NEW METHOD TO ENHANCE THE WEARABILITY OF TITANIUM ALLOY ROTOR BLADE FOR AERO-ENGINE

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Abstract

In order to improve the wearability of damping platform of titanium alloy rotor blade of the aero-engine. Many technologies such as explosion spray. plasma spray.etc.have already been adopted in succession abroad to change the performance of the contact surface of damping platform between blades.These kinds of method have a lot of disadvantages such as the coating is apt peeling off.and unstable quality.etc.It is so hard to meet the request for the aviation products that developing a new welding equipment and technology become a task of top priority. This text has introduced the JQGP-80 type welding system and technology with domesticization material developed independently.The technological principle is that the mixture of hard alloy particles and solder are brazed onto the surface of the blade damping platform through high-frequency reaction heating under the circumstances that the vacuum operating unit is filled with the protecting argon atmosphere.The adoption of this technology has overcome the shortcoming of traditional method, improved greatly the wearability of titaniumalloy blade, and met the security and performance requirement of the engine and plane.

1 Introduction

The new material,technics and methode emerge in endlessly along with the development of science and technology to meet the need of national construction.Titanium alloy is used popularly in the manufacturing of aero parts.titanium aeroengine roter vane is one of it.But the capability which resist wear between metal is so low as to affect the performance and longevity of the aero plane.In oder to change the wear-resist capability ,many kind of methode had been tested such as explode spray,plasma spray etc.But all of that are very difficult to meet the need of aero part because of the coat shelling off and unstable quality.

Through investigation we know that a new welding methode has being used to change wear –resist capability of the vane in other country .In our country ,although related equipment had been introduced into by a few coporation ,but the welding technology and assistant material and tools are getting along with blockage state.

In oder to improve the rotor blade wear –resist capability , piercing thorough obstacle of the welding technology,developing related welding system,optimizing and selecting assistant material are all very important and valuable work to be down.

2 2. Technical difficulty

2.1 Lack of hardware and technical information

Because this methode is new welding technology,we have neither the experience nor the data information and experiment instrument.So the first urgent affairs to be down are developing related welding system .In this system ,many kind of technique such as vacuum technology, electric and electronic technology,autocontrol technology ,welding technology etc.are involved with,so there are more difficulty we have to face.

2.2 The blade material is so special as to form welding disfigurement easily

This welding methode is mainly used to weld TC4 or TC6 titanium alloy rotor blade of aeroengine.Titanium alloy have many better

performance ,such as light weight ,good erode-resist and hot stability.But it's chemical capability is vivacity so that it is difficult to weld them.The welding capability of TC4 and TC6 material was analysed as below:

1）The material become brittle because of being polluted by the clearence element

The titanium alloy appetency to oxygen,hydrogen and nitrogen are very strong.So the oxidation layer is formed easily and result tobogganing of the material's tenacity and Plasticity.Therefore,the oxidized layer must be wiped off drastically before welding and certain degree purity inert protection gas also must be offered during welding .

2）Material capability changing caused by the metallograph changing

TC4 and TC6 belong to α + β alloy,the content of alloy element is higher ,it could produce ω photograph,so the temperature should be controlled while welding to prevent changing of material capability.

3）Air hole come into being easily

The main reason which result the air hole comeing into being is that the material is polluted by the oil or water.The carry capability and tiredness intensity will reduce because of the hole comeing into being of the air hole. the size ,dimension and position of the air hole are all defined in the standard of all the country.It is very easy to produce air hole when welding titanium alloy ,and it is difficult to reduce them ,so it is a practical difficult problem to be solved ,and this question also is hotspot to be researched by the factory, research institute and academy.

2.3 The structure of welding joint is special and welding process is difficult

2.3.1 Characteristic of the welding process

Generally speaking ,during brazing process the melted filler metal profit the mother maerial to be welded and fill in the welding gap through capillary phenomena.But this welding is a special welding methode,during this process,the grain of hard alloy are studded and welded into the melted filler metal on the surface of the damp plateform of the blade. The structure of welding joint between this welding and general welding is obviously different,so the welding process is difficult.

In addition, because the size of blade damping platform to be welded is so small that the operating reachability is worse. In order to avoid the melted welding material flowing all around to the side of the protruding platform, the welding craft parameters we have to adopt, such as :the are borer material melting retention time are shorter ,the welding temperature are lower. in this case, it is unfavorable to discharge the gas and impurity from melting pool,and cause the inside Gas hole or dregs defect.

2.3.2 Difficult point of the welding craft

In order to avoid welding gas hole produced by pollution of air,control the welding quality and obtain the required performance of the blade, the following several problemes are to be well settled:

1)Develop the special-purpose mixing equipment, to enable hard alloy particles distributing evenly in the weld and guarantee the required performance.

2)Design high-frequency reaction coil, combine choicing the matched welding the craft parameter, to get the homogeneity of work piece heating temperature.

3)Control welding seam shaping, guarantee that the size is required.

3. Technical research

The technique research content mainly includes two following respects:

1)Develop specially the welding system (including welding auxiliary equipment).

2)Try to find out the domesticization material and the weld craft, optimize weld parameter. Work concretly as follows:

Seeking the optimum domesticization welding and auxiliary material .

Develop the reaction coil suitable for brazing the titanium alloy blade.

Optimize the welding parameter used for domestic material (welding voltage , welding current, welding temperature and so on).

Study the influence of purity of protecting atmosphere on tendentiousness of gas hole when welding.

3.1 The development of special welding

system

We have developed the JQGP-80 type welding system at first, this system is mainly made up by operating room , vacuum system , power system , temperature survey system , control system , cooling system , mixer and auxiliary frock ,etc.. Its main performance and characteristic data are sketched as follows:

3.1.1 Technical parameter

The effective area: diameter 800 mm , length 1200mm

Working pressure: 1.01* 105 Pa

Vacuity of limit: 5* 10-2 Pa

High-frequency power frequency: 66 kHz

High-frequency power: 80 kW

Voltage of the power: 3 phase 380Vs

Gas kind: High pure argon (Ar)

Press the rising rate: 2OPa/h

3.1.2 Welding system construction and the characteristic

1)Operating room of the vacuum

(1)The whole stainless steel structure vacuum operating room can prevent the titanium alloy part from pollution effectively .

(2)The operation glove pressure balancing system are specially designed to balance the internal and external pressure of the glove effectively , meanwhile , to avoid the infiltration of the atmosphere molecule , stop the source of pollution gas.

(3)The gate adopted the special pneumatic clenching type structure can be opened or locked through automation control, the self-adaptation seal under the positive pressure and negative pressure situation can also be realized, every Technical parameter such as short smoking vacuum time in this operating room, good sealing performance etc.,meets the production's requirement.

2)Vacuum system

Vacuum system adopt two group mechanical pump produced by Germany and pump made in China. The vacuity of limit reaches 5* 10-2Pa, there are also one mechanical pump connected parallelly in vacuum system separately which is used for realizing the dynamic circulation of the protection gas and the regulation of little negative pressure working state in the operating room.

3)High frequency reaction welding power

The heat utilizing the high-frequency magnetic field produced by high frequency reaction welding power within the metal is used for welding. With the development of semiconductor, the transistor power have many advantages :such as high dependability, output power adjusted conveniently , responding fast and accurate control, high efficiency. Through comparing and studying , we choose to use T G 80-66 types transistor high frequency power in this project.

4）The temperature survey and closed ring control

The temperature survey and closed ring control in enormous quantities small size work piece heated using high frequency reaction power is a difficult problem all the time in welding and heat treatment field. At present,the way of control Adopt looking method with eyes by operator basically. The operator disconnect the pedal switch of power when The temperature reach the requirement of welding, frequently turn on and off afterwards, until all the work piece is welded.

Some of similar import equipment adopt the photoelectricity to survey and control the temperature in way of turning on or off high-frequency power, these method’s have some shortcoming such as slow responding, worse control precision etc. so we adopt the infrared thermoscope made by America Company as examining component in this project to realized temperature survey without contacting the work piece . we also Select 818 meter imported from Britain for temperature controlling. and control peak value of the power of heating and base value through utilize the warning terminal port of 818 meter ingeniously, and control lower limit temperature using the contactless time relay and control base value of the power of heating and peak value time, realize heating temperature controlling evenly of work piece with the way of PFM modulation heating pulse companying with the inertia of system's self heat dissipation to meet the technological requirement. at the same time,it improved the working condition of high-frequency power and guaranteed the consistency of weld quality of the products.

5)Control system

The control system adopts DELTA ELECTRONICS.INC. Company DVP series PLC (DVP60ES00R),combined industry grade man-machine interface (Model PWS-3260-DTN HITECH)as whole coordinating core for welding system movements and working.

It has low prices, good system stability, having a good environment adaptability etc. DVP series offer WINDOWS (WPLSOFT) programming tool, it also have three order inputs way ,the procedure way , ladder picture way and order functional diagram (SFC), powerful auxiliary function , the readability is strong, and it is easy to safeguard. About The system controls principle picture please to see Fig.1.

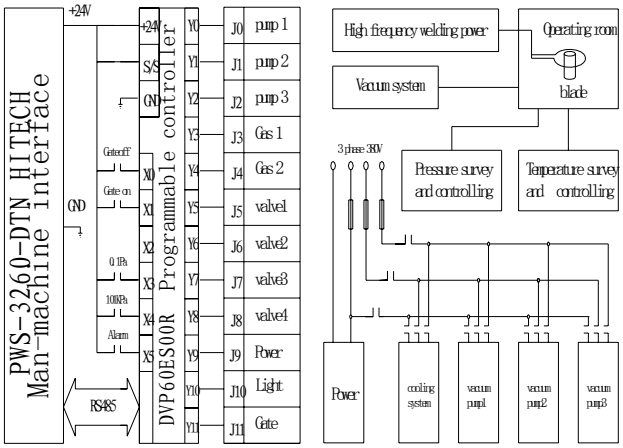

Fig1. principle diagram of contro lsysytem

6)The auxiliary welding equipment

We Have developed the Model JC-60 vibration type mixer。First ,mix the welding material with the special hard alloy particle in certain proportion and pack the mixture into stainless steel bottle, and then put the stainless steel bottle onto the JC-60 mixer through long-time vibration and mixing to get fully and evenly mixed welding material,by this means we has solved the homogeneity problem of hard alloy particle's distribution.

While making the solvent and sticking pharmaceutical, we have adopted the assisted tool , such as balance , moving the liquid tube , glue head burette ,etc.. to ensure the accuracy of proportion disposed .

3.2 the optimization of welding craft

The main craft problem which we face one is that the auxiliary material domesticization ,the other is that welding gas hole exceed standard in production. So, the focal point of working is optimumly seeking welding auxiliary material, optimizing the welding craft parameter, reducing the inclination of gas hole.

3.2.1 Optimumly seeking domesticization welding and it's auxiliary material

Through comparing testing, the welding auxiliary material chosen are as follows:

1) Solering material : B-Ti57
2) Hard alloy particle: W C
3) Poly methyl acrylic acid cube ester
4) Acetone
5) Xyol
6) Cube ester of acetic acid
7) Anhydrous ethanol
8)stop-off agent
9)High pure argon

3.2.2 The optimization design of the high-frequency reaction coil

Through Optimization design and adjustment about the induction coil circle's form, Circle quantity we have solved the homogeneity problem while the work piece is heated.

3.2.3 Reduce the gas hole inclination

In the experiment, we take the following measurements to reduce the inclination of gas hole.

1)Increase the material drying process, adjust the ways, such as the power of heating , heating time ,etc., on the one hand to reduce the gas source, on the other hand to ease going out of gas from the molten bath.

2)Improve the vacuity. The vacuity reached 1Pa before welding superioring to the ordinary welding requirement.

3)Adopt the high pure argon to control the atmosphere in the stove strictly , to reduce the impurity and the dew point of the atmosphere, avoid producing gas hole because of the

impurity pollution.

Because gas hole's production also have great relations with the moisture in the welding material ,hard alloy particles,solvent and welding parameter. So,in order to help gas in the molten bath go out easily while welding, we have adopted an unique technology with which the pressure of the working atmosphere can be adjusted to a litlle lower degree than normal , through testing we also have optimized and seeked the better parameter like weldeing voltage, electric current and heating time etc. to have reduced the appearing probability of the gas hole.

3.2.4 The optimizing of technological process and welding parameter

Through a large number experiments , the optimized welding process and welding parameter are as follows:

1)The compounding of welding auxiliary materials

(1) the proportion of hard alloy: 40% - 60%

(2) The proportion of brazing filler metal: 40%-60%

(3) mixing time in the special-purpose mixer: 1 6h

(4) Mixed alloy powder must be stored in dry sealed stainless steel container.

(5) Compound of special alloy soldering paste

Before welding, mix the binder and alloy powder evenly to get the special alloy soldering paste. Among them, the alloy powder accounts for 80%, the binder accounts for about 20% (the composition of binder is about 10%- 15%Poly methyl acrylic acid cube ester,the others are the compound of many special-purpose solvent).

2)Technological process

Through a large number of craft tests that the Confirmed technological process are as follows: the hard alloy powder Screening → drying of welding filler metal → Mixing → making the sticking pharmaceutical → Washing the surface to be welded → coating alloy soldering paste → Applying the sotp off agent → Welding → Inspection → Mend welding → Inspection. After finishing the damping platform welding of the blade back side, then carry on machining, and next carry on welding the damping platform of the blade basin side according to the above-mentioned procedure, and so on.

3)The optimumed welding parameter are as follows:

Welding voltage : 190 V
Welding current: 80 A
the flow of Protecting gas: 6 L / min- 8 L / min
Working vacuity of operating room: 1 P a
Brazing temperature: 945+15℃

3.3 Results and discussing

Fig. 2 shows the micro metallography of the welded blade using the above-mentioned optimumed technological process and parameter.

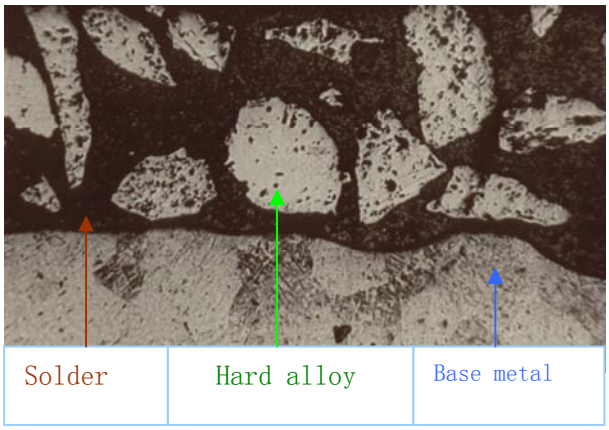

Fig2.The metallography picture of the weld

From Fig. 2 we can see that the hard alloy particles distributes evenly, the joint combined well, and the welded the blade have already passed the inspection of the quality standard.

While testing we still find that the blade comprehensive performance have great relation with the mixed proportion of hard alloy particles and the welding filler metal material while welding,see Fig.3 to get its relation.

When it is too high in proportion of hard alloy particles ,we can see it is apt to losing dregs; and the wearability will reduce by a large margin when it's proportion is too low, through a large number of craft tests, We have found :

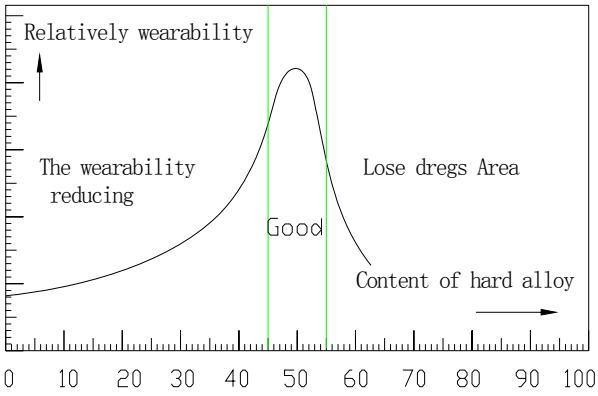

Fig3. Relationship between the proportion of hard alloy and wear-resisting

when its mixed proportion is between 40% to 60% ,the wearability of the blade and it's comprehensive performance are best.

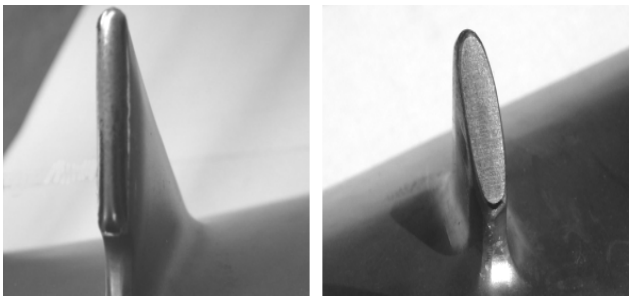

Fig4. The appearance of the finished blade

4. Conclusion

Through the research of this technique,we suc ceed in developing the special-purpose system of welding , and have grasped the welding technology of the domesticization material. We also have overcome the deficiency of various countries' similar technology and get some innovati to some extent, embody in concretly:

1)By means of adopting the way of PFM heating pulse frequency modulation the work piece heating temperature were controlled evenly. we have adopted more new technology, such as the pressure auto adjusting system with which the pressure of the working atmosphere can be adjusted to a litlle lower degree than normal to help the gas in the molten bath go out easily while welding, the self-adaptation Seal construction under the Positive pressure and negative pressure situation, have reduced the gas hole inclination ,and betterly meets the welding technological process requirement.

2)The welding system is reliable, easy and simple to operate and the system function is steady , that has filled the gap of the welding equipment manufacturing field in China.

3) Domesticization welding and auxiliary material's welding craft are steady, and have been used in formal production already,the work piece welding quality is superior to foreign countries standard level,and have received good remark by expertfrom practice application. The Development and application of this new technology have improved the titanium alloy rotor blade wearability effectively and indicate that the welding quality of blade can guarantee the performance of the aero-engine and the plane.

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