HVMC Diffusion Bonding Capability

Process Summary

Diffusion bonding is a method of joining two similar or dissimilar materials by application of high pressure and high temperature at the mating (or faying) surfaces between the two individual metal parts. The mating surface between the two metal parts is properly cleaned and often finished machined to provide an oxidation free and flat surfaces to create a sound joint througout the mating surface area. The process discussed here is solid-state type. However, liquid phase diffusion bonding process is also a variant [1].

Diffusion bonding of materials in the solid state is a process for making a monolithic joint through the formation of bonds at atomic level, as a result of closure of the mating surfaces due to the local plastic deformation at elevated temperature which aids interdiffusion at the surface layers of the materials being joined [2].

Process Advantages

- Diffusion bonding has the ability to produce high integrity joints with very good metallurgical (defect free interfaces) and mechanical properties.
- Joints created using diffusion bonding with optimised process parameters exhibit strength and ductility equivalent or better than the parent metals.
- Joining of dissimilar materials with different thermo-physical characteristics, which is not possible by other processes, may be achieved by diffusion bonding. Metals, alloys, ceramics and powder metallurgy products have been joined by diffusion bonding.
- No filler materials or solders are required to create a diffusion bond which makes this process cost effective from a consumables perspective.
- Diffusion bonding is free from ultraviolet radiation and gas emission so there is no direct detrimental effect on the environment, and health and safety standards are maintained.

Typical Applications

- Diffusion bonding is widely used in combination with superplastic forming (SPF) process to create light weight aircraft engine fan blades with hollow internal structure.
- Diffusion bonding is primarily used to create intricate forms for the electronics, aerospace, and nuclear industries.
- Since this form of bonding takes a considerable amount of time compared to other joining techniques such as explosion welding, parts are made in small quantities, and often fabrication is mostly automated.

Catapult capabilities

Equipment	Specification	Typical Applications
200T SPF press **At AFRC:** **https://www.strath.ac.uk/research/advancedformingresearchcentre/ourwork/ourequipment/hotforgingforming/**	- 200t press force capable of SPF and diffusion bonding of alloys - Control and monitoring system ensures close loop management for ram force, temperature and argon pressure - Static force from 200kN to 2000kN - Platen dimensions 760 x 760 mm - Max daylight 700 mm - Main ram stroke 500 mm - Tool thermocouples: 6 - Heating power 28 kW - Temperature accuracy at 920°C is ±10° - Number of gas lines: 3	- Forming of mid-sized single and multi-sheet structures with intricate design features. - Capable of SPF and diffusion bonding of various alloys.
1200T SPF press **At AFRC:** **https://www.strath.ac.uk/research/advancedformingresearchcentre/ourwork/ourequipment/hotforgingforming/**	- 1200t press capable of SPF and diffusion bonding - Overall dimensions h x w x d = 7656 x 6515 x 4499 mm - 2400 x 2000 mm heating platens - Machine control and monitoring system - Static force from 500 kN to 12000 kN - Max daylight 2000 mm - Main ram stroke 1500 mm - Tool thermocouples: 12 - Heating power 375kW - Temperature accuracy at 950°C is ±10°C - Number of gas lines: 3	- Capable of producing production sized parts (large aero-engine fan blades) through SPF and diffusion bonding. - Gas pressure forming capability.

Table1: Diffusion bonding capabilities at HVMC centres.

Figure1: ACB Loire 200T superplastic and diffusion bonding press at AFRC

Figure2: ACB 1200T superplastic forming/600T Hot creep forming press at AFRC

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References:

1. http://www.msm.cam.ac.uk/phase-trans/2005/Amir/bond.html
2. Kazakov N.F(1985, English version), `Diffusion Bonding of Materials', Pergamon Press.