

Development of High-temperature Vacuum Brazing Equipment

Abstract: Describe the development of vacuum and high temperature brazing alloys and brazing process characteristics. According to Inconel718 super alloy brazing process requirements, high-temperature vacuum brazing equipment should have a high vacuum and low leakage rate, high temperature control accuracy, high temperature uniformity, a certain heating rate and cooling rate. Elaborate on the structural characteristics of high-temperature vacuum equipment and the key technologies, including temperature uniformity, vacuum and pressure rise rate and automation of heating room.

Keywords: High-temperature alloys; Vacuum brazing furnace; Vacuum brazing; Temperature uniformity;

Brazing is an ancient method of connection, after a long process of development. After the invention of various welding methods, appeared in other welding method instead of the brazing trend. However, In recent decades, Soldering had great increased and extensive application on the basis of modern technology development. Not only in brazing methods, but also has new progress on brazing alloy materials. It is widely applied for aerospace, auto, chemical, aviation, machinery, electronic, war industry & civilian industry. The brazing technology is a sophisticated connection technology today. Three major modern weld technology are brazing ,press welding and fusion welding.

Vacuum brazing must in vacuum condition, it is a brazing way without any soldering flux. Its principle is heating parts & brazing alloy, Make the liquidus temperature than the parent metal solder melting solidus temperature is low, Using liquid solder to wet parent metal, filling and joint clearance with parent metal dissolution and diffusion and connect parts.

With the development of science and technology, Industry in the future will take more and more new material, new structure and new manufacturing technology, the connection technology as a branch of manufacturing technology will be developed rapidly. The vacuum brazing as important connection technology, it has unique advantages and flexibility for new material connection and intricate structure manufacturing.

1.Process characteristics of Inconel718 brazing (high temp alloy)

Inconel718 performance characteristics: Under 650 °C has high yield strength and the plastic good characteristics, and have high corrosion resistance, irradiation resistance and oxidation resistance. Good weld ability, easy to take shape. In order to improve the plastic and toughness of Inconel718 alloy welded joint, developed has good mechanical properties and thermal performance of high temperature nickel base alloy welding material. By properly adjusting Inconel718 of carbon and niobium content in high temperature alloy, and carries on the deposition under a certain technological parameters, and then to diffusion annealing, solid solution and aging treatment. According to the request of Inconel718 alloy brazing process, high temperature vacuum brazing equipment should have the following technical parameters requirements.

1.1 Vacuum degree

Vacuum degree has cold vacuum degree and hot vacuum degree. Cold vacuum degree is to prevent soldering welding parts and components inside the furnace is oxidation.

Hot work vacuum degree is also known as vacuum degree, is refers to the heat from the beginning to air cooling during the period of vacuum furnace, it is due when heated, the workpiece and fixture to product gas. At the same time, use and adhesive tape solder paste filler metals also can produce gas due to the volatilization of binder. The precipitation of gas will be cold vacuum degree was reduced. But in the brazing temperature requirements in furnace, vacuum basic back to cold so in solder solidus line below 50 °C ~ 100 °C increased stability temperature and holding time to restore the vacuum degree.

1.2. The heating rate

Separation of gas and heating rate is to ensure that the workpiece solder volatile gas can be fully, but also make the workpiece heated evenly, reduce or prevent heat stress caused by the deformation.

1.3. Stable temperature and holding time

Stability refers to the brazing temperature and time when heated to a temperature close to solder, near the solidus temperature and heating suspended at this time, keep the temperature for a period of time. Its purpose is to reduce the temperature gradient component, to uniform the temperature of the component parts.

1.4. Brazing temperature

Brazing temperature is one of the main parameters of brazing process. In the brazing temperature, both to ensure the solder to melt completely, under the effect of capillary filling joint clearance, and compared with parent metal metallurgy; At the same time should also complete the parent metal heat treatment process of a process, improve the braze welding head mechanical properties.

1.5. Brazing heat preservation time

Heat preservation time is solder fill the gap and control the crucial stage of alloying, the joint strength and the influence of brazing temperature with similar characteristics. A certain time of heat preservation is solder with the parent metal necessary for mutual diffusion and form a solid combination.

1.6. Cooling rate

The cooling rate has a great influence on the joint quality. Slow cooling rates will cause the parent metal product grain growth; Rapid cooling rate is beneficial to the weld microstructure of refinement, reduce the dendritic segregation, thus improve the joint strength. But too fast cooling rate also can cause cracking due to thermal stress.

1.7. Melt temperature

Melt temperature is too high will cause the workpiece surface oxidation, and at the same time also can cause the pollution of furnace heating elements.

2. The structure characteristics of high temperature vacuum brazing equipment

In order to meet the high temperature alloy brazing technology, its key technologies, we in the device's structure design, thermal design, temperature control method, the thermal deformation precision influence and have adopted a series of cooling speed, etc. Measures, especially the more surface area than the use of control technology, make temperature well enough to achieve

high precision temperature control performance. Brazing equipment mainly consists of furnace body, heating room, magnesium, strong cold trap, vacuum system, water cooling system and electric control, etc

2.1 Furnace design

Furnace for horizontal circular cylinder, the use of double jacketed cooling wall structure, the double thick steel plate (to achieve high vacuum degree, both inside and outside wall material selects the high quality stainless steel) drum flange welding and become, after the structure intensity is high, not easy to deformation and dislocation, and weld less, can ensure the sealing performance. Jacket in circulating cooling water, and is equipped with cooling water channel, makes the furnace tube in cooling water run unobstructed, make the furnace in use process will not produce thermal deformation.

Water-cooled electrodes mounted on the furnace body, temperature measuring thermocouple, gas equipment, pressure gauge and rings, etc. And set on the side of the cylinder workpiece temperature detecting interface, can connect more artifacts thermocouple, the interface can also be used in the detection of furnace temperature uniformity.

Oven door open the door for former jacketed cooling wall structure, adopting double elliptical head layer (inside and outside wall materials are of high quality stainless steel) and circular flange welded together, the structure of high strength, resistance to high pressure, to ensure the long-term use of deformation. O ring mounted on the flange, shut vacuum oven door. In the central oven door is equipped with observation window, used for observation in furnace, at the same time equipped with electrodes are introduced and the device such as temperature control is introduced. Oven door open for lateral form, by turning hinge connected to the furnace. Rotating hinge for up and down and before and after the adjustable form, easy to install. Preloaded institutions in the form of the handwheel manual compression.

2.2 Heating chamber design

Heating chamber is the heart of the vacuum brazing equipment, brazing equipment, the design of each part are around it. It determines the structure of furnace body, geometry size, the configuration, the heating power of the vacuum system, electric control method, the size of the rose, cooling rate and temperature uniformity, etc. Related to the rationality of the whole equipment, technology and economy, and guarantee the quality of the soldering process. As a key technology of temperature uniformity in the high temperature brazing plays an extremely important role in the uniform temperature in the working area is beneficial to get even, smooth and solid combination of soldering fillet welding head. If the temperature below the melting point of solder solder not completely melt temperature, temperature is higher than the melting point of solder, solder will be lost. So control in furnace temperature uniformity $\pm 3\text{ }^{\circ}\text{C}$ is the focus of the device, take five district heating and five zone temperature control to ensure that the furnace temperature uniformity $\pm 5\text{ }^{\circ}\text{C}$, and our equipment to ensure that the furnace temperature uniformity within $\pm 3\text{ }^{\circ}\text{C}$, the five district heating, namely in the heating room decorate the five groups and the tropics, the door on a group, a set of bottom panel, side tube arrangement on the three groups. Tropical was added to each group should have a thermocouple temperature control, respectively connected to the respective temperature control table, measure their own temperature, and according to the temperature control instrument set to control the heating range over a certain period of time in a certain heating temperature to

achieve a certain value, if heating in a heating zone below the set speed, while the temperature control table feedback to PLC, PLC to control thyristor voltage regulator output current, to control tropical temperature, so it can be precisely controlled groups and tropical. Adopt the way of temperature control and can solve large due to the constant temperature zone area in furnace temperature is not uniform.

2.3 Strong cold system

In order to improve the productivity, ensure welding quality, shorten the workpiece in a furnace The cooling time, effective circulation cooling measures must be taken. About circulating cooling way in general can be divided into two kinds: one kind is a heat exchanger is put in the furnace shell of so-called circulation way; The other is a heat exchanger in so-called external circulation way outside the furnace. This furnace design when considering save space, reduce cover an area of an area, the inner loop cooling way, mainly composed of high pressure big volume centrifugal fan, water cooled finned tube heat exchanger and the strong cold air, etc

2.4 Magnesium trap

Design in order to prevent the welding process of steam into the pollution of oil diffusion pump, vacuum pump group in the pump group and furnace configuration between trap, trap composed of cooling water pipe and heat sink. Convenient to remove the maintenance, trap at the same time also can prevent back to the furnace pollution diffusion pump oil is processed workpiece

2.5 Vacuum system

In vacuum brazing protection, degassing and purification role. Obtain high vacuum degree is a key problem of vacuum brazing, we adopt domestic units, by using many times, we find that it back to oil and gas leakage and short service life exist many problems, such as can not fully meet the requirements of the process performance of certain goods, while the equipment is adopted with large pumping speed, high ultimate vacuum and efficient cooling unit, is greatly shortened the time to time, improve the service life of the vacuum pump, but also solved many problems such as oil and gas leakage.

For vacuum equipment, we pay more attention to pressure rise rate is the key technology, adopting large pumping speed of the unit can improve the extraction speed, but in furnace can not improve the quality of vacuum degree. In order to guarantee the quality of the vacuum degree in the process of furnace body, we always pay attention to the welding quality of weld, avoid funnelled, and reduce the weld as soon as possible. Funnelled detection is very important also, conventional leak detection method is not only response is slow, and the equipment must be to high vacuum leak detection, the leak detection work to bring a lot of the same. Now we use the helium mass spectrometer leak detector, simple operation, high accuracy, can be detected - 8-10 orders of magnitude leakage rate, the reaction time of only $1\text{ s} \sim 2\text{ s}$, at the same time also has the voice alarm function. This not only greatly improve the working efficiency, but also guarantee the quality of the vacuum degree, makes the equipment rate of pressure rise can reach 0.2 Pa/h .

In order to meet the ultimate vacuum equipment $5 \times 10^{-4}\text{ Pa}$ and pressure rise rate is 0.2 Pa/h of the technical requirements, we have adopted is given priority to with oil diffusion pump for vacuum pump, pump before use rotary vane vacuum pump, and coupled with an appropriate composition of roots pump level 3 high vacuum pump group. 2.6 measurement system measuring system including temperature, time and pressure (vacuum) measurement and control. Radiation temperature measurement is across the screen close to the work zone furnish

thermocouple sensor, is used to control the temperature. Commonly used thermocouple as a "platinum and platinum rhodium + 13%" or "platinum and platinum rhodium + 10%". Vacuum measuring of vacuum gauge. Vacuum in vacuum gauge measurement range for low resistance, ionization gauge measuring range, high vacuum and high vacuum. Vacuum brazing furnace to use these two vacuum gauge at the same time, also can use compound vacuum gauge. 2.7 electric control district heating elements more power is supplied by independent magnetic voltage regulator. Control part is composed of SCR and microprocessor temperature mechanical action of programmable control and PLC programmable control, can realize the following functions: (1) temperature programmable control, completed by temperature control meter. (2) the temperature and vacuum degree, according to the real-time recording and real-time records show that two kinds of temperature, thermocouple temperature control thermocouple temperature and workpiece, workpiece thermocouple monitor internal temperature of the workpiece weld, can grasp the workpiece online status, adjust temperature process parameters; (3) and other mechanical vacuum pump, vacuum valve operation switch programmable control; (4) water, electricity and over temperature, over current, cutoff and wrong operation phenomena such as adopt alarm and interlock protect each.