DEVELOPMENT OF A COMPACT WIRE FEEDING MECHANISM FOR MICRO ELECTRO DISCHARGE GRINDING

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Abstract
An attempt has been made to fabricate a compact wire feeding mechanism for micro EDG. Traveling wire is used as the tool electrode and moves around a carbide wire guide. The wire tension and speed are controlled using a friction pad and directly driven wind-up system. The supply and wind-up spools, both are of insulating material sandwiching the friction pad and mounted on a shaft. A precision miniature geared DC servomotor rotates the shaft. An insulating bracket developed in an FDM (RPT) system is used to hold the motor in place. The shaft is supported at the other end by a metallic tailstock centre. Horizontal and vertical pulleys are used to guide the wire perpendicularly and move it around the wire guide. The entire setup is mounted on a precisely ground metallic base plate. This setup ensures accurate positioning of the wire edge as opposed to problems of wire lag and vibration experienced in wire EDM.

Keywords: Micro EDG, Wire Feeding Mechanism, Design, Discharge Gap, Discharge Energy

1. INTRODUCTION

In the new millennium, there has been a spurt in the need for micro machining of fine shafts/rods in several fields, ranging from electronics to biomedical applications. However, conventional machining techniques have been unable to meet most of this challenge. Micro electro discharge grinding (Micro EDG) has come forward as a very useful solution to satiate this growing need. The advantages accrue from the fact that there are no process forces and it can be used to machine any electrically conductive material irrespective of its hardness. The requirement of extremely small value of energy is also achieved on the choice of reduced and controlled capacitive discharge, which facilitates machining of spindles and micro pins with very small material removal per discharge leading to smaller craters due to erosion and hence good surface finish. The problem of electrode wear associated with conventional EDM is also eliminated as a traveling wire electrode carries out machining.

The problems in the import of such machines have instigated the development. Efforts are made to design, develop and fabricate a wire feeding attachment for the micro electro discharge grinding purpose, which can be integrated any type of EDM. Process parameters such as discharge gap and discharge energy are also simulated and studied with a view to achieve better process control and optimization.

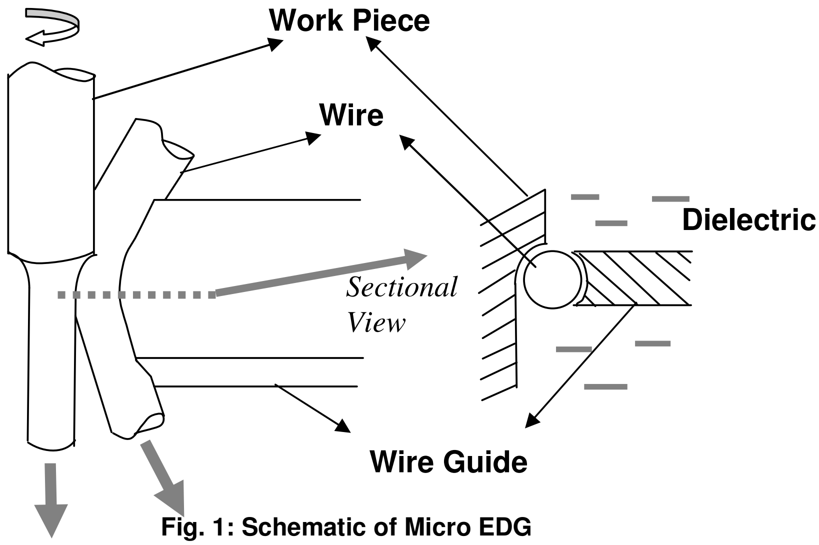

Fig. 1: Schematic of Micro EDG

2. BACKGROUND

Some, very precise, conventional machine tools can manufacture objects at the micron level. However, difficulties occur due to the material properties of the tool, such as elasticity, thermal effects etc. The main problem with mechanical machining techniques is that they commonly work on one structure at a time. This makes them suitable for prototypes but not for mass production [1].

Micro EDG has come forward as an excellent solution to the above need. Micro EDG is the process by which spark machining of rotating work piece against a traveling wire electrode is performed. The relative movement between the work piece and traveling wire supported by a wire guide to maintain constant discharge gap, controls the shape of the micro pin.

Heeren et al. [2] have reported machining of microelectrodes of diameter 34 µm and length 1170 µm using a spindle rotating at 3500 rpm against a sacrificial work piece. Triangular (37 µm side, 772 µm length) and rectangular electrodes (19 µm x 26 µm, 758 µm length) have been machined with spindle rotation turned off. They have modified the AGIE compact die-sinking machine with a micro generator and micro machined silicon using deionized water instead of an oil as dielectric.

Masuzawa et al. [3] have applied WEDG for electrode preparation with a wire of 200 µm. V guides of sapphire was used to support the main shaft. Deionized water was used as dielectric. Water was poured at machining point using a medical injection needle. Electrodes of 40 µm and 80 µm were used to study parameters such as clearance and wear ratio.

Masuzawa et al. [4] have also developed a wire drive system composed of a wire guide, a brake and wind up system. The wire tension and wire speed are controlled by a brake and wind up system. Experiments conducted with rod rotated at 2000 rpm demonstrated straightness and repeatability of machined diameter within 1µm for a 34µm diameter rod.

Masuzawa, Okajima and Taguchi [5] have reported the development of an EDM lathe with WEDG, head, work and electrode spindles guided by V blocks and belt driven by DC motor. They realized grooves of 80 µm in 200 µm micro holes and eccentric drilling was tested which yielded good accuracy of profile at the bottom of hole.

Micro EDG has come forward as the most powerful method to produce micro pins and micro spindles. By providing transverse and axial feed to a table and simultaneously a rotary motion to work piece against a wire electrode, micro spindles can be fabricated [6]. A schematic of a micro EDG process is illustrated in Fig 1.

The production of microstructures demands a drastic reduction of the discharge energy. This is also necessary to avoid wire rupture. The discharge energy mainly influences the surface. In case of too high discharge energy, the geometry of the discharge craters might affect the contour accuracy. When small tooth-like structures are machined, the process induced tensile residual stresses may lead to an undesired deformation. If in addition the surface quality has to be improved by trim cuts, a further reduction of discharge energy will be inevitable.

The EDM machine has to be well equipped for micro machining purposes. The wire transport system has to guarantee a smooth and even wire run-off and safe disposal. The generator has to supply the necessary low energy pulses. High axes accuracy and sensitive gap width controls as well as the maintenance of a low dielectric conductivity are further requirements on a micro EDG machine.

Another aspect to which requires special attention is the surrounding conditions i.e. temperature stability, avoidance of vibrations and cleanness.

The following essential requirements for a micro EDG were identified:

a. Precision spindle and collets to hold and rotate the micro spindle against the wire.
b. NC table to give relative feed between the spindle and wire electrode in X & Y axes.
c. Traveling wire as tool electrode.
d. A low pulse energy source.
e. System with a low stray capacitance.

To fulfill requirement (c), a wire feeding mechanism was designed.

3. OUTLINE OF THE DESIGN

A micro EDG attachment consisting of a wire feeding mechanism is designed and fabricated to integrate with an existing 4 axis CNC wire EDM machine.

The highlights of the wire feeding mechanism are:

- Spool design to maintain constant wire feed
- Clutch design for maintaining proper tension
- Servo motor for continuous torque characteristics
- Brackets to hold motor and shaft
- Bracket design by Fused Deposition Modeling.

The AutoCAD model of the wire feeding mechanism is illustrated in Fig. 2.

The pulleys are required for guiding the wire from supply spool to take up spool through the wire guide. They are of a wear resistant insulating material to reduce the overall capacitance. Three Dowel-pins are provided on the flange to locate and provide motion to the take-up pulley mounted on the central spindle. The main functions of the central bracket are to support the horizontal studs, which in turn carry the vertical pulleys guiding the wire from supply spool to take-up spool via two horizontal pulleys and a triangular wire guide.

The end-support-bracket provides essential tailstock rigidity to the main spindle. It avoids any deflection and bending of the spindle during rotation. The end-motor-bracket is designed for spindle support and rigidity with low capacitance value. The objective of this as well is to support the geared-motor. The base plate supports all the components of wire feed mechanism namely central bracket, wire guide, end support bracket, end motor bracket and pulleys. The smooth functioning of the wire feed mechanism depends on the positional accuracy of the different components with respect to each other. The supply spool is made up of insulating material with precision clearance fit with the spindle.

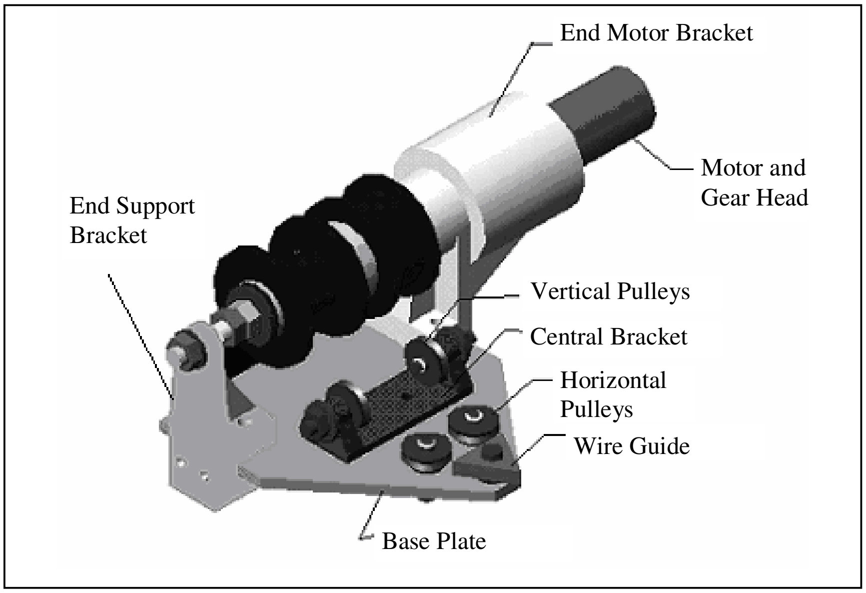

Fig. 2: Model of the Wire Feeding Attachment

A spacer provides the gap required between the supply-spools and take-up spool along with a clutch (friction pad) in between them to provide the required wire-tension. A miniature precision DC-servo motor is used to provide the wire feed-motion to the electrode. The main purpose of the wire guide is to reduce vibration and positional inaccuracy to the wire electrode. Thus the wire guide would also maintain stable discharge gap and enhances repeatability of machined spindles. The complete unit fabricated as per the design is shown in the photograph, figure 3 below.

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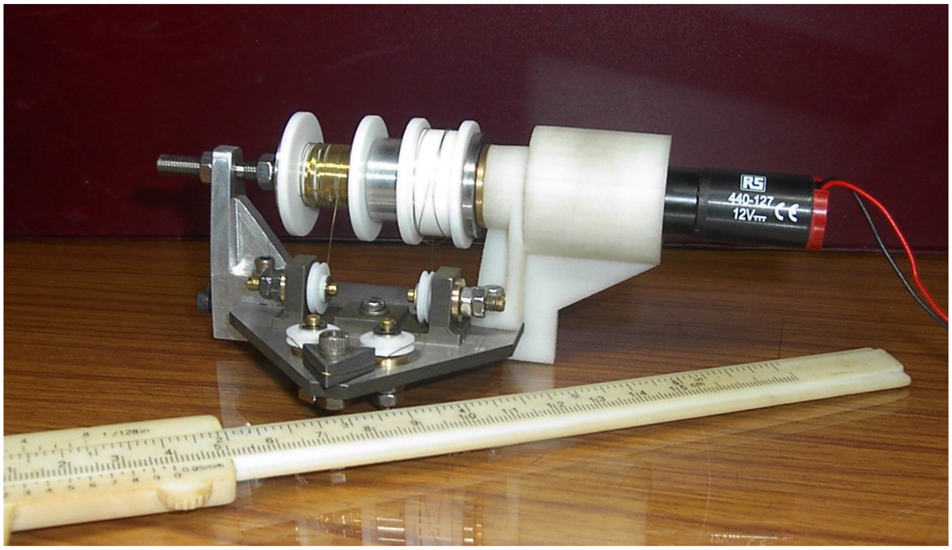

Figure 3: Photograph Showing the Assembled Micro WEDG Unit

Thus the wire guide would also maintain stable discharge gap and enhances repeatability of machined spindles. The complete unit fabricated as per the design is shown in the photograph, figure 3 below.

4. CONCLUSION

This setup, which is of unique design and is based on a modular, monolithic and bare minimum components design approach (mechatronics) all set to carry out high precision micro machining (in progress) for a variety of applications ranging from automotive nozzles to biomedical instrumentation. Some of the key elements of the effort include:

a. The setup is portable, compact and can be integrated with any ED-machine using the pulse generator (in the finishing mode) and NC table of the machine.

b. The modular concept would able to take the unit to any configurations to develop other types of futuristic machines like Micro USM, Micro ECM etc.

c. The system is working satisfactory and is ready for testing its performance in conjunction with a micro lathe.

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