Improved Temperature Control System Research of Sound Insulation Cotton Heat Sealing Machine

Luang Zhao & Heng Cao

School of Mechanical and Power Engineering, East China University of Science and Technology, China

ABSTRACT: In order to do large scale line length heat-sealing for the sound insulation cotton and resistance to flame clad-ding layer materials of new aircraft, the system has been improved according to the original heat sealing machine temperature control system. It uses thermocouple sensor of high response to collect the temperature signal. And it also controls the output power of pulse digital DC power supply by S7-200 PLC based on the principle of PWM. Therefore, it meets the requirements of temperature control. Eventually, the temperature control system can ensure heat sealing requirements of the new type materials after test research.

Keywords: Improved Temperature Control System; Sound Insulation Cotton; Heat Sealing Machine

1 INTRODUCTION

In an aircraft company project, we need to do heat-sealing for the sound insulation cotton resistance to flame burn through cladding layer PEEK materials of new large aircraft. According to party A, the material standardizes CMS-PL-908 and CMS-PL-909. The standard requirement is that film heat sealing peel strength can not less than 2 pounds per square inch after heat-sealing. The heat sealing temperature of heat sealing equipment must be effectively controlled due to the high temperature requirement of heat sealing material, the fast velocity increase of Nickel-chromium alloy temperature, the larger thermal inertia and the maximum heat sealing length is up to 4m. The open-loop temperature control system of original heat sealing machine can't meet the requirement of heat sealing temperature. we must develop new heat sealing temperature system so as to real-time monitor heat sealing temperature of heat sealing machine nickel-chromium alloy heating and make the heat sealing temperature in the best heat sealing temperature range of heat sealing materials .

In order to meet the above requirements, we establish heat sealing machine temperature control system based on the principle of PWM pulse width modulation, which are composed of hardware such as PLC, temperature sensors, nickel-chromium alloy heating, and touch screen and so on. The temperature system has the characteristic of high response and can be real-time temperature

monitoring and control for the nickel-chromium alloy heating. It also has temperature alarm, temperature setting, temperature real-time display and other functions, ensuring the accurate control of heat sealing temperature.

2 SUMMARY OF HEAT SEALING MACHINE TEMPERATURE CONTROL SYSTEM

Heat sealing machine temperature control system uses PLC - 200 as the processor of heat sealing temperature control and chooses SMART touch screen to interactive with PLC. It also makes the setting of temperature control, real time data display and other functions. The structure diagram of temperature control system is shown in figure 1.

At first, Using the actual temperature value measured by the patch type thermocouple of OMEGA, transmits it to the PLC - 200 by means of thermocouple module EM231 and then by A/D conversion module. PLC - 200 makes a comparison between the actual temperature value transmitted and the target temperature value settled by SMART touch screen. According to the difference, using fuzzy algorithm, through a series of algorithms, regulates the output duty ratio of the digital pulse generator by a solid state relay on and off based on the principle of pulse width modulation PWM. Thus, adjusting the output power of digital pulse generator and realizing temperature control of nickel-chromium alloy heating.

Fig.1. Temperature system structure diagram plate directory.

3 RESEARCH ON PLC TEMPERATURE CONTROL SYSTEM SOLUTION

3.1 Improved temperature control system pre-stage test

Text the above have described that it was because thermal inertia that open-loop temperature control was prone to excessive overshoot and affected ealing quality even burned the material. S ealing temperature curve when open-loop control have been shown in Figure 2. After setting the target temperature (such as 150°C) and running about 5s, the first heat sealing temperature reach operating temperature requirements of 150 degrees and then stop heating Nickel-chromium alloy resistance. It can be clearly seen in the follow figure that the temperature continues to rise, and rise to close to 177 degrees after the first stopping heating about 1.5s. The temperature has been far more than the heat sealing temperature range of sound insulation cotton coated layer PEEK materials. Heat sealing materials are modified or destroyed under the condition of highly temperature. The temperature rising rate slow down slightly, when the heating time of heat sealing temperature is 4s. It is because its heat exchange with the outside world is also a corresponding increase as Nickel-chromium alloy resistance heated. After the test, it have found that the material's thermal inertia, heating temperature difference and heating rate is proportional to the relationship, is inversely proportional to the heating time. Therefore, our research group do some improvements according to the original device hardware. Controlling digital pulse generator output power through the switch quantity, decreasing heating rate, and increasing the smaller heating time to control the thermal inertia of the material, in order to achieve the purpose of heat sealing quality.

Fig.2. Heat sealing temperature curve of open loop temperature control

3.2 Temperature control system

Figure 3 intercept three sections of temperature control procedures from the main program in the purpose of illustrating the temperature control of heat sealing machine is from PLC which uses PWM pulse width modulation closed loop control principle. In the ladder diagram, VW70 refers to the difference between the target temperature and real-time temperature .when VW70 is greater than 9 degrees, the output pulse width VW18 is equal to 9. when VW70 is less than 9 degrees, making the difference an integer ,outputting pulse width VW18 and getting T40. Assuming that the value of pulse width VW18 is 5, that is delay timer T40 in former 0.5 seconds duration is 1, in latter 0.5 seconds the value is 0. And then using the value of delay timer to control the ratio of work between the heating time and unheating time. The working principle is in fact that using an Solid State Relay acts as a switch, adjusting the duty ratio of pulsed digital power supply through the switch quantity, so as to adjust the input power of the digital pulse generator. When the difference between the target temperature and the real-time temperature is greater than 9, make the digital pulse generator with 90% of the power for electrical heating heat sealing pressure head; When the difference between the target temperature and the real-time temperature is less than 9, What value is the difference of the certificate ,and then using tenths of a few power for heating heat sealing pressure head; When the target temperature is less than the real time temperature or temperature difference is less than 3 degrees, digital pulse generator stop heating. Among them, the manual input pulse width VW18 is 1, and using the lowest 10% power to heat the heat sealing pressure head, whose temperature must be fallen slowly. That's the heat quantity is less than heat emission quantity of the pressure head in the air, otherwise the temperature continues to rise, too much more than the target temperature. In this way, changing the temperature control of pulse type heat sealing machine. Reducing greatly the material thermal inertia of high quantity in the case of heating rate did not reduce much. The rising rate is much slower

when the real-time temperature is more close to the target temperature. It's very well to reduce the temperature overshoot, moreover, the heating time is not affected much.

Fig.3. PLC ladder diagram of simple PID temperature control

3.3 The effect of improved temperature control system

When As shown in figure 4, line 1 is the unmodified open-loop control systems(way 1 for short)heat sealing temperature curve, line 2 is the heat sealing temperature curve of simple PID control system based on PWM pulse width modulation (way 2 for short).In the figure, it is not difficult to see that the heat sealing temperature curve of way 2 obviously fall behind of way 1, due to the maximum output power of digital pulse generator limited to 90%.In the way 2,it adopts simplified PID temperature control method based on PWM. It can be seen from the figure that after the heat sealing temperature curve of way 2 is close to the set working temperature about 5s, the heat sealing temperature curve is obviously slow down. It is because the way 2 reduce the power output of the digital pulse generator according to the temperature of feedback loop of Nickel-chromium alloy resistance heated. It can be seen that the overshoot volume of heat sealing temperature curve in way 2 is very small, and after the first wave, temperature almost stabilize within the plus or minus 3 degrees. It shows that simplified PID temperature control based on PWM method is simple, effective and can meet the use requirements. Multiple trials in different heat sealing machine equipment, the temperatures all can meet the requirements and improve quality and rate of the heat sealing.

Fig.4. Heat sealing curve contrast figure of temperature control system after the improvement

4 HEAT SEALING TEST

4.1 Test date

Number After the modification of the temperature control system, we need to do heat sealing test for new material in order to verify that the new temperature control solution can meet the required heat sealing requirements. According to literature consulting and preliminary test, we can know that the best temperature of new material is 160°C, the choice of heat sealing pressure is 0.7 MPa, the choice of heat sealing time is3 s. Test method is to cut out 150 hot sealing samples whose width is 1 inch in the use of heat sealing sample whose length is up to 4 meters heat sealing sample, according to the requirement and number them. Then test peel strength of each heat sealing sample through the peel strength tester , and make them into form.

Figure 5. 160°C peel strength distribution (p=0.7Mpa, t=3s)

4.2 Result analysis

From the peel strength distribution of 160°C heat sealing sample as figure 5 described, we can know that using improved temperature control solution, the peel strength of heat sealing sample made by soundproof cotton coated layer are all more than the application requirements of 2 pounds per inch. From the above figure, we can also clearly see that the biggest peel strength of part sample is far higher than application requirements of 2 pounds per inch

and reach more than 4 pounds even the given maximum of 4.5 pounds per inch. By the analysis, this is due to the anyway fiber of Plastic film stick together when the plastic film of sound insulation cotton coated is folded and heat-sealed. Then the peel strength is not the peel strength of heat sealing sample, but the fibre tensile strength of plastic film. This sample also meets the requirements.

5 CONCLUSION

After improving the original open-loop control solution of heat sealing machine temperature, heat sealing temperature control solution based on PWM has solved the problem of material thermal inertia that original plan cannot solve very well. After putting these equipment to use for 3 months, the improved temperature control system works stably for Heat sealing effect.

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