Effect of EDM Parameters on the Surface Roughness of Tungsten Carbide

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Abstract:

Electrical discharge machining is a well- known machining process. It is one of the earliest non-traditional machining process. It is a thermal erosion process which is based on thermoelectric energy between the work piece and electrode. Its capability of machining in hard and difficult to cut materials has made it most popular. In past few years materials having unique metallurgical properties have been developed to meet the demands. Tungsten carbide is widely used in Industry due to its unique properties combination of hardness and wear resistance. But the machining of the tungsten carbide is very difficult, but micro EDM is very effective method because the hardness of the material is not an important parameter. The investigation of the operating parameters is a crucial step in machining. The economy and productivity of the machine is depends upon the machining parameters. So that's why optimization of the parameters is very important. In this paper, we try to find optimized procedure by variation of different parameters so that process can be carried out in maximum Material Removal Rate (MRR) & Minimum Surface roughness.

Keywords: - EDM, surface roughness, TiC, machining. .

1. Introduction:-

The EDM process can be compared with the conventional cutting process, except that in this case, a suitably shaped tool electrode, with a precision controlled feed movement is employed in place of the cutting tool, and the cutting energy is provided by means of short duration electrical impulses. EDM has found ready applications in the machining of hard metals or alloys which can not be machined by conventional method. It thus plays a major role in machining of dies, tools, etc. made of tungsten carbide, satellites or hard steels.

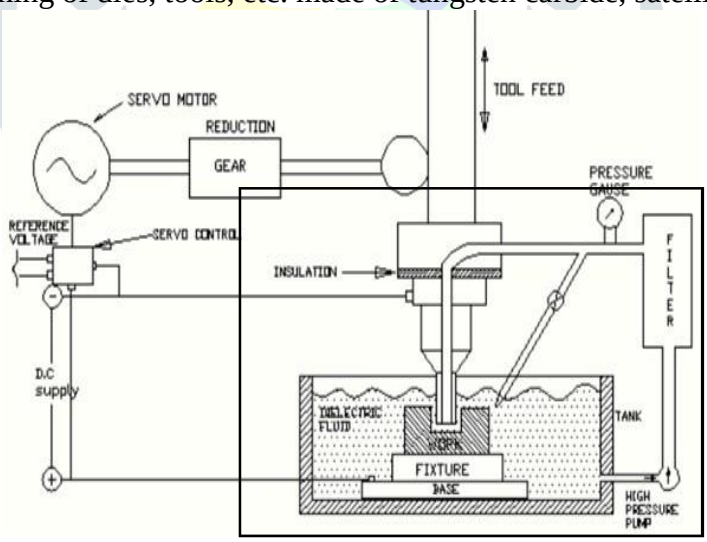

Fig. 1

Electric Discharge machining is used to remove metal through the action of an electric discharge of short duration and high current density between the tool and the work piece. The electrical energy is used to generate electric spark and material removal mainly occurs due to thermal energy of spark. This process can be used for any electrical conductor materials irrespective to their hardness and toughness.

The working principle of EDM is removal of material by the rapid action of electric sparks taking place between tool and the work piece. There is no direct contact between the tool and the work piece. A thin gap of 0.05 mm is maintained between them through servomotor known as spark gap. Both the tool and the work piece are submerged in the dielectric fluid.

Figure Show the electric setup of the Electric discharge machining. The tool is made cathode and work piece is anode submerged in an Insulating liquid such as dielectric fluid. The electrode and work piece are connected to a suitable power supply.

The power supply generates an electrical potential between the two parts. When the voltage across the gap becomes sufficiently high dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps. These sparks happen in huge numbers at seemingly random locations between the electrode and the work piece. As the base metal is eroded, and the spark gap subsequently increased, the electrode is lowered automatically by the machine called servomotor. Several hundred thousand sparks occur per second, with the actual duty cycle carefully controlled by the setup parameters. These controlling cycles are sometimes known as on time and off time.

The finished EDM work piece can exhibit several distinct layers. The surface layer will have small globules of removed work piece metal and electrode particles adhering to it, which are easily removed. The second layer is called the white or recast layer where EDM has altered the metallurgical structure of the work piece. The third layer is the heat-affected zone or annealed layer. This layer has been heated but not melted.

All of these surface conditions are affected by:

The EDM cycles of on-and off-time. The duty cycle, which is the ratio of on-time relative to total cycle time. The gap distance between the work piece and the electrode. Work piece cavity is measurably larger than the electrode. This dimensional difference is called the overcut or kerf. This kerf dimension is critical during the fabrication of the electrode.

Ram EDM machines are also known as diesinkers or vertical EDMs. They range inside from tabletop models to large CNC units. Ram EDMs have four sub- systems:

A DC power supply to provide the electrical discharges, with controls for voltage, current, duration, duty cycle, frequency, and polarity. A dielectric system to introduce fluid into the voltage area/discharge zone and flush away work and electrode debris, this fluid is usually a hydrocarbon or silicone based oil. A servo system to control infeed of the electrode and provide gap maintenance.

2. Flushing

One of the most important factors in a successful EDM operation is the removal of the metal particles (chips) from the working gap. Flushing these particles out of the gap between the workpiece to prevent them from forming bridges that cause short circuits.

A. Flushing Ram Type EDM

Flushing is the most important function in any electrical discharge machining operation. Flushing is the process of introducing clean filtered dielectric fluid into the spark gap. Flushing applied incorrectly can result in erratic cutting and poor machining conditions. There are a number of flushing methods used to remove the metal particles efficiently while assisting in the machining process. Too much fluid pressure will remove the chips before they can assist in the cutting action, resulting in slower metal removal. Too little pressure will not remove the chips quickly enough and may result in short-circuiting the erosion process.

B The Servo Mechanism

EDM machines are equipped with a servo control mechanism that automatically maintains a constant gap of about the thickness of a human hair between the electrode and the workpiece. It is important for both machine types that there is no physical contact between the electrode and the workpiece, otherwise arcing could damage the workpiece and break the wire. The servomechanism advances the electrode into the workpiece as the operation progresses and senses the work-wire spacing and controls it to maintain the proper arc gap which is essential to a successful machining operation.

3. Important parameters of EDM

Spark On-time (Pulse Time or T-on): The duration of time (μs) the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is really controlled by the peak current and the length of the on-time. The on time setting determines the length or duration of the spark. Hence, a longer on time produces a deeper cavity for that spark and all subsequent sparks for that cycle, creating a rougher finish on the work piece.

Spark off-time (Pause Time or T-off): The duration of time (μs) between the sparks (that is to say, on-time). This time allows the molten material to solidify and to be washout of the arc gap. This parameter is to affect the speed and the stability of the cut. Thus, if the off- time is too short, it will cause sparks to be unstable. Off time is the period of time that one spark is replaced by another. A longer off time, for example, allows the

flushing of dielectric fluid through a nozzle to clean out the eroded debris, thereby avoiding a short circuit. These settings can be maintained in micro seconds. Arc gap (or gap): The Arc gap is distance between the electrode and work piece during the process of EDM. It may be called as spark gap. Spark gap can be maintained by servo system.

Discharge Current (Current IP): Current is measured in amp Allowed to per cycle. Discharge current is directly proportional to the Material removal rate. Duty Cycle (τ): It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the total cycle time (on-time pulse off time). Voltage (V): It is a potential that can be measure by volt it is also effect to the material removal rate and allowed to per cycle. Over cut: It is a clearance per side between the electrode and the work piece after the marching operation. Width: Width is the throwing of a spark in a specific time, and it changes frequency of that sparks.

Frequency: Frequency and Width have reverse ratio. Additionally, the machining time can be decreased by increasing the frequency, but in that case the surface quality is decreased directly. Polarity: With the polarity, the polarity of electrode or the work piece material can be changed. Regulation: Regulation is the parameter which control the Gap and Gain. Gap: Gap adjusts distance between work piece and electrode. If gap set too high, number of sparks will be decreased and time of process will be increased, also if gap adjusts too low, number of parks will be increased and time of process will be decreased but surface quality will be also decreased. Dielectric Fluid: In EDM material removal mainly occurs due to thermal evaporation and melting. As thermal processing is required to be carried out in the absence of oxygen so that6 the process can be controlled and oxidation avoided. Oxidation often leads to poor surface conductivity of work piece. Hence dielectric fluid should provide an oxygen free machining environment. Further it should have enough strong dielectric resistance so that it does not breakdown electrically too easily but at the same time ionize when electrons collide with its molecule.

The Dielectric fluid has the following functions:

It helps in initiating discharge by serving as a conducting medium when ionized, and conveys the spark. it concentrates the energy to a very narrow region. IT helps in quenching the spark, cooling the work, tool electrode and enables arcing to be prevented It carries away the eroded metal with it. It acts as a coolant in quenching the spark. The dielectric generally fluid used is transformer or silicon oil, Kerosene and de-ionized water are used as dielectric fluid. Tap water can not be used as it ionizes to easily and thus break down due to presence of salts as impurities occur. It is also applied through the tool to achieve efficient removal of molten material. The basic requirements of an ideal dielectric fluid are:

- Low Viscosity.
- Absence of toxic vapours.
- Chemical neutrality.
- Absence of inflaming tendency.
- Low cost.

Tool (Electrode) material: The tool material should be such that it would not undergo much tool wear when it is impinged by positive ions. The basic characteristics of electrode material are:

- High electrical conductivity: Electrons are cold emitted and there is less bulk electrical heating.
- High thermal conductivity: for the same heat load, the local temp. rise would be less due to faster heat conducted to the bulk of tool and thus less tool wear.
- Higher Density: for the same heat load, and same tool wear by weight there would be less volume removal and tool wear and thus less dimensional loss and efficiency.
- High melting point: High melting point leads to less tool wear due to less tool material melting for the same heat load.
- Cost: It should have low cost.

The most commonly used electrode materials are brass, copper, graphite, Al alloys, and copper-tungsten alloys.

4 Materials and methods

One of the important features of EDM method is its implementation independently from mechanical characteristic of machined material. When the voltage is applied to the electrode and work piece, electrons detached from electrode (cathode) runs through the work piece in an accelerated mode. While proceeding, they hit neutral dialectic molecules and detach electrons which speed up the flow of electrons to the anode by similar collisions. This movement of electrons causes a leak current dialectically and evaporates dielectric fluid on that part. In evaporated fluid, current increases rapidly. At the end, between the electrode and work piece, there

appear a plasma channel. This channel melts/dissolves crater both from work piece and tool. Following the break down of plasma, the whole evaporation and some of the solution blends with the dielectric fluid. Therefore, a crater comes into being on electrode and work piece. The crater consisting of many plasma channels enables the surface manufactured.

Surface roughness is an important factor in EDM. The parameters that affect surface roughness are current, pulse on-time, pulse off-time and gap voltage.

5. Experimental study

The working parameters applied for manufacturing tungsten carbide which is hardened at a depth of 2 mm by electrical discharge machine with the help of copper electrodes used in the experiments. All the experiments are done by RAM TYPE EDM.

6. Results

Under the condition of 7 A current, 100 µs pulse on-time and 12 µs pulse off-time, the rougher surface is obtained, however the less rough surface is derived under the condition of 6 µs pulse on-time and 100 µs pulse off-time. Besides, increase in pulse off-time decreases the roughness of the surface.

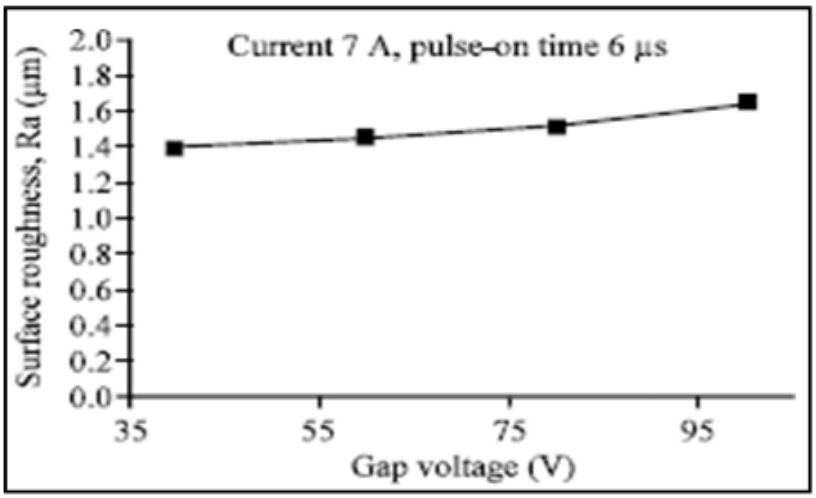

Fig 2

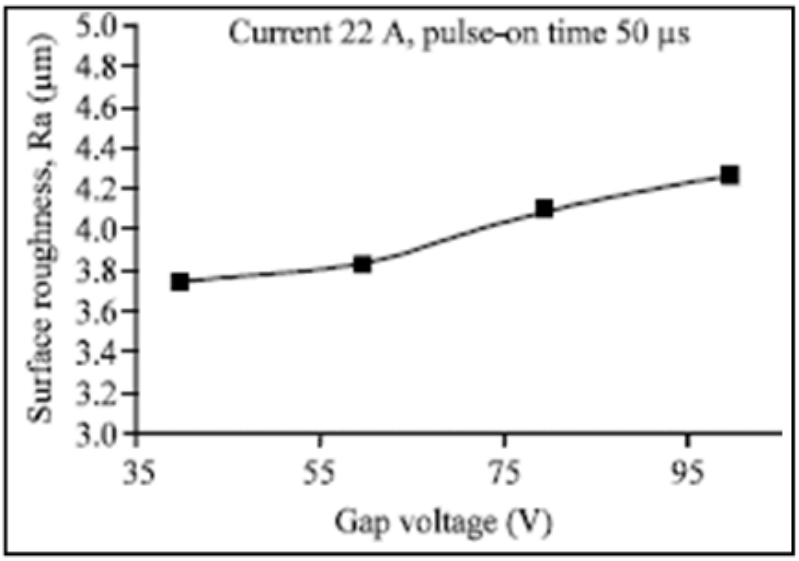

Fig 3

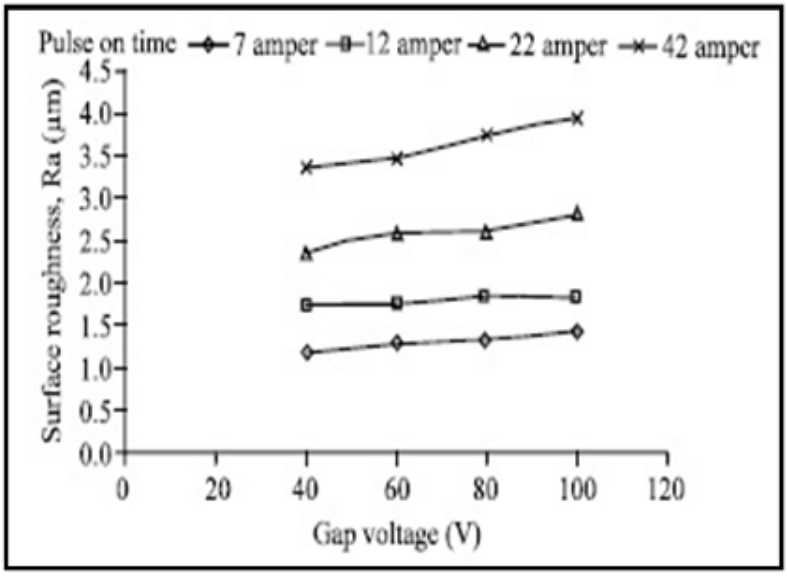

Fig 4 Ra, Roughness Values, Constant

7. Conclusion

It is found that highest roughness values are obtained at 100 Us pulse on time and 42 ampere current. It shows that with the increase in pulse on time and current there is increase in surface roughness. While proceeding, they hit neutral dialectic molecules and detach electrons which speed up the flow of electrons to the anode by similar collisions. This movement of electrons causes a leak current dialectically and evaporates dielectric fluid on that part. In evaporated fluid, current increases rapidly. At the end, between the electrode and work piece, there appear a plasma channel. This channel melts/dissolves crater both from work piece and tool.

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