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Controlling of EDM Servo System Using Fuzzy Logic Controller

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Abstract: Electrical discharge machining (EDM) is a machining process used in non traditional manufacturing. It is established for heat energy between electrode and work piece. It is use in servo system as a comparison the gap voltage reference value and confirm that the electrode travels at a prepare level to preserve the correct spark gap and draw back the electrode. For controlling the gap the fuzzy control principle, simulation is conducted in MATLAB /SIMULINK, the result shows that the controller can work well with quick response, no overshoot output and high control precision. Its performance is more efficient for control systems.

Keywords: EDM; Fuzzy control.

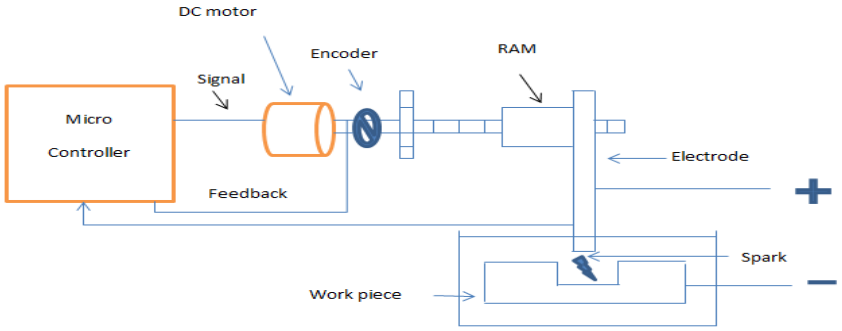
1. Introduction

Electrical discharge machining (EDM) is a process of electrically removing material from conductive and semi conductive material by sequences of rapidly frequent current discharges between a work piece and electrode in presence of a dielectric. The EDM is a thermal method, which removed the material through heat. The heat is define as flow of electricity among work piece and electrode in the shape of spark. When the material was heated the spark originates occur in the target point and create material vaporizes and melt.

In the process of the electrical discharge, a spark happens within a gap between the electrode and the work piece. Then the electrical energy is transformed into thermic energy to smelting a size of material away from the work piece. The gap distance is typically between 0.01mm to 0.05mm. Experts in the field of EDM have explained that active control of the gap distance can significantly increase the efficiency of sparking process in terms of material removal rate [1].

The EDM generates sparks between electrically conductive work piece and a shaped electrode. As part of the material is corroded, the electrode is gradually decrease into work piece and this process continues until the cavity gap same shape of electrode [2]. There is no direct contact between work piece and electrode eliminating mechanical stresses, vibration and chatter issues during machining [3]. The electrode (tool) and work piece must be electrically conductive. The servo mechanism keep the space between work piece and electrode where the space is like thickness of human hair to avoid the contact with each other. Through EDM process the electrode and work piece are immersed in the dielectric oil, which is an electric insulator. This help to control the arc discharge. The work piece and electrode are connected to suitable power supply. Which is produced electrical potential between the tools. The sparking frequency is between 2,000 to 500,000 per second and these sparks occurs simultaneously [4]. A dielectric material is necessary to keep the spark gap between work piece and electrode. In order to keep the spark gap between work piece and electrode The fluid is used as Electrical insulator While. The servo system block contains the model of dc motor with RAM and lead screw, as shown in Figure 1. When the gap is insufficiently close between work piece and electrode then the servo system will keep the gap between the tools.

Figure-1. EDM System



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Controller will increase the feeding rate in order achieve a credible and stable EDM process, it needs an optimal gap width to be kept throughout the complete corrosion session The information of the actual gap distance is required to control the gap width. However, straight measurement of the actual gap width between the tools is practically not possible. To overtake this problem, indirect measurement of the gap width using feedback signal of the gap voltage is used for corrosion process monitoring.

The voltage of the gap average can reveal the gap discharge condition approximately. When the circuit open more and more, the average voltage is high, which indicates that the spark gap is quite big. The control system proceeds the average gap of voltage and then contrast with a reference voltage of servo motor of the electrode towards the work piece when the error is positive and reduces or pull back from the workpiece when the error is negative.

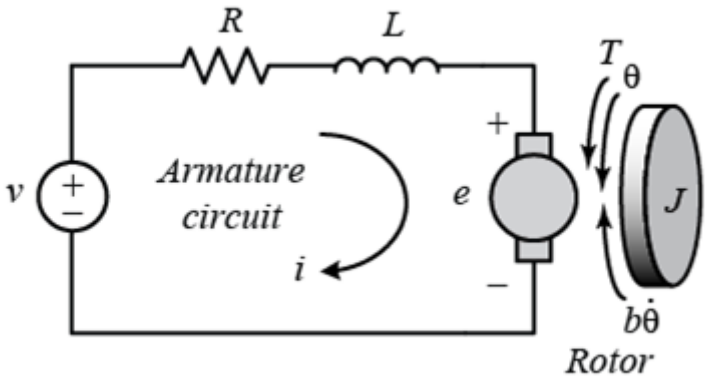
Many of controllers have been explored for the EDM process control for years. In Chang [5] the study included the design of robust PI controller for the gap control and that developed the H2 performance. The suitable feed rate and transferred signals for the interpolator is produced from the signals, which are transmitted in a computerized numerical controller (CNC). Via EDM method, the feedback expands and disturbed because of the powder creates in the gap. The H2 decrease the square of the tracking errors for the insignificant system, including perturbation to develop the tracking performance of the perturbed system. The speed of erosion system with optimal robustness is faster than those without the optimal robustness A research by Andromeda, *et al.* [6], [7] studied to control the gap by ram servo control system the difference voltage between the voltage gap and voltage reference will lead the ram servo to control the gap .The main goal is to optimize the PID parameter and based on IAE (integral absolute error) fitness function to be sure a robust, stable and controlled system.

A research in Chen, *et al.* [8] is designed an intelligent controller based on fuzzy RBF (Radial Basis Function) neural network to achieve real-time control of EDM online parameters. The simulation results illustrations that this intelligent controller can recognize real-time adjustment of EDM online parameters, so meet the condition of development machining Effectiveness and enhancing processing stability. In this paper the focus is to develop the fuzzy controller for EDM process.

2. Mathematical Expression

The servo DC motor is used extensively in control system for analytical purpose. It is necessary to establish the mathematical models for DC motors for EDM applications. The equivalent circuit diagram in figure 2 to represent a dc motor.

Figure-2. Schematic Representation of The Considered DC motor



The motor torque, *T* is related to the armature current, *i*, by a constant factor, *K*. This relationship can be expressed as:

$$T = Ki \tag{1}$$

The back electromotive force (emf), *Vb*, is related to the angular velocity by:

$$Vb = K\omega = K\frac{d\theta}{dt} \tag{2}$$

$$J\frac{d\theta^2}{dt^2} + B\frac{d\theta}{dt} = Ki \tag{3}$$

$$L\frac{di}{dt} + Ri = V - K\frac{d\theta}{dt} \tag{4}$$

Using the Laplace transform, equations (3) and (4) can be written as:

$$JS^2 + BS\theta(s) = KI(s) \quad (5)$$

$$LSI(s) + RI(s) = V(s) - KS\theta(s) \quad (6)$$

Where is denotes the Laplace operator. From (6):

$$I(s) = \frac{(V(s) - KS\theta(s))}{(R + L(s))} \quad (7)$$

And substituted it in (5) to obtain:

$$JS^2\theta(s) + BS\theta(s) = \frac{K(V(s) - K(s))}{(R + L(s))} \quad (8)$$

From equation (8), the transfer function from the input voltage, V (s), to the output angle, directly follows:

$$Ga = \frac{\theta(s)}{V(s)} = \frac{K}{S\left((R + LS)(JS + B) + K^2\right)} \quad (9)$$

3. Fuzzy Logic Controller

Fuzzy logic control is a control algorithm based on a linguistic control strategy [9]. A fuzzy controller transforms a linguistic control strategy into an automatic control strategy, and fuzzy rules are created by expert experience or knowing database. FLC doesn't essential any hard mathematical computation similar to the others control system, FLC just usages straightforward mathematical computation process to emulate the expert knowing. In the FLC, the membership functions (MF's) for inputs error (e) and change of error (che) as displayed in figure (3) and figure (4). In figure (5) shown the voltage control u(t) of the output variable for the FLC.

A fuzzy logic control generally contains of the following:

1. Fuzzification.
2. Rule base and Inference engine.
3. Defuzzification .

Figure-3. Membership function for error

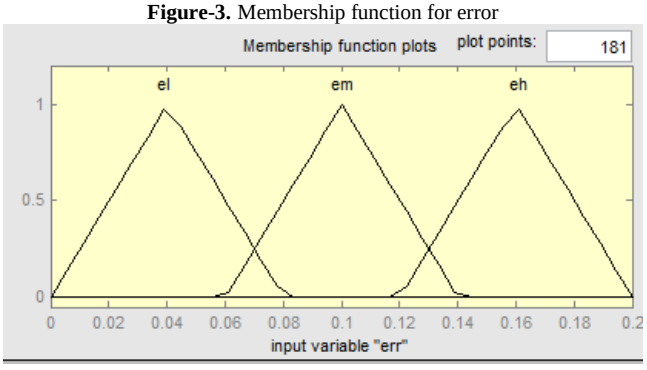


Figure-4. Change of Error

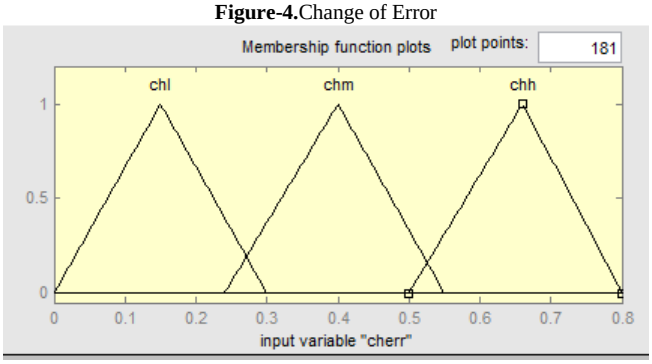
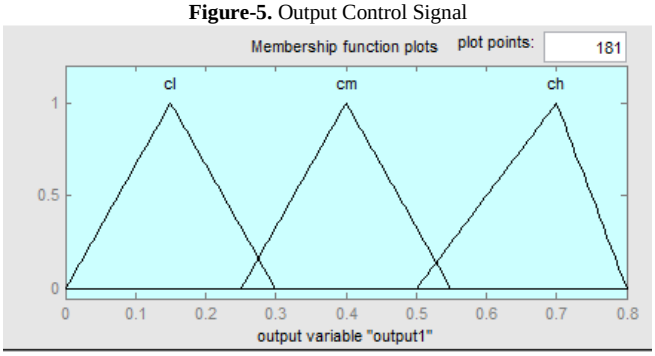


Figure-5. Output Control Signal



4. Simulation and Result

The model of simulation with the fuzzy controller for the speed control of DC servo motor is developed in Matlab as displayed in the figure 6. The simulation output of the FLC for System is represented in Figure 7.

Figure-6. Simulink model of DC Motor Speed Control

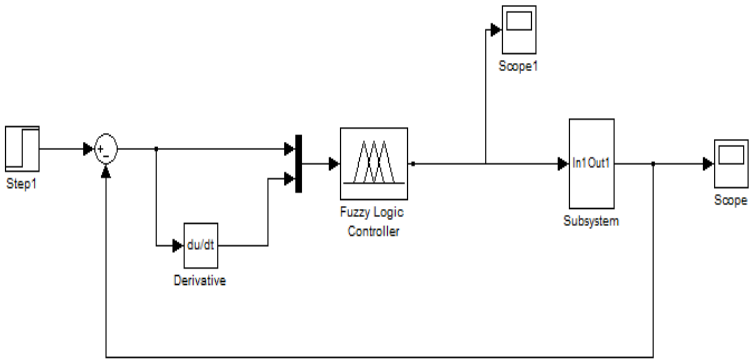


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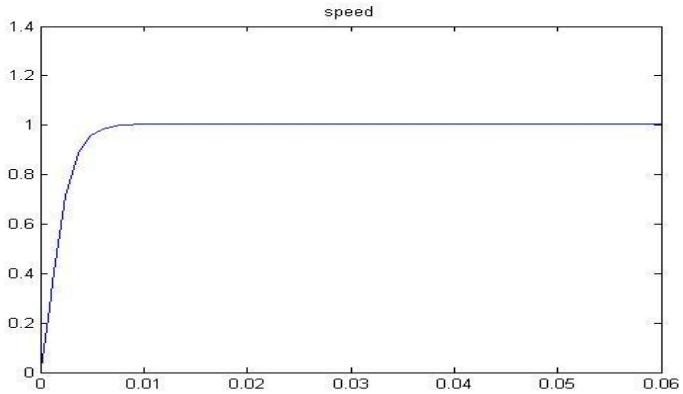
Figure-7. output response



From above figure, it can be simply realized that the overshoot has been significantly reduced with fuzzy logic controller.

5. Conclusion

The control system is a heart for EDM and its servo feed control system. So to determine a better positioning system in controlling DC motor for EDM servomechanism. In this paper, speed control of DC-drive based on fuzzy logic control. This method improved the characteristics of dc motor such as smooth starting, acceleration, precision, performance, and small change of reference speed that will be no over shoot and robustness in speed drive controller if compare with conventional speed drive controller as to reliability.

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