Performance analysis of Induction Motor using Different Controller for Speed Control

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Abstract - The most commonly encountered electric motors in industry are induction motors. In recent years the control of high-performance induction motor drives has received widespread research interests. It has been valued more not only because it is the most used motor in industries but also due to their varied modes of operation. It has good self-starting capability, simple, rugged structure, low cost and reliability etc. Induction motors have been used in past mainly in applications requiring a constant speed. It has attracted the attention because such machine are made and used in largest numbers and also due to their varied mode of operation both under steady state and dynamic states. Induction motor finds its place amongst more than 85% of industrial motor drives and as well as single phase form in various domestic usages

***Key Words*: Speed Control, PI controller, PID controller, Fuzzy Logic Controller, Combined PI and Fuzzy logic controller, Combined PID and Fuzzy logic Controller.**

I .INTRODUCTION

The speed control of induction motor is more complicated than that of dc motor, especially when, comparable accuracy is desired. The main reason for this can be attributed to the complexity of the mathematical model of the induction machine, as well as the non-linear power converters supplying this motor. It is very important to control the speed of induction motor for the application in industries and in engineering.

There are many types of speed control. Speed control techniques of induction motors can be broadly classified into two types' scalar control and vector control. Scalar method only the magnitude of voltage or frequency of the induction motor.

Induction Motor Modeling

An induction motor (IM) is a type of asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. Other commonly used name is squirrel cage motor due to the fact that the rotor bars with short circuit rings resemble a squirrel cage (hamster wheel).An electric motor convert's electrical power to mechanical power in its rotor. There are several ways to supply power to the rotor. In a DC motor this power is supplied to the armature directly from a DC source, while in an induction motor this power is induced in the rotating device. An induction motor is sometimes called a rotating transformer because the stator (stationary part) is essentially the primary side of the transformer and the rotor (rotating part) is the secondary side. Induction motors are widely used, especially poly phase induction motors, which are frequently used in industrial drives. As a general rule, conversion of electrical power into mechanical power takes place in the rotating parts of an electrical motor. In dc motor, the electrical power is conducted directly in armature the rotating part of the motor through brush or commutates and hence dc motor called as conduction motor but in case of induction motor the motor does not receive the electrical power by conduction but by induction in exactly same way as the secondary of a 2-winding transformer receives its power from the primary. That is why such motor known as induction motor. In fact, an induction motor can be treated as a rotating transformer i.e. one in which primary winding is stationary but the secondary is free to rotate. Of all the AC motors, the poly phase induction motor is the one which is extensively used for various kinds of industrial drives. Three-phase induction motors are more commonly employed in adjustable-speed drives than the three-phase synchronous motors. Three-phase induction motors are of two types, squirrel-cage induction motors (SCIMs) and slip-ring (wound-rotor) induction motors (SRIMs). Stator windings of both types carry three-phase windings. Rotor of SRIM is made of copper or aluminum bars short-circuited by two end rings. Rotor of SRIM carries three-phase winding connected to three slip rings on the rotor shaft. When 3-phase supply is connected to three-phase stator winding, rotating magnetic field is produced. The speed of this rotating field, called synchronous speed, is given by

$N = 120 * F / P$ rpm

Where,

F = supply frequency in Hz

N = Speed in rpm

P = number of poles

II .PI Controller

The PI controller (proportional integral controller) is a feedback controller. It drives the plant which is to be controlled with a weighted sum of error and the integral of that value

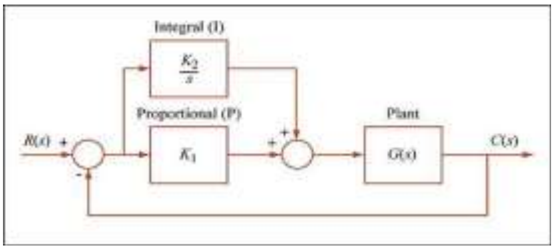

Fig 1.1 Basic block of PI Controller

PI controller increases the order and the type of the system by one. It also causes the steady state error to reduce to the zero, which is not the case for proportional only control in general. PI controller improves damping and reduces maximum overshoot. It also decreases the bandwidth and improves the rise time.

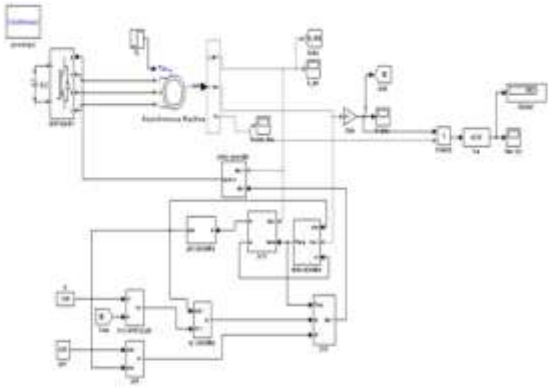

Fig 1.2 Simulation with PI controller

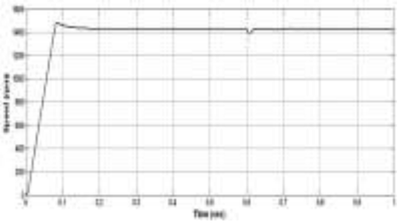

Fig 1.3 Speed response of Induction motor on full load condition with PI controller

the PI controller is most widely adopted in industrial application due to its simple structure, easy to design and low cost. Despite these advantages, the PI controller fails when the controlled object is highly nonlinear and uncertain. PI controllers are very often used in industry, especially when speed of the response is not an issue. A control without D mode is used when

1. Fast response of the system is not required
2. Large disturbances and noise are present during operation of the process
3. There is only one energy storage in process (capacitive or inductive)
4. There are large transport delays in the system.

Therefore, we would like to keep the advantages of the PI controller

III. PID CONTROLLER

The PID controller (proportional integral derivative controller) is widely used in industrial control system. A PID controller calculates an “error” value as the difference between the measured process variable and the desired set point.

The PID controller calculation involves three separate constants and is accordingly sometimes called three-term control i.e. the proportional, the integral and derivative value which is denoted by P, I and D. A proportional controller may not give steady state error performance which is needed in the system. An integral controller may give steady state error performance but it slows a system down. So the addition of a derivative term helps to cure both of these problems.

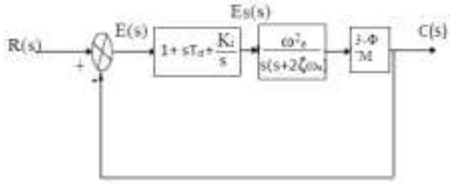

Fig 2.1 Basic block of PID Controller

An investigation performed in 1989 in Japan indicated that more than 90% of the controllers used in process industries are PID controllers and advanced versions of the PID controller.

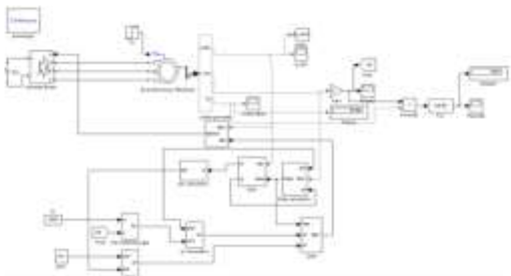

Fig 2.2 Simulation with PID controller

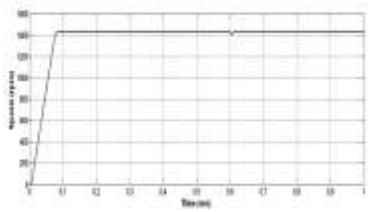

Fig 2.3 Speed response of Induction motor on full load condition with PID controller

IV. Fuzzy Logic Control System

Fuzzy control is based on the fuzzy logic theory which was first proposed by Zadeh. Fuzzy controllers are rule-based controllers that use “if–then” format for the control process. In this format, several variables could be used either in condition or conclusion side of the "if–then" rules. As a result, the mathematical model of the system is not required in fuzzy control, so it can be applied to Nonlinear systems.

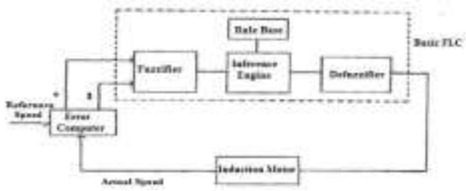

Fig 3.1 Block diagram of a Fuzzy Logic Controller

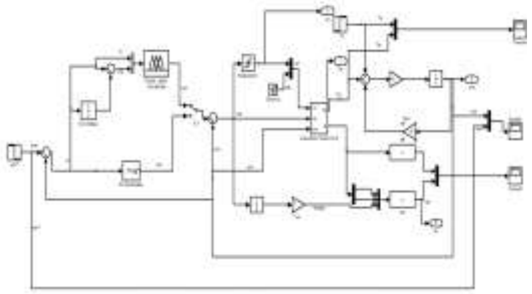

Fig 3.2 Simulink Model of Fuzzy Controller

Fuzzy technique have gained in wide acceptance in expert systems, control units and in wide range of applications because of fast adaptation, high degree of tolerance, smooth operation, reduction in the effect of non-linearity, easy if-else logics and inherent approximation adaptability. A fuzzy logic controller (FLC) has already been proved analytically to be equivalent to a non-linear PI controller when a non-linear defuzzification method is used. Also, the result from the comparisons of conventional and fuzzy logic control techniques in the form of a FLC and fuzzy compensator showed fuzzy logic can reduce the effects of non-linearity in a DC motor and improve the performance of a controller

V. Fuzzy PI Controller

To take over the advantages present in both FL (negligible overshoot and undershoot) and PI (zero steady-state error) controllers, a hybridization of FL and PI controllers, called fuzzy pre-compensated PI (FPPI) controller, is done and is used as a single controller.

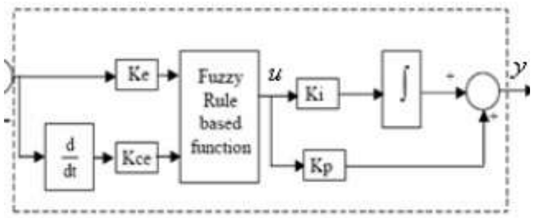

Fig 4.1 Block of Fuzzy PI Controller

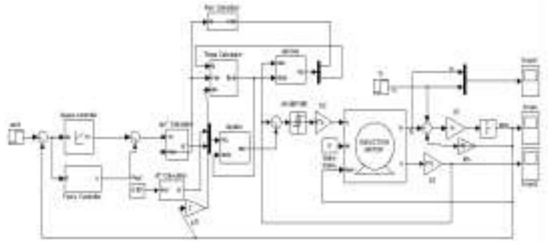

Fig 4.2 Simulink Model of Fuzzy PI Controller

Fig 4.3 Speed response with Fuzzy PI controller

Some particular features such as overshoot and undershoot happening in the speed response, which are obtained with PI controller can be removed and this controller is much useful to loads where the torque/speed of the motor varies every moment.

The speed response with this controller has no overshoot and settles faster in comparison with FL controller. It is also noted that there is no steady-state error in the speed response during the operation when hybrid controller is activated. In addition, no oscillation occurred in the torque response before it finally settle.

VI. FUZZY PID CONTROLLER

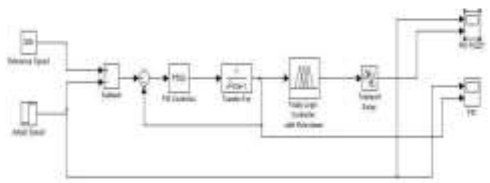

Fig 5.1 Simulation with Fuzzy PID Controller

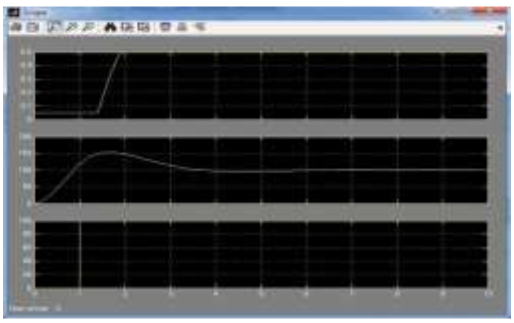

Fig 5.2 Speed response with Fuzzy PID controller

Instead of all conventional strategies, PID and FUZZY-PID controllers are very different in Nature and are efficient for speed controlling of three Phase ac induction motor. But PID controller is very Much useful because it uses auto tuning. Once it is tuned it tracks the output according to the provided Input. But it suffers from more overshoot and settling Time. The PID in simulated and real time implemented forms has greater over shoots besides longer settling time.

Controller intended to drive the three phase induction Motor. Fuzzy Controller has offered negligible Settling time than PID controller and with almost no overshoot. The work reveals that that speed controlling of induction motor with Fuzzy-PID controller is smooth and easy than PID controlling method.

Conclusion

For Speed Control of Induction Motor various Controller have been Studied. The Speed response f different Controller analyzed using MATLAB Simulation.

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