Performance of DC Motor Supplied From Three Phase AC-DC Rectifier

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Abstract

In the last decades, considerable advancements have been made in the power electronics industry. The adjustable speed drive is very important for the control of motor speed, because many products can be handled, transferred and easily controlled. This paper discusses the performance of dc motor speed, field flux and loading on the ratio between input r.m.s armature current and average value in a separately exited dc motor fed from three-phase ac to dc rectifier.

Keywords: DC-motor, Electronic Drive, Voltage and Current Form Factor

1. Introduction

In the last decades, considerable advancements have been made in the power electronics industry. The adjustable speed drive is very important for the control of motor speed, because many products can be handled, transferred and easily controlled [1,2]. A method of control is mainly decided by the nature of the load. Some loads require very wide speed range while others require limited one. This implies that before deciding a certain control scheme, load requirements should be studied, for example, electric train and car need wide range of speed while lathes needed limited speed range [3,4,5]. The r.m.s values of current and voltage are responsible for copper losses while average value are responsible for torque produced. In previous author study it was shown that the form factor of armature is high in single phase half and full-wave rectifier systems [6]. The accurate prediction of the performance of dc motor can be determined by accurate evaluation of its parameters. A number of tests has been carried out such as open and short circuit tests to estimate the parameters of the dc motors. They include the parameters of the field and armature circuit, the iron and mechanical losses, the speed voltage coefficient and rotor moment of inertia. This paper discusses the performance of dc motor speed, field flux and loading on the ratio between input r.m.s armature current and average value in a separately exited dc motor fed from three-phase ac to dc rectifier. Also the paper discusses the voltage and current form factor, which has been taken as measure of motor losses in relation to its output torque.

2 -Variable Speed Drives

Variable speed drives can be mainly subdivided into two main types namely ac and dc drives.

2.1 - AC Drives

This type of drives is used whenever an a.c. supply is available. The driving mechanical power is produced by an a.c. electric motor. The motor could be of induction, synchronous, universal or permanent magnet type. Induction motor is the most widely used due to its robustness, low price and high efficiency. Speed control of a.c motors can be successfully achieved by input supply frequency variation. This has been recently realized by the developments achieved in power electronics. Frequency variations can be achieved by using a cyclo-converter or an inverter.

2.2- D.C. Drives

The dc motors are normally employed for different types of dc drives. In fact the variety of dc motors known yields different types of running characteristics thus suiting almost most of applications known. Speed control of dc motors can be achieved by either controlling its armature voltage or field flux or both. Advantages offered by using dc motors include (1) Smooth speed control. (2) High efficiency. (3) Wide speed range, because for speeds lower than rated values, armature voltage control can be used; while for speeds higher than rated speed, field control can be utilized. (4) High over load capacity.

However commutation problems added to high motor cost resemble major disadvantages in using dc motors, in addition dc supply is not always available. On the other hand, new advances in power electronics made it possible to convert ac into dc supplies. With the development of power electronic devices, it is possible to convert ac into controllable dc. However, such a conversion is associated with the production of extra harmonics. These harmonics in turn produce extra motor losses and hence motor is usually de-rated to avoid excessive heating.

3- Motor Parameters Evaluation

The accurate prediction of dc machines performance when fed from a rectified ac supply can be achieved by accurate evaluation of its main parameters. Therefore, number of tests has been carried out to estimate these parameters. The parameters measured are speed voltage coefficient Kv, armature and field resistance and inductance, iron and mechanical losses and rotor moment of inertia. The results are as follow: Armature circuit r_a = 6.25 Ω, L_a = 0.03582 H, Field circuit, r_f = 625 Ω, L_f = 51.762 H, T_f = 0.0828 sec. The dc motor losses are: Mechanical Losses = 28 watt at n = 1500 r.p.m , Mechanical Losses = 41 watt at n = 1800 r.p.m, Iron loss = 14 watt at V_a = 110 V and n = 1500 rpm , Iron loss = 9 watt at V_a = 110 V and n = 1800 rpm , J= Inertia of rotor = 0.256 kg. m^2

4- Three-phase Full-Wave Rectifiers Supply

The three-phase four wires full-wave bridge rectifier is shown in figure 1. This circuit is equivalent to the single-phase full wave rectifier. It is clear from figure 1 that 2 diodes are used to convert the current from ac to dc. The dc current flow from the diode in the upper-half to the diode in the lower-half. During every cycle in the three-phase circuit, the process to convert ac to dc is repeated 6 times as compared to single-phase, therefore the dc output wave is more continuous and has high harmonic content.

The form factor of armature current in single-phase half and full-wave rectifier systems is observed to be high [6]. This is due to the discontinuous pattern of the currents. The performance of dc motor which is supplied from three-phase full wave rectified supply is investigated in the following section. The dc motor was connected to three phase supply as shown in figure 1. The operation of dc motor, for no load case is shown in figures 2 and 3, and for load case is given in figure 4. From figures 2 ,3 and 4 the following points can be concluded: (a) Current form factor has improved i.e. approached unity. (b) An increase in field current resulted in subsequent increase in current form factor at the same value of motor speed. (c) Adding an inductance to armature circuit improves current form factor (added inductance act as a low pass filter). (d) For an added armature inductance of 200 mH current form factor approached unity. (e) An increase in no-load speed resulted in slight decrease in current form factor. In comparing this three phase study with single phase case [6], it is clear that the three phase full-wave rectified supply yielded the best performance, (FFI approached unity), followed by single phase full-wave rectifier system then by single phase half-wave rectifier system. The reason is that the ratio of the period of conduction to that of non conduction increases as we increase the number of current pulses per cycle.

5 - Conclusion

The performance of the dc motor which is supplied from three phase full-wave rectifier is studied for the no-load and load conditions. It was shown that the FFI and FFV of wave shape of the motor are related to the no-load and load conditions and the three-phase full wave rectifier of the supply system. The three-phase full-wave rectifier supply is more suitable for the motor as compared to single-phase, half-wave and full-wave rectifier system. Generally speaking it was observed that, for the drive systems which is investigated in this paper, an increase in field current is accompanied by a consequent increase in FFI.

6- References

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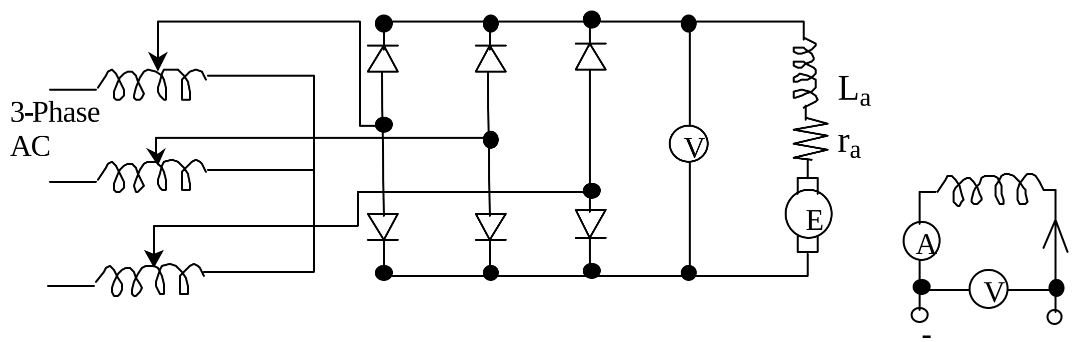

Fig. 1 Three-phase full wave rectifier supply to dc motor

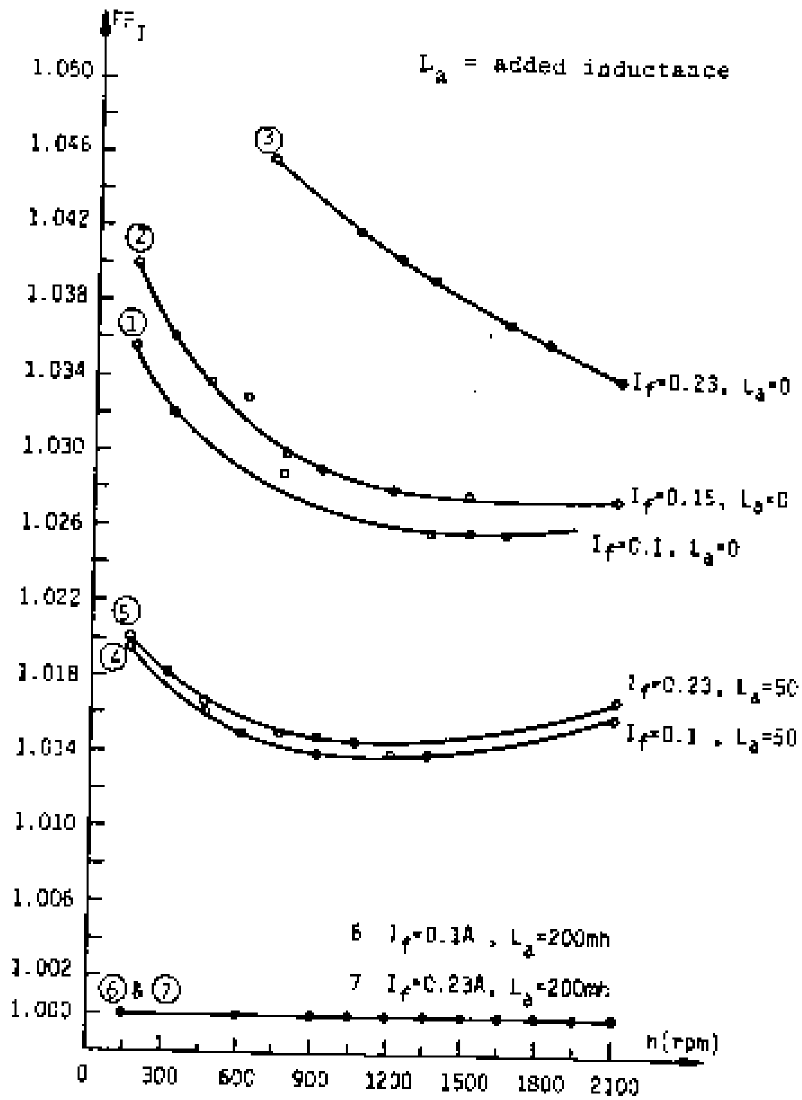

Fig. 2-Variation of motor current form factor versus speed at different values of field excitation and no-load case with different added inductance with three-phase rectifier ac Supply.

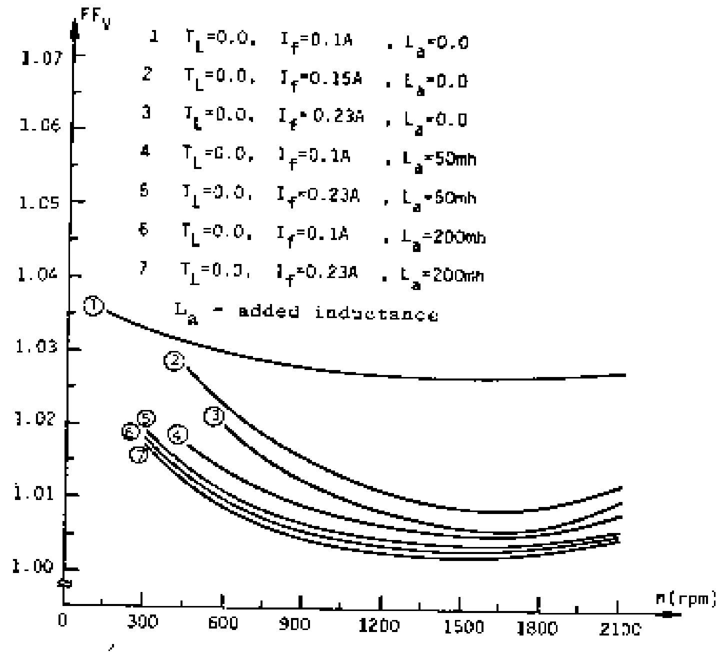

Fig. 3- Variation of motor voltage form factor versus speed at different values of field excitation and no-load with different added inductance supply three-phase rectifier ac supply.

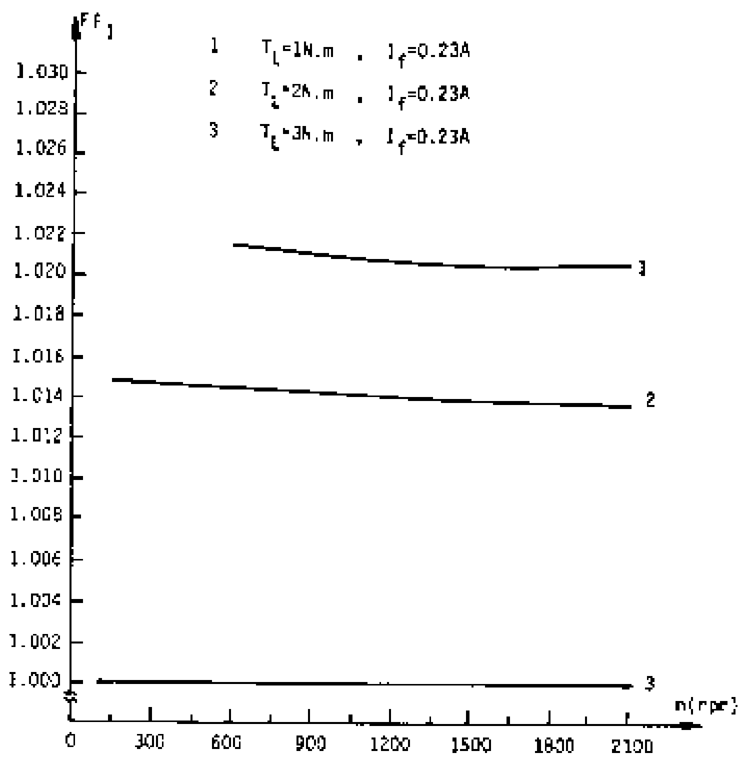

Fig. 4- Variation of current form factor versus speed at constant values of field excitation and loading with different loads with three phase ac supply.