is associated with good appearance and soundness. Arc mode was not directly related to appearance, soundness or stability.

Weld metal porosity was the only type of metallographically or radiographically discovered defect. The porosity ranged from small (0.010 in. diameter) pores to larger, irregular voids. The latter were apparently caused by erratic solidification which, in turn, was caused by turbulant arc and puddle action.

Of interest was the definite correlation between even the small porosity and welding parameters. Filler metal feed rate was the only parameter significantly affecting weld soundness. Low filler metal feed speeds gave completely sound welds; high filler metal speeds gave large voids. The small pores occurred between these two extremes. Hypothetically, perhaps even the small porosity is caused by arc turbulence.

The accuracy of the results reported depends largely on the correlation between the experimental results and mathematical model derived from those results. The standard error of the calculated ratings gives an indication of how well the observed values and calculated values agree. Approximately 67% observed ratings or measurements will fall within ±1 standard error of the calculated ratings. Approximately 95% will be within ±2 standard errors. This assumes a normal distribution for the observed ratings.

Table 5 lists the standard errors of the calculated ratings. The standard errors for weld soundness and arc stability appear to be somewhat out of line. Calculated ratings of these responses should not be interpreted to be exact. However, the main objective is not to determine exact values, but to reveal trends. The indicated trends are not invalidated by inexact predicted ratings or measurements.

## Conclusions

The following conclusions should be considered applicable only to the particular conditions specified in the paper. The restrictions include material, welding position, arc atmosphere, and range of welding parameters.

1. The conclusions may be summarized as shown in Table 6. The summary shows the reaction of each of the nine responses as each main factor is increased. The responses move in the direction indicated by the arrows.

2. Filler metal feed speed is the single most important factor in gas metal-arc and pressurized inert gas metal-arc welding. Increased wire speed acts to decrease weld appearance, weld soundness, arc stability, and weld deposit width and will increase weld penetration, the depth-to-width ratio, reinforcement, area, and will cause the arc to operate in the spray mode.

3. Arc voltage was the most important factor in influencing the arc mode of metal transfer. As would be expected, increased arc voltage caused the arc to operate in the spray mode. Increased arc voltage also acted to increase arc stability, weld penetration, width, and cross-sectional area.

4. Increased welding travel speed served to decrease weld penetration, width, reinforcement, and area. Spray transfer was encouraged by faster travel speed.

5. Increased chamber pressure resulted in a decrease in weld appearance, arc stability, and weld width, and an increase in depth-to-width ratio, and overall weld area.

6. Using good weld appearance and soundness as criteria, a maximum weld depth-to-width ratio would result at 29 v, 800 ipm filler metal feed speed, 70 ipm travel speed, and 92 psia chamber pressure.

7. High filler metal feed speeds (above 1000 ipm) should be avoided because of poor weld appearance and soundness above this level.

8. Weld appearance and soundness generally occur together. A deterioration in one is usually accompanied by a deterioration in the other.

*Acknowledgments*

The efforts contributed by many individuals to complete the reported study are gratefully acknowledged. In particular, appreciation is expressed to J. K. Lynch of the Systems Group who gave meaning to the many numbers; to J. T. McLoud who designed and built the welding control system; to W. L. Bush and R. J. Merlini for their advice; to the Graphic Arts, Photography, and the Metallographic departments for their essential assistance; and finally to Miss Connie Wehr of Computer Sharing Services in Denver who helped to complete the involved matrix computer program.

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# USSR Welding Research News

By Rudolph O. Seitz

*Avtomaticheskaya Svarka* 22, No. 4 (April 1970)

- Erokhin, A. A. and Utlinskii, G. G.: The role of nitrogen in the formation of porosity in welding austenitic Cr-Ni steels.—It is shown that the cause of porosity in austenitic welds may be saturation of the weld pool with both hydrogen and nitrogen. In the presence of titanium and aluminum in the austenitic steel the weld porosity is substantially reduced. The authors advance the hypothesis that the beneficial effect of these elements is related to an increase in the nitrogen solubility (6-8).
- Marishkin, A. K. et al.: Electrode wire burn-off in the automatic welding with systematic short-circuiting of the arc gap.—Analytical proof is presented of the independence of the burn-off coefficient of the continuous or discontinuous burning of the arc (9-11).
- Makara, A. M. et al.:Effect of a soft layer on the properties of welded joints in high strength steels.—It is shown that the ultimate strength of welded joints in thermally hardened steels depends on the adhesive strength of the soft layer which is determined by its relative width (12-14).
- Lazko, V. E.: Influence of base metal composition on the susceptibility to brittle failure of joints in high strength steels.—It is shown that the effect of the alloying elements on the mechanical properties of the weld differs from the rules applicable to the base metal. The structure and the mechanical properties of the weld metal have been studied in relation to the alloying of high strength steels with silicon, manganese, chromium and nickel (15-19).
- Gotal'skii, Yu, N. and Struina, T. A.: Carbon distribution in the fusion zone of dissimilar steels in the presence of structural heterogeneity.—Experimental data are presented which show that in the fusion zone between dissimilar steels, where as a result of heating structural heterogeneity has been produced, decarburization takes place on the side of the less highly alloyed metal. The rate of progress of these processes is a func-

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with the higher solution treatments.

From the results presented it seems clear that, in applications where 718 weldment ductility and impact strength are important, a high-temperature postweld solution treatment (~2000° F for 1 hr) should be specified. Lower-temperature solution treatments do not provide acceptable ductility and impact values.

## Conclusions

1. Room-temperature mechanical property data have been obtained for alloy 718. Optimum tensile properties were obtained using a double aging treatment at 1325 and 1150° F and with a pre-aging solution treatment temperature around 1900° F. The impact strength can be improved by using higher solution-treatment temperatures (2000–2100° F) but this entails some sacrifice in tensile strength. The improvement in impact strength is a result of the absence of an embrittling grain-boundary precipitate which forms only during low-temperature solution treatments. It is of interest that this phenomenon completely overrides the increase in grain size which should decrease the impact strength. This grain boundary precipitate was not identified. It is formed as the result of exposure to the solution treatment temperature rather than by the subsequent aging process, since it was not present before heat treatment but was present after solution treatment at the lower temperatures. It was not affected by quenching from the solution treatment temperature, although some slight improvement in impact strength was accomplished.

2. Welding parameters for the gas tungsten-arc and gas metal-arc processes have been determined. Strict control of the welding parameters is necessary to ensure successful welds.

3. Mechanical properties have been determined for alloy 718 weldments. The tensile properties compare favourably with the metal except with respect to ductility.

4. Heat input in welding has a considerable influence on the mechanical properties of alloy 718 weldments. Low heat inputs give improved tensile strength, tensile elongation, and impact strength.

5. A Laves phase has been detected in the fusion zone of untreated weldments. It is suggested that the presence of this Laves phase is the reason for the poor impact and ductility properties of alloy 718 weldments.

6. Elimination of the Laves phase can be accomplished by using a high solution treatment temperature after welding. On exposure to temperatures of 2000° F and above, dissolution of the Laves phase occurs—and, on subsequent aging, the weldment possesses much improved impact strength and ductility.

### *Acknowledgements*

The author wishes to express thanks to J. Zabrodsky of the Canadian General Electric Company Ltd., Peterborough, for his cooperation and many useful discussions. Thanks are also expressed to J. Newbury and A. Blouin for their assistance in the experimental work and to Dr. R. Packwood for the electron-probe microanalyses. Finally, thanks are accorded to Dr. K. Winterton, Head of the Welding Section, for his interest and encouragement in this work.

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(*Continued from page* 520-s)

tion of the welding variables, although the chemical composition of the fused metals is not affected (20-24).

- Kotel'nikov, D. I.: Analysis of a joint between 1 Kh18N9T steel and Armco iron, obtained by diffusion welding.—The micro-X-ray and metallographic examination of such a joint has shown a range of transitional structures from the ferrite of the iron to the austenite of the 1Kh18N9T. Diagrams and formulas are presented for selecting the optimum welding parameters (25-27).

- Khrenov, K. K. et al.: Effect of vibration on joint formation in the cold welding of aluminum and aluminum alloys.—The effect of vibration on the specific upsetting pressure, the strength and deformation of single-point joints produced by cold welding has been studied. It is shown that the specific pressure necessary to form a joint is reduced by 30-35% and the deformation by 10-20% compared to static welding conditions (28-30).

- Kazimirov, A. A. et al.: Strains and stresses in welded joints in 01915 aluminum alloy.—An experimental study has been made of the transverse shrinkage and the longitudinal residual stresses in butt welds in 01915 aluminum alloy. It was shown that welded structures made of this alloy, if unstrained, undergo deformation in time (31-34).

- Kasatkin, B. S. et al.: Static strength of the top beam of the welded skip frame of a single cable lift fabricated from high-strength 14 kh 2 G M R low-alloy steel have been analyzed. The results have made it possible to revise some aspects of the calculation and of the design features of the projected welded skip frames (35-37).

- Lebedev, V. K. and Zavadskii, V. A.: Calibration of the welding current amplitude meters of resistance welders. —Apparatus for calibrating the welding current meters of resistance welders is described (38-40).

- Yunger, S. V. et al.: Effect of current polarity on the properties of the facing weld in the submerged arc welding of clad steels.—A special study with type 25-12 wire showed that in order to reduce the amount of fusion of the carbon steel and to lower the dilution of the alloy steel weld metal straight polarity must be used (41-43).

- Patskevich, I. R. et al.: Twin-arc three-phase welding in an external longitudinal magnetic field.—The method of twin-arc three-phase welding in an induced constant longitudinal magnetic field has been studied. It was found that the use of such a field improves the head formation and the stability of the welding process at higher speed (44-46).