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Roll Diffusion Bonding of Titanium Alloy Panels

An extensive research and development program was conducted in an effort to fabricate T-stiffened panel assemblies of a recently developed titanium alloy (Ti-8Al-1Mo-1V) by roll diffusion bonding. The titanium alloy was selected because of its highly favorable weight/strength characteristics for launch vehicle structures. Included in a report of the work accomplished in this program are descriptions of the design and fabrication of subscale and full-scale test panels, details of the laboratory testing and evaluation of panel specimens, and studies comparing the roll diffusion-bonded titanium alloy structures with equivalent aluminum alloy structures.

One major result of the program was the fabrication of quality roll diffusion-bonded titanium alloy panels which possess excellent strength characteristics under tensile and compressive loads. The following is a summary of conclusions that have emerged from this program:

1. The single-unit construction provides structural integrity at reduced weight in comparison with existing or similar aluminum structure.
2. Material properties in properly bonded joints are equal to or greater than parent material properties.
3. Sound, roll diffusion-bonded titanium T-stiffened panels are particularly strong in columnar compression and in tension.
4. Integral fillet radii, panel flatness, and close-dimensional control can be achieved in roll diffusion-bonded panels.
5. For the Ti-8Al-1Mo-1V titanium alloy, duplex annealed properties can be achieved by air-cooling the roll diffusion bonding packs.

6. To achieve successful bonding, titanium alloy components within the pack must be clean, and the contact between the titanium parts must be complete, intimate, and without intervention by foreign material.
7. To assure acceptable titanium alloy material quality, all possible precautions must be taken to remove contaminating gases from steel components within the pack, the pack must be fully purged prior to heating and rolling, and a vacuum of 200 microns or less must be maintained within the pack.
8. To assure best possible results in the roll diffusion process, the pack should be uniformly heated during a heating cycle which allows one hour per inch of pack thickness.
9. Separation of steel from titanium after rolling can be assured by replacement of commercially pure titanium alloy foil between steel and titanium alloy details.
10. To remove possible iron contamination from the titanium alloy, the diffusion bonded panel should be chemically milled to remove approximately 0.002 inch from all surfaces.
11. Inspection of bond joints can be successfully accomplished by the fluorescent dye penetrant process.
12. Limiting factors on pack size at this time are weight handling capacity, furnace opening dimensions, and rolling mill minimum and maximum width accommodation.

Several major obstacles must be overcome before roll diffusion bonding is accepted as a production process. Objectives to be attained include:

(continued overleaf)

1. An efficient, practical method of removing steel filler bars from titanium panels after the diffusion bonding operation.
2. Solution of the thermal expansion and contraction problem which, in this program, caused severe damage to titanium panels in the areas at both ends of the pack.
3. Cost reduction of precision machined steel filler bars.
4. Development of an acceptable method, other than welding, for making repairs to bond joints.
5. Utilization of a pack to produce the maximum quantity of diffusion bonded material in one heating and rolling cycle.

Notes:

1. Although this program was concerned specifically with launch vehicle structure development, the information made available should also be of interest in connection with applications to submersible craft and to other types of structure in which weight/strength ratio and integral construction are important considerations.

2. Complete details may be obtained from:
Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
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Patent status:

No patent action is contemplated by NASA.

Source: A. G. Jones, J. Bennett,
C. Muser, T. E. DeWitt, and F. Koeller
of North American Rockwell Corporation
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