

Design of Pulse Circuit of EDM Diesinker.

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Abstract - Electrical Discharge Machining (EDM) is a non-traditional process that uses no mechanical forces to machine metals. It is extremely useful in machining hard materials. With the advantages, EDM has to offer and its presence as a common and useable technique, along with the other machining processes available to the industrial world, there is an added strain on the environment. The scope of this paper includes a simplified design and analyzing the power supply of EDM and the resulting outputs. A simplified model is used to analyze the process. The main categories of flow scrutinized in the model are material flow and energy flow.

Key Words: Pulse generation, spark creation, circuit design, 555 timer, frequency control, voltage and current control.

1. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal nontraditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark.

The new concept of manufacturing uses non-conventional energy sources like sound, light, mechanical, chemical, electrical, electrons and ions. With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed. New developments in the field of material science have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Non-traditional machining has grown out of the need to machine these exotic materials. The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. The problems of high complexity in shape, size and higher demand for product accuracy and surface finish can be solved through nontraditional methods. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in

the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of nontraditional process.

The Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts.

EDM has been replacing drilling, milling, grinding and other traditional machining operations and is now a well-established machining option in many manufacturing industries throughout the world. And is capable of machining geometrically complex or hard material components, that are precise and difficult-to machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas.

1.1 EDM System

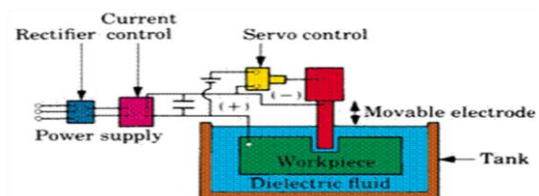


Fig -1: Schematic dig. Of EDM

1.2 EDM Working Principle

- It is a process of metal removal based on the principle of material removal by an interrupted electric spark discharge between the electrode tool and the work piece.
- In EDM, a potential difference is applied between the tool and work piece.
- Essential - Both tool and work materials are to be conductors.
- The tool and work material are immersed in a dielectric medium.
- Generally kerosene or deionized water is used as the dielectric medium.

- A gap is maintained between the tool and the work piece.
- Depending upon the applied potential difference (50 to 200 V) and the gap between the tool and work piece, an electric field would be established.
- Generally the tool is connected to the negative terminal (cathode) of the generator and the work piece is connected to positive terminal (anode).
- As the electric field is established between the tool and the job, the free electrons on the tool are subjected to electrostatic forces.
- If the bonding energy of the electrons is less, electrons would be emitted from the tool.
- Such emission of electrons are called or termed as 'cold emission'.
- The "cold emitted" electrons are then accelerated towards the job through the dielectric medium.
- As they gain velocity and energy, and start moving towards the job, there would be collisions between the electrons and dielectric molecules.
- Such collision may result in ionization of the dielectric molecule.
- Ionization depends on the ionization energy of the dielectric molecule and the energy of the electron.
- As the electrons get accelerated, more positive ions and electrons would get generated due to collisions.
- This cyclic process would increase the concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap.
- The concentration would be so high that the matter existing in that channel could be characterized as "plasma".
- The electrical resistance of such plasma channel would be very less.
- Thus all of a sudden, a large number of electrons will flow from tool to job and ions from job to tool.
- This is called avalanche motion of electrons.
- Such movement of electrons and ions can be visually seen as a spark.
- Thus the electrical energy is dissipated as the thermal energy of the spark.
- The high speed electrons then impinge on the job and ions on the tool.
- The kinetic energy of the electrons and ions on impact with the surface of the job and tool respectively would be converted into thermal energy or heat flux.
- Such intense localized heat flux leads to extreme instantaneous confined rise in temperature which would be in excess of 10,000°C.
- Such localized extreme rise in temperature leads to material removal.
- Material removal occurs due to instant vaporization of the material as well as due to melting.
- The molten metal is not removed completely but only partially.

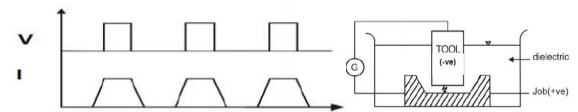


Fig -2: Required pulse

- Upon withdrawal of potential difference, plasma channel collapses.
- This ultimately creates compression shock waves on both the electrode surface.
- Particularly at high spots on work piece surface, which are closest to the tool.
- This evacuates molten material and forms a crater around the site of the spark.
- The whole sequence of operation occurs within a few microseconds.
- Thus to summarize, the material removal in EDM mainly occurs due to formation of shock waves as the plasma channel collapse owing to discontinuation of applied potential difference
- Generally the work piece is made positive and the tool negative.
- Hence, the electrons strike the job leading to crater formation due to high temperature and melting and material removal.
- Similarly, the positive ions impinge on the tool leading to tool wear.
- In EDM, the generator is used to apply voltage pulses between the tool and job.
- A constant voltage is not applied. Only sparking is desired rather than arcing.
- Arcing leads to localized material removal at a particular point whereas sparks get distributed all over the tool surface leading to uniform material removal.

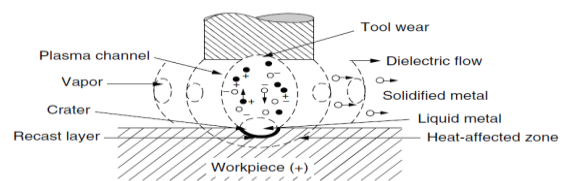


Fig -3: Spark generation process

2. Design of Pulse Circuit

Power supply converts AC to DC used to produce sparks between tool and work piece. Solid state rectifier is used to convert AC to DC. A fraction of Dc power is used to generate a square wave signal with the help of an astable 555 multi-vibrate oscillator. This signal triggers a bank of power transistors that act as high speed switches to control the flow of remaining DC power. It creates high power pulsed output responsible for generating sparks between electrodes.

Power supply should also be able to control the parameters like voltage, current, duration and frequency of a pulse, duty cycle and electrode polarity.

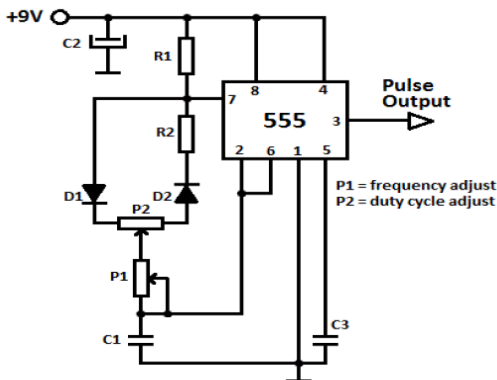


Fig -4: Schematic dig. Of pulse circuit

This is a pulse generator with adjustable duty cycle made with the 555 timer IC. The circuit is an astable multivibrator with a 50% pulse duty cycle. The difference from the standard design of a 555 timer is the resistance between pins 6 and 7 of the IC composed of P1, P2, R2, D1 and D2.

The diodes D1 and D2 set a definite charging time for C1 which produces a 50% duty cycle in a normal case. The duty cycle (n) is dependent on P1 and P2 in the following manner:

$$n = 1 + P2/P1$$

If P2 = 0 (n=100%) then the frequency can be approximately calculated with the following formula:

$$f = 0.69 / ((2 * P1 + P2 + 4.7k\Omega) * C1)$$

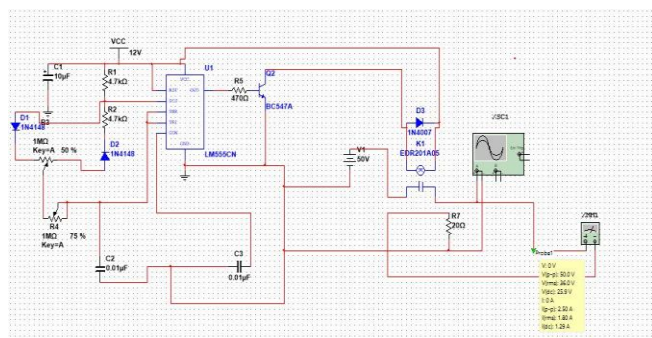


Fig -5: Pulse circuit designed in NI-Multisim software

The total circuit is divided in to two parts. One is known as driver circuit, which produces the pulse of 12V and another one is relay part, through which the required voltage can be obtained.

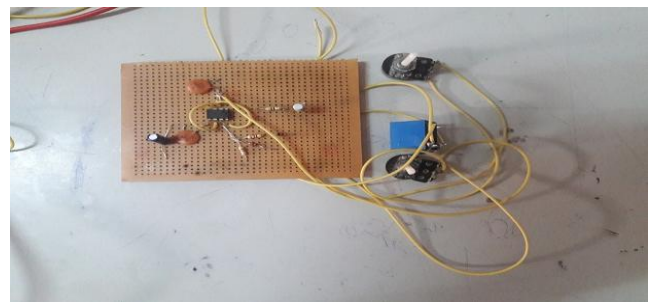


Fig -6: Arrangement of components on board

The transistor BC107 has three different regions.

- Active region
- Saturing region
- Cutoff region

Here active region has no use. In the saturation the saturation region it will be ON and maximum current will flow. In the cutoff region it will be OFF where minimum current will flow means zero.

2.1 Simulation Result

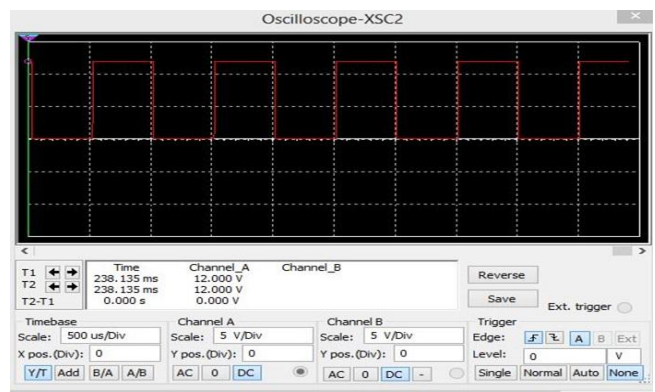


Fig -7: Pulse formed through simulation

Table -1:

| Pulse circuit component list | | | |
|------------------------------|---------------|------------|----------|
| ITEM NAME | SPECIFICATION | VALUE | QUANTITY |
| Diode | IN4148 | - | 2 |
| Diode | IN4007 | - | 5 |
| Transistor | BC107 | - | 1 |
| IC | LM555 | - | 1 |
| Electrolytic capacitor | - | 10µF | 1 |
| Electrolytic capacitor | - | 2200µF | 1 |
| Ceramic capacitor | - | 0.01µF | 2 |
| Resistance | - | 4.7kΩ,470Ω | 1,1 |

| | | | |
|-----------------------|---|--------------|---|
| Variable resistance | - | 1M Ω | 2 |
| Relay | - | 32A,12V | 1 |
| Step down transformer | - | 12V | 1 |
| Rectifier | - | 5A | 1 |
| Capacitor | - | 4700 μ F | 1 |
| Variac | - | 0-270V | 1 |

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Fig -8: Practically spark generation

3. CONCLUSIONS

The above designed circuit shows the result that it can produce pulse wave which is required for generation of spark in the EDM diesinker. The duty cycle and frequency can be adjusted according to our requirement. It can be very useful for experiment purpose.

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