Measurement of Efficiency, Consumption, Power Factor and Mechanical Torque for GEMBRAP Single-Phase Electric Motor Designed for Table Fans

Majid Poshtan, Ph.D., Associate Professor

California Polytechnic State University (Cal Poly)

San Luis Obispo, CA, 93405, USA

July 1st, 2018

INTRODUCTION

Ordinary table fans are run by single-phase induction motors, which rotate at a different speed as their mechanical torque changes. Regular fan blades apply variable mechanical torque at variable speed. Hence the fan runs at an equilibrium speed that the electric torque and the mechanical torque become equal. The size of the blades and their shape are important factors to develop the mechanical torque for the electric fans. Single-phase induction motors in table fans have low efficiency but a simple structure and low cost. The quality of these motors can be tested by their power losses and efficiency.

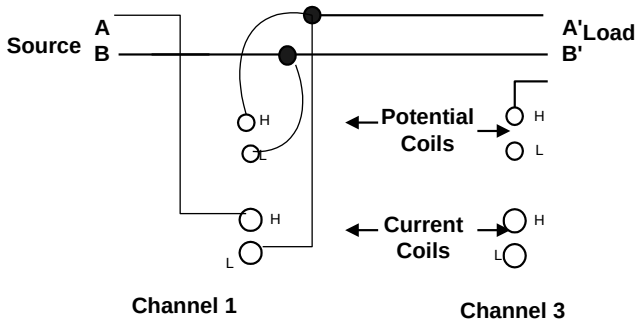
The GEMBRAP company designs and develops electric motors, including small size, single-phase electric motors suitable for small table fans. Dr. Poshtan tested one of the GEMBRAP's small single-phase motors that is designed for small table fans against a similar sized motor, which is called the "Reference" motor in this report.

EQUIPMENT

1. GEMBRAP single-phase electric motor
2. Yokogawa Digital Multi-Meter
3. Fluke Digital Multi-Meter
4. Dynamometer (Magtrol 705-6)
5. Torque-Speed readout (Magtrol 4618)3)
6. Power Supply (Magtrol 4636)
7. Digital Photo Tachometer
8. Single-phase 120 V, 60 Hz, Source

CIRCUIT DIAGRAM

Figure 1 : Connections of Yokogawa power meter for Single-Phase Induction Motor Experiment



PROCEDURE

The GEMBRAP single-phase motor was tested at the rated load of the "Reference" motor used in table fans sold on the U.S. market running identical 3-blade propellers at about 1450 RPM. The input voltage; current, active and reactive power, inrush current, output mechanical torque, speed, etc. were measured and recorded here.

It has been observed that GEMBRAP motor has higher efficiency, higher maximum torque, lower power loses, lower consumed reactive power, and lower inrush current than the "Reference" motor.

The following equations were used to calculate the power consumption, efficiency, reactive power and mechanical power.

$$P_E = (VI) * P_f$$

$$Efficiency = \zeta = \frac{P_{mechanical}}{P_{electric}}$$

$$Reactive\ Power = Q = \sqrt{\left((VI^2) - \left({P_e}^2\right)\right)}$$

$$Mechanical\ Power = P_m = Mechanical\ Torque * Angular\ Velocity = \tau * \omega$$

COMPETITIVE ANALYSIS

A competitive analysis was performed with a single-phase 35 Watts electric motor commonly used to run small table fans. For this test, two new identical table fans manufactured by a leading competitor and commonly sold on the US market were used. The "Reference" fan works by its original motor, and the second fan works by the GEMBRAP single-phase small motor. Table 1 shows the performance of the two motors running similar fans with identical 3-blade propellers.

Table 1: Test results for GEMBRAP Motor and the Reference Motor

Tests	GEMBRAP Motor	Reference Motor
Efficiency	75.30%	16.28%
Mechanical Load (W)	6.23	5.67
Power Consumed (W)	8.27	34.83
Power Losses (W)	2.04	29.16
Speed (RPM)	1466	1456
Torque (lb.in)	0.36	0.33
Reactive Power (VAR)	20.64	28.86
Voltage (V)	116.1	116.1
Current (mA)	191.5	389.6
Max Torque (lb.in)	1.07	0.69
Min Speed (RPM)	905	1065
Inrush Current (mA)	981	1121

CONCLUSION

1. The GEMBRAP motor has a maximum efficiency of 75.3% at 1466 RPM, while the “Reference” motor has an efficiency of 16.28% at 1456 RPM, that is, the GEMBRAP single phase motor shows 4.6 times higher efficiency than the “Reference” motor.
2. The GEMBRAP motor’s active power consumption is less than one quarter of the “Reference” motor.
3. The GEMBRAP motor’s maximum torque is higher than the “Reference” motor, , and its reactive power consumption is 28.4% less.