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AUTOMATED SYSTEM FOR HEATING IN DIFFUSION WELDING OF CERAMIC COMPOUNDS WITH CERAMICS

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Key words: *diffusion welding, ceramics, heating, equipment, automation*
Summary: *A survey was made of the importance of systems for heating in vacuum diffusion welding of ceramic compounds. The disadvantages of induction heating systems were examined. It was developed a computerized management system that allows the realization of complex thermo-deformational cycles, archiving and processing of information from the experiments and repeatability of the welding cycle without the use of feedback based on temperature*

The development of advanced technologies is associated with the development of products made of new materials which includes units of welded joints with ceramics. One of the main reasons for the rapid development of technologies that require new materials and compounds is the upcoming energy crisis related to the depletion of oil and the introduction of renewable energy sources. The problem of storage of electricity leads to a qualitatively new demands on materials and assemblies used in batteries for electrical cars and communication devices. The same applies to the development of computer technology, electronics, power electrical engineering, general machinery and tools for processing, automotive, aircraft (Fig1) rocket building and defense industry.

Diffusion welding in vacuum of assemblies of metal with ceramics is a method suitable for use in these sectors due to the high quality of the welded joints. It is used for welded joints in the composition of different metals including, metals and ceramics (Fig.2), metals and / or glass, metals that are hard to melt. [1].

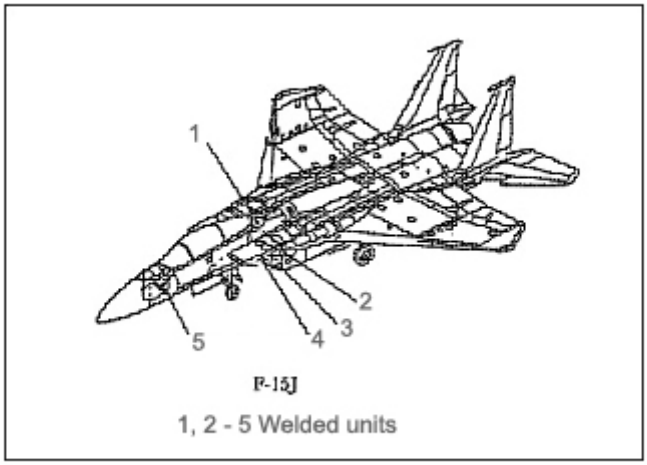

Fig.1 Diffusion-vacuum-welded units in aircraft

Diffusion- vacuum-welded joints with ceramics have high strength, resistance to operate at high and low temperatures in aggressive environments and do not change their properties during electromagnetic radiation and radioactive impact. They have the needed stability and longevity during work, resistance to thermo strikes, moisture and pressure. Welded joints retain their geometry due to the relatively low temperatures of welding and the use of intermediate layers which are lowering the raised tensions..

Fig.2 Welded joints of metal with ceramic

Studies that are related to the welding ability of ceramic compounds are a contemporary strategic direction.

Welding of ceramics compounds in plants is carried out in installations for vacuum diffusion welding.

It is known that the range of pressures in vacuum devices, which allows modern technology and those in space propulsion is divided into five groups: low (1.10-3) high (1.10-3 to 1.10-6) very high (1.10 - 6 to 1.10-9) over high (1.10-9 to 1.10-12), space (1.10-12 to 1.10-14) mmHg.

In welding installations it is typically used low and high vacuum, ie 1.10-2 to 1.10-7mmHg.

The welding of the parts is done in a vacuum chamber (Poz.1) and the vacuum is provided by successively acting pump (Poz.2) and diffusion (Poz.3) pump. The management and continuity of action is performed using valves (Poz.4) (Fig.2).

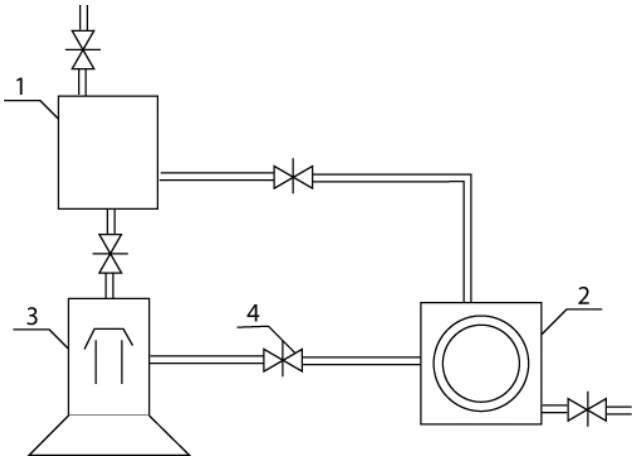

Fig.2. Scheme of installation for diffusion welding in vacuum.
Poz.1 - vacuum chamber; Poz.2 - pump;
Poz.3 - Diffusion pump; Poz.4 – Valves

The following major technical requirements for equipment for vacuum diffusion welding have been defined [2]:

- Full tightness
- Sufficient mechanical and thermal strength

Negligible amounts of gas penetrated into the vacuum chamber can dramatically alter the degree of the vacuum and to deteriorate efficiency of the equipment [3].

In the literature [2] it is known a detailed classification of types of installations for diffusion welding in vacuum.

In terms of filing the necessary pressure to the apparatus, parts are welded with hydraulic or pneumatic pressure or pressure achieved due to heat expansion of materials.

Depending on the degree of vacuuming: low and high vacuum.

From the perspective of the source of heat: induction, resistance, radiation, cathode, and combined methods of heating.

Degrees of automation: with manual, semi and automatic control.

The choice of system for heating depending on the characteristics of welded details is crucial.

In Institute of Metal Science was developed an installation for vacuum diffusion welding with induction heating. The heat is given to the surface of the details, and inside them is heated by heat transfer [4]

An important parameter of the induction heating is the distance between the inducer and the details. Reducing the gap increases the efficiency of heating, but the transition into a critical value causes overheating. The critical value of the gap depends on properties of the materials.

Notable are the results of studies that reflect the influence of welding procedure on the mechanical properties of the compounds obtained by induction heating [5, 6].To solve the problem of "Welding of ceramic compounds with ceramics" we cannot use

the already existing heating system due to the following reasons:

1. Inability to realize the required relatively low speeds of heating and cooling (below 50 0S/min).
2. Large temperature gradients due to the heating of the ceramic part by metal part of the welded compounds.

During the conducted experience the welded joints are deteriorating due to the above reasons (Figure 3).

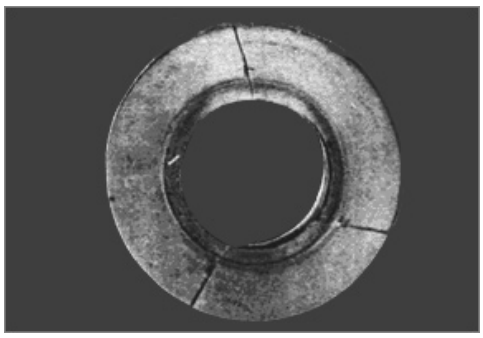

Fig.3. Photo of the welded joint with transverse cracks in the ceramics

To avoid these shortcomings, we created a combined system for heating (Fig.4)

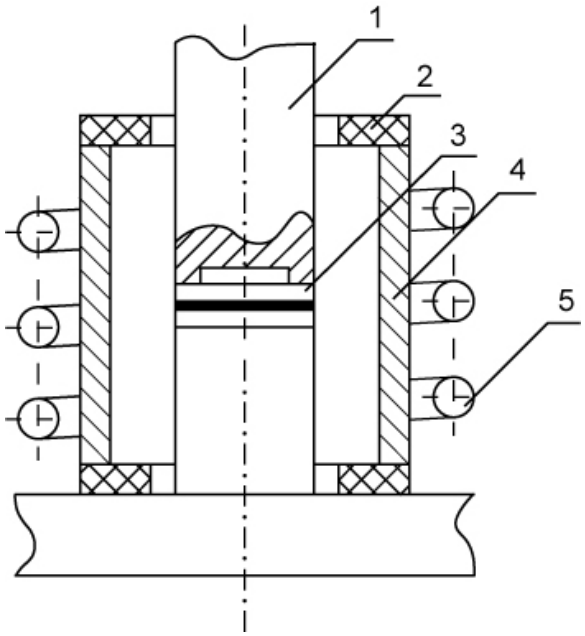

Fig.4 The system of indirect radiation heating: 1 - Fixing tool; 2 - Insulator; 3 - Welding compound; 4 - tube element, 5 Inducer

The system of indirect heat radiation consists of two pieces of ceramic insulators (upper and lower) tube elements made of heat resistant steel and inducer. The inducer heats up the pipe detail and the pipe in its turn heats the radiation welded joint. Radiation heating system is attached to the underside of the table providing a device centric welding pressure.

The temperature of the welded specimens is monitored through feedback conducted through thermocouple welded to the upper capacitor fixing tool.

To achieve the necessary repeatability and get a chance to back up the results a

computerized management system was created.

The system consists of PC, controller and software. It works in real time with feedback on temperature, while the temperature regulation is done by adjusting the power thyristor preubrazuvatel of the frequency.

The pressure from the hydraulic system to the welded joint is managed by the relay controller. It is also possible to assign two different degrees of pressure Controller regulates and maintains the specified limits in the basic parameters of the welding process: the time of welding, the speed of heating (cooling), application (removal) of the pressure in two grades, retention time, and temperature of the welding in accordance with the specified program..

The system that manages the welding thermal cycle has the following major characteristics:

-number of thermal zones (areas where speeds are set to heating / cooling as a function of time) - 20бр.

-range velocities of heat - V_h = 1 to Z00 º C / min.

range-speed of cooling - V_c = 1 to 300 º C / min

-temperature heat T_{max} = 1200° C with an accuracy of of maintaining± 5 ºC

maximum-length cycle of welding 24 hours

The software for the controller can provide:

a) Setting and magnetic recording medium of the main parameters of welding cycle, temperature (T) and pressure (p) as a function of time.

b) Ability to repeat the welding cycle, without temperature feedback through sampling and retention of the power as a function of time.

The controller employs the installation of thermocouples from the type: nickel / chrome - nickel and platinum / rhodium-platinum. (NiCr - Ni and PlRo - Pl)

The programming is done by setting the necessary data in programming mode "Stage" (poz.1 of Fig.5).

In the № box of the program table is entered the serial number of the stage of implementation, afterwards it is entered the initial temperature and the temperature that is to be reached in the later stages, the rate of heating (if the stage is detention value of 0 is applied) and if there is force applied during the stage (value of 1 is applied). In the column "Time" the computer automatically calculates the time required to complete a stage..

All stages of the welding thermal cycle are described sequentially in the table and after the entering of the final stage the computer presents the cycle in a graphic form (poz.4, Fig.5).

In "Measurement" mode the operator can monitor the current temperature at its measurement point (poz.2, Fig. 5).

The computer system enables the recording of temperature and power during the performance of the welding cycle, which facilitates the work of archiving data from the experiments and enables verification of the deviations of the actual welding thermal cycle from the one that was set initially.

During the welding on the computer display the actual curve of the welding thermal cycle is shown parallel with the one that was set in ”Stage" mode.

The data from each experiment can be recorded on magnetic media, which also allows for archiving of results and for storing the parameters of the welding

procedures and if necessary repeating the welding cycle with or without feedback on temperature.

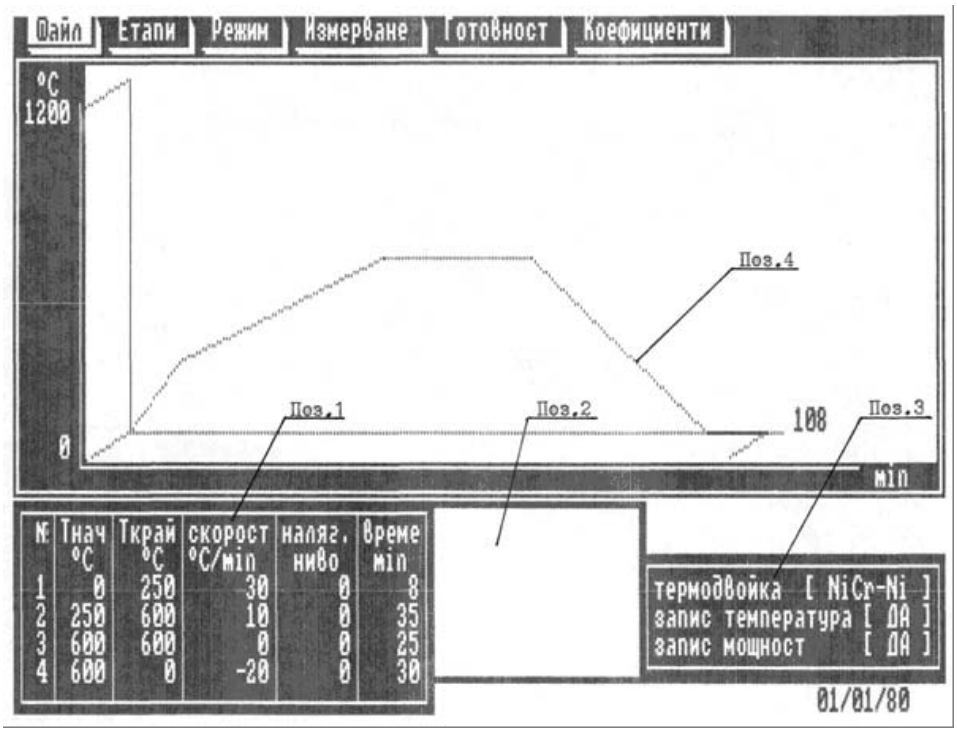

Fig.5 State of the display in programming mode

With the created system for vacuum diffusion welding with computerized and combined heating system were welded strong and solid joints with ceramics. They were subjected to mechanical tests, metallographic analysis, differential thermal analysis, electron microscopy and thermo-electrical measurements .

The high requirements to conduct the experiments led to the improvement of the installation for vacuum diffusion welding in the following areas:

Device for indirect (radiation) heating was created;

Special device was developed, providing centric pressures;

It was developed computerized management system that allowed the realization of complex thermo deformational cycles, archiving and processing of information from experiments using a PC and a possibility for recurrence of the cycle without the use of feedback on temperature.

All these improvements in practice created a new and better system that is adapted to both the modern research work and to the development of small series of diffusion welded joints with ceramics.

The study of the interaction between metal and ceramics in the process of diffusion- welding in vacuum lead to many results. Some of them help to clarify the processes in the contact area; others accumulates technological background in a promising field of modern technologies such as the joining of metals with nonmetals and allowing the successful combination of their advantages in constructions with new quality

REFERENCES

[1] Бадьянов Б. Н., Давыдов В. А., Паршин С. Г., “Сварочные процессы в Электронном Машиностроении”, Государственное образовательное учреждение высшего профессионального образования Ульяновский государственный технический университет, Ульяновск; Учебное пособие; 2007

[2] Казаков Н. Ф. „Диффузионная сварка във вакууме”, М.„Машиностроение”, 1968, 74 стр.

[3] Назаренко О. К. и др. “Электроннолучевая сварка“. М. „Машиностроение” 1966, 128 стр.

[4] Безручко, И. “Индукционный нагрев для обемной щамповки“, Л., Машиностроение,1987 г.

[5] Ямболиев Т. „Влияние на индукционното нагряване върху свойствата на съединение твърда сплав – стомана” Научни трудове на Русенския Университет - 2008, том 47, серия 2

[6] Iamboliev, T., Valkanov, S. Steel-Nard Alloy Joint Obtained by, Heating out of Induction Coil, Jurnal of Fundamental Scienses and Applications, Vol.15, 2009.

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