Analysis of Direct Current Motor in LabVIEW

E. Ramprasath, P. Manojkumar, P. Veena

Abstract—DC motors have been widely used in the past centuries which are proudly known as the workhorse of industrial systems until the invention of the AC induction motors which makes a huge revolution in industries. Since then, the use of DC machines has been decreased due to enormous factors such as reliability, robustness and complexity but it lost its fame due to the losses. In this paper a new methodology is proposed to construct a DC motor through the simulation in LabVIEW to get an idea about its real time performances, if a change in parameter might have bigger improvement in losses and reliability.

Keywords—Direct Current motor, LabVIEW software, modelling and analysis, overall characteristics of Direct Current motor.

I. INTRODUCTION

AN Induction motor is commonly known as the work horse of an industry owing to the robust nature, rugged construction and reliable operation. DC motors in the industrial plants have been replaced with robust and less complex AC induction motors and the speed control technique was achieved after the invention of the semiconductor devices. Nowadays, PWM techniques widely used to control the induction motor. When the power electronics started to boom the accurate speed control of induction motors are possible which pays a path to eliminate the use DC machines and the boom of induction motor started. These equipments have been designed and manufactured in such a robust way that some of them are still working and used in the production industries such as in metal industries. A particular configuration, the compound DC motor was widely used, for example for lifting where sudden rejection of load occurs [1].

There are different types of DC Motor they are widely classified into two types they are Self-Excited and Separately Excited motors [2]. Normally Self-Excited motor are does not need an additionally supply to the rotor but in the case of separately excited motors there should be a two different supply, one is to the armature and the another one is to the field winding. Both must be separately excited but in the case of self-Excited motor they are classified into three types according to the types of connections. DC Series motor, DC shunt motor and DC Compound motor [3].

E. Ramprasath was with the Electrical and Electronics Engineering is now with the Power Electronics and Drives, K.S.Rangasamy College of Technology (e-mail: ramprasath009@gmail.com).

P. Manojkumar is with the Electrical and Electronics Engineering,, K. S. Rangasamy College of Technology, Namakkal. India – 637215, Anna University Chennai, Tamil Nadu, India (e-mail: manojkumaran.p@gmail.com).

P. Veena is with the Electrical Engineering Department, KSR Institute for Engineering and Technology, Anna University Chennai, Tamil Nadu, India.
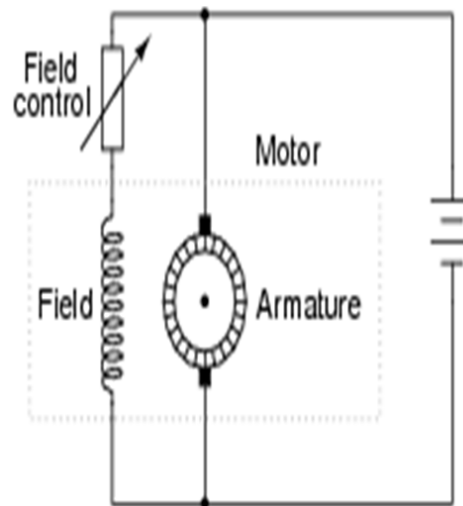
Fig. 1 Equivalent circuit parameters of direct current motor

II. TEST FOR DIRECT CURRENT MOTOR

A. No-load Test

This test is performed to determine the no load input of the DC motor, no load current of the DC motor and no load power losses, can be found using this no load test of the motor. How the no load torque affects the machine performance, This test is performed by applying different values of applied voltage which will be below and above of the rated voltage of DC motor without connecting to the external load [4].

B. Full-load Test

Full load test is also known as the short circuit load test which are performed to determine the short circuit current of the motor (I_{sc}) with rated voltage applied to the field. The locked rotor test on the Direct Current motor is done by holding the armature of the motor mechanically from turning in any direction, and applying a voltage which is below the rated voltage to the armature [5].

III. DC MOTORS

This characteristic is also known as **electrical characteristic**. Torque is directly proportional to armature current and flux. In DC series motors, field winding is connected in series with armature. Thus, before magnetic saturation of the field, flux Φ is directly proportional to Ia Therefore, before magnetic saturation Ta α Ia^2. At light loads, Ia as well as Φ is small and hence the torque increases as the square of the armature current [6].

In case of DC shunt motors the field flux Φ to be constant. Though at heavy loads, Φ decreases in a small amount due to

increased armature reaction. But as we are neglecting the change in the flux Φ, we can say that torque is proportional to armature current. Hence the Ta-Ia characteristic for a dc shunt motor will be a straight line through origin. Since, heavy starting load needs heavy starting current, shunt motor should never be started on a heavy load

As flux Φ is assumed constant, we can say N α Eb. But, back emf is also almost constant, the speed remains constant. But practically, Φ as well as Eb decreases with increase in load. But, the Eb decreases slightly more than Φ, and hence the speed decreases slightly. Generally, the speed decreases by 5 to 15% of full load speed only.

IV. LabVIEW Introduction

National Instruments developed LabVIEW software for the first time in the year 1986 for the Apple Macintosh Company. It was conceptualized as a programming environment for hardware control. The graphical user interface, which is used to simulate the controlled instrument on the computer, monitors itself with the help of LabVIEW software [7].

The word LabVIEW is an acronym for Laboratory Virtual Instrument Engineering Workbench which is a graphical programming language based on graphical icons instead of number of programming codes for simulation purpose. These programs are known as Virtual Instruments, due to their operational replica of physical instruments, like temperature monitor, spectral scopes, pressure gauges, cathode ray oscilloscopes, and multi-meters [8].

In LabVIEW the data flow of the program will be from left to write, but in C/C++ programming codes will be executed in order of top to bottom, errors in the LabVIEW will be easily identified during the execution of the program itself [9].

V. Simulation and Analysis of Direct Current Machine

Machine's modelling developed in Laboratory Virtual Instrument Engineering Workbench software is based on the mathematical expressions. Mathematical equations are first derived then converted into models using icons from the arithmetic board for further implementation in LabVIEW for graphical analysis [10]–[15].

Simulation of Direct Current motor load test needs certain parameters that are described in Table I. To analyze the parameters are considered to be an important factors.

TABLE I
LOAD TEST PARAMETER

Symbols	Parameter	Input Values
J	Motor inertia	kg-m^2
B	Viscous damping co-efficient	10^6
R	Motor resistance	Ω
L	Motor inductance	mH
K_{emf}	Back-emf constant	V/rad/s
K_t	Torque constant	N-m/A

The above parameters are used to model the DC Series motor. By changing the above input parameters corresponding

values can be obtained in the form of graphical representation in LabVIEW with the help of the graphical palate.

Values are made constant throughout the simulation because small changes in these input values will deviate simulation result.

TABLE II
VARIABLE INPUT PARAMETER

Symbols	Parameter	Input Values
v	Applied voltage	volts

Motor internal parameter are taken from the best operating conditions of Direct Current motor these values are made constant for the simulations of motor. For a particular operating load condition these values are made constant. Parameters can be changed before simulating for different load condition. They corresponding characteristics curve can be drawn.

TABLE III
OUTPUT VALUES

Symbols	Parameter	Values in SI units
θ	Angular position	Rad/s
$I_{(t)}$	Current	Amps

A.. Simulation of Direct Current Motor Load Test

Current consumed by the motor measured in amperes ratings. They measured in the milliseconds. Maximum current absorbed by the motor depends upon the load and no loaded conditions generally measured in terms of amperes. There are ripples due to the harmonics present.

$$T \propto \emptyset\, Ia \qquad (1)$$

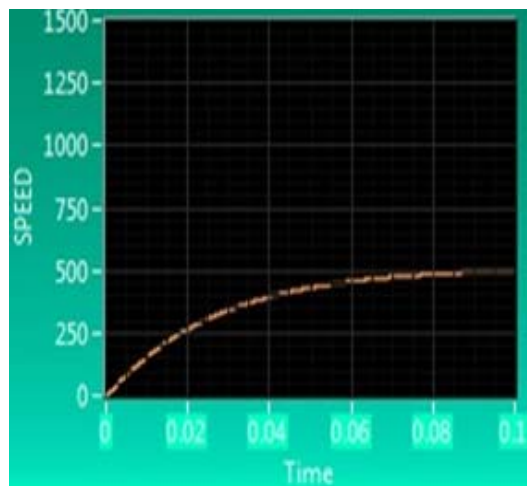$$N \propto \frac{Eb}{\emptyset} \qquad (2)$$

Fig. 2 Speed waveform of direct current motor

The speed of the waveform touched towards is 500 rpm which depends upon the given supply of the motor. The maximum current measured here is around 4 amperes due to the starting current of the motor.
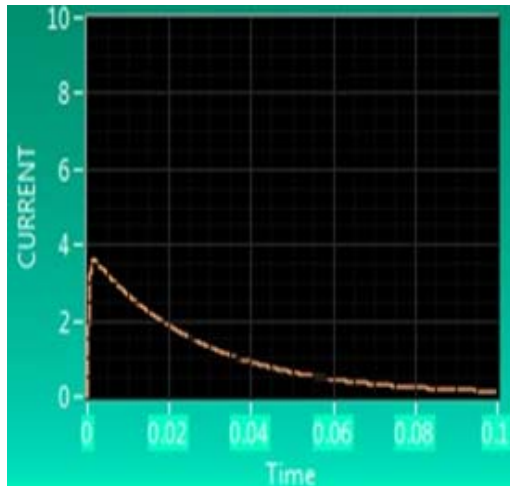
Fig. 3 Current waveform of direct current motor

Normally torque vs speed characteristics are also known as mechanical characteristics. Electrical characteristics are further classified into the torque vs Current characteristics and speed vs current characteristics.

Mechanical characteristics of Direct Current motor are to be analysed in that torque vs speed characteristics plays a major role in analyses of Direct Current motor. In this simulation the torque vs speed characteristics are analysed for the study of Direct Current motor which are modelled by the mathematical calculation.

Fig. 4 Torque vs current characteristics of dc motor

Torque and current increases in a straight line due to the fact torque is directly proportional to the current. The maximum torque is directly proportional to square root of current before the flux reaches the saturation point. If the flux reaches a saturation point then they will be independent each other.

Speed vs current characteristics shows that whenever there is an increased in speed there will be decreased current. In Fig. 5 there relation between the speed and current is shown in an opposite direction when the speed tends to decrease

automatically current starts to increase this shown in the graph where the modeled direct current motor graph drawn during decreasing the speed.
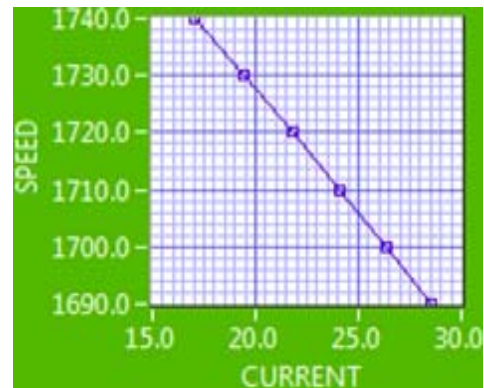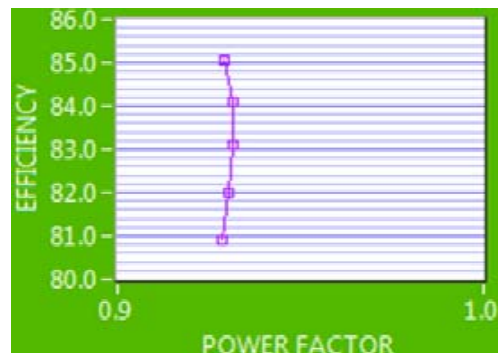

Fig. 5 Speed vs current of dc motor

Fig. 6 Efficiency vs power factor

Fig. 7 Current vs output Power

Current vs output power shows as straight line whenever the current increases the output power also increases at the same time.

VI. CONCLUSION

The analysis of this experimental result shows that Direct current motor model was built with the LabVIEW software. It

can be used to model and simulate the working process of Direct Current by which motor performance calculated, is set to compare with the real time operating consideration of the Direct Current motor for the optimal operation of machines.

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E. Ramprasath born in Attur, Tamil Nadu, India. Received B.E degree in Electrical and Electronics engineering from Velalar College of Technology, Thindal, Erode, Tamil Nadu, and India. Now currently pursuing M.E degree in Power Electronics and Drives at K.S.Rangasamy college of Technology, Tiruchengode, Namakkal, Tamil Nadu, India. His area of interest is Power Electronics and Drives, and Electrical Machines.