the traditional power frequency transformer boost microwave power vs the new digital variable frequency microwave power

Design of electrical control system of industrial microwave equipment with digital variable frequency power supply

Compared with the traditional power frequency transformer boost microwave power supply, the new digital variable frequency microwave power supply
It has the advantages of high efficiency, wide adaptability of the power grid and continuous power adjustment, and can feedback the working status and fault information of the microwave power supply and the magnetron. This paper develops an industrial microwave intelligent control system based on the new digital variable frequency microwave power supply, which improves the automation level, stability and reliability of industrial microwave equipment, and is of great significance for the promotion and application of industrial microwave equipment.

Microwave processing technology is the use of microwave high-frequency electric field effect to heat, dry, sterilize, catalyze, etc. It is a new type of special processing technology, and it has great prospects in industrial applications.

The magnetron is the source of microwave radiation and is the core component of microwave equipment. An industrial microwave device typically contains multiple magnetrons. The magnetron is a high voltage load and requires a specific microwave power source for driving to operate properly. Magnetron power supplies are decisive for the performance and efficiency of microwave equipment. The traditional microwave magnetron power supply has the disadvantages of low efficiency, large weight, and unadjustable power. In this paper, an industrial microwave electrical control system based on digital variable frequency microwave power supply is developed for continuous industrial microwave equipment, which realizes continuous adjustment of microwave power, significantly reduces equipment volume, and effectively improves system efficiency and automation, in line with industrial microwave. The development trend of equipment.

1 digital frequency conversion microwave power supply
1.1 Comparison of variable frequency microwave power supply and traditional microwave power supply
The magnetron used in this paper has a rated power of 1 kW and a radiated microwave frequency of 2,450 MHz.

The traditional industrial microwave equipment adopts a power frequency transformer boost combined with a half-wave voltage doubler rectifier circuit as a driving power source of the magnetron, and the circuit is as shown in FIG. The working principle is: single-phase 220 VAC input voltage, boosted by high-voltage inverter, AC voltage above 2 k V on the auxiliary side of

the secondary side; half-voltage double-voltage rectification, anode and filament of magnetron A DC high voltage of 4 k V or more is generated to drive the magnetron to generate microwaves; the secondary side of the high voltage transformer adopts a double tap structure, and the filament tap generates a preheating current of the magnetron filament, which is generally about 3.3 VAC/10 A. The high-voltage transformer adopts the form of a leakage magnetic transformer. The artificially added silicon steel lamination forms a magnetic flux leakage branch between the primary and secondary coils, and utilizes the saturation effect of the main magnetic circuit and the unsaturated characteristic of the magnetic leakage branch, through the magnetic leakage branch. Dividing and absorbing the flux fluctuations when the primary voltage changes, stabilizing the anode voltage in the case of input voltage fluctuations, ensuring stable operation of the magnetron [4]. The magnetron emits microwaves to operate in the intermittent mode, and the adjustment of the average microwave power is achieved by changing the on-off time ratio of the input side fire switch.

The traditional microwave power supply mainly has the following disadvantages: the power frequency transformer is bulky, heavy, and inefficient; the anode voltage of the magnetron is open-loop regulated by the leakage magnetic branch of the high-voltage transformer, and lacks feedback control, which is not conducive to the working state of the magnetron and Stable control of microwave power; microwave instantaneous power can not be controlled, only the average power of microwave can be adjusted by fire switch, which can not meet the requirements of strict requirements for instantaneous power or fine control of microwave process control; frequent switching of magnetron, magnetron The service life is greatly shortened, and the use and maintenance costs are high.

Therefore, the paper developed a digital variable frequency microwave power supply, as shown in Figure 2. The variable frequency microwave power supply adopts high frequency switching power supply as the main circuit structure. The input side is converted into high frequency AC voltage by the soft switching inverter circuit after input and rectification. After high frequency transformer boosting and output side rectification and filtering, the magnetron is obtained. The anode voltage and the anode voltage are adjusted by adjusting the frequency of the switching tube control signal, that is, the switching tube operates in the PFM mode (frequency range 40~60 k Hz). The secondary side of the high-frequency transformer adopts a double-tap structure, which can simultaneously provide the anode voltage and the preheating current of the filament. The variable frequency microwave power supply is designed with anode voltage and anode current sampling feedback circuit. The microwave output power can be calculated by the feedback amount. Through the digital closed-loop control algorithm, the anode voltage value can be adjusted in real time to realize the constant power output of the magnetron. The power supply design has a digital communication interface, which can interact with an industrial control unit such as a PLC. The output power value of the magnetron is set by the upper-level industrial control unit, and the industrial control unit can also obtain the working status and fault information of the microwave power supply through the digital communication interface.

The test conditions are as follows: the output microwave power of the magnetron is 850 W. When the input voltage changes within 180~240 V, the working efficiency curve of the variable frequency microwave power supply and the traditional microwave power supply is shown in Figure 3. When the input voltage changes within 180~264 V, the input power curve of the

variable frequency microwave power supply and the traditional microwave power supply As shown in Figure 4. Efficiency refers to the total efficiency of the output microwave power of the magnetron to the input side of the microwave power supply (ie, the total efficiency of the microwave power supply and the magnetron).

1) Adaptability to input side voltage fluctuations, the variable frequency power supply is significantly stronger than the traditional microwave power supply. The input voltage is increased from 180 V to 240 V. The efficiency of the variable frequency power supply is basically stable at about 64%, while the efficiency of the conventional microwave power supply is reduced from 61.2% to 55.5%; the input voltage is increased from 180 V to 264 V, and the input power of the variable frequency power supply. The amount of change is 218 W, and the input power variation of the conventional microwave power supply is 489 W.

2) The overall efficiency of the variable frequency power supply is about 64%, which is higher than the traditional power supply, and as the grid voltage rises, the efficiency advantage of the variable frequency power supply is further expanded.

In summary, the digital variable frequency microwave power supply has the following obvious advantages:

1) The power conversion is realized by a soft switch. The transformer works in a high frequency state. The volume and weight of the power supply are much lower than the conventional power supply, and the power efficiency is also improved.

2) Through the fine adjustment of the anode voltage, the control magnetron operates in constant power mode, the microwave power is continuously adjustable from 250 to 1200 W, and the power frequency transformer type power supply is adjusted by controlling the on-off time ratio of the input side fire switch. Compared with the average microwave power, the instantaneous power adjustment and control of the microwave is realized, and the process performance of the microwave device is improved;

3) Excellent grid voltage adaptability and output power stability, ideal for industrial field applications;

4) It has perfect protection functions such as input overvoltage, input undervoltage, power supply over temperature, surge protection, etc., and the magnetron works in continuous output mode, and the service life is greatly extended, thereby greatly reducing the use cost of industrial microwave equipment and Equipment failure rate.

1.2 Communication and control of digital frequency conversion microwave power supply
The variable frequency microwave power supply has a dedicated communication interface to interact with the host. The communication interface circuit of the microwave power supply is a 3.3 V TTL level, and is interconnected with a self-developed control relay board. Figure 5 is a block diagram of a typical variable frequency microwave power control system.

PFM is a square wave signal that controls the relay board to send to the variable frequency power supply. It works in the frequency modulation mode. The output value of the microwave power is set. The corresponding relationship between the frequency of the PFM signal and the microwave power setting value is shown in Table 1. FG is the feedback signal sent by the variable frequency power supply to the control relay board, indicating the working status of the variable frequency power supply and the fault type information. Figure 6 is the waveform diagram of the FG signal. When the variable frequency power supply and the magnetron are working normally, the FG signal is the frequency. 100 Hz, 50% duty cycle square wave signal; GND is the reference potential of the TTL level signal.

The control relay board functions as a signal conversion. The single control relay board can realize the control interaction of up to 18 variable frequency power supplies, and communicates with industrial controllers such as PLC through the RS485 electrical interface. In the industrial microwave equipment, the PLC obtains the working state and fault type information of the corresponding variable frequency power supply from the control relay board through the free port protocol or the MODBUS protocol, and also sets the microwave output power corresponding to the variable frequency power supply by controlling the relay board. . The variable frequency power supply has a complete diagnostic function, which can feed back the power supply itself and the fault information of the magnetron to the PLC, which is convenient for system diagnosis and maintenance. Table 2 shows the correspondence between the number of FG signal failure type pulses and the specific fault type.

2 microwave equipment machine electrical control system

2.1 Overall design of electrical control system

The industrial microwave equipment designed in this paper has a total microwave power of 15 kW. It adopts the overall structure of a box tunnel furnace. The microwave box is connected by three boxes. The microwave power of a single microwave box is 5 kW. The magnetron is selected from Samsung OM75P (11), and the transmitted microwave frequency is 2450MHz, and the rated output power is 1k W, which is air-cooled. The whole equipment is equipped with 15 air-cooled magnetrons and variable frequency microwave power supplies. The single microwave box is equipped with 5 magnetrons and variable frequency microwave power supplies.

Figure 7 is a schematic diagram of an electrical control system for an industrial microwave device. The system uses the McGMT brand MC100 series small PLC, the model is MC100-1614BRA1. The PLC is powered by 220 VAC and its resource configuration includes 16 digital input points, 14 relay output points, 2 analog input channels, and 1 analog output channel.

The conveyor speed of industrial microwave equipment is continuously adjustable from 0.5 to 5 m/min. The transmission motor selects a three-phase 380 VAC 4-stage AC asynchronous motor with a transmission motor power of 1.5 kW. The transmission motor is regulated by the high-performance inverter MV300G-4T2.2 of Megmeet. The output frequency range of the inverter is continuously adjustable from 5 to 50 Hz. The digital output point Y0 of the PLC is used to transmit the inverter enable control. The analog output channels (AVO+, AO-) are used to transmit the inverter output frequency reference. The analog given voltage is 1~10 V

corresponding to the transmission inverter 5~50 Hz. Output frequency.

Each of the first to third microwave boxes has five sets of variable frequency microwave power sources and magnetrons, and each of the main contactors controls the start and stop of the microwave power source. The digital output points Y2, Y3 and Y4 of the PLC are used to control the microwave start and stop of the first to third boxes, respectively. The dehumidifier fan is used to extract a large amount of water vapor generated by the material during the microwave heating process, and the heat extraction fan is used for extracting the heat generated during the operation of the microwave power source and the magnetron, and is a two-stage three-phase 380 VAC 1