Suggested topics for future research in resistance welding

By N. T. Williams (United Kingdom)

A number of "state-of-the-art" reviews have recently been carried out in the field of resistance welding, from which a series of areas can be identified where research should either be continued at a higher level of effort or where new research programmes should be initiated. The opportunity has been taken to summarise these areas in a single document which it is hoped could be used as a basis to generate appropriate work programmes in universities, research institutions or industrial research departments. The potential areas of research are listed in groupings depending on the main topic of interest and the list should not necessarily be construed as an order of priority.

In compiling this report, the author wishes to thank the following for their assistance :—

Dr. K. I. Johnson, Dr. R. Rivett—The Welding Institute, UK. Dr. D. Dickinson—Republic Steel Corp. USA.

Doc. IIS/IIW-779-83 (ex doc. III-752-83) submitted to Commission III "Resistance welding and related welding processes" of the IIW.
Dr. N.T. Williams is at the Research Centre of British Steel Corporation, Port Talbot, Glamorgan, United Kingdom.

1. Basic research

There is a need to develop a satisfactory model for nugget growth in spot welding. Back-up investigations aimed at giving this understanding include :—

(i) A computer modelling of the various stages of weld nugget growth should be pursued.

(ii) Determine the relative importance of surface resistance, bulk resistivity and interface resistance on weld formation.

(iii) Further evaluation of the effect of surface condition i.e. roughness, texture and chemistry on weld growth.

(iv) The validity of the critical expulsion limit should be confirmed and the relationship between this limit and the nominal current level required to make a satisfactory weld established. The factors which affect both these factors should be systematically determined.

(v) Determine the influence of the base material type on the shunting effects between adjacent welds.

2. Process developments

(i) Determine the importance of the mechanical characteristics of spot welding machines on weld quality.

Particular attention needs to be given to the influence of impact loads and follow-up characteristics on electrode wear.

(ii) The advantages or disadvantages of pre-programming the electrode load profile on spot weld quality.

(iii) Due to the need for more efficient usage of electrical supplies, there is an upsurge in the use of DC welding equipment. There is a need to determine the advantages or disadvantages of the available systems i.e. frequency conversion or secondary rectification for spot and projection welding.

(iv) Carry out a systemic comparison of AC versus DC welding systems for spot and projection welding.

(v) Quantify the effect of head approach rate when projection welding.

(vi) Optimisation of solid projection designs.

(vii) Determine the importance of seam welding machine design on weld quality.

(viii) Evaluate the potential of DC seam welding to high speed lap and mash welding of steel sheet in thicknesses up to 1.5mm.

(ix) Optimise welding parameters and electrode profile for narrow and wide seam welding at high welding speeds.

(x) Optimise parameters for weld bonding aluminium and steel and investigate means of ensuring consistent weld quality and adequate electrode life.

3. Control and instrumentation

(i) Development of more accurate sensors and instrumentation for the measurement of resistance welding parameters e.g. current, time, electrode force, dynamic resistance and secondary resistance of cables, secondary connections etc.

(ii) Develop suitable shop floor instrumentation to aid the more effective setting up of welding machines together with suitable calibration equipment.

(iii) Carry out a systematic comparison of existing monitoring and feedback systems and determine their effectiveness in a range of production situations.

(iv) Develop feedback systems based on multi-parameter monitoring.

(v) Develop and evaluate more effective computer control systems including multi-machine control of single and multi-spot welding machines.

(vi) Assess the economics of various control systems and their effectiveness in terms of efficient power regulation and usage for resistance welding machines.

(vii) Continue the development of effective computerised centralised control systems.

4. Electrode materials and design

(i) Evaluate, define and quantify the various mechanisms responsible for electrode wear with the aim of building up a computer model suitable for the prediction of electrode wear in any application.

(ii) Develop and investigate new electrode materials and designs.

(iii) Carry out additional work on the effect of electrode material, design and force on current density profiles and surface resistance.

5. Weldability of materials

In terms of the material being welded, the more important areas requiring urgent investigation include :—

5.1. Aluminium alloys

Because of the need to decrease the weight of commercial and passenger vehicles, the use of aluminium and its alloys is increasing in this particular application. In order to ensure that such alloys can be welded at the production rates encountered in the vehicle industry, the following investigations have to be completed :—

(i) Development of suitable welding procedures and techniques for spot welding of aluminium alloys.

(ii) Determine the causes of the high degree of inconsistency between welds when spot welding aluminium alloys and overcome this problem.

(iii) Methods of extending electrode life.

5.2. Steels

Despite the considerable amount of work which has been carried out on mild steel, a number of aspects require further investigation in order to give a full understanding of the process. In addition, arising from the potential increase in usage of high strength steels, it is necessary to investigate the problems which may inhibit the general application of these steels.

5.2.1. Mild steel

(i) Additional work is necessary to evaluate the effects of steel chemistry on weldability.

(ii) Determine the factors which control the type of failure on peel testing.

(iii) Influence of surface cleanness and oil films on weldability.

(iv) Projection welding of thin sheets of thickness $<$0.4mm.

(v) Develop techniques for welding "rusty" steel which are suitable for the repair of commercial and passenger vehicles.

5.2.2. High strength steels

(i) Determine satisfactory welding proceedures suitable for high production rates for the various types of high strength steels of yield strength up to 500 N/mm^2.

(ii) Evaluate various acceptance criteria for solution hardened, precipitation hardened and dual phase steels of yield strength in the range 250-900 N/mm^2.

(iii) Ascertain the cause and significance of partial plug failures on rephosphorised steels.

5.2.3. Coated steels

(i) Evaluate and define the mechanisms involved in electrode wear.

(ii) Determine the influence of coating type on the temperature developed at the electrode/workpiece interface.

(iii) Develop an effective weld through primer system.

(iv) Optimise projection design for various types of coated steels.

(v) Develop techniques and optimise welding parameters for seam welding of zinc, iron zinc and aluminium coated steels.

(vi) Assess weldability of new coated steels developed with a view to overcome the problem of electrode contamination.

(vii) Assess the corrosion resistance of spot and seam welds and investigate the effectiveness of various weld repair systems.

(viii) Develop welding techniques for laminates.

5.2.4. Stainless steels

(i) Optimise welding conditions for ferritic stainless steels.

(ii) Determine the stress corrosion characteristics of spot welds in ferritic and austenitic stainless steels.

(iii) The projection welding characteristics of ferritic and austenitic welds.

5.2.5. Non-ferrous materials

(i) The corrosion resistance of spot welds in Inconel.

6. Weld design

(i) Determine the engineering properties that a spot weld must achieve as a function of material properties, joint design and intended service requirements. The use of finite element analysis of actual parts will probably be required.

(ii) Optimise design stresses for resistance welds and to determine minimum weld strengths.

7. Weld testing

Additional work is required to correlate peel and chisel test results with the designed load-carrying capacity of the weld. In addition, the development of alternative "shop floor" type tests which may have better correlation with load-carrying capacity than peel or chisel testing should be undertaken.

7.1. Tensile tests

(a) Because of the wide variety of tensile test geometries, a stress analysis of critical spot welds in, for example, an automobile should be made and, from these data, several well-designed tensile test specimens should be selected such that the data obtained from these tests will be directly applicable to automobile design.

(b) In order to use spot weld strength in design, the relationships between single spot weld tests and multiple welds (as used in cars) needs to be perfected.

(c) Additional data should be obtained on the effect of specimen geometry, sheet thickness, weld diameter, electrode indentation, spot array, testing speed, welding procedures, testing temperature, and testing after corrosive environment exposure for both mild steel and high strength steels (using steels of automative thicknesses) should be generated.

(d) Using the above data, additional analytical approaches should be continued to predict spot weld tensile strength, based upon joint configuration, base metal strength and/ or chemistry, material thickness, nugget size, electrode indentation, post weld treatment, and testing conditions.

7.2. Torsion tests

(a) The torsion test should be evaluated as a testing technique for high strength steels.

(b) Correlations should be developed between torsion and tensile testing of spot welds.

7.3. Impact tests

(a) Very little data are available on impact tests of spot welds on high strength steels. Data should be obtained on the effect of specimen geometry, thickness, spot diameter (position in lobe curve), electrode identification, spot array, welding procedures, testing temperature, and testing after exposure to a corrosive environment.

(b) Work on impact collapse and energy absorption upon structural collapse of sheet metal sections should be performed in order to provide data for models.

7.4 Fatigue tests

(a) Additional data are needed on the effect of specimen geometry, thickness, spot diameter, electrode indentation, spot array, welding procedures, testing temperature, and testing after exposure to a corrosive environment.

(b) Additional work on the effect of random loading on high strength spot weld fatigue should be conducted.

(c) Work on finite element analysis of spot weld fatigue loading and fracture mechanics predictive approaches should be continued.

(d) Analysis of the fatigue strength required of spot welds in the components of an actual automobile should be performed.

8. Qualification procedures

(i) It is clear that the qualification procedures vary from company to company. This creates an inconsistency in trying to design an alloy based upon weldability. Therefore, a uniformly acceptable baseline procedure (with each company adding additional conditions, if needed) should be developed. This type of recommended procedure for high strength steels is being developed by the International Institute of Welding.

(ii) Variations in qualification results have been noted on the same material when tested in various laboratories. A round-robin testing programme would develop statistics on the accuracy and reproducibility of the qualification procedures, and accuracy of measuring equipment.

(iii) If several materials were used for the round-robin (including several plain carbon and several high strength steels of identical strength levels), statistics on the heat-for-heat variability and whether the test procedure is sensitive to these variabilities would be identified.

9. Robotics and automation

(i) The wider usage of robotic systems in autobody.

Announcement :

National Welding Seminar—**WELDING-'85**
will be held on December, 1985 in Calcutta.

—Call for technical papers has been circulated.
For further details contact :

The Hony. Secretary, Calcutta Branch
Indian Institute of Welding,
C/o, Advani Oerlikon Ltd.
P/6, C I T Road (Scheme No. IV)
Calcutta-700 014.