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Fabrication of a High Voltage Supply for Plasma Arc Generator and its Application in Wood Ablation Carving Arts

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Abstract: *A high voltage plasma arc generator (26kV) has been designed and fabrication with the help of a fly-back transformer (FBT). The generator operates with a homemade fixed DC power supply (24V, 4 Amps). In general, the FBT is provided with a built in Voltage Multiplier circuitry i.e. arrays of capacitors and diodes, the arrays multiply the output voltage of the FBT thus producing a beautiful branched high voltage corona. In this study the plasma arc is used for wood ablation carving experiments.*

Keywords: Plasma Arc Generator, High Tension Voltage Supply, Wood Carving with Plasma Discharge, Wood Ablation, Wood Carving Technique, Organic Material Ablation.

1. INTRODUCTION

The tools are the main backbone in all disciples of works. They always designed according to their application for proper utilizations. In Fine Artwork, special tools are required for a peculiar artwork. In this work, we have designed and fabricated a DC High Voltage generator to produce a plasma arc for wood carving. For this purpose, a common CRT television fly-back transformer circuit is used to obtain 26kilovolts plasma arc.

The plasma is an ionized-gas-state generates in the path between two high tension electrodes, the potential differences of the electrodes breakdown the resistance in flow of high energy electrons through the air path hence plasma is generates. When plasma arc electrons strike to the opposite (target) electrode they produced heat effect. The greater numbers of electrons in plasma higher will be the heat effect. The Electron Beam Welding (EBW) based on this method. With the help of EBW welding can carried out between the metals of high melting points.

2.MATERIAL AND METHOD

An oscillator circuit designed and fabricated to drive FBT for high volts plasma arc generation shown in Figure1. The oscillator inductor made by winding the coils directly on the Ferrite core of FBT. For primary coils, (P1 and P2) center-tapped 12 turns winded with Ø1.0mm copper wire, where as the feedback coils (FB1 and FB2) center-tapped 6 turns winded with Ø0.8mm copper wire. Two high power NPN transistors 2N3055 used as oscillator driving device. FB1 and FB2 attached to their corresponding bases of the transistors through 42 Ohm/5Watts resistors.

A voltage divider supply circuit made with 27 Ohm/5Watts and 270 Ohm/5Watts resistors to trigger the transistor´s bases. As the FBT has built-in voltage multiplier circuitry therefore, the HV voltage output always has polarity characteristic i.e. the CRT terminal is with positive polarity while corresponding is terminal has negative polarity. A homemade fixed DC voltage supply 24V, 4 Amps used throughout the experiments.

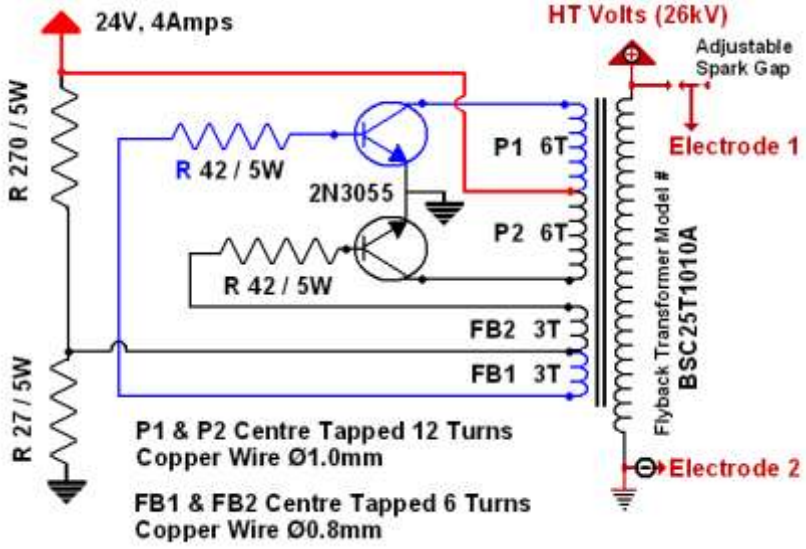

Fig.1. Circuit Diagram of High Volts Plasma Arc Generator

The fabricated assemblies are shown in Figure2.

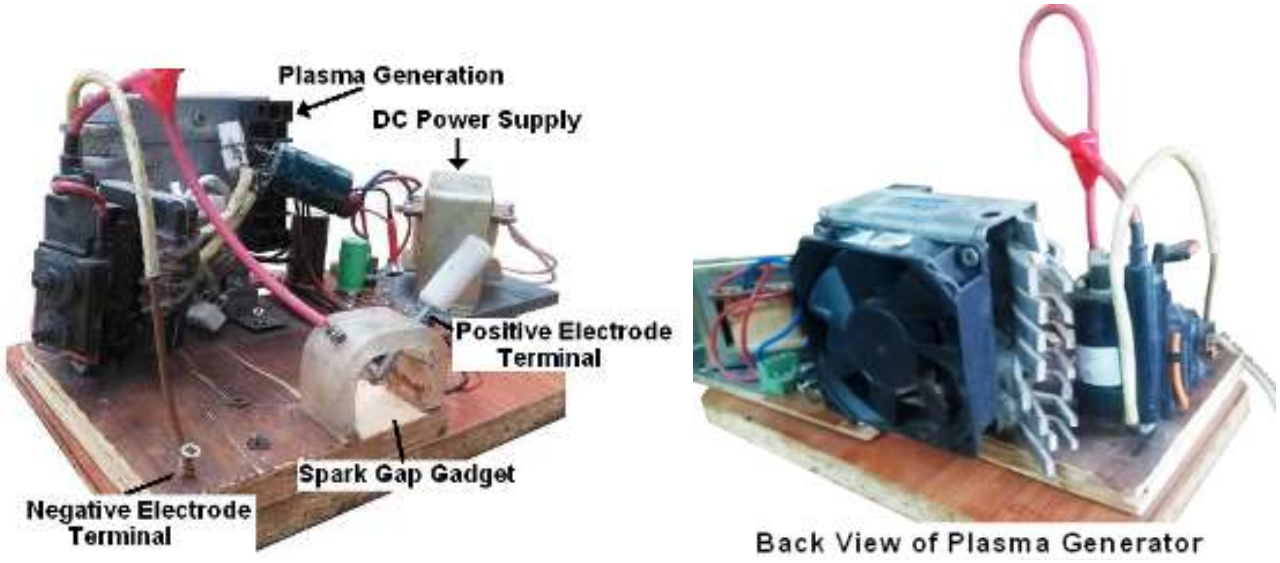

Fig.2. Electric Plasma Arc Generator

To obtain a variable intensity of HV plasma an adjustable spark gap gadget incorporated within the transmission line of Electrode1. The adjustable spark gap gadget is shown in Figure3. The Spark gap is vice versa of the intensity of the plasma arc i.e. higher the spark gap lower the intensity of the plasma arc, therefore, lower will be the ablation rate.

Two ten inches pieces of High Tension cables provided one end with safety handles with needle tip and other end with crocodile clamp for connecting with the HV voltage output Figure4.

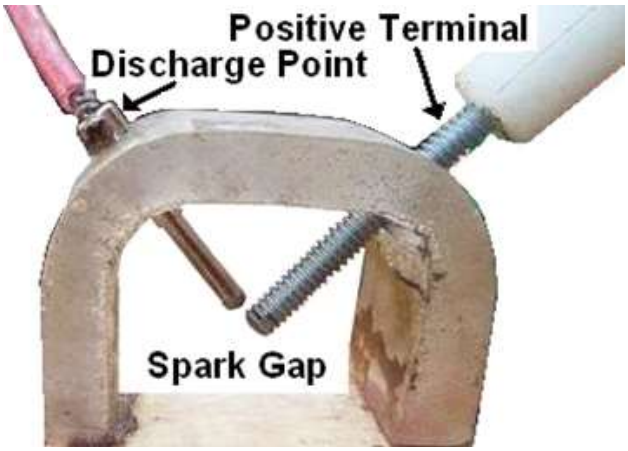

Fig.3. Adjustable Spark Gap Gadget.

Fig.4. Negative and Positive Electrodes.As the dry wood is a good insulator for ablation purpose an electrolytic conductor solution is needed. For this purpose the solution is prepared by dissolving five grams of Sodium Carbonate in one liter of water. During plasma ablation work, the affected area becomes heat up and the water evaporates left over dry salt, thus stops the plasma arc ablation therefore, the electrolytic solution continuously applied during plasma carving work. The nib of fountain pen has been modified to apply electrolytic solution accordingly Figure5.

Fig.5.Modified Fountain Pen for Electrolytic Sketching Application

3. SAFETY PRECAUTIONS

Working with high voltage is highly dangerous and becomes lethal when safety ignored. For more safety precautions:

- Always keep the power plug out of the power socket when the plasma arc generator not in use.
- Never try to touch the electrodes tips even in off condition.
- Always grip the electrode rods at least 10cm away from the discharge tips of the electrodes.
- For safety precaution when the system turns off and the power plug is disconnected, touch the negative electrode tip to the Spark Gap Gadget to discharge the accumulated voltage of the Fly back transformer voltage multiplier built-in circuitry.
- Whenever a person gets tired of working, he or she should quit his job at once, because tiredness increases the ignoring attitude and thus severe accident could be occurred.

4. EXPERIMENTS

4.1 Spark Gap Experiment

To drive the high voltage plasma arc generation, a homemade fixed voltage DC power supply (24V, 4Amps) is used. In order to control the intensity of plasma arc a spark-gap gadget has been installed in one of the electrode cable. By increasing the spark gap, the intensity of the plasma arc reduces Figure6A and Figure6B.

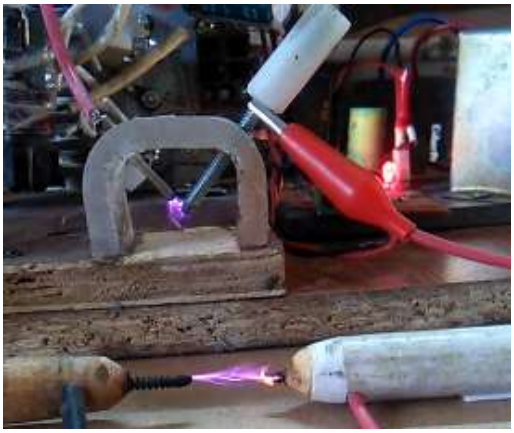

Fig.6A. Narrow gap of spark-gap gadget gives high intensity arc

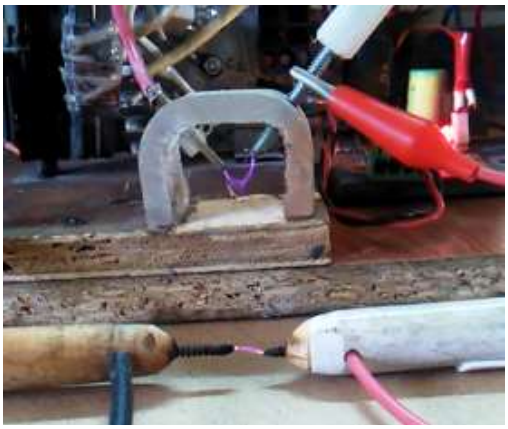

Fig.6B. Wide gap of spark-gap gadget gives low intensity arc

4.2. Plasma Arc Ablation Propagation (PAAP) Experiments in different woods

Initially, the experiments carried out by using two different types of commonly available wood including Cedar wood and Pine wood. For PAAP experiment, the each woodblock marked with two parallel lead pencil lines 50mm apart. Two spots on the

woodblocks showed the points where the electrodes were connected. Before, experiment the woodblocks surface properly soaked with the electrolytic solution. It has been observed that the soft portions of the veins absorb more electrolytic solution as compared to denser portion. Although the electrodes fixed diagonally across the veins the plasma ablation always propagates therein the softer region in uncontrolled manner. The results showed in Figure7A and Figure7B.

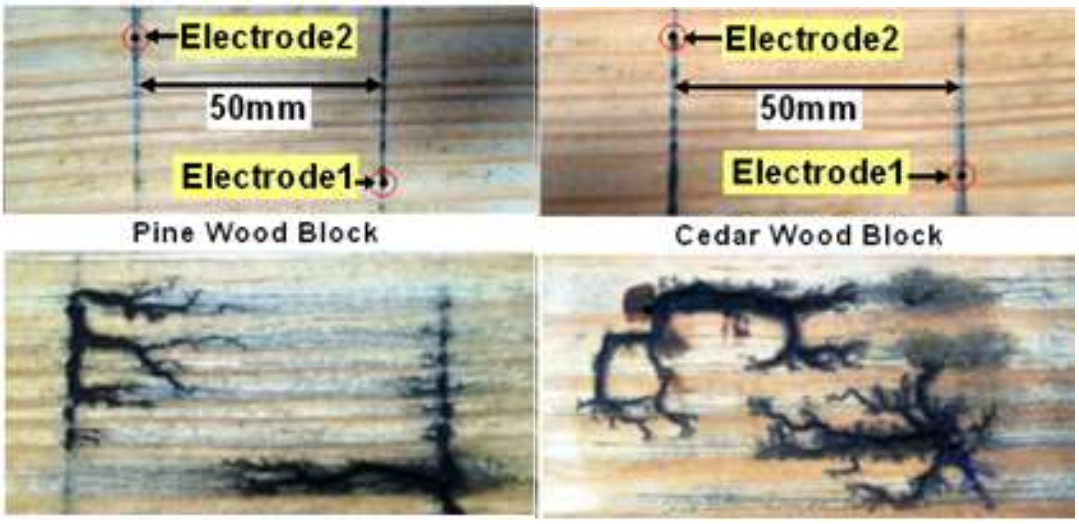

Fig.7. Electric Plasma Arc Ablation Propagation in different woods.

It has been observed that the lead-pencil also effects due to graphite contamination. For a controlled PAAP experiment, sawdust wood product "LASANI" quarter inch thick sheet also subjected for further experiment.

4.3. PAAP Experiment with LASANI sheets

In this experiment small LASANI Sheet is used. The surface of the sheet rubbed with 80 Grit wood sand papers and wetted with the electrolytic solution and the electrodes connected in such a way that the positive electrode fixed to the peripheral side of the sheet where as the negative electrode connected in the middle of the sheet. The LASANI Sheet manufacturing usually carried out with evenly distributed fine wood chips and or fine wood sawdust. The fine sawdust sheet has uniform capillary properties, therefore a uniform spreading of electrolytic solution occurs and thus a beautiful PAAP pattern was obtained is shown in Figure8.

Fig.8. Electric Plasma Arc Ablation Response on a Fine Wood Powder Sheet.

4.4. PAAP Experiment on Wood

This experiment was conducted on an Air Rifle wooden stock. The stock was rubbing with 80Grit wood sand papers in order to remove the polish coating. When the clear surface appeared, the electrolytic solution thoroughly applied and the PAAP experiment was conducted with simultaneously changing the position of both the electrodes. The result is shown in Figure9.

Fig.9. Electric Plasma Arc Ablation Pattern Generation on Air Gun Stock.

4.5.PAAP Experiment with course wood sawdust LASANI

A piece of quarter inch thick LASANI Sheet (12"× 12") was taken and slightly rubbed with 80 Grit wood sand papers to smooth top layer. The experiment carried out by drawing a free hand portrait with the fountain pen. This time a little portion of sketch was draw with a fountain pen and it was immediately processed. In this way, the PAAP process was carried out by small portions of artwork accordingly until entire work completed. The result is shown in Figure 10A is without any coating. Figure 10B coated with Acrylic Lacquer coating.

Fig.10A.Freehand Electric Plasma Arc Ablation Art Work without Glaze Coating.

Fig.10B.Freehand Electric Plasma Arc Ablation Art Work with Glaze Coating.

4.6. PAAP Experiment with LASANI Sheet

In this study, PAAP applied on a sketched picture. The result is shown in Figure11.

Fig.11.Free Hand Electric Plasma Arc Ablation Sketching Art Work.

5.CONCLUSION

Working with High Voltage is a risky hobby but with safety measures creative activities could be achievable. Wood is a non conductor material. The PAAP activity requires a temporary conducting path for ablation artwork. For a temporary conducting path Sodium Carbonate electrolytic solution is used. Actually, whenever the ablation starts, the temperature rises, due to which the electrolytic solution dries up, but before that, the wood burns and turns into carbon, which replaces the electrolytic conductor and the ablation remains continue. In these study five grams of sodium carbonate dissolved in one liter of water. During experimental work it had been observed that uniform distribution of electrolytic solution is necessary to achieve a controlled pattern in PAAP. It also observed that it is not necessary the ablation propagate remains within the area between the electrodes.

Since both the electrodes have polarity and charged particles of similar polarity repel each other, therefore, PAAP is also found around both the electrodes, which can be reduced by creating electrolytic path. Initially, two common types of Cedar wood and Pine wood blocks subjected for experiments. Each wood block marked with two lines 50mm apart. Two spots were marked diagonally 20mm for electrode1 (positive) and electrode2 (negative). First the two wooden blocks are thoroughly wetted with the electrolytic solution. The electrodes placed to their respective spot and the plasma arc generator switched on. The observations show that PAAP occurred and propagated along the soft tissues of the wood veins, because these parts of the vein absorbed and holds more electrolytic solution to that of hard tissues part. These observations were verified by using LASANI sheet. LASANI is a wood product manufacture from the fine wood chips and fine sawdust. This gives LASANI sheets a uniform texture. When similar experiment had

been conducted on LASANI sheet, a very beautiful PAAP formation occurred. During PAAP heat is also generates, the heat evaporates the water of the electrolytic solution and thus tend to slowdown the ablation but the path remains active due to carbon particles produced after wood burning, this phenomenon helps to controls the ablation process. Therefore, to make the PAAP desirable, a fountain pen nib modified for proper application of electrolytic solution to control and keep continue the ablation process.

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