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Diffusion Welding of Nickel-based Superalloys

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Abstract

Ni based superalloys can be welded by diffusion bonding. Temperature, diffusion coefficient, activation energy and Boltzmann constant influence the quality of diffusion bonding, so obtaining the best condition for welding is considered. Showing the suitable condition for diffusion welding of nickel-based superalloys is the aim of this paper.

Keywords

Diffusion Welding, Nickel-base superalloys, Welding Parameter

1- Introduction

Ni based superalloys are considerably less weldable than cobalt superalloys. Because of the presence of the strengthening phase, the alloys tend to susceptible to hot and PWHT cracking. Hot cracking occurs in the weld heat affected zone and the extent of cracking varies with alloy composition and weldment restraint. So Ni based alloys can be welded by diffusion bonding.[1]

Diffusion welding is a solid state process that produces coalescence of the faying surface by the application of pressure at elevated temperature. The process does not involve macroscopic deformation or relative motion of workpieces. A solid filler metal may or may not be inserted between the faying surfaces. [2]

2- Diffusion Welding Parameter

Temperature, diffusion coefficient, activation energy and Boltzmann constant influence on the quality of diffusion bonding. One of the application of diffusion welding is joining of nickel superalloys such as Inconel 600, wrought Udimet 700 and Rene 41. A Schematic representation of diffusion welding using electrical resistance for heating is shown in fig1.

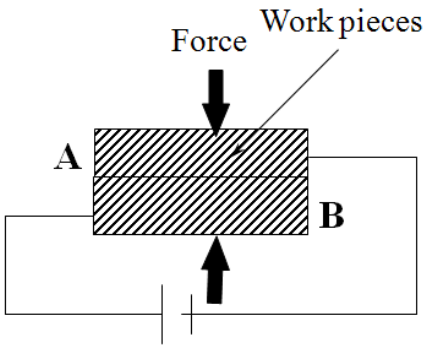

Figure - Schematic representation of diffusion welding using electrical resistance for heating

Diffusion welding of nickel superalloys is more difficult than with other alloys and there are many challenges in this procedure. The temperature is one of the most important parameters in diffusion welding of superalloys. It needs temperatures close to the melting point of the alloys. Table 1 shows the melting points and appropriate temperatures for diffusion welding of some superalloys.

Table - melting temperature and welding temperature of superalloys

superalloys	Melting temperature(c)	Welding temperature(c)
Inconel 600	1205-1260	1090
Haselloy X	1230-1285	1120
Wrought Udimet 700	1275-1340	1170
Cast Udimet 700	1300-1350	1190
Rene 41	1290-1345	1180
Mar-M 200	1315-1370	1205

In addition, because of high hot strength of nickel-based superalloys, high pressure should be applied. Also a clean surface is necessary for getting a high-quality bonding. Ambient atmosphere and surface oxides dissolving should be controlled. Nickel fillers are often used especially for rough surfaces. The time and pressure needed for each superalloy are shown in table 2.

Table - Time and pressure needed for each superalloy

superalloys	Pressure(psi)	Time(h)
Inconel 600	100-500	0.5
Haselloy X	100-500	4
Wrought Udimet 700	1000	4
Cast Udimet 700	1200	4
Rene 41	1550	2
Mar-M 200	1000-2000	2

Filler metal is particularly important for the quality of the diffusion zone. It is not possible to join materials without suitable filler metals. Filler metals for superalloys can be seen in table 3.

Table - Suitable filler metals for diffusion welding of superalloys

superalloys	Filler metal
Inconel 600	Ni
Haselloy X	Ni

Wrought Udimet 700	Ni-35Co
Cast Udimet 700	Ni-35Co
Rene 41	Ni-Be
Mar-M 200	Ni-25Co

3- Conclusion

1- Temperature, diffusion coefficient, activation energy and Boltzmann constant influence the quality of diffusion bonding.

2- Diffusion bonding needs temperatures close to the melting point of the alloys.

3- because of high hot strength of nickel-based superalloys, high pressure should be applied.

4- workpiece surface, ambient atmosphere and surface oxides dissolving should be controlled.

References

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