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Design and application of the technical training set for plc- based power supply unit developed for industrial applications

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Abstract

Design and control of a prototype training set, which especially the students studying in institutions offering education at undergraduate and associate levels can employ as a PLC (Programmable Logic Controller)-controlled simulator of the power supply unit of electroerosion machinery (electrical discharge machinery) that are used frequently during industrial manufacturing processes, has been actualized through this work, for the purpose of training qualified technical personnel needed by companies, who are specialized in control and electromechanics. The training set, therefore, contributes to a large extent to the training process in favor of faculty members, who are to train personnel for the sector, and in favor of students, who should be able to acquire proper education. Working on the prototype allows students to acquire knowledge and practical skills and then make use of those skills for maintaintenance, repair and control of machinery.

Keywords: Power supply, plc, educational technology.

1. Introduction

Today, EDM (Electrical Discharge Machining) is an extraordinary material processing method, which is widely used. Its convenience for tooling easily the pieces that are difficult to shape with especially CNC or similar machinery, materials that are extremely hard, and materials that have complex forms, has made utilization of the method widespread (Çoğun, Kocabaş, & Özgedik, 2004; Halkaci, 2002; Ekmekci, Elkoca, Tekkaya, & Erden, 2005; Ekmekci, Elkoca & Erden, 2005). Metal particles are removed from the machined piece through controlled electrical discharges, by the electro-erosion machinery. Each repetitive discharge creates a small crater in the workpiece. Continuous wandering of the electric arc copies the shape of the template to the workpiece until the final shape is produced. Unlike conventional machinery, hardened pieces and hard metal tips can be machined easily by this technique (Doval-Gandoy, Pasandin, & Fernandez, 2005). That feature creates a vast application possibility for the

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machinery. An important advantage of the electrical discharge machinery is that no cutting force is involved Furkan Makine Sanayi (Furkan Machinery Industries, 2000). Figure 1 illustrates the principal diagram of the sink-type electrical discharge machinery (Cogun, & Akaslan, 2002).

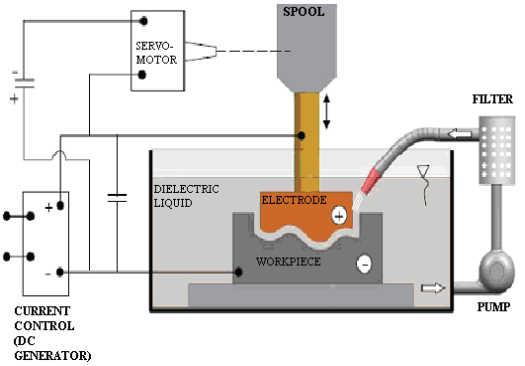

Figure 1. Physical illustration of sink-type EDM machinery

The three essential elements of the physical principle that makes electrical discharge machining (EDM) possible is an electrode, a workpiece and some dielectric liquid. There are small particles in the dielectric liquid. DC voltage in the range 80-200 V is applied to the electrode. An electric field is formed between the electrode and the workpiece. That field eventually creates sparks (or electric arcs), which cause thermal reactions on the workpiece. By this way, particles of metal starts to be removed from the surface of the workpiece. The process is repeated through the servo mechanism control unit until the work piece takes the desired form. Any kind of parameter pertaining to the machining process is determined by the power supply unit.

2. Design of the Power Supply Unit

The essential factor for machining through electro-erosion, which is one of several machine tooling methods, is being able to adjust the metal removing rate well. Metal removing rate and surface roughness depend on electrical discharge duration and magnitude of the electric current. If the magnitude of the current increases, so does the metal removing rate, but surface roughness occurs at the same time. On the other hand, if erosion frequency is increased, then the surface roughness decreases, but the electrode is accordingly worn away more, as a result. The metal removing unit, which is required for electrical discharge machining basically consists of the following components: DC power supply (capable of very fast switch on-off action), dielectric liquid, work piece, electrode and servomotor system

In order to design a good generator for metal removing operation in electrical discharge machining technique, the GAP voltage must be determined accurately, and then the power supply unit should be designed accordingly, because the EDM system works through control of that gap voltage which is between the work piece and the electrode. In addition to this, parameters like pulse duration of the spark between the electrode and the work piece, and the wait duration after each pulse should be considered because they are essential to the power supply design (Wollnberg, Shulze, & Timm, 1995).

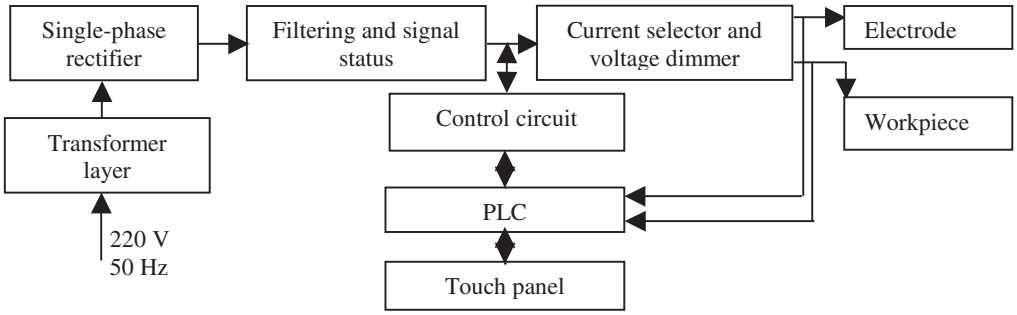

Figure 2. Block diagram of the designed power supply

The dielectric breakdown has been observed to be occurring at 80 V for the power supply unit, which has been developed in laboratory size according to the related parameters, therefore, the gap voltage is 80 V. In the meantime, 25 A of current flows through the electrode, depending on the rate of operation. Frequency of the power supply is 12,5 KHz. Hence, pulse (t_{on}) and wait (t_{off}) times have been limited. Figure 3 shows a photo of the power supply unit that has been designed. The first, second and third racks of the cabinet respectively house the transformer, AC/DC converter, single-phase rectifier and filtering units; circuits to adjust the gap voltage, t_{on}, t_{off}, wait and removal times; and the servomotor drive and other circuits (Figure 3).

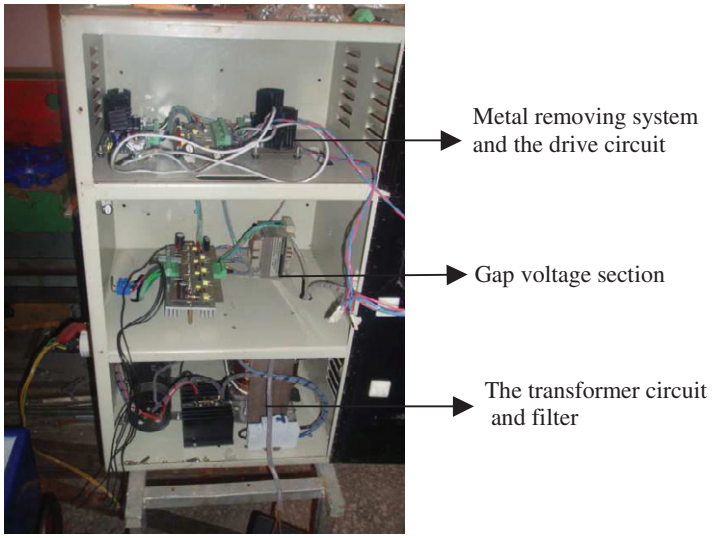

Figure 3. The designed power supply unit

Since the power supply unit that has been developed for electro-erosion machinery is employed as a DC supply, a DC-type servomotor has been preferred for this work in order to drive the shaft that is to move the guide, to which the electrode has been attached. The DC servomotor with the specifications stated in Table 1 has been employed for the Z axis to move the guide.

Table 1. Technical specifications and driver types of DC servomotors

Axis	Voltage	Current(A)	Power (W)	Torque(Nm)	Rotation Rate (rpm)	Servomotor
Z	12 DC	6,5	80	1,27	3000	DC Servomotor

3. Power Supply Unit Control

Panasonic FP-X series PLC has been utilized for the control unit. Two-output DC/AC converter has been employed to obtain the desired analog outputs from the PLC. Figure 4 shows the block diagram pertaining to the PLC control operation.

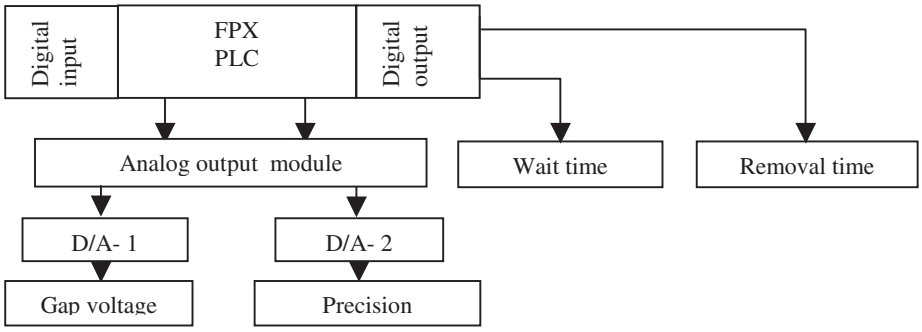

Figure 4. Functional block diagram of the PLC output modules

The power supply unit is a PLC-based, touch-panel-controlled system, whose touch panel control functional block diagram is shown in Figure 5.

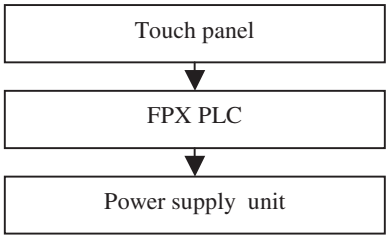

Figure 5. Touch panel control functional block diagram

Touch Panels are touch screens that allow users to control systems. They are very widely utilized in industry. They may be called some sort of tiny computers. Analog and digital signals (1 bit is transmitted as the digital signal, whose duration has been set) that are transmitted from the touch panel determine operation status of the power supply unit through PLC (Figure 6).

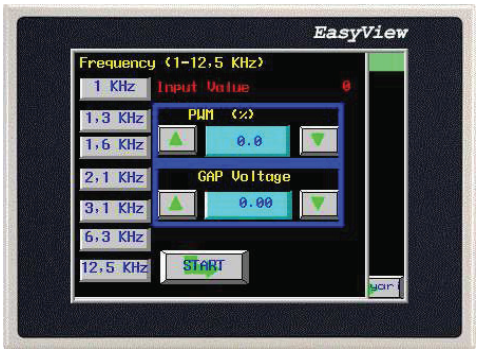

Figure 6. Touch panel operation status

As Figure 6 shows, pulse frequency, PWM setting and the gap voltage can be adjusted during operation. Figure 7 depicts the power supply training set that has been designed and developed.

Figure 7. The designed power supply unit training set

4. Conclusion

Because of their sensitive nature, even small mistakes that might be made during operation of electrical discharge machines impair product quality and cause serious economic losses to enterprises. The prototype, which has been designed for the purpose of helping students gain practical experience in that subject, provides a kind of simulator functionality as well. The algorithm, which has been developed to perform the required tasks, has been created and tested in computer environment, and then loaded to the PLC. Special cards and motor drive circuits have been developed and produced to control current and voltage applied to the power supply unit, which has been developed in laboratory size. As the final work, a touch panel has been employed to let the user enter the required parameters for the simulator. By this way, the students are able to observe the control actions to be performed on the prototype, besides it will be possible to minimize the number of mistakes that might be made during learning and control process. The prototype is considered as a part of the education system to furnish means of development in that subject for especially technical students. The training set will also contribute to the work of trainers who are in charge of raising personnel for the sector.

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