Notice of Retraction

After careful and considered review of the content of this paper by a duly constituted expert committee, this paper has been found to be in violation of IEEE's Publication Principles.

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A Novel Plasma Cutting Power Supply

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Abstract—This paper presents a method that the designed half-bridge inverter air plasma cutting machine power supply uses the non high frequency arc technology and analyzes the working principle of non high frequency arc, and gives detailed work cutting process timing diagram. The cutting machine power supply, it uses the controller-TMS320F2812 to control the entire power system, and the use of the chip UC3854 power factor correction circuit. When compared with the traditional cutting power supply, the designed plasma cutting power supply has a simple structure, low energy consumption, small electromagnetic interference and so on. In addition, the power system has been modeling and simulation, and built a prototype and verified.

Keywords- plasma arc cutting power supplye; high-bridge; active power factor correction

I. INTRODUCTION

In recent years, cutting technology in the industrial field plays an increasingly important role. Plasma cutting technology can be widely used, mainly because of its wide range of cutting, and high efficiency. Air plasma cutting is a new type of thermal cutting technology, with energy concentrated, strong cutting ability, high speed, a narrow cutting slit and so on[1].

Conventional plasma cutting machine uses high-frequency high-voltage (HF) electric arc technology, which has some disadvantages with a complex structure, high energy consumption, electromagnetic interference etc. The new plasma cutting machine overcomes the above shortcomings, by using of non-high-frequency electric arc technology, which has more excellent cutting performances.

This paper designs high power air plasma cutting machine power supply by using of non-high-frequency electric arc technology, whose output current is up to 100A, no-load voltage of 300V. It has easily igniting, and a good Cutting quality.

II. Traditional high-frequency arc Plasma Cutting Power Supply

Fig.1 shows the overall structure of the traditional plasma cutting power system. High-frequency arc ignition circuit consists of 555 trigger circuit, single-ended FLY-BACK converter and spark plugs (FD) etc.

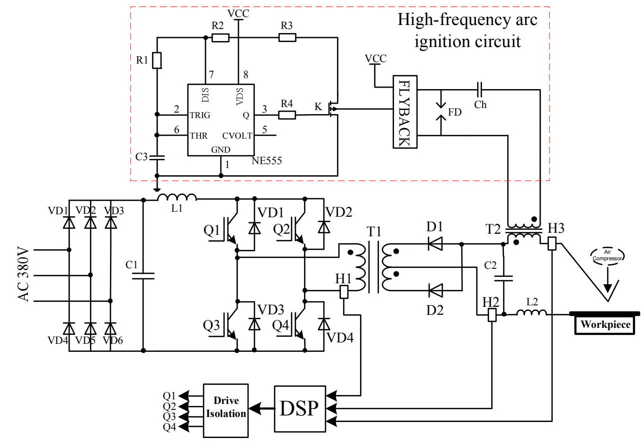

Fig.1 Traditional structure of cutting the power supply

Trigger circuit 555 produces high-frequency driving pulse. When the first driving pulse was generated, the energy of FLY-BACK converter's transformer primary was coupled into the secondary side, so that the voltage of spark plug was rising. When the voltage of spark plugs at both ends reached the breakdown voltage, the spark plug would be short circuit breakdown. At this time, capacitor Ch and the FLY-BACK converter's transformer leakage inductance would occur to be resonant oscillation and produce HF signal. High-frequency high-voltage signal which was added between the electrode and the nozzle, and forms a plasma channel, was boosted and then outputted by coupling transformer [2~3]. The Process reached the conditions of electric arc. High-frequency high-voltage signal, its Breakdown voltage of air was up to above 5000V and oscillation frequency reached 300k ~ 3MHz.

Although this technology has greatly enhanced the rate of cutting and improved cutting quality, the resulting HF signal is bound to produce a lot of interference to the power supply's control circuit and peripheral equipments, which will affect their normal work, a big energy loss and the a enormous loss of components.

III. NON HIGH-FREQUENCY ARC PLASMA CUTTING POWER SUPPLY

Compared with the traditional high-frequency electric arc technology, non-high-frequency arc ignition circuit structure is simple, Low Loss, less demanding of the performance on the switch and its application prospects good. Figure 2 shows that the use of non high frequency arc technology designs of the power supply structure in this paper [4].

Projection supported by Special Foundation of Provincial key discipline, Natural Science Foundation projects of Shaanxi Province(2007E207), and The research projects of Shaanxi provincial department of education(Natural Science Research Project) (08JK372)

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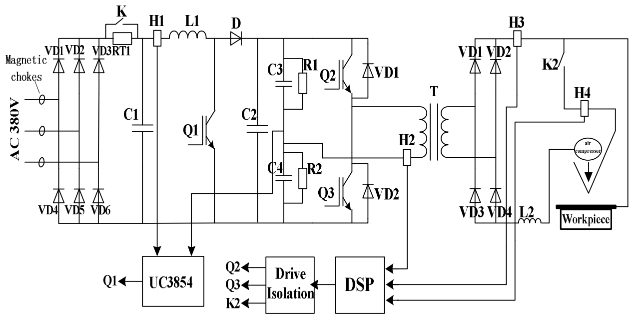


Fig.2 Non-High-Frequency Plasma Cutting Power Supply

Its power conversion circuit passes through EMI filtering, firstly. In order to suppress power supply input common-mode interference, the power supply's input will be stringed into the magnetic chokes which can filter out high-order harmonic signals and prevent them from string into the power grid. In order to suppress the transient power due to opening of voltage and shorted filter capacitor currents caused by the impact, power supply's design needs to join the soft-start circuitry. Secondly, using Boost Active Power Factor Correction Circuit has some advantages, one can achieve power factor correction power supply's input power, thereby reducing grid pollution, on the other hand, the follow-up of the inverter circuit can provide a stable DC voltage, and facilitate the supply of constant current output control[5]. When current signal passes through the PID regulator, it will produce the control pulse of inverter circuit. The control pulse achieves constant current output of power system.

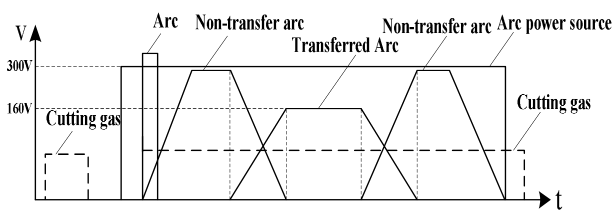


Fig.3 Timing diagram of plasma cutting process

Figure 3 shows a non high frequency arc cutting power supply's timing diagram. Before the beginning of metal cutting, it should be preceded by the pre-pass cutting gas until the gas path unobstructed and then prepared to cut. Initially, cutting torch should be in the state of short- circuit, at this time, gas pressure should reach intended targets. The mechanical, thermal and electromagnetic, under the joint action of three kinds of compression, ignite non-transferred arc. When cutting the work-piece, by the control switching (K1), non-transferred arc would be transformed into the transfer-arc, then the normal start cutting. After the cutting was completed, cutting torch was away from the work-piece and non-transferred arc was formed. And then, the control switch was disconnected and electric arc was extinguished, the lag a few seconds off gas to help protect the nozzle.

A. Power Factor Correction Circuit Design

Figure 2 shows the system uses active UC3854 high power factor integrated control chip, to correct the system power factor, which can provide a stable DC voltage for follow-up of the inverter circuit. Three-phase rectified voltage by the Boost step-up circuit, its output voltage can be achieved steady 750V. The selection of boost inductor, the size of which is decided the size of the output side of high-frequency ripple current. As the maximum peak current occurs, the line voltage is a minimum, so line current peak is given by (1):

$$I_{line(pk)} = \frac{\sqrt{2} \times P_{in}}{V_{in(\min)}} = 66.15A \tag{1}$$

In general, the inductor's ripple current peak is set as the maximum line current peak of 20%. The equation (2) is given by:

$$\Delta I = 0.2 I_{pk} = 13.23A \tag{2}$$

The value of Inductance is the current peak of the lowest half-wave rectified output voltage, and this voltage is decided by the work cycle and the switching frequency. The equation (3) is given by:

$$D = \frac{V_0 - V_{in(pk)}}{V_0} = 0.36 \tag{3}$$

At this point, the voltage value of inductance should be as follows (4):

$$L = \frac{V_{in} \times D}{f_s \times \Delta I} = 0.72mH \tag{4}$$

The value of the output capacitor size is concerned with the output DC voltage, output ripple voltage hold time, the size of the ripple current. Hold time is that the converter is not the output, only by the duration of the output capacitor to maintain normal output voltage. The output capacitor is given (5):

$$C_0 = \frac{2 \times P_{out} \times \Delta t}{V_0^{\ 2} - V_{0(\min)}^{\ \ 2}} = 3429 \mu F \tag{5}$$

B. Host Controller Hardware Design

Figure 4 shows the power control system hardware structure. The main controller chip model uses the Texas Instruments' controller TMS320F2812. Current is detected by Hall-current sensor LA 150-P. In order to eliminate interference and over-voltage on the impact of the controller, the detected signal passes by limiting, filtering, and then the signal is sent to A / D circuit. A / D channels are used for sample collection: guidance arc current, cutting current, gas line pressure and so on, and it realizes the protection of the over-current, overheating, pressure inadequate .

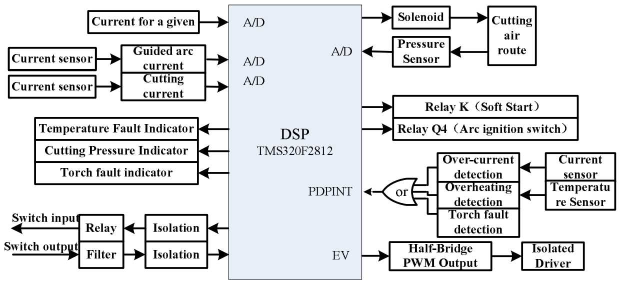


Fig.4 Schematic diagram of the system master Controller hardware

C. *Operational processes*

Figure 5 shows the system's main operating processes. After system initialization, testing is whether three-phase rectifier voltage is larger than a particular threshold. The result is as to determine whether to proceed with the soft start. If the cutting torch is installed well, then it will be passed to the gas to purge gas path. When the torch switch is closed, the turn-on guide arc IGBT, at this time, cutting gas is ignited in the non transferred arc. When the torch is enough to close the work-piece, the electric arc becomes the transferred arc, and the output current increases. At this point disconnect the guide arc- IGBT, through the PID control adjusts the output PWM. After cutting, cutting torch is away from the work-piece, and then the guide arc IGBT is turned on again ， closing the torch switch, turning off the system power, and delaying off gas.

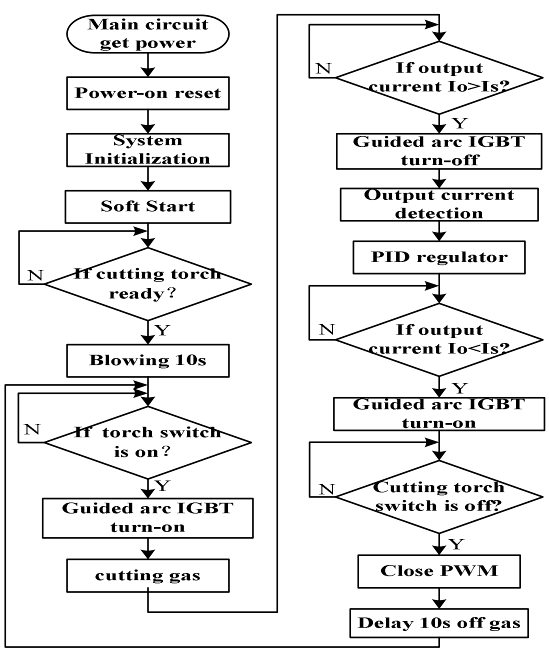
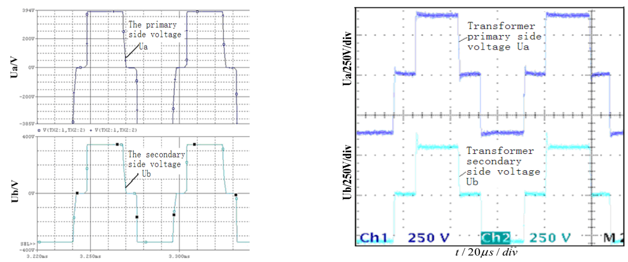


Fig. 5 the main flow chart

IV. Simulation and experimental results

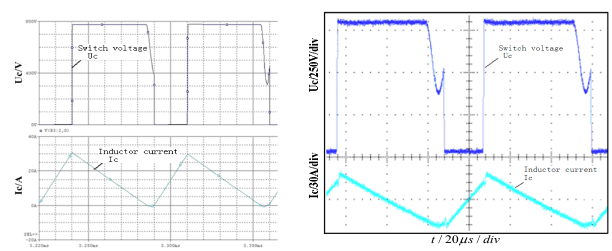
Based on the above analysis, in order to better verify the expected results, this paper designed the cutting power for the power of 16kW, no-load voltage of 300V, cutting current in the range of 30 A ～ 100A continuously adjustable, half-bridge switch frequency selection 20kHz, transformer change ratio of 6:5. Carried out by PSPICE modeling and simulation, the simulation results and the prototype of the measured waveform comparison are as follows:



a. Simulation Waveform　　b. Experimental waveforms

Fig.6 transformer primary side and secondary side voltage waveform

Figure 6 shows the transformer primary side and secondary side voltage waveform. From the theoretical calculation we can see, after a three-phase rectified voltage is about 513V, after PFC power factor correction and DC-link capacitor voltage divider get transformer primary side voltage of 375V. As the transformer turns ratio of 6:5, the maximum of the secondary side voltage is about 300V or so. The simulation and experimental waveforms comparison shows that the basic theory and practice in line.



a. Simulation Waveform　　b. Experimental waveforms

Fig.7 the voltage waveform of Boost switch and the current waveforms of boost inductor

Figure 7 shows the voltage waveform of Boost switch and the current waveforms of boost inductor. The boost inductor's current is expressed as the continuous conduction mode （CCM）, Boost switching frequency is 14kHz, and the basic line simulation and experimental waveforms are basically consistent.

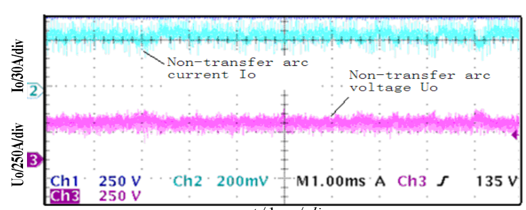


Fig.8 non-transfer arc voltage and current experimental waveforms

Figure 8 shows that the non-transferred arc is ignited between the nozzle and the electrode voltage and current waveforms, the voltage is about 200V, and the current is approximate 30A

V. CONCLUSION

This paper design air plasma cutting machine power supply by using of non high frequency electric arc technology, the main part of which uses half-bridge inverter circuit. The circuit uses UC3854 power factor correction circuit and the adoption of DSP chip as the controller to control the system. Experimental verification of the plasma cutting machine solves the deficiencies of traditional high-frequency high-voltage arc plasma cutting machine. It has a high success rate of arc ignition, a small disturbance to surrounding numerical control equipment, cutting good quality with a broad application prospects.

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