Detection of backlash phenomena in induction motor

Science, Physics

ASSIGN BUSTER

The problem our thesis work will solve is to reduce backlash in induction motor. Backlash is described as a mechanical form of dead band that can lead to error on hole location, if the motion required to machine the holes causes a reversal in axis direction it also lead to loses of motion between input and output shafts, making it difficult to achieve accurate center in equipment such as machines tools etc. The main problem are vibrations from motor as a result of high ripple torque in the motor.

The motor is a kind of an AC machine in which alternating current is supplied to the stator directly and to the rotor by induction from the stator. Induction motor can appear in a single phase or a poly phase. (Toufouti, et al, 2013).

In construction, the motor has a stator which is the stationary portion consisting of a frame that houses the magnetically active angular cylindrical structure called the stator lamination. It stack punched from electrical steel sheet with a three phase winding sets embedded in evenly spaced internal slots.

The rotor which is the rotatory parts of a motor is made up of a shaft and cylindrical structure called the rotor lamination. It stack punched from electrical steel sheet with evenly spaced slots located around the periphery to accept the conductors of the rotor winding (Ndubisi, 2006).

The rotor can be a wound type or squirrel cage type. In a poly phase motor, the three phase windings are displaced from each other by 120 electrical degrees in space around the air-gap circumference when excited from a balanced poly phase source, those windings (stator winding) will produce a magnetic field in the air-gap rotating at synchronous speed as determine by the number of stator poles and the applied stator frequency (Bimal, 2011).

In the controlling of electrical motor; the introduction of micro-controllers and high switching frequency semiconductor devices, variable speed actuators where dominated by DC motors.

Today, using modern high switching frequency power converters controlled by micro-controllers, the frequency phase and magnitude of the input to an AC motor can be changed and hence the motor's speed and torque can be controlled. AC motors combined with their drives have replaced DC motors in industrial applications because they are cheaper, better reliability, less in weight, and lower maintenance requirement. Squirrel cage induction motors are most generally used than all the rest of the electric motors as they have all the advantages of AC motors and they are easy to build.

The main advantage is that motors do not require an electrical connection between stationary and rotating portion of the motor. Therefore, they do not need any mechanical commutators to the fact that they are maintenance free motors. The motors also have lesser weight and inertia, high efficiency and high over load capability. Therefore, they are cheaper and more robust, and less proves to anyfailureat high speeds.

Furthermore, the motor can be used to work in explosive environments because no sparks are produced. Taking into account all the advantages outlined above, induction motors must be considered as the perfect electrical to mechanical energy converter. However, mechanical energy is more than often required at variable speeds, where the speed control system is not a trivial matter. The effective way of producing an infinitely variable motor speed drive is to supply the motor with three phase voltage of variable amplitude.

A variable frequency is required because the rotor speed depends on the speed of the rotating magnetic field provided by the stator. A variable voltage is required because the motor impedance reduces at low frequencies and the current has to be limited by means of reducing the supply voltage. (Schauder, 2013).

Before the days of power electronics, a limited speed control of the motors was achieved by switching the three stator windings from delta connection to star connection, allowing the voltage at the motor windings to be reduced. Induction motors also available with more than three stator windings to allow a change of the number of pole pairs.

However, a motor with several windings is very costly because more than three connections to the motor are needed and only certain discrete speeds are available. Another method of speed control can be realized by means of a wound rotor induction motor, where the rotor winding ends are brought out to slip rings (Malik, 2013). However, this method obviously removes the main aim of induction motors and it also introduces additional losses by connecting resistor or reactance in series with the stator windings of the motors, poor performance is achieved.

With the enormous advances in converterstechnologyand the development of complex and robust control algorithms, considerable research effort is devoted for developing optimal techniques of speed control for the machines. The motor control has traditionally been achieved using field oriented control (FOC). This method involves the transformation of stator currents in a such manner that is in line with one of the stator fluxes. The torque and flux producing components of the stator currents are decoupled, such that the component of the stator current controlling the rotor flux magnitude and the component controls the output torque will differ (Kazmier and Giuseppe, 2013).

The implementation of this system however is complicated. The FOC is also well known to be highly sensitive to parameter variations. It also based on accurate parameter identification to obtain the needed performance.

Another motor control techniques is the sensor less vector control. This control method is only for both high and low speed range. Using the method, the stator terminal voltages and currents estimate the rotor angular speed, slip angular speed and the rotor flux. In this case, around zero speed, the slip angular velocity estimation becomes very difficult.

Motivation for the work

When we were on training in machine in our office, we are told gave us a drawing to produce a machine shaft. During the process, when we feed in a cut of 10mm to the machine, it would cut 9. 5mm and when we wanted to drill a hole at the center of the job, it would drilled it off centered, we called on our supervisor after we have wasted much time, power and materials.

Surprisingly, after his supervision, he told us that backlash in the machine is responsible for that and he instructed us to use another machine which we did and got what we need immediately. Therefore, that ugly experience motivated us to research on how to reduce high ripple torque in induction motor which is the main causes of vibrations that lead to the backlash in the industrial machine.

STATEMENT OF THE PROBLEM

- The statement of the human problem our research work will solve is to reduce backlash in industrial machine.
- Explanation of the problem

BACKLASH

Backlash can be defined as the maximum distance or angle through which any part of a mechanical system may be moved in one direction without applying appreciable force or motion to the next part in mechanical sequence and is a mechanical form of dead band. More so, it is any non-movement that occurs during axis reversals.

For instance, when x – axis is commanded to move one inch in the positive direction, immediately, after this x – axis movement, these x-axis is also commanded to move one inch in the negative direction if any backlash exists in the x-axis, then it will not immediately start moving in the negative direction and the motion departure will not be precisely one inch.

So, it can cause positioning error on holes location, if the motion required to drill the holes causes a reversal in axis direction, it also causes loses ofmotion between reducer input and output shafts, making it difficult to achieve accurate positioning in equipment such as machines tools etc. The main cause of this problem electrically is vibrations from electric motor as a result of high ripple torque in the induction motor.

Benefits of solving the problem

1. High-quality products will be produced.
2. Productivity will increase because adjustment and readjustment of machine feeding handle or feeding screw to eliminate backlash have been reduced.
3. The operational cost will be reduced.
4. Greater efficiency will be guaranteed.
5. Greater accuracy and precision of product will be guaranteed.
6. Wasting of materials will be highly reduced.

RESEARCH OBJECTIVES

1. To develop a model that will control the error to achieve stability using DTC and fuzzy logic with duty ratio.
2. To determine the error in the torque of the machine that causes vibration which lead to backlash that result in production of less standard products.

3. To determine the position of the stator flux linkage space vector in the poles of the induction motor.
4. To determine the stator linkage flux error in the induction motor that also causes vibration.
5. To simulate the model above in the Simulinkenvironmentand validate the result.

SCOPE AND LIMITATION OF THE WORK

This project work is limited to the use of fuzzy logic controller with duty ratio to replace the torque and stator flux hysteresis controllers in the conventional DTC techniques. The controllers have three variable inputs, the stator flux error, electromagnetic torque error and position of stator flux linkage vector. The inference method used was the Mamdam fuzzy logic inference system. The deffuzzification method adopted in this work is the maximum criteria method.

SIGNIFICANCE OF THE WORK

The importance of this work in industry where induction motor drives are mainly in application cannot be over emphasis.

As earlier noted, induction motors because of their ruggedness simple mechanical structure and easy maintenance; electrical drives in industries are mostly based on them.

Also, a wide range of induction motor applications require variable speed, therefore induction motor speed, if not accurately estimated will affect the efficiency of the overall industrial processes. Equally, the harmonic losses if not put in check will shorten the life p and efficiency of the motor inverter. Based on the above, it is aimed at reducing the principle causes of the inefficiency in the DTC induction motor and improves the performance of the system.

ORGANIZATION OF THE WORK

The work is organized into five chapters. Various control techniques were discussed in chapter two, in chapter three, we discusses the methodology, design and implementation of the direct torque control of induction motor using fuzzy logic with duty ratio controller.

Chapter four discusses data collection, analysis and the simulated results showing the system using conventional method of control and the proposed fuzzy logic with duty ratio method of control under applied load torque conditions.

Conclusion, recommendations and suggestion for further work are mentioned in chapter five.