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THE POWER SUPPLY SYSTEM AND CONTROL UNITS OF PLASMA NITRIDING

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Switching power supply system and control units of ion plasma nitriding (IPN) is presented. Details of the construction method, hardware processing unit and merits of pulse mode of power supply are explained in the paper.

Key words: computer control, processing, switching, sensors, voltage and current, controlling unit.

Introduction

To create a glow discharge on the surface of the component part, a three-phase alternating and direct current can be used. In this case, unlike DC, in the case of alternating current, heater should be located in accordance with the phases of voltage. With the current rectification in order to avoid arcing needed emergency shutdown system. The use of modern electronic systems, emergency shutdown, you can apply a constant current. Power supply units are calculated in accordance with the size of heating units and current ranges from 20 to 450 kVA. Crucial for ensuring the safety of the plant, plasma nitriding is given the necessary transfer of power to the workpieces through the insulator to prevent short circuits even at voltages up to 1000 V.

The control unit provides control and monitoring of the entire process of plasma nitriding. Temperature adjusting parts (with thermocouples or optical pyrometers special), the gas mixture in the plasma, and by the pressure in the heater – the width of the luminous zone. The increasingly widespread uses due to the good reproducibility of the results of processing are modern installations plasma nitriding with microprocessor based control systems.

Constructive method for providing modes hardening treatment, minimizing energy consumption

Since the process of IPN effectively passes in a fairly narrow range of operating conditions, the job and the maintenance of their values with as little most appropriate to carry out the automatic computer control. The system provides the necessary information to be collected from respondents sensors, conducting and processing the information received, in accordance with the algorithm, complex issues control signals to the appropriate nodes, systems and components for the maintenance of sufficient conditions for compliance with the technological mode of treatment.

In the case of automatic computer control can process products of different grades of steel, regardless of the load of the working chamber. The input parameters in this case are the requirements of the design documentation in the depth of the hardened layer and its hardness.

Domestic and international experience of IPN of various grades showed that by controlling the flow of the algorithm changes in the density of nitrogen in the process, may be formed on the deeper layers of steels, and the use as a fluid mixture of $H_2 + N_2 + Ar$ gives significantly better results than the use of ammonia.

The control system elemental composition of the working gas atmosphere, and given the technological requirements, must have the necessary speed and is equipped with the appropriate

sensors, controls and management.

For temperature control of the process using the IPN temperature sensors placed in sensitive terms of technological requirements in workpiece areas. The system creating the necessary vacuum in the chamber must have sufficient capacity to maintain the specified process conditions. It contains a set of sensors for measuring pressure with the compositional content of the gas atmosphere in the chamber.

The power supply system is applied on the basis of the maximum ratings of the loading chamber parts. At the same time lays the little headroom (between 10–15%), which provides the necessary degree of reliability. The system provides the necessary power subsystem lock, and control power consumption.

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Development of block diagrams created experimental equipment for study of ion-plasma nitriding

Based on the analysis of available information on existing schemes equipment for low-temperature ion nitriding of metallic materials in the plasma glow discharge in nitrogen, here, it is decided to implement an improved version – gas thermo cyclic ion nitriding in a discontinuous mode. In this process through the use of pulse current discharge and gas thermal cycles of saturation of the surface layers significantly reduces the processing time, the cost of electricity and the reaction gases improved the performance of component parts, because due to the low temperatures and low exposure time there is no softening of the core products.

The quality of the metal-nitride treatment depends essentially on the basic parameters of the parameters – the voltage and temperature. Until the early 1980's used water-cooled units, in which the discharge was achieved by direct current (cold wall method). A serious drawback of this option is the large temperature differences in the load and hence a large spread of the results of processing, and relatively low load density, high energy consumption and the merging of thermal and chemical processes. Substantial progress can be achieved through the use of a pulsed discharge. Ripple decreases the power supply installation and improves the uniformity of temperature in the load. Typical values for the pulse duration are from 50 to 100 microseconds, and for the pulse frequency – 100–300 microseconds.

In the case of the nit riding process control device with the circuit generating the control voltage thyristor voltage at the electrodes of the discharge chamber [1] thyristor phase control allows you to adjust the power only in the range of half the period of the AC line voltage (50 Hz) with the timing depending on the desired output power. Thus, the minimum discrete output control thyristor is greater than 10 ms, which does not ensure the operation of the equipment in the mode of pulsed discharge due to poor performance. Also, the lack of such an option is sufficiently large dimensions thyristor required to implement the process of power.

The task was to create a work of experimental electronic equipment for the study of physical and mechanical characteristics of the nitrided layers produced with variable pulse voltage on the substrate in the gas low-pressure arc discharge.

In order to increase reliability, manageability and performance of the equipment and ion nitriding increase efficiency developed a new device. Such a complex process to programmatically control the ion nitriding consists of a vacuum chamber, process gas inlet system, pressure and temperature sensors, input process parameters and process control block. Process control block includes an inverter voltage converter made by IGBT transistors. IGBT transistors can operate at a high operating frequency, providing continuous control of the output circuit and its adaptation to the current load in real time. The bandwidth of the control is greater than 1 kHz (i. e. the adjustment is performed every millisecond – at least ten times more frequently than in the thyristor control). Using a

regulator power inverter configured as a converter IGBT transistors, yields the desired discharge pulse mode output voltage in the form of various variations of the conductivity of the plasma.

The drawing is a structural diagram of an apparatus for adjusting the ion nitriding.

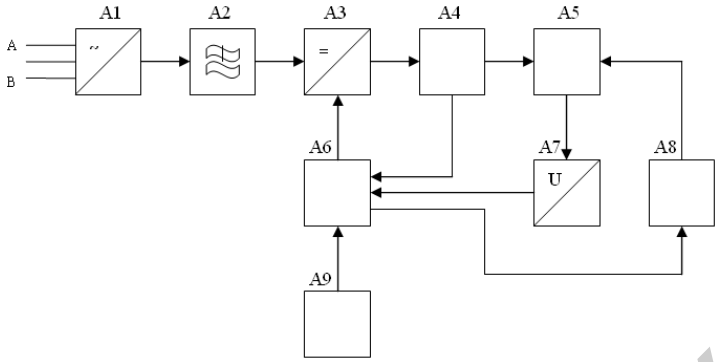

Fig. 1. Block diagram of hardware processing unit for ion-plasma nitriding:
A1 – line rectifier, A2 – line filter, A3 – Inverter voltage converter, A4 – current sensor, A5 – camera plasma nitriding, A6 – control process, A7 – a temperature sensor, A8 – process gas inlet system, A9 – an input parameter process

Mains voltage three-phase rectified Larionov bridge A1 goes through the surge A2 inverter DC-AC converter A3, made on a half-bridge circuit for high-power IGBT transistors. From the output of the converter transformer A3, which provides galvanic isolation from the industrial network, variable pulse voltage of 500 V with a frequency of 25 kHz via the current sensor is applied to a substrate A4 chamber plasma nitriding A5. The current control method of nitriding given supply pulse duration required at a constant frequency pulses (PWM method) process control block A6 to inputs of which the signals of the magnitude of current sensor A4 temperature sensor substrate A7 and the specified parameter values to the input process parameters A9.

Power Supply Systems

Using the equipment for ion-plasma system XTO pulse discharge power supply with a controlled current pulse allows to:

– avoid local concentration of energy in the discharge and thus prevent heat and "scorching" of sharp edges of parts;

– treat the relatively narrow grooves, the inner surface of through and blind holes of small size;

– minimize the duration and energy consumption in microarc cleaning on heating;

– effectively manage the flow of working gas in the chamber by changing the ratio "current pulse–pause".

The control unit also provides the system lapping process gases A8 cyclogram in accordance with the nitriding process.

Benefits of Pulse Power Supply System

The advantages of pulse mode power supplies are ability to achieve a high rate stabilization of the operation through feedback, high efficiency, wide input voltage range, insensitivity to the frequency of the input AC voltage affects only the input rectifier and filter, insensitivity to the quality of supply such harmonic alternating current, the ease of the use of remote control for on and off, small size and light weight, and in general, the smaller cost are the benefitting attributes of pulse mode of power supply. Details are as explained.

Low cost in production this resulted to low price to the consumer: in pulse power supplies, devices used in the design are not expensive, for example, low-frequency transformer, which makes up a large part of the cost of linear power supplies. Lower cost through mass production of standardized hardware components and the development of key high-power transistors. In addition, lower cost pulse transformers with comparable power ratings and the use of less powerful force

elements for the system operation.

Lower cost which is due to the mass production of standardized hardware components and the development of key high-power transistors achieved the lowest price power base of switching power supplies. The greater the power output switching power supply, the cheaper is the source compared to the cost of a similar line source. Less cost means a big budget savings.

Smaller size and weight : usually with smaller size and weight compared to the same power line for the power supply lower weight due to the fact that with increasing frequency, it can use smaller transformers with the same transmit power. Weight can be determined by mainly of heavy powerful low frequency power transformers and high-power radiator elements operating in a linear mode. In addition, higher frequency conversions significantly decrease the output voltage of the filter size (use capacitors significantly smaller capacity than rectifiers operating on mains frequency). Rectifier itself may be formed in a simple half-wave circuit, without the risk of increased output voltage ripple.

Compensation on output voltage: compensation on output voltage when the load on the long lines, equipment connected to a power supply is designed for a specific voltage rating. Since it may be at a considerable distance from the power source, an important factor is the loss in the wires. They can compensate by increasing of the connection from the power supply to the equipment, which will increase the output voltage of the power source.

Stable output parameters over a wide temperature range: the output parameters are usually current and voltage. When operating at maximum load after a short time in the unit at the temperature protection is triggered. The load is usually supplied with nominal load current, which is a current that must always be given to the load regardless of the circumstances, for a long time, while maintaining the level of pulses. The quality of the output voltage noise and electrical interferences allows simultaneous supply of different loads. The pulse power source can be connected to the load and operating in the linear mode, and the load, operating in dynamic mode. In this case, for stabilizing the output parameters of pulse power supply is necessary to use filters of various types (inductive and capacitive) to the output circuits.

Relative reliability: pulse power supply more reliable due to the presence of a modern power integrated circuits protection against various contingencies, such as short circuit, overload, over voltage, sometimes polarity output circuits. High efficiency causes less heat loss, which in turn causes overheating of the smaller base element source, which is also an indication of reliability. Reliability resulted to less cost of repairs and therefore saving budget.

Improved circuitry and high frequency conversion of high efficiency (up to 90–98%): high efficiency due to the fact that most of the losses in switching power supplies due to the transient processes in the key moments of the switching element. Because most of the times the key elements are in the same steady state on or off, the energy losses are negligible. The voltage drop is a critical parameter in the calculation of the performance and power dissipation. Transformer power supplies for the stability of the output voltage stabilizer is required, which introduces additional losses

Low power consumption: pulse power supplies are suitable for computer equipment, office equipment, consumer electronics almost exclusively pulse. Linear power supply low power remained basically only in the following areas. The design parameters are highly efficient; therefore, it has lower power consumption and high reliability.

Easy adaptation to domestic conditions: pulse power supplies operate in the domestic power grids with standard power quality that is pulse power supplies accept a wide range of supply voltages, unattainable for the line. Adapting to the domestic conditions of operating device and easy to use.

Pulse power supplies as a digital device: until recently, most of these devices were analog, but today analog devices almost completely superseded by digital models, among the benefits is particularly highlight the versatility of digital models. characteristics of digital device do not vary with changes in temperature, system for the calculation and the signals are only two stable states (0 and 1).Therefore, they are much more reliable, high reliability which nullifies the possibility of losing the necessary signals, due to physical aging characteristics of analog components subject to changes, designed digital circuit will give the same results during the entire period of operation. Digital device do not depend on the precise tolerances components. Characteristics of digital circuits virtually unchanged.

The design of switching power supplies on the basis of integrated circuits: recently, the

world's rapidly developing design and manufacture of switching power supplies for high-power integrated circuits. Capacity of these power sources ranging from hundreds of milliwatts to hundreds of watts. Specialists of have developed a number of families of such circuits. This makes it possible to build a pulse power supply with an input supply voltage in the range of 16 to 400 V. The advantages are: eliminate external discrete components than significantly reduce system cost, remote control, programmable current limiting, over load protection of low and high input voltage, overheating of the crystal. In standby mode provide which significantly reduces the power consumption from the mains, shorten development time and saving on production and enhance manufacturability.

Heat generated: in practice, the simultaneous operation of two sources the total heat release in a linear regulated power supply unit is substantially higher to a pulse power supply. The linear power supply uses two separate windings of the power transformer.

Conclusion

Control unit and switching power supply system for nitriding equipment have been discussed. The constructions of the experimental equipment have been explained. The full apparatus are also highlighted. The control method of nitriding given supply pulse duration required at a constant switching pulses. The control unit is to ensure control and monitoring of the entire process of plasma nitriding.

Features and benefits include: high output current, small size and weight, connector of the remote measurement, remote control with an external voltage source or a variable resistor current control scheme with an indicator that prevents over-current power supply, protection against overheating, protection against overvoltage. Pulse power supply unit provides the user with a convenient service installation and monitoring of output voltage.

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