Better Brazing

Study of Vacuum Furnace Atmospheres for Brazing Titanium Honeycomb Panels

Mass spectrometer analyses are made to indicate the presence of C, Co and CO_2 under four conditions

BY BRUNO DUMEZ

ABSTRACT. During the course of design of a vacuum brazing procedure for honeycomb titanium panels, vacuum furnace atmospheres were analyzed with a mass spectrometer. The vacuum furnace atmospheres in a hot-wall type cylindrical quartz vacuum furnace held at 2 to 4.1 X 10^{-4} torr were analyzed over a brazing cycle both empty and containing a portion of a graphite heating element. Values for C, CO, and CO_2 are reported for each case. Analysis of the furnace atmosphere was also conducted at temperature in a cold-wall vacuum furnace which utilized graphite heating elements, both in a clean condition and containing oxidized heat shields. Values are reported in graph form for C, CO and CO_2 for these two cases also.

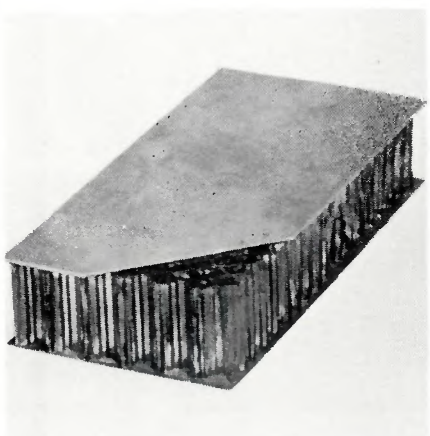

Fig. 1—Titanium honeycomb panel specimen

Introduction

In the course of designing a vacuum brazing procedure for titanium honeycomb panels (Fig. 1), the composition of several different vacuum furnace atmospheres was studied using mass spectrometry. The design of a vacuum brazing procedure for titanium honeycomb panels was undertaken in anticipation of the use of this material in the construction of the mach 3 aircraft of the near future. Other assembly techniques for these panels, such as diffusion bonding, have been attempted; but such problems as achieving intimate contact of the faying surfaces have limited their use.

With this in mind an investigation into the choice of brazing filler metal and the purity of the vacuum atmosphere required for the successful brazing of titanium honeycomb panels was undertaken.

Experimental brazes in 0.05 mm (0.002 in.) thick pure titanium strip were made using a 95Ag-5Al, a 72Ag-23Cu-5Ti and a 49Ti-49Cu-2Be brazing filler metal. All experimental brazes were made in a hot-wall, cylindrical quartz vacuum furnace. Subsequent to performing this portion of the work, Compton, et al.,[2] published complete data on the choice of filler metal for brazing thin foil titanium structures. From among the five brazing filler metals that they found suitable for brazing thin foil titanium structures, the 45Ti-45Zr-4.7Be-5Al brazing filler metal was chosen as most desirable for brazing titanium honeycomb panels.

DR. DUMEZ is general manager of ADMP, 2 Rue Phillippe-Dartis 2, 95-Saint-Gratein, France.

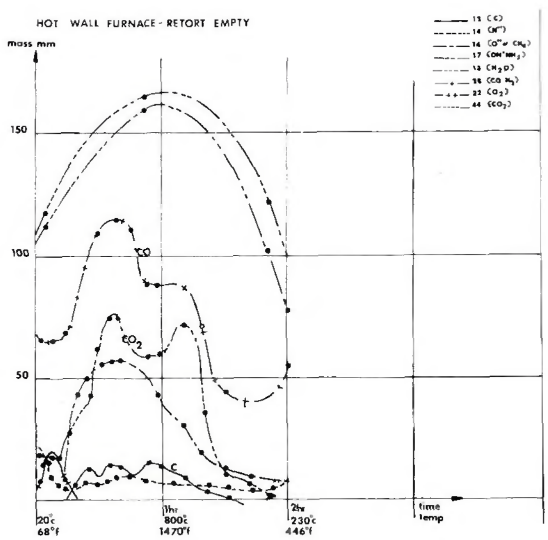

Fig. 2—Mass spectrometer readings of the atmosphere in an empty hot-wall quartz vacuum furnace during a simulated brazing cycle

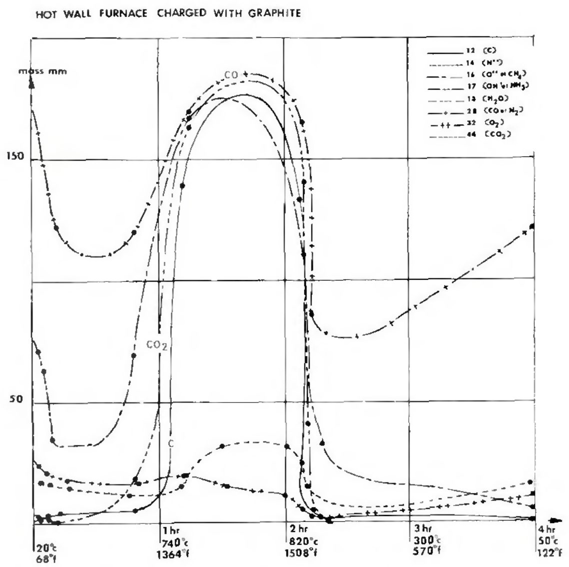

Fig. 3—Mass spectrometer readings taken in the same furnace as in Fig. 2, but with part of a graphite heating element included

Therefore no further work was conducted on this problem and no data is presented in this paper on studies conducted for the purpose of choosing a brazing filler metal for titanium honeycomb panels.

Attention was then turned to the vacuum brazing procedure itself. The rate of heating for brazing of the titanium honeycomb panels, which in production may reach 28 by 60 in. (71 by 152 cm) in size, must be fairly rapid and closely controlled. This eliminated consideration of the use of hot-wall furnaces for the vacuum brazing of the panels. Use of a cold-wall furnace utilizing molybdenum or tantalum heating elements of a size that would be required for vacuum brazing of these panels would be prohibitive from an economic standpoint. A cold-wall furnace of this type could be used economically if it was possible to use graphite heating elements without affecting the properties of the titanium brazements.

To determine the effect of the use of graphite heating elements on the composition of the vacuum furnace atmosphere, a mass spectrometer was used to analyze a variety of furnace atmospheres resulting from different furnace conditions with and without graphite heating elements. The results of these vacuum furnace atmosphere studies are presented below.

Vacuum Furnace Atmosphere Analyses

Mass Spectrometer Procedure

The mass spectrometer used for analyzing the vacuum furnace atmospheres was a QMM-16 quadripole type of French manufacture, with a resolution from mass 0 to 150, a preamplifier range up to 10^{11} ohms, and a test sensitivity of 10^6 ohms.

The mass spectrometer was used to scan the vacuum atmosphere during typical furnace cycles of heating and cooling for the furnace atmospheres studied. As the abscissa for the mass spectrometer curves shows, the length of time that these cycles lasted varied from two to four hours. The ordinate of these curves gives the mass of the various constituents of the vacuum atmospheres. The furnace conditions studied and the results obtained are given below.

Hot-Wall Furnace Atmosphere

For purposes of comparison, the first vacuum atmosphere analyzed was that produced in a hot-wall, cylindrical 3.9 in. (100 mm) diam. quartz vacuum furnace. The furnace was evacuated by mechanical and diffusion pumps. A thermocouple placed inside the retort was used to record the temperatures of the cycles. A heating cycle was run with the retort empty. The vacuum at the anticipated brazing temperature was between 2 and 4.1 x 10^{-4} torr. The mass spectrometer readings for the furnace cycle are reported in Fig. 2, as the temperature of the cycle was varied during heating and cooling. Note that the CO curve reaches 115, CO_2 reaches 75 and that the C curve remains very low.

Hot-Wall Furnace with Graphite

A portion of a graphite heating element which had not previously been heated was then placed in the same hot-wall furnace used for the first analysis, and a heating cycle was run. The mass curve versus temperature for this cycle is shown in Fig. 3. With the graphite in the furnace the C curve reaches 175 and consequently CO reaches 185 and CO_2 reaches 180 at the maximum temperature. Note the low O_2 content of the vacuum furnace atmosphere due to the fact that the O present has been decomposed to form CO and CO_2.

Cold Wall Furnace—Clean

An analysis was then made of the vacuum furnace atmosphere produced in a cold-wall furnace which used graphite heating elements (Fig. 4). The radiation shields in the furnace were clean. The furnace was 40 in. (1016 mm) in diam and 60 in. (1524 mm) high. At temperature, the vacuum held in the furnace was the same as for the hot wall type, 2 to 4.1 X 10^{-4} torr.

The results of the analysis of a heating cycle made with the mass spectrometer are shown in Fig. 5. This curve shows that C goes up to 170 at the maximum temperature, CO is fairly constant at 180 over the duration of the cycle, and that CO_2 is relatively low at 65 maximum.

Cold-Wall Furnace—Dirty

To determine the relative importance of cleanliness in a cold-wall furnace, oxidized radiation shields were installed in the clean cold-wall furnace previously studied. The vacuum at temperature was held to the same level as previous cycles, 2 to 4.1 X 10^{-4} torr. The results of the mass spectrometer analysis are shown in the curves in Fig. 6. The C content of the vacuum atmosphere was 170, the same as for the cold-wall furnace with clean radiation shields. The CO content reached 165, slightly less than for the clean furnace cycle, and the CO_2 remained relatively low at 120.

Conclusions

From the mass spectrometer studies of the vacuum furnace atmospheres above, it appears that bare graphite heating elements may not be used for the vacuum brazing of titanium due to the contamination by carbon and subsequent increase in oxidation potential of the vacuum furnace atmosphere.

In the future we intend to coat the graphite heating elements with alumina and determine if this will prevent carbon from the graphite heating elements from contaminating the vacuum furnace atmosphere.

Acknowledgment

This research has been made possible by the assistance of Mr. Ronteix of the Riber Company, France, who provided technical assistance in the mass spectrometer analyses.

References

1. *Brazing Manual,* AWS Committee on Brazing and Soldering, American Welding Society, 1963

2. Compton, W.A., Smeltzer, C.E., Malik, R.K. and Hammer, A.N., "Braze Alloys for Titanium Foil Structures", *Metals Engineering Quarterly,* Aug. 1968 American Society for Metals.

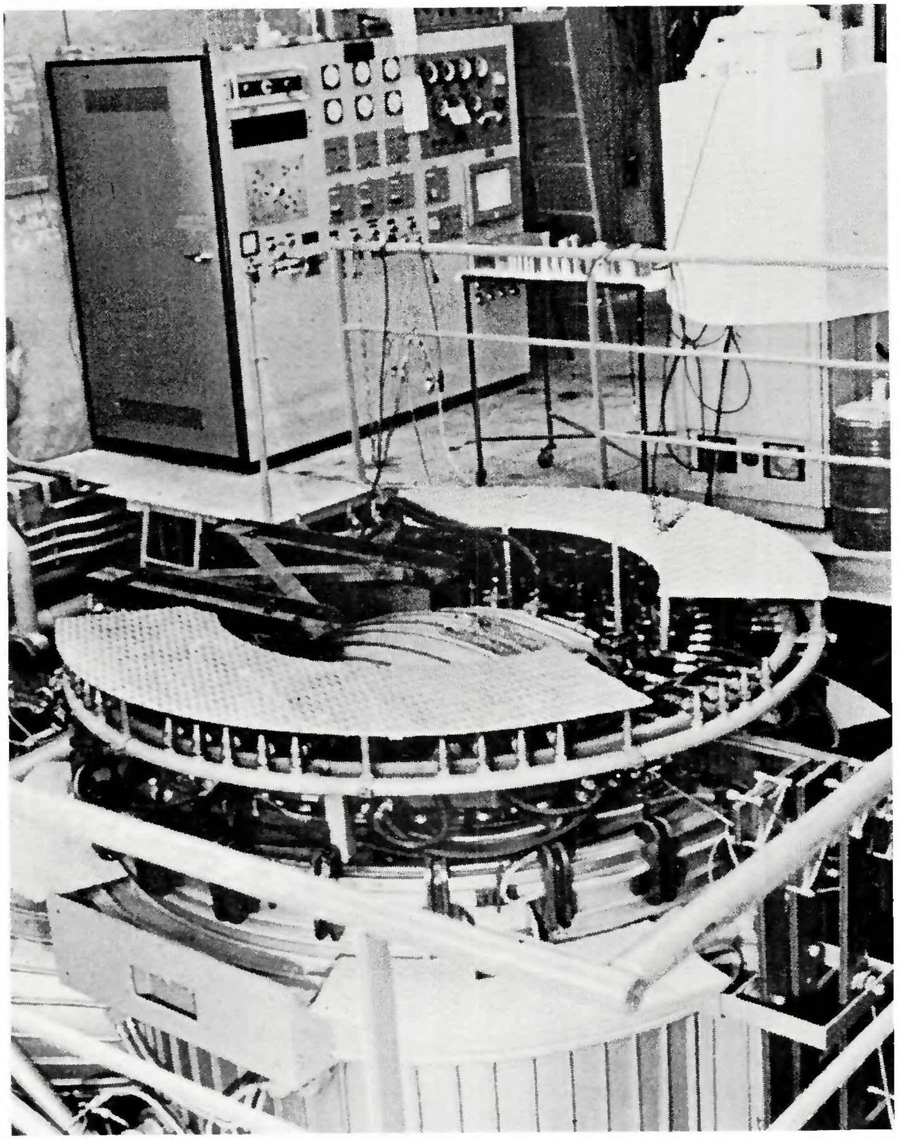

Fig. 4—Upper section of a cold-wall vacuum furnace that made use of graphite heating elements

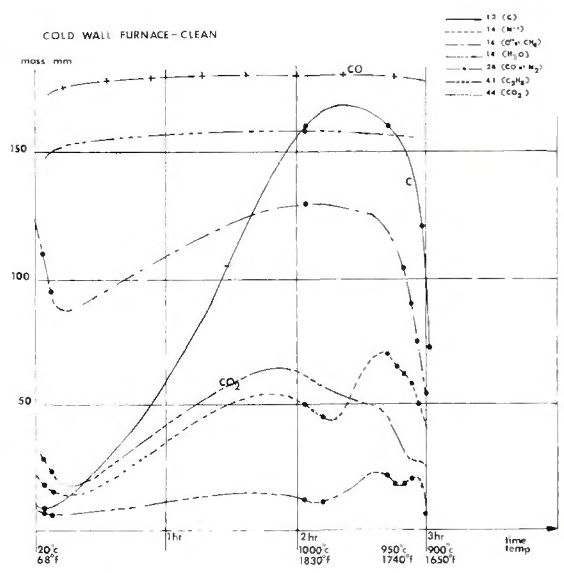

Fig. 5—Mass spectrometer readings of the atmosphere in a cold-wall vacuum furnace with graphite heating elements and clean radiation shields

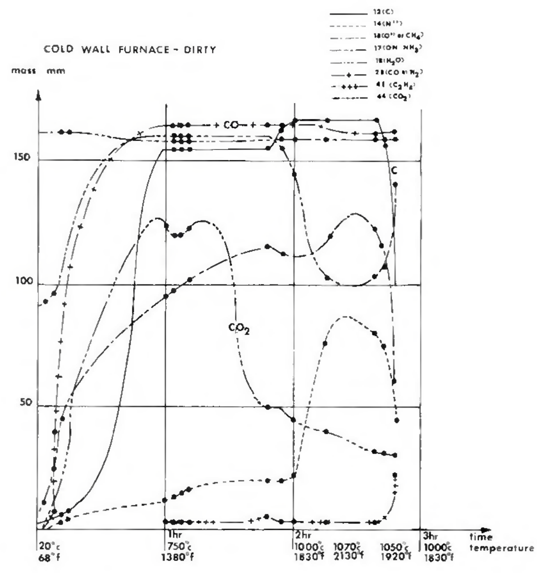

Fig. 6—Mass spectrometer readings taken in the same furnace as in Fig. 5, but with dirty (oxidized) radiation shields