=8.5\Omega$ ,  $t=6\text{s}$ . The maximum and minimum acceleration arrives  $60\text{mm/s}^2$  and  $18\text{mm/s}^2$ . The effective turn is  $U>R_m>t$ . The maximum force is  $280\text{N}$  on the other side the minimum one is  $20\text{N}$  which is found in this study.

**Keywords:** Acceleration; Current; Variable resistance; Series circuit; Voltage; time; Micro DC motor

## Introduction

The motor acceleration and force is an important parameters in series circuit with other resistance. Therein the variable resistance has been adopted to draw the relationship curve to observe the trend and value for further research on it. Furthermore the big effective factor will be proceeded further to search the deep intrinsic nature between them. Because DC motor is simpler one to compare with AC motor the DC motor has been searched firstly to gain the satisfactory result to control it is the destination of this paper [1-4]. In the controlling the motor the detail factors are important parameters for us to regulate and arrive the destination of control. All the base is the mathematical modelling to motor for the convenient regulation in advance. Therefore in this study the fit modelling has been established and simulate the all the properties happened to motor for searching deep intrinsic relation. Therein the course has been modelling with electrical and mechanical parameters to look forwards to finding the severe failure phenomenon i.e. Stall matter. It makes the abnormal working even no rotary so that it must be substituted for another good one which makes the time to increase so as to prevent from wasting time to create benefit. So the modelling may proceed

with all the matter to solve these problem in prediction. This is the most aim to be solved in this paper and further direction.

## Modelling for Motor Properties

According to power defining it gains

$$\text{So } dP = d(Fv) \quad (1)$$

Here F is motor force; v is its speed.

According to electric principle in terms of Figure 1 it has

$$\sum P = P_m + P_v = \sum(i_m^2 r_m + i_v^2 r_v) \quad (2)$$

$$P_m = i_m^2 r_m \quad (3)$$

Here  $P_m$  is motor power;  $P_v$  is variable power;  $r_m$  is motor resistance;  $r_v$  is variable resistance;  $i_m$  is motor current;  $i_v$  is variable current.

From energy conservation law it has

$$P_m t = \frac{1}{2} I_m \omega^2 = Fvt \quad (4)$$

According to (1) and (4) it has

$$\frac{1}{2} I_m \omega = FRt \quad (5)$$

Here  $\omega$  is angular speed.

The rotary inertia of motor armature is

$$I_m = \frac{1}{2} m R_m^2 \quad (6)$$

From (5) it has

$$\omega = \sqrt{2FRt / I_m} \quad (7)$$

From (3) it has

$$F = 9.55 \frac{i_m^2 r_m}{2nR} \quad (8)$$

Since

$$n = \frac{30\omega}{\pi R^2} \quad (9)$$

According to (7), (8) and (9) it has

$$\omega = \sqrt[3]{\frac{9.55 i_m^2 r_m \pi}{15m}} \quad (10)$$

$$v = R \sqrt[3]{\frac{9.55 i_m^2 r_m \pi}{15m}} \quad (11)$$

And

Here  $R_m$  is armature diameter;  $n$  is rotation;  $t$  is time;  $m$  is mass of rotor ie armature.

$$a = \dot{v} = \dot{\omega} t = \frac{R}{3} \sqrt[3]{\frac{9.55 i_m^2 r_m \pi}{15m t^2}} \quad (12)$$

From (9) it has

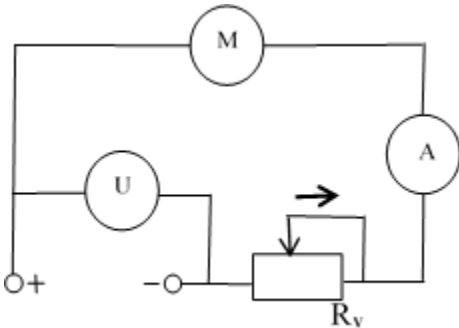
$$n = \frac{30}{R^2} \sqrt[3]{\frac{9.55 i_m^2 r_m t}{15m \pi^2}} \quad (13)$$

$$dT = 9.55 \frac{i_m^2 dr_m}{n} \quad (14)$$

And

$P$  is from (3),  $T$  is from (14) and  $n$  is from (13),  $F$  is from (8).

Here  $T$  is torque (Figure 1).



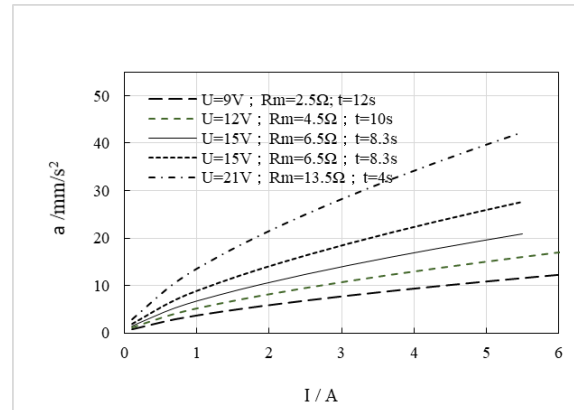
**Figure 1:** Circuit simulation under motor and variable resistance  $R_v$ .

The motor armature mass is 5.7g and its diameter  $f$  is 14 and 16mm in this study. The motor resistance is supposed 10 $\Omega$ , 15 $\Omega$ ,

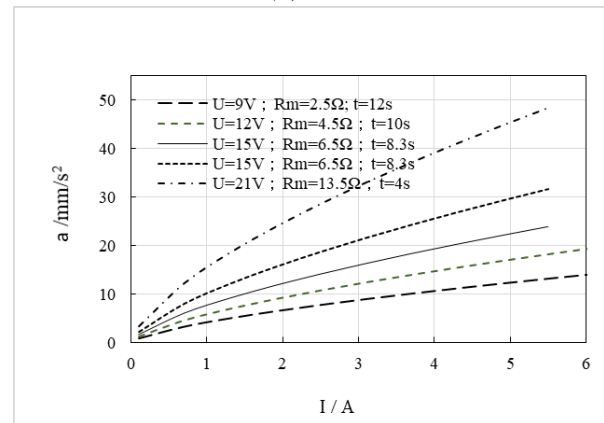
20 $\Omega$ , 25 $\Omega$  for each stage whilst the voltage is used 8V, 12V, 16V and 21V respectively. The maintaining time in variable resistance is 44s, 6s, 8.5s, 10s, and 12s respectively. The motor armature mass and voltage being 6V, 9V, 12V, 15V, 18V and 21V, its resistance being 2.5 $\Omega$ , 4.5 $\Omega$ , 6.5 $\Omega$ , 8.5 $\Omega$ , 13.5 $\Omega$  and time from 12s to 4s are used to simulate the equation which is deduced in model as above. Discussion is proceeded as below.

## Discussions

The motor acceleration will increase as its current increases and the same as above will happen as to force. When the voltage increases acceleration will be big with radius of 7mm and mass of 5.7g as seen in Figure 1 and resistance increases it will be big too. It will decrease when the voltage become big. So the effective factor turn is  $U > R_m > t$  which is concluded in this paper. In nominal current of 1A the acceleration will distribute to 4~17mm/s<sup>2</sup> whilst in stall current of 6A it will arrange from 15~50mm/s<sup>2</sup>.



(a)  $R=7mm$

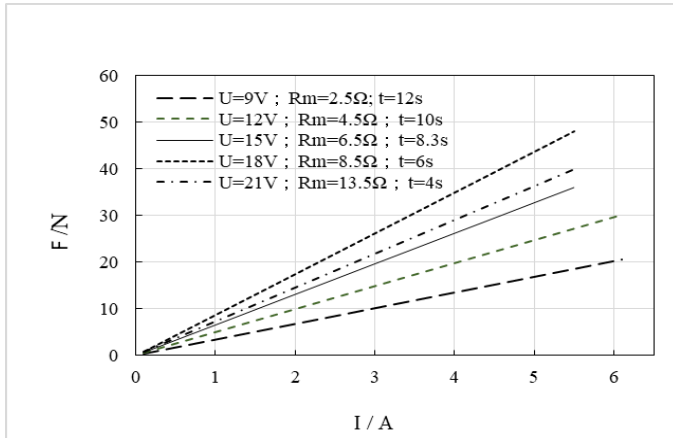


(a)  $R=8mm$

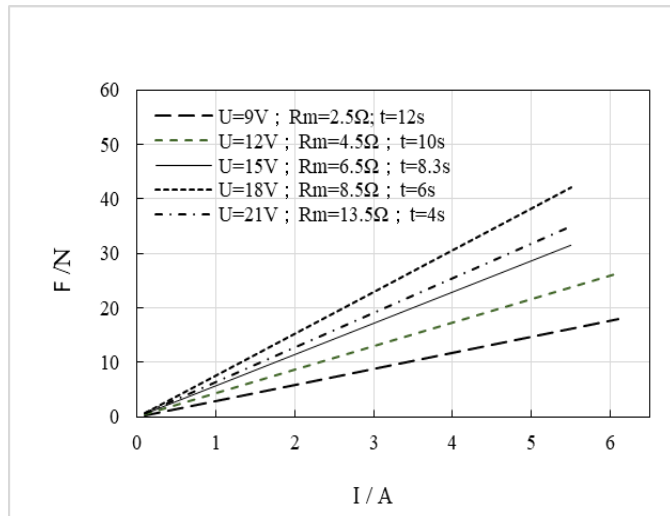
**Figure 2:** The curve of acceleration and current with  $R$  and  $m=5.7g$  in the motor

In Figure 2 the same trend is gained as above mention with radius of 8mm and mass of 5.7g in armature. The rate acceleration can attain from 4mm/s<sup>2</sup> to 20mm/s<sup>2</sup> whilst the stall one can attain

from  $18\text{mm/s}^2$  to  $60\text{mm/s}^2$  as above mention in terms of prediction. The force in Figure 3(a) arranges from 20N to 50N in rate status with radius of 7mm and the same mass of armature in time of 4~12s whilst it arranges higher than 50N in stall in terms of prediction, Like 10A of current. Meantime the force in Figure 3(b) arranges from 18N to 42N in rate status with radius of 8mm and the same mass of armature in time of 4~12s whilst it arranges higher than 42N in stall in terms of prediction.



(b)  $R=7\text{mm}$



(c)  $R=8\text{mm}$

Figure 3: The curve of force and current with  $R$  and  $m=5.7\text{g}$  in the motor.

Overview the maximum acceleration has been at  $t=4\text{s}$ ,  $R_m=12.5\Omega$ ,  $U=21\text{V}$  whilst the minimum one has been at  $t=12\text{s}$ ,  $R_2=2.5\Omega$ ,  $U=9\text{V}$ . The effective turn is  $U>R_m>t$  which expresses the important factor among these three parameters. The former is formed through  $U$  and  $R_m$  common role so it is higher than secondary condition. This is high value which makes role to motor rotor to increase its acceleration and force. So we choose the big voltage and resistance to promote motor rotor properties (Figure 2,3).

## Conclusions

The acceleration and force can be presented in a nominal & stall status. It can be controlled through resistance. But the acceleration is too small in terms of armature radius of 7mm and time of long because of their strong role. So if we promote its value it shall be controlled that current and voltage is main factor in this research. The conditions of  $t=4\text{s}$ ,  $R_m=12.5\Omega$ ,  $U=21\text{V}$  result in the biggest stall force 280N according to change time, resistance and voltage. Then it is  $t=8\text{s}$ ,  $R_m=8.3\Omega$ ,  $U=18\text{V}$ ;  $t=8\text{s}$ ,  $R_m=6.5\Omega$ ,  $U=15\text{V}$ ;  $t=10\text{s}$ ,  $R_m=4.5\Omega$ ,  $U=12\text{V}$  and  $t=12\text{s}$ ,  $R_m=2.5\Omega$ ,  $U=9\text{V}$  with the smallest 85N in turns. The effective turn is  $U>R_m>t$  which expresses the prior factor among these three parameters.

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