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No-Load and Load Tests on 3 Phase Induction Motors used in Irrigation Pumping with Balanced and Unbalanced Supply

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Abstract

Agriculture is the major ocupation in villages and is backbone of India, where irrigated agriculture sector plays an important role in economic development and poverty alleviation of the nation. About 75% of present population of India obtains its livelyhood from the same. Iirrigation is harnessing of water resources for the crops by using motor pumps. Usually wells, tanks, perennial canal and multipurpose river valley projects are worked out. As electrical motors are very affordable and cheaper they are the usual choice to drive pumps. Due to the variation in supply to the pump motor the expected performance is not achieved and lead to variation in machine parameters. The operation of 3 phase motor on single phase supply leads to negative effects like overheating, insulation failure, torque pulsation, de rating and reduction in efficiency. In spite of these adverse effects on motor and irrigation power supply feeder, it is observed that farmers run their 3 phase motor on reduced voltage condition using capacitor splitter and other such. A study of operation of 3 phase motor on no-load and load is performed with balanced and unbalanced voltage condition. Simulation is performed in MATLAB/SIMULINK package for the comparison and justification.

Keywords: *3 phase motor, irrigation, no-load and load tests, performance*

INTRODUCTION

India is a developing country with number of villages mainly dependent on agriculture. Agriculture has been a source of livelihood for more than 2/3rd of our population. As agriculture, horticulture, sericulture mainly depends on continuous water supply and farmers depend on seasonal rainfall for supply of water for proper cultivation. Hence, it is necessary

to opt for artificial application of water (Irrigation) using electrical motors and pumps for the continuous water supply. Irrigation is the base for about 55-60% of total agricultural output. India has an irrigation potential of about 140 million hectares and out of which only 38-45% is cultivated area, which benefited from the irrigation projects. Recognizing the importance of irrigation as a crucial input in India's agricultural development harnessing of water resources for irrigation through motor pumps is very necessary.

LITERATURE SURVEY

The literature survey has shown that water is the basic need for the agriculture, horticulture and sericulture etc. Agriculture is the largest consumers of water approximately 70% and more water drawn from the different sources [1]. Diesel engine coupled pumps for irrigation was used in the early days by the farmers but necessity of onsite fuel storage, higher service requirement, rising prices of oil and crisis forced them to use electric motors. Later electricity being clean as well as economically viable became the choice and dependable source of power for irrigation applications. Electrical motors used for pumps can provide years of trouble free service for long duration, low maintenance cost, dependability and ease of control when properly selected, operated and maintained. Most of the large electric motors used for irrigation are squirrel cage, 3 phase, 440V Induction motors because of their easy maintenance, low cost and simple construction [2]. Three-phase service requires additional conductors compared to single-phase service and requires different metering equipment as well. Hence, three phase service costs more to utilities. Therefore, utilities usually prefer to install single-phase service unless there is a specific demand for three-phase power at the site. As an alternative to utility installed three-phase supply power electronic devices like, rotary phase converters, static phase converters and variable frequency drives (VFD) have been used for decades to generate three-phase power from available single-phase source [3–5]. Also, it is noticed that working of 3 phase induction motor fed by single phase supply using convertors lead to severe ill effects on Induction motors like decrease in motor life due to imbalance in voltage and current, production of harmonics, overheating of winding, torque pulsation, insulation degradation and inefficiency that affect the power grid and damages the equipments [4– 7]. Normally, water for the irrigation is obtained from surface level water such as river and dams or ground

level water. The ground water is assessed by boreholes. Submersible pumps are installed on the boreholes. The surface water is assessed from surface pumps. Both the submersible and the surface pumps are driven by electrical motors operated on either a single phase or three-phase power supply and the failure of motor is quite natural due to several reasons wherein adequate care is necessary while choosing. The centrifugal pump is the machine most commonly used to move liquids from one place to another [8, 9]. The comparative study of characteristics of three phase induction motor is needed to understand the behavior of the motor at specific time of observation. The computer simulation software such as MATLAB/SIMULINK provides the environment to simulate and analyze the performance of a three phase induction motor for the wide variety of imposed constraints. These simulations provide step by step results and parameters for the comparative discussions [10–13].

A continuous hunt for the development and use of new and renewable energy sources is gradually increasing its penetration to reduce the peak demand on the generating system and is crucial. Thus, the renewable energy sources have become a more important contributor to the total energy consumed in the world. Among them solar energy is cleaner than any other energy. This has lead to the growth of solar PV pumping and associated systems to supply rural requirements. A cost effective photovoltaic (PV) fed 3 phase Induction motor drive is becoming popular for the rural pumping applications [14–16].

SIMULATION OF INDUCTION MOTORS USED FOR IRRIGATION

MATLAB/SIMULINK 2009b is the tool used to simulate the induction motor and is very necessary to justify the choice of motor. The simulation output convinces the choice of motor and judicious use of water to get adequate performance and profit. The simulation setup in MATLAB/SIMULINK uses the induction motor having the rating 3 phase, 415V, 50Hz, 7.5A, 1500rpm, 3.7KW/ 5Hp, efficiency of 85%.

To evaluate and measure, an analysis is required in view of power consumption discharge, cost and maintenance. Operation of three-phase induction motor under balanced and unbalanced (single phase supply) conditions is carried out and various important parameters are tabulated for the study.

SIMULATION OF NO LOAD AND LOAD TEST ON 3 PHASE INDUCTION MOTOR

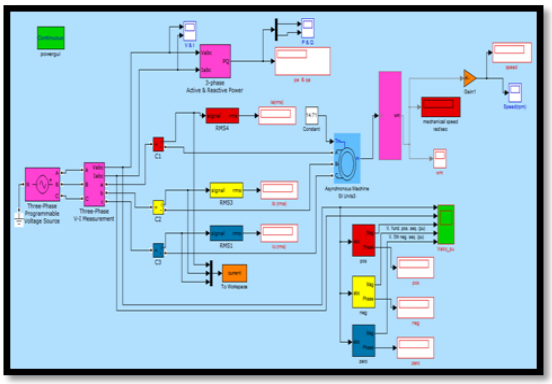

Fig. 1: *Simulation of 3 Phase Induction Motor on No Load.*

Figure 1 shows the SIMULINK model of test of induction motor on no load running on three phase programmable voltage source. This model consists of asynchronous machine, 3 phase V-I measurement block, three phase active and reactive power measurement block, signal to RMS converters, sequence analyzer blocks, source impedance block, load and scopes. Different values of voltage are supplied from three phase programmable voltage source to the motor torque given to the motor (No load/load) and speed is measured. Simulation is done using MATLAB / SIMULINK. Three phase VI measurement is used to measure the instantaneous voltage and current. The values of current of each phase obtained from current measurement block are converted into RMS using signal to RMS converter. Three phase active and reactive power on the supply side is measured using three phase active and reactive power measurement block. Magnitudes and phase angle of positive, negative and zero sequence of voltage and current are measured using sequence analyzer block. Display block and scope displays the results

EXPERIMENTAL SETUP OF NO LOAD AND LOAD TEST ON 3 PHASE INDUCTION MOTOR ON WORK BENCH

Following is the circuit used to conduct No load and load test on Induction motor on the workbench.

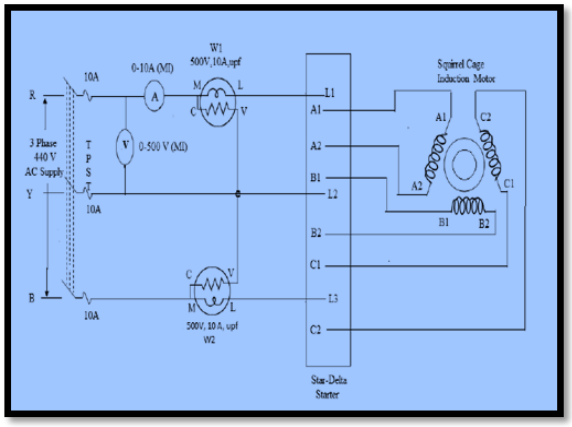

Fig. 2: *Circuit Diagram for the No Load Test on 3 Phase Induction Motor.*

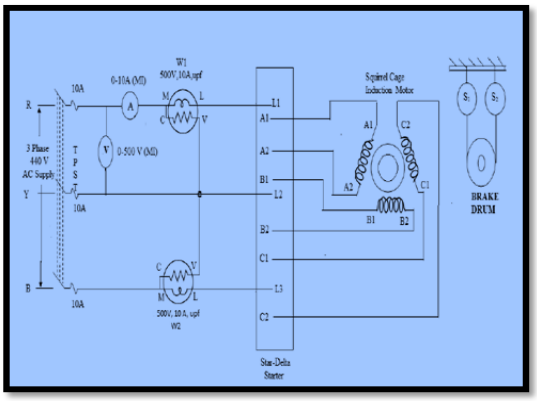

Fig. 3: *Circuit Diagram for the Load Test on 3 Phase Induction Motor.*

Fig. 4: *Photographic View of Test on 3 Phase Induction Motor.*

Practical results obtained are compared with simulation results and are tabulated in the table for the comparative study.

Table 1: *Comparative Results of Practical and Simulation on No-Load.*

No Load	Practical Results			Simulation Results			
SL NO	Voltage (Volt)	Current (Amp)	Speed (rpm)	Current (Amp)	Speed (RPM)	P (W)	Q (VAR)
1	415	3.6	1501	3.53	1500	84.55	1790
2	360	2.8	1501	2.9	1500	81.77	1347
3	200	1.75	1500	1.69	1499	76.14	416.2

Table 2: *Comparative Results of Practical and Simulation on Load.*

Load	Practical Results				Simulation Results				
SL NO	Voltage (Volt)	Current (Amp)	Speed (rpm)	Load (kg)	Current (Amp)	Speed (rpm)	P (W)	Q (VAR)	Tm (N-m)
1	415	3.6	1499	0	3.42	1498	161.3	1732	0
2	415	5	1469	11	5.07	1468	1877	1771	10.79
3	415	6	1458	15	6.1	1457	2511	1819	14.71

EXPERIMENTAL STUDY OF EFFECT OF OPERATION OF 3 PHASE INDUCTION MOTOR WITH BALANCED AND UN BALANCED SUPPLY

The following shows the results for operation of Induction motor on balanced modes of supply for load and no load conditions.

Table 3: *Comparative Results of Operation of Motor on Balanced Supply for Load and No Load.*

	Balanced condition			No load			Load (10.79 N-m)		
	V_R(V)	V_Y(V)	V_B(V)	I_R(A)	I_Y(A)	I_B(A)	I_R(A)	I_Y(A)	I_B(A)
UVB	240	240	240	3.45	3.45	3.45	5.41	5.41	5.41
	210	210	210	3.02	3.02	3.02	6.19	6.19	6.19
	110	110	110	1.71	1.71	1.71	14.66	14.66	14.66
OVB	260	260	260	3.79	3.79	3.79	5.06	5.06	5.06
	280	280	280	4.03	4.03	4.03	4.79	4.79	4.79
	300	300	300	4.32	4.32	4.32	4.57	4.57	4.57

Note: UVB- Under volt balanced, OVB- Over volt balanced.

The following table shows the results for operation of Induction motor on unbalanced modes of supply for load and no load conditions.

Table 4: *Comparative Results of Operation of Motor on Unbalanced Supply for Load and No Load.*

	Unbalanced condition			No load			Load (10.79 N-m)		
	V_a(V)	V_b(V)	V_c(V)	I_a(A)	I_b(A)	I_c(A)	I_a(A)	I_b(A)	I_c(A)
UVU	240	210	110	7.39	6.57	2.69	17.01	8.61	8.98
	210	240	110	6.62	7.36	2.55	16.65	11.54	5.88
	240	0	240	11.88	8.32	12.53	28.12	10.64	28.56
OVU	272	264	252	4.42	3.95	3.06	6.49	4.34	4.53
	290	272	282	4.67	3.45	4.12	5.35	3.43	5.76
	300	295	255	5.37	5.25	2.16	8.32	5.18	3.40

Note: UVU- Under volt unbalanced, OVU- Over volt unbalanced.

CONCLUSION

The work carried out has successfully shown the operation of three phase induction motors used for the pumping operations on no load and load with balanced and unbalanced supply conditions in MATLAB/SIMULINK. The parameters like voltage, current, power, speed and impact of imbalance and load are analyzed and have given clear information about the possible impacts on motors performance and life span. The comparative study gives the necessity of a controller or a protective mechanism to avoid such operations to safeguard the motors. As a scope for improvement, a protective mechanism must be designed to avoid the operation of three phase motor other than three phase regular supply.

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