N66-19621

ANALYTICAL AND STATISTICAL STUDY ON THE EFFECTS OF POROSITY LEVEL ON WELD JOINT PERFORMANCE

PROGRESS REPORT, 18 FEBRUARY 1965

Presented at Marshall Space Flight Center by John F. Rudy - Martin Denver

NASA CR71053

I. OBJECTIVE

The objective of this program is to establish a correlation between defects — primarily porosity — and mechanical behavior of a weld. A more specific objective is to be able to use this relationship to derive working weld acceptance criteria. It is recognized that the industry is already in operation with not one, but several weld acceptance criteria. This program does not intend to duplicate these criteria, but to make them more definitive. In essence, the benefit of this program is to place the user in a position to confidently accept more defects in the as-is condition, so that the introduction of the specific defect, which is weld repair, will be minimized. This argument can be more fully appreciated when consideration is given to the reduction in mechanical properties which is caused by multiple repair.

II. DISCUSSION

The practical success of this program depends on the ability to make the criteria more definitive. If relationships for more accurate prediction of the influence of a defect are to be made, the defect must be more accurately defined in terms of those characteristics of the defect which influence the mechanical properties of the joint. Thus, we must develop a classification system which considers, in greater detail than present criteria, size, shape, and position of the defect with respect to the boundaries of the weld puddle. Once the classification system is derived, the relationship between the system and mechanical properties will be established by a straightforward empirical approach using statistical techniques.

The first task in the study of defects is to find the defects to study. The practical task to which the program has been addressed for the larger part of the effort to date, is to find a means of producing defects with sufficient predictability and consistency of occurrence to allow a statistically planned and efficient program to be conducted. If we are to obtain the

II. DISCUSSION (Continued)

required numbers of defects within a given classification, we must develop a technique for producing defects which introduces a minimum of welds which must be scrapped as good.

At the beginning of the program it was established that the defects which would be produced would be done so with a minimum of deviation from standard welding procedures. This is necessary in order that the influence which is measured reflects the defect itself, rather than the means which was used to produce the defect. Since current technical thinking attributes the larger part of porosity type defects to hydrogen or water vapor, artificial means of introducing these contaminants have been the primary experimental variables.

III. PRESENT STATUS

Contaminants have been introduced to weld beads by contaminating the surface of the weld filler wire, or by contaminating the shield gas which surrounds the electrode. Filler wire treatments have included the following:

1. As received.
2. 600°F dry atmosphere bake.
3. Surface cleaning with an alkaline solution.
4. Exposure of the wire to high-humidity, warm air.
5. Soak wire in hot water.
6. Anodize the wire with various current densities, bath temperatures, and times to obtain a porous coating.
7. Cathodically charge wire with hydrogen.

The above wire treatments generally did not give sufficient porosity, in the downhand welding position, to enable a broad range defect study. The anodized wires did give porosity, but not enough to provide the whole range of experimental interest. Perhaps later work on horizontal position welding will show more promise for these techniques.

The second technique, adding contaminant gas to the shield gas, has been more successful in providing a controlled and predictable level of porosity. We have added moisture up to a dew point of approximately +40°F, and hydrogen

III. PRESENT STATUS (Continued)

up to the ratio 15 CFH hydrogen to 80 CFH helium, and have added mixtures of the two gases in levels up to these values. Cross-section micrographs and x-rays were shown which demonstrated that, with flat welding, the high extreme of porosity which is of interest was obtained with a +25°F dew point, zero hydrogen; or with low dew point (as received), and 5/80 hydrogen. In the horizontal welding position "bad" porosity was obtained with lesser amounts of hydrogen and moisture. A conclusion from these data is that predictable levels of porosity can be obtained with horizontal welding at contamination levels which are sufficiently low to have a minimal influence on arc stability and arc heat input. Thus, a modification of the program was suggested which places the major emphasis on horizontal welding, which will be followed by verifications in the defect-porosity characteristic in the vertical and flat positions.

Side effects were illustrated in terms of arc current and arc voltage stability with various levels of contamination. Side effects were also illustrated in terms of bead surface, showing a deterioration in surface smoothness with increasing hydrogen or moisture.

IV. CONCLUSION

The conclusion which can be offered at this time is that the program has developed sufficient background information to enable predictable and controllable introduction of defects to aluminum welds. We had preliminary correlations between mechanical properties and defective welds to establish the range of experimental interest for a controlled statistical program. At this time, we are able to initiate the intentional defect program in a statistical fashion to develop the final correlation which is the objective of the program. Mechanical properties will be reported in both longitudinal and transverse tension, ultimate strength, tensile strength, bead shape, welding parameters, and elongation in gage lengths of .2, .4, .6, .8, 1.0, and 2.0 inches.