# DMIC



## ALUMINUM

Interest in the development of fluxless methods of brazing aluminum continues. The 3-year NASA program at Aeronca has been completed and the final report issued (see June 3, 1966, Review of Recent Developments).[1,2] The conclusions drawn do not vary greatly from those previously reported. The feasibility of inert-atmosphere brazing of X7005 honeycomb sandwich structures using No. 719 brazing alloy followed by heat treating and quenching was demonstrated. Optimum results were obtained when the base metal was clad with the brazing alloy. Aeronca also identified two new brazing alloys that show promise. Brazing alloys from the Al-Ge-Si-Zn and Al-Ge-Si-Ag systems can be used at about 1000 F and do not diffuse into the base metal as much as commercially available materials.

Avco/Nashville is working on a program to establish the technology needed to fabricate complex aluminum header-to-tube heat exchangers by brazing without a flux.[3] Commercial brazing alloys are also being used in this program. The new brazing alloys under study are modifications of the aluminum-silicon system by adding copper, indium, and germanium. Perhaps the most important item of general interest revealed by this study is the discovery that extruded, thin-wall tubing can have surface defects that are revealed only during brazing. Others have reported similar experience when salt-bath dip-brazing 6061 aluminum, which can be related only to the condition of the filler wire used.[4] Capillary flow varies considerably even when wetting behavior is good. Vacuum heat treatment of the filler wire improves the capillary flow when this situation is encountered.

The use of vacuum brazing to fabricate aluminum assemblies, which requires that no post-brazing cleaning operations be incorporated, has been proven feasible at Martin.[5] Complex assembly parts are prepared after the usual cleaning methods by brazing with commercial filler alloy in a $10^{-6}$ torr vacuum. At the end of the brazing cycle, the assemblies are quenched in gaseous helium. The gaseous quench eliminates possible flux residues inherent in other aluminum brazing techniques and also prevents the formation of other compounds on the aluminum.

Some interesting comparative data on the mechanical properties of several welded aluminum sheet and plate alloys have been developed by Douglas in its stress-corrosion studies.[6] Table 1 and Figure 1 present these data. The objective of this program is to provide engineering data on threshold levels of stress for a 500-hour corrosive-medium exposure. A step-loading technique is being used. The stress-corrosion work is not far enough along for meaningful results. Also, the program has required some alteration because Alloys 7002 and 7016 have been discontinued by their producers. Alloy 2021 replaces these alloys.

A final report has been issued by Southwest Research on the feasibility of using getter elements to reduce or prevent hydrogen-induced porosity in aluminum welds.[7] Inert-gas tungsten-arc welds were made in Alloys 2014-T6 and 2219-T87 with the getters (titanium, zirconium, and calcium as essentially pure metals and mishmetal for cerium) applied by several different techniques. The results were negative; porosity was not eliminated or significantly reduced. In some cases, porosity was increased because of side effects. A number of other possible getters were also evaluated without success.

## NICKEL

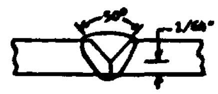
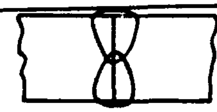
General Electric investigators are expanding previous research on TD-Nickel joining to TD-Nickel-Chromium (see the September 16, 1966, Review of Recent Developments).[8] The ultimate objective is to produce jet engine and aerospace components from the new dispersion-strengthened alloys. Oxidation studies of brazed joints in TD-Nickel-Chromium indicate this alloy reacts differently than TD-Nickel. The TD-Nickel is subject to external preferential oxidation, but the new alloy is not. Brazed joints in TD-Nickel-Chromium fail as a result of internal preferential oxidation of the brazing alloy at the joint interface. To overcome the internal oxidation, a new brazing alloy was developed by adding silicon to one of the alloys GE found best for use with TD-Nickel. The new alloy, called TD-50 (Ni-20Cr-10Si-9Mo-21Fe-2Co, max) produced joints in TD-Nickel-Chromium which were not subject to gross internal oxidation.

The Solar program on yield-strength-controlled diffusion bonding includes the fabrication of a combustion can and a cooling panel to be made from TD-Nickel.[9] A new technique has been developed to gain an improvement in lap-joint strength and ease of production. Three joint concepts were tried: prebeveled, serrated, and included-molybdenum wires. The high-temperature strengths of these joints are shown in Table 2. The strength of the prebeveled joint is about the same as that of a joggled and scarfed joint, but the forces in the short transverse direction of the base metal are lower when it is used.

Two recent articles in the open literature should be of value to those who desire to weld

TABLE 1

TIG DCSP PARAMETERS FOR WELDING ALUMINUM SHEET AND PLATE

| Base Metal | | Filler Wire | | | Tungsten Electrode | | | Weld Travel | Current | Arc Voltage | Shield Gas | | Joint Design & Pass Sequence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alloy | Thick | Alloy | Diam. | Speed In/Min | Type | Dia. | Tip | In./Min. | Amps. | Volts | Type | Flow C.F.H. | |
| 2219 | .125" | 2319 | 1/16 | 81 | 2% TH | 1/8 | 1/16 | 43 | 210 | 12.5 | He | 50 | |
| 2014 | .080" | 4043 | 1/16 | 65 | 2% TH | 1/8 | 1/16 | 43 | 125 | 13 | He | 75 |  |
| 7002 | .125" | 5180 | 1/16 | 75 | 2% TH | 1/8 | Point | 17 | 140 | 13 | He | 40 | |
| 7106 | .090" | 5180 | 1/16 | 66 | 2% TH | 1/8 | Point | 42 | 150 | 11 | He | 40 | For 7002 Alloy Sheet |
| 2024 | .080" | 4145 | 1/16 | 66 | 2% TH | 1/8 | Point | 44 | 125 | 13 | He | 40 |  |
| 7039 | .125" | 5039 | 1/16 | 22 | 2% TH | 1/8 | Point | 12 | 165 | 10 | He | 125 | For 2219, 2014, 7106, 2024 & 7039 Sheet |
| 2219 | 3/8" | 2319 | 1/16 | 10 | 2% TH | 5/32 | 5/64 | 6 | 385 | 12 | He | 125 | |
| 7039 | 1" | 5039 | 1/16 | 10 | 2% TH | 3/16 | 5/64 | 4 | 590 | 11 | He | 100 |  |
| 2014 | 1" | 4043 | 1/16 | 15 | 2% TH | 3/16 | 3/32 | 4 | 590 | 12 | He | 100 | |
| 2024 | 1" | 4145 | 1/16 | 11 | 2% TH | 3/16 | 3/32 | 6 | 590 | 12 | He | 100 | For all Plate |

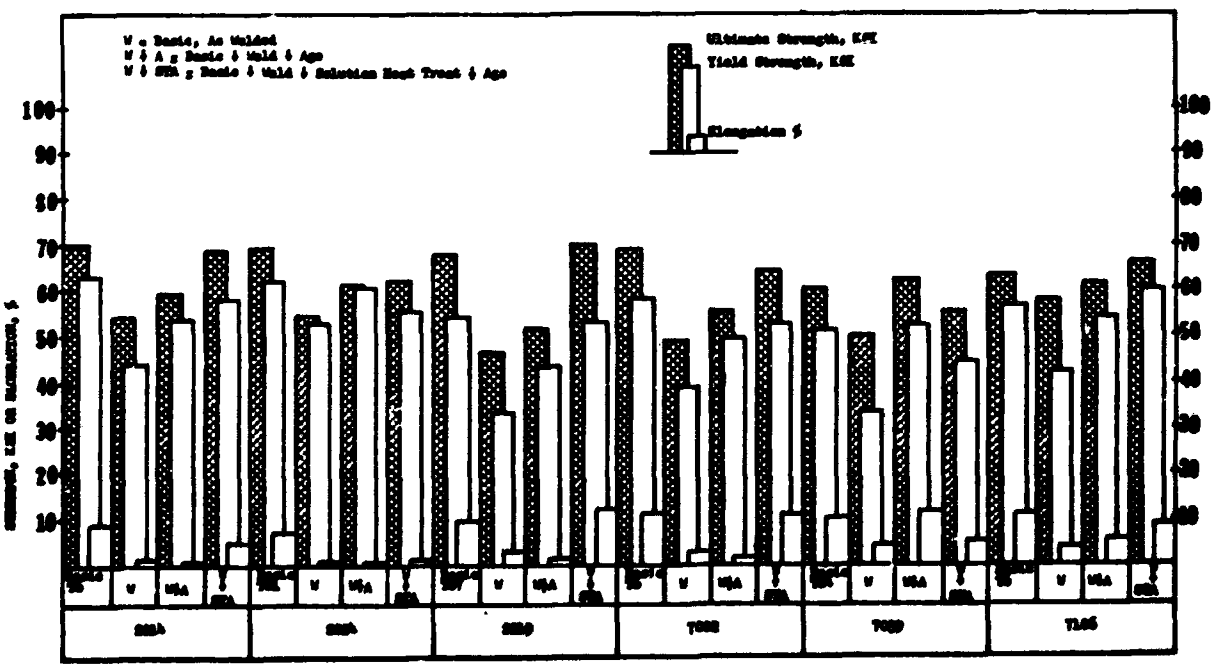



FIGURE 1. EFFECT OF WELDING AND POSTWELD HEAT TREATMENT ON TENSILE PROPERTIES OF ALUMINUM-SHEET ALLOYS(6)

TABLE 2. TENSILE-SHEAR STRENGTH OF DIFFUSION-BONDED TD-NICKEL JOINTS[9]

Test Temperature 2000 F; 0.030-Inch-Thick Material

| Joint Type | Average Joint Thickness, in. | Average Joint Width, in. | Average Overlap, in. | Average Tensile Stress, ksi | Average Shear Stress, ksi | Average Mode of Failure, percent: Parent Metal | Average Mode of Failure, percent: Delamination |
|---|---|---|---|---|---|---|---|
| Prebeveled | 0.0328 | 0.501 | 0.310 | 15.3 | 1.63 | 90 | 10 |
| Serrated | 0.0388 | 0.498 | 0.306 | 7.4 | 0.94 | 0 | 100 |
| Molybdenum wires in joint | 0.0339 | 0.499 | 0.298 | 12.1 | 1.36 | 90 | 70 |
| Joggled and scarfed (past work) | -- | -- | -- | 13.6 | 1.39 | -- | -- |

René 41, Hastelloy X, or nickel-base, high temperature alloys in general. The results of a microstructural study of simulated weld-heat-affected zones in René 41 are reported by Northrop engineers.[10] No new criteria are given for the successful welding of René 41, but a better understanding of effects on the microstructure can be derived from the report. The development effect required to establish the procedures for welding the forged parts for the nozzle of the Phoebus 2 rocket are outlined by Aerojet-General investigators.[11] The study included nondestructive testing, welding-operator qualification, filler-metal qualification (Hastelloy X), and repair welding.

## REFERENCES


(1) Kramer, B. E., and Potter, D. Y., "Development of High Strength, Brazed Aluminum, Honeycomb Sandwich Composites Adaptable for Both Elevated and Cryogenic Temperature Applications -- Volume I, Brazing Alloy Development and Selection", Final Report ER-986, Aeronca, Inc., Middletown, O., Contract NAS 8-5445 (September 30, 1966) DMIC No. 68066.

(2) Kramer, B. E., and Potter, D. Y., "Development of High Strength, Brazed Aluminum Honeycomb Sandwich Composites Adaptable for Elevated and Cryogenic Temperature Applications -- Volume II, Manufacturing and Testing", Final Report ER-986, Aeronca, Inc., Middletown, O., Contract NAS 8-5445 (September 30, 1966) DMIC No. 68067.

(3) Preliminary information reported by Avco Corporation, Nashville, Tenn., under U. S. Air Force Contract AF 33(615)-2783.

(4) Private communication with TRW, Inc., Cleveland, O.

(5) Schwartz, M. M., Gurtner, F. B., and Shutt, P. K., Jr., "Vacuum (or Fluxless) Brazing -- Gas Quenching of 6061 Aluminum Alloy", Report EATR, Edgewood Arsenal, Md. (March, 1967).

(6) Preliminary information reported by Douglas Aircraft Company, Inc., Aircraft Division, Long Beach, Calif., under U. S. Air Force Contract AF 33(615)-5419.

(7) Willhelm, A. C., "Study on Development of Saturn Manufacturing Technology for Welding Methods and Techniques to Reduce Hydrogen Porosity", Final Report, Southern Research Institute, Birmingham, Ala., Contract NAS 8-20307 (October 28, 1966) DMIC No. 67321.

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(10) Wu, K. C., and Herfert, R. E., "Microstructural Studies of René 41 Simulated Weld Heat-Affected Zones", Welding Journal, 46 (1), 32s-38s (January, 1967).

(11) Fletcher, C. W., Flens, F. J., and Glasier, L. F., Jr., "Welding of Thick Sections of Hastelloy X for the Phoebus-2 Nozzle", Welding Journal, 46 (4), 290-303 (April, 1967).


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