"SIMULATION OF SPEED CONTROL OF DRIVES : CONTROLLING BY APPLIED VOLTAGE"

SHAMBULINGANA GOUDA [1], DR PRABODH KHAMPARIYA[2]

[1]Research Scholar, BE, M Tech, (PhD in Electrical Engineering) , Sri Satya Sai University of Technology & Medical Sciences, Sehore,Madhya Pradesh, India

[2]Professor and Head EEE Department Sri Satya Sai University of Technology & Medical Sciences,Sehore, Madhya Pradesh, India

Abstract – The induction machine is the work horse of the industry. It has rugged construction and is suitable for many high power applications. Induction motors are the most widely used electrical motors due to their reliability, low cost and robustness. However, induction motors do not inherently have the capability of variable speed operation. Due to this reason, earlier dc motors were applied in most of the electrical drives. But the recent developments in speed control methods of the induction motor have led to their large scale use in almost all electrical drives. Out of the several methods of speed control of an induction such as pole changing, frequency variation, variable rotor resistance, variable stator voltage, constant V/f control, slip recovery method etc., the closed loop constant V/f speed control method is most widely used. In this method, the V/f ratio is kept constant which in turn maintains the magnetizing flux constant so that the maximum torque remains unchanged. During starting of an induction motor, the stator resistance and the motor inductance (both rotor and stator) must be kept low to reduce the steady state time and also to reduce the jerks during starting. On the other hand, higher value of rotor resistance leads to lesser jerks while having no effect on the steady state time. The vector control analysis of an induction motor allows the decoupled analysis where the torque and the flux components can be independently controlled (just as in dc motor). This makes the analysis easier than the per phase equivalent circuit.

***Index Terms* - Three Phase Induction Motor, Space Vector Modulation, V/F Control, Transient Analysis, Slip, Steady State Analysis, Induction Motor Electric Motor Drive, Matlab , Simulink.**

1.INTRODUCTION

Acceptance machines are the most broadly utilized electrical engines because of their unwavering quality, minimal effort and vigor. In any case, enlistment engines don't intrinsically have the capacity of variable speed activity. Because of this explanation, prior dc engines were applied in the vast majority of the electrical drives. Yet, the new advancements in speed control strategies for the acceptance machines have prompted their huge scope use in practically all electrical drives. Out of the few techniques for speed control of an acceptance, for example, post changing, recurrence variety, variable rotor obstruction, variable stator voltage, steady V/f control, slip recuperation strategy and so forth, the shut circle consistent V/f speed control technique is most broadly utilized. In this *technique, the V/f proportion is kept consistent which thusly keeps up the polarizing motion steady so the most extreme force stays unaltered. During beginning of an acceptance machine, the stator opposition and the machine inductance (both rotor and stator) should be kept low to diminish the consistent state time and furthermore to lessen the bastards during beginning. Then again, higher estimation of rotor opposition prompts lesser rascals while having no impact on the consistent state time. The vector control investigation of an enlistment machine permits the decoupled examination where the force and the transition segments can be freely controlled (similarly as in dc machine). This makes the examination simpler than the per stage identical circuit. High powerful execution of Induction Motor drives practically identical to Vector controlled drives can be accomplished utilizing Direct Torque Control (DTC) method without complex co–ordinate changes and PWM calculations. The DTC calculation is straightforward, strong and innately speeds sensor less. Direct Torque Control is a helpful strategy for wide reach speed control applications like Traction and EVs. In its current structure, DTC–IM is utilized for fast reach only. To accomplish diminished force swells, decreased THD of stator flow and less variety in exchanging recurrence of VSI took care of Induction machine drive for wide reach speed control applications. This research work actualizes execution list based cross breed motion assessment, variable width force and transition hysteresis band regulators and improved exchanging vector tables. The presentation list is determined from working pace, THD of stator current and exchanging recurrence of the Power Electronic (PE) gadget utilized in Voltage Source Inverter (VSI).*

LITERATURE REVIEW

AUTHORS	REVIEW
Zhongning Ye and Bin Wa (2001)	• introduced the recreation of the three-step strategy for motor drive, with an emphasis on the electrical faults of the acceptance motor. • The training tool is shown using the important parts of the MATLAB / SIMULINK tool drawers. Stator flux is believed to be used to detect electrical faults in the receiving motor.
Hamid Nejjari et al.	• They developed a strategy to analyze electrical faults in recording engines. (2000) suggested. The proposed method depends on the vector approach of the park. Nakamura et al. (2006) recommended an alternative methodology that focuses on the secret Markov model for debugging recording engines and is commonly used in the field of speech recognition.
Toliyat and Lipo (1995)	• They have shown that errors lead to an imbalance in the impedance of the frame, so that the frame can draw irregular flows of steps . This is the result of the development of negative order currents in the line.Negative bundling flows can also be caused by voltage imbalances, machine submergence, etc. Kliman et al.

TABLE 1.1:Literature Review

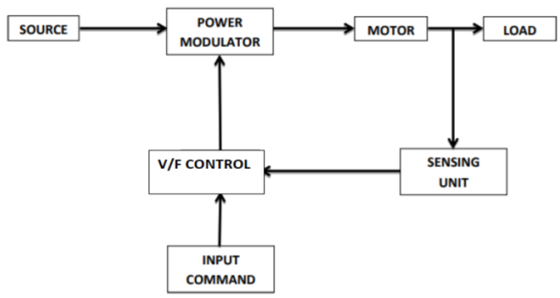


Figure 1: Block Diagram Of An Electrical Drive

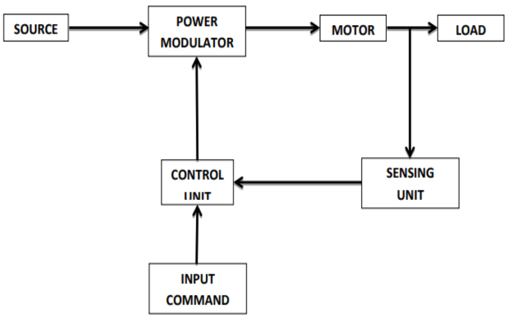
Three phase Induction motors have been the workforce for several industrial, manufacturing, propulsion and transportation applications for the past several years. A rough estimate shows that about 64 percent of the industrial motors belong to induction motors. The operational modes of an induction motor in an industrial environment can be divided into three:

1) starting,

2) speed control and

3) energy efficient operation.

In starting and speed control modes, the dynamic response of the drive is uppermost in the mind, whereas energy efficient operation is performed during steady state operation. Several papers have already been published in the above-mentioned areas. This thesis work employs a few biologically inspired optimization algorithms towards the performance enhancement of the



three-phase induction motor during starting, speed control and energy efficient operations. The following sections carry out the literature survey on the above- mentioned modes of operation of induction motor.Be it domestic application or industry, motion control is required everywhere. The systems that are employed for this purpose are called drives. Such a system, if makes use of electric motors is known as an electrical drive. In electrical drives, use of various sensors and control algorithms is done to control the speed of the motor using suitable speed control methods. The basic block diagram of an electrical drive is shown below:

Figure 1: Block diagram of an electrical drive

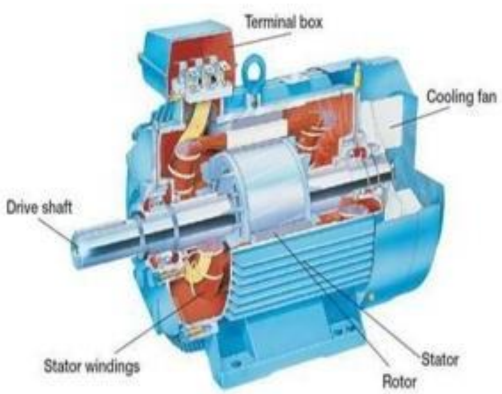
Earlier only dc motors were employed for drives requiring variable speeds due to ease of their speed control methods. The conventional methods of speed control of an induction motor were either too expensive or too inefficient thus restricting their application to only constant speed drives. However, modern trends and development of speed control methods of an induction motor have increased the use of induction motors in electrical drives extensively. Induction motor.In this paper, we have studied the various methods of speed control of a 3- and compared them using their Torque-Speed characteristics. Also, the transients during the induction motor were studied using MATLAB Simulink and the effects of starting of a 3- various parameters such as rotor and stator resistances and inductances were analysed. Also different control algorithms such as P, PI and

PID control were studied by simulating them in MATLAB Simulink and were compared.

2. Construction of Induction Motor

The Induction Motor has a stator and a rotor. The stator is wound for three phases and a fixed number of poles. It has stampings with evenly spaced slots to carry the three-phase windings. The number of poles is inversely proportional to the speed of the rotor. When the stator is energized, a moving magnetic field is produced and currents are formed in the rotor winding via electromagnetic induction. Based on rotor construction, Induction Motors are divided into two categories.

In Wound-Rotor Induction Motors, the ends



of the rotor are connected to rings on which the three brushes make sliding contact. As the rotor rotates, the brushes slip over the rings and provide a connection with the external circuit.

In Squirrel-Cage Induction Motors, a ―cage‖ of copper or aluminum bars encase the stator. These bars are then shorted by brazing a ring at the end connecting all the bars. This model is the more rugged and robust variant of the Induction Motor.

2.1 Induction Motor Principle:

Principle: It is an asynchronous motor when 3ph supply is given to the stator, flux is induced in the stator and due to the mutual induction flux is transform from stator to rotor. The current is generated in the rotor due to short circuit copper bars in the rotor cuts the rotating flux .Hence torque is experienced and rotor rotates. When the stator winding is energized by a three- phase supply, a rotating magnetic field is set-up which rotates around the stator at synchronous speed Ns. This flux cuts the stationary rotor and induces an electromotive force in the rotor winding.

As the rotor windings are short-circuited a 8 current flows in them. Again as these conductors are placed in the stator‟s magnetic field, this exerts a mechanical force on them by Lenz"s law. Lenz"s law tells us that the direction of rotor currents will be such that they will try to oppose the cause producing them. Thus a torque is produced which tries to reduce the relative speed between the rotor and the magnetic field. Hence the rotor will rotate in the same direction as the flux. Thus the relative speed between the rotor and the speed of the magnetic field is what drives the rotor. Hence the rotor speed Nr always remains less than the synchronous speed Ns. Thus Induction Motors are also called Asynchronous Motors.

Figure 2: Internal parts of induction motor

2.2 Factors Affecting Efficiency of Induction Motor Drives

There are several factors which affect the efficiency of induction motors drives such as partial loading, harmonics, rewinding, power quality, parameter variation etc. These factors are discussed in brief in the following sections.

Partial Loading

Among all electrical AC drives, 3-Φ induction motors are mainly used due to its inherent advantages i.e. ruggedness, reliability, relatively low cost and easy operation. These machines offer years (around 20 yrs) of service when precisely selected, operated and maintained. In general, induction motor handles around 70% industrial load on a utility, therefore it becomes imperative to pay major attention to the maximum efficiency operation of such AC derives. Fundamentally, high efficiency operation of induction machine can be obtained when it is operated near to rated speed and torque. The significant improvement in machine materials, design and construction techniques may further improve the induction motor efficiency.

3. SPEED CONTROL OF INDUCTION MOTOR DRIVES (METHODS)

1. V / f control or frequency control.

2. Changing the number of stator poles.

3. Controlling supply voltage.

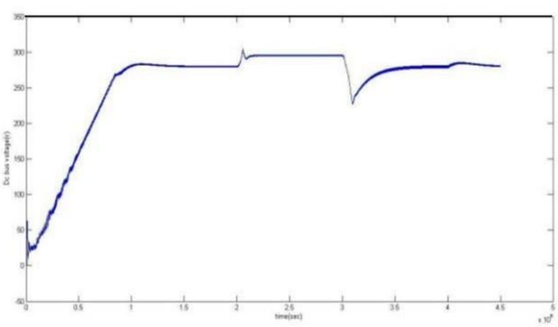
4. Change in the resistance of stator and rotor circuit

V/f control or frequency control: We vary the stator voltage in such a way that the flux remains constant by simultaneously varying the supply frequency such that the ratio V/f remains constant. The AC supply is rectified and then applied to a PWM inverter to obtain a variable frequency, variable magnitude 3-ph AC supply.

The electromagnetic torque developed by the motor is directly proportional to the magnetic field produced by the stator and the flux produced by the stator is proportional to the ratio of applied voltage and frequency of supply. Therefore, by varying the voltage and frequency by the same ratio, flux and hence, the torque can be kept constant throughout the speed range. This makes constant V/f method the most common speed control method of an induction motor.

Changing the number of stator poles: In this case of speed controlling method , it is very complicated to change the stator poles where it is time taking and there is change in design of the induction motor .so in this method we cannot make any change in stator poles so, we rarely use this method.

Controlling supply voltage: A very simple and economical method of speed control is to vary the stator voltage at constant supply frequency. The three-phase stator voltage at line frequency can be controlled by controlling the switches in the inverter. As seen from the equation the developed torque is proportional to the square of the stator supply voltage and a reduction in stator voltage will produce a reduction in speed. Therefore, continuous speed control may be obtained by adjustment of the stator voltage without any alteration in the stator frequency



Change in the resistance of stator and rotor circuit: In this method of speed control of three phase induction motor rheostat is added in the stator and rotor circuit due to this voltage gets dropped .In case of three phase induction motor torque produced is given by $T \propto sV2\ 2$. If we decrease supply voltage torque will also decrease. But for supplying the same load , the torque must remain the same and it is only possible if we increase the slip and if the slip increase motor will run reduced speed. In this way we can control the speed of induction motor

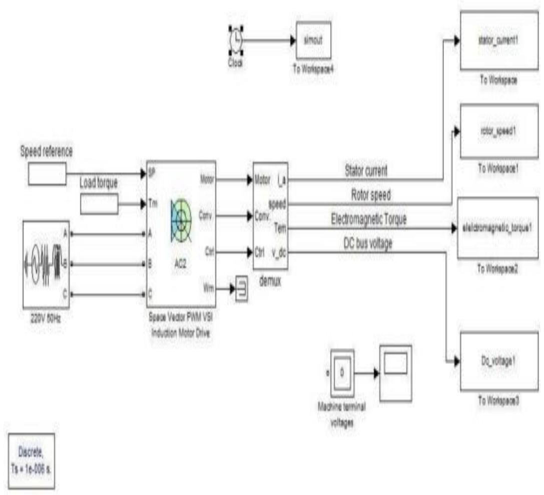


Figure 3: open loop PI controller for v/f ratio control method

4. **The waveforms of open loop PI controller of v/f ratio method**:

Figure 4: variation of dc bus voltage versus time

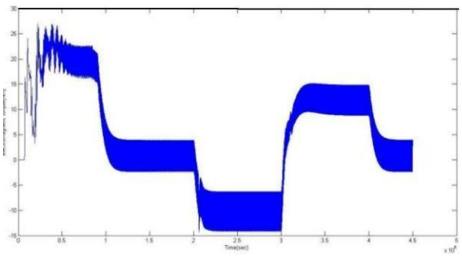


Figure 5: variation of torque versus time

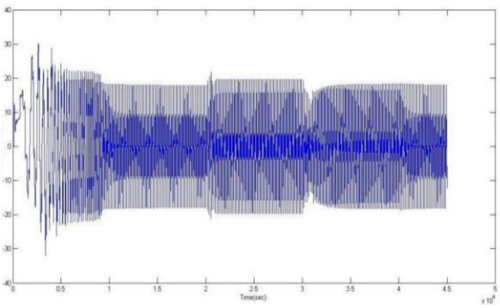


Figure 6: variation of stator current versus

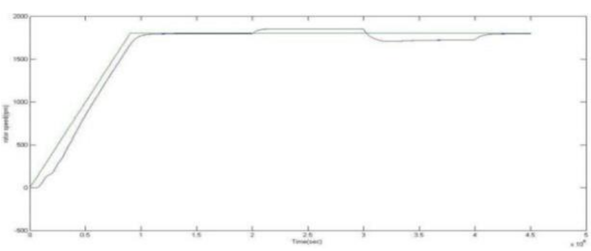


Figure 7: variation of rotor speed versus time

5.Factors Affecting Efficiency of Induction Motor Drives

The performance of the induction motor drives such as partial load, harmonics, rewinding, power consistency, parameter variance, etc. is influenced by many factors. The following articles address these considerations briefly.

Partial Loading

The 3-way induction engines are primarily used with all electrical AC drives due to their inherent advantages: robustness, durability, comparatively low costs and ease of service. These devices provide years of operation (around 20 years) when correctly picked, controlled and managed. In general, the induction engine manages an industrial load of around 70% on a utility, which implies it is crucial to pay greater attention to the full performance of such AC derives. Basically, when run close the rated speed and torque, high performance activity of induction machines can be accomplished. The substantial development in system parts, architecture and fabrication methods will further increase the motor performance in induction.

Harmonics

The function of the inverter driven induction motor at high frequencies contributes to losses due to two forms of harmonics: Space harmonics referred to as stray losses.The time harmonics in the excitation of a converter added to the unit, resulting in losses of time harmonic.

Stray Losses

The air flow difference of the space wave harmonics allows the system to experience street losses (high frequency errors). The key triggers of these harmonics are the differences in the position of stators and rotor slots and the mmf phase harmonics. These losses are related to the specific motor frequency and can be predicted to rise with the increase in the fundamental motor frequency.

High Frequency Time Harmonic Losses

An significant problem in today's electronic power management is the impact of time-harmonic frequency rise on harmonic motor losses. There are also valid explanations for control and motor acoustic noise, which justify for the strong inverter frequency of the carrier. Contrary to these claims, large engine losses may be induced by the carriers' large time harmonic frequency.

Rewinding

If the engine dies, fast repair and replacement are primarily two methods of avoiding output losses in front of engine customers. Excellent materials will reach optimum performance as in the previous stage, but the bad rewind contributes to higher energy usage and a shorter life due to higher ambient temperatures.

After rewinding the induction machine performance and power factor will greatly effect. The producer and consumer can then retain an appropriate register with no loss of load and pace during selling and buy. These reports may be valuable for rewinding effect measurement.

Unbalance Supply Voltage

While supplied by unequalled terminal voltages, induction motor output (speed and torque profile) is adversely affected. The accessible 1950 literature indicates that researchers concentrated on 3-fold induction motor output in voltage imbalances in relation to total current drawn, current imbalance factor, torque ripples, productivity and factor loss, rate loss, overheating isolation damages or computer failure factor [39].

Equal magnitudes and phase angle of 1200 in three stages, reflect the 3-fold mechanism in equilibrium. Every divergence from the parameters specified contributes to a system mismatch. The statistical concept of imbalance can be presented according to various criteria, including the Association of National Electrical

Manufacture (NEMAs), the College of Electrical and Electronic Engineers (IEEE's) and IECs.

Voltage Sags

The RMS voltage drop in the associated power grid for short term is known as a "voltage decline." This issue in power quality is primarily attributed to machine failures. This is also likely due to loose links and the immediate start of heavy loads (the broad starter motor draws a strong in-rush current). For this phenomenon, the IEC term is "dip." Voltage decay triggers significant process problems and often vulnerable electrical loads sometimes go or shut down, which contributes to low quality items and severe production savings as well as a spike in engine temperature.

Parameter Variation

Both education and researchers performed a large amount of efficiency tests in order to monitor AC drives and DC drives effectively and precisely. The study brings them to the vector control principle. AC drive vector control is somewhat close to individual torque and flux control. The high efficiency of an induction engine can be accomplished by vector power. The methods of vector control are very susceptible to the variance of system parameters. However, with temperature and magnetic core saturation the motor parameters change. Computer flux is calculated offline in the direction of vectors by parameters that may be mistake attributable to parameter variations. If the vector controller does not change the error, the system output can be degraded by steady state error and transient speed and torque oscillations.

6.Modeling of Induction Motor Drive

The mathematical model of the drive mechanism comprises the induction engine model, PWM inverter models, PI speed controls and comprehensive engine and inverter failure models. The modelling expectations of the drive method are as follows.

1) The inductive motor's three-phase stator windings are balanced and generate Magneto Motive Force (MMF) spread sinusoidally in vacuum.

2) The DC link voltage accessible at inverter input terminals is considered to be free of ripple.

3) The three-phase sinusoidal currents moving through the engine are often presumed clear of ribbons.

4) Inverter and converter flipping transients are ignored.

5) Between switching system change times is small.

6) Three-phase converter input currents are sinusoidal

7.CONCLUSION

The need for sophisticated induction machine drives has risen exponentially over the past few decades. Over the past few years, the growth in industrial motor drives has exceeded with great expansion. The production of industrial drives is due to the rise in demand for effective and reliable process control. The transfer and regulation of electric power for different applications is a major concern for power electronics. Defining the limits of power electronics systems in relation to advances in power machines, microprocessors, microcontrollers and personal computers is rather repetitive. The area of electric drives has expanded rapidly due to developments in semiconductor technology, signal processing and digital controllers. These technical advances help to build a highly efficient AC Drive with low dissipation of power and precise control structures.

In order to control the speed of induction machines such as scalar and vector control, there are different control strategies available. The scalar control over the complex vector control algorithm provides low cost and fast implementation. The Volts per Hertz (V/F control) method is Scalar Control's most common technique. Because of its simplicity and relatively good speed accuracy and low implementation cost, this technique is most commonly used in adjustable speed drives of the induction motor. To control voltage and frequency, the Pulse Width Modulation technique is commonly used. Insulated Gate Bipolar Transistors (IGBT) and Power MOSFETs are the most common power devices used for motor control applications. IGBTs are a bipolar transistor at the base of whaich a MOSFET is operated. The IGBT devices are fast switching devices that require low drive current and can be used at high switching frequencies for these devices.

Electric motor drive research and design is a boring work. Motor drive development involves several phases, such as prototype style motor drive development; test it for performance and then go for final design. This is the mechanism of time consumption. Using various simulation tools, it is possible to reduce this time or speed up the design process. This can help with optimal solutions to save energy and money to some degree. When researching the internal interaction of a complex system, or a subsystem within a complex system, simulation plays an important role. Valuable insight into the simulation method can be gained by adjusting simulation inputs and analysing the resulting output. It is possible to research their interaction with the system by varying the variables.

PSIM is simulation software intended for the simulation of power electronics, motor control and dynamic systems. PSIM includes simulation at the circuit level and device level. A good algorithm dedicated to electrical circuits is used by PSIM. PSIM offers a strong simulation environment with quick simulation and a friendly user interface to solve the problems in the design of the power electronics system. The PSIM consists of three components: the schematic programmed PSIM, the simulator PSIM, and the Sim view waveform display programmer. Using PSIM with its sub circuit feature, it is possible to manage large systems.

REFRENCES

1. Stephen J. Chapman (2012). Electric Machinery Fundamental; Second Edition; McGraw-Hill companies.
2. O. I. Okoro (2008). Introduction to Matlab/Simulink for Engineers and Scientists; Second Edition; John Jacob‘s Classic Publishers Ltd.
3. P. S. Bimbhra (2005). Power Electronics; 3rd Edition; Khanna Publishers.
4. A. E. Fitzgerald et. al. (2003). Electric machinery; Sixth Edition; McGraw publishers.
5. A.E. Fitzgerald, Charles Kingsley, Jr. And Stephan D. Umans (2002). -Electrical Machinery‖, McGraw-Hills Publications.
6. -IEEE Standard Test Procedure for Polyphase Induction Motors and Generators‖, volume 112, issue 1996 of IEEE, by IEEE Power Engineering Society.
7. D. W. Novotney, et. al. (editor) (1986).-Introduction to Field Orientation and High Performance AC drives‖, IEEE IAS tutorial course, 1986.
8. Gopal K. Dubey (2011). -Fundamental Of Electrical Drives‖, Narosa Publication House, Second Edition.
9. Scott Wade, Matthew W. Dunnigan, and Barry W. Williams,(1997). -Modelling and Simulation of Induction Machine Vector Control with Rotor Resistance Identification‖, IEEE transactions on power electronics, vol. 12, no. 3, may 1997.
10. R. Krishnan (2001). Electric motor drives, modeling, analysis and control, first edition, Pearson education Inc.
11. Ned Mohan, Tore M. Undland, William P. Robbins (2003). Power electronics converters, application and design, third edition, John willy.
12. Ramon Blasco Blasco Gimenez (1995).-High Performance Sensorless Vector Control of Induction Motor Drives‖, The University of Nottingham.
13. Gopakumar, K. : Power Electronics and Electrical Drives, Video Lectures24-35, Centre for Electronics and Technology, Indian Institute of Science, Bangalore.Texas instruments, Scalar (V/f) Control of 3-Phase Induction Motors, application report, July 2013.