PROCEEDINGS for INTERNATIONAL CONGRESS ON WELDING RESEARCH

July 13 and 14, 1984

Sheraton-Boston Hotel
Boston, MA.

THEME OF CONGRESS:
WELDING RESEARCH IN THE WORLD AND THE CHALLENGES FOR THE 80'S

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General Co-Chairmen: Dr. G. W. Oyler, Executive Director, Welding Research Council, USA
Prof. Y. Arata, Director General, Welding Research Institute, Osaka University, Japan

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Dr. A. A. Wells, Director General, The Welding Institute (UK)

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C. Smallbone, Executive Director, Institute of Welding (South Africa)

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1. Analysis of World-Wide Welding Survey
   Dr. C. B. Shaw, Jr., Project Manager, Rockwell International Science Center (USA)

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PROCEEDINGS
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STATE OF THE ART AND PROSPECTS OF WELDING ENGINEERING DEVELOPMENT IN THE CMEA COUNTRIES

Dr. B. E. Paton

Director, E. O. Paton Electric Welding
Institute of the Ukrainian SSR Academy of Sciences
Kiev, USSR

The present report has been prepared in accordance with the proposal made by Dr.J.Škriniar, President of IIW, and in connection with the discussion of problems of R&D management at the Congress of Commission VII. Information for the report was supplied by six European Socialist countries-members of CMEA, i.e. Bulgaria, Hungary, GDR, Rumania, the USSR and Czechoslovakia, whose welding engineering reached the high standard and possessed the rich historical background.

Welding is a comparatively young technology of obtaining permanent joints which has radically changed the fabrication of metal structures. In 1981 by the decision of UNESCO the whole world marked the centenary of one of the greatest inventions of the XIX-th century, i.e. of electric arc welding (N.Benardos). As the analysis of peculiarities of the development of welding engineering shows even nowadays it remains the field where all industrial countries and lately the developing ones as well consider it necessary and expedient to carry out researches and developments on a large scale.

The common trend of welding engineering development in the CMEA member-countries in the last 5-10 years is the intensification and improvement of the quality. The annual increase in welded metal structure fabrication is over 3 million tons and within the next few years such high rates of growth will remain the same together with slowing down the further increase in the number of welders (Fig.1).

During last two decades the wide and well-equipped material-and technical basis of welding production, the branching network of training the engineering and scientific personnel, of research design and technological institutes with experimental and pilot-production enterprises were created. There are practically in all European CMEA member-countries scientific-research centres, acting as a leading organization in welding in a country as a whole or in the largest engineering industry. All this considerably rises the contribution of scientists and specialists of the CMEA member-countries to the world fund of knowledge on welding engineering (Fig.2). If we consider only the fundamental and theoretical works among the total number of publications, this contribution will be even more significant, i.e. more than 55%.

Our countries can solve on their own any complex operational problems and create the necessary scientific stock for the future in the field of metal welding due to the sufficiently powerful and versatile scientific potential and also to the wide scientific-technical cooperation, the importance of which can scarcely be exaggerated.

The specialists from the CMEA countries work successfully in many Commissions of the International Institute of Welding and are seriously concerned with the expansion of these activities, with finding the new efficient forms of the international cooperation.

To jointly solve the most important scientific and technical problems in the field of welding within the scope of CMEA, the Agreement on Cooperation was made in 1972 and the Coordination Centre on the problem "Welding" was organized on its basis.

A welding institute or a scientific-production complex is singled out as leading one from each cooperating country, namely: Welding Institute (Sofia, Bulgaria), Machine Industry's Institute of Technology (Budapest, Hungary), Central Institute of Welding (Halle, GDR), Welding Institute (Gliwice, Poland), Welding and Material Testing Institute (Timishoara, Rumania), the E.O.Paton Electric Welding Institute (Kiev, USSR), Welding Research Institute (Bratislava, Czechoslovakia). Other national research and design institutes, industrial enterprises participate in the work of the Centre as well. The joint activities and the works performed at the national level cover the main fields of welding science and engineering.

When assessing the welding achievements and development prospects, one should proceed from the main task of welding production, i.e. the rise of reliability and efficiency of welded structures which are the final product of welding engineering.

The level of adaptability of welded structures for industrial application, the materials used, welding processes and equipment are of the decisive importance for saving the raw materials, power and labour resources in the welding production. In this connection the great attention is paid to the investigations in the field of improvement of mechanical properties and weldability of structural materials.

The concepts of the nature and kinetics of cold and hot cracks in the weld metal and the HAZ are clarified on the basis of the latest mathematical and physical methods. The investigations performed are taken as a basis for the development of new weldable steels, high-strength and structural general-purpose steels being among them, low-alloy steels suitable for electroslag welding without subsequent heat treatment. The data bank on mechanical properties of welded joints being formed within the cooperation scope will practically solve the problems on selecting the optimum technology for welding of various structures and materials in a short time and with minimum expences.

The elimination of brittle and fatigue fractures is the important direction to enhance the reliability of welded structures. The increase of cold resistance is undoubtedly associated with the selection and production of steels and welding consumables. Meanwhile, in a number of cases the most efficient are constructive and operational methods for increasing the reliability and endurance of weldments and structures. This direction of researches is of current interest today.

Main gas pipelines may serve as an example. The increase of yield strength and cold resistance of metal is known to cause the decrease of its relative resistance to fracture in a tough state. Therefore, to attain the simultaneous increase of steel strength, to ensure cold resistance required and higher resistance to the propagation of unsteady tough fracture is difficult enough, and, as far as 100 and more atmosphere pressure gas pipelines are concerned, it is scarcely achievable in the near future. This problem can be eliminated if to apply the multilayer pipes. Welding of such pipes of a relatively thin metal considerably increases their resistance both to brittle and tough fractures, when using commercial steels. The manufacture of such pipes has already been mastered in the USSR.

The fields of application of multilayer products and structures will be considerably widened. At present the positive results have been obtained in the USSR on the production of so-called quasi-laminated metal for welded structures, this metal preserving all advantages of commercial multilayer materials but at the same time possessing the considerably higher hardness.

The application of constructive and operational measures is justified for increasing the cyclic fatigue life of structures, because the fatigue strength resistance of welded joints does not practically depend on the mechanical properties of the base metal. It is proved that in the majority of cases the treatments of welded joints based on artificial application of high compressive residual stresses in the weld zones are the most efficient. Such measures include, in particular, the pulse (explosion) and ultrasonic impact treatments developed in the USSR.

Metal consumption of welded structures will continue to decrease due to the wide application of high-strength steels, particularly, of low-alloy ones having the structure of tempered martensite or bainite. These steels successfully combine high strength with a sufficient ductility and cold resistance, they are satisfactorily processed and welded. The combination of structural materials, having various strength and service characteristics and also the billets of different kinds (of rolled stock, castings, forgings and shapings) in welded members, connections and parts of structures is very effective for decreasing the metal consumption. A number of intergrated scientific problems in the field of processing technology of fabrication and erection of various-purpose metal structures have been successfully solved. The computerized designing of structures is widely used, the standard and norms of design being improved. This contributes to the designing new structures which are efficient as to metal and labour consumption. The quantity of welds and their sections are continuously decreased, the line mass production is provided and the fast assembly with minimum welding operations is ensured.

The near future is unthinkable without the wide application of welded and glued structures of polymeric materials. The easy-to-weld thermoplastic materials are mainly used nowadays. However, in the not distant future the necessity will arise in broadening the operational possibilities of welding of materials, possessing the limited weldability, and of promising composite materials as well. The serious attention will be paid to the development of manufacturing welding processes, mechanized welding equipment and, first of all, that for site conditions, methods and means for NDT of welded joints of plastic materials. Welders of GDR have already great achievements in this field. Similar researches and developments are being carried out in Bulgaria and the USSR.

In the field of development of the technology of welding of certain kinds of structural materials one should mention the technology of copper welding without preheating (Poland), explosion welding of transition pieces of the "steel-aluminium-aluminium alloys" type (Poland, USSR), friction welding of dissimilar metals and alloys (Poland, USSR), technology of welding of stainless and heat-resistant steels of a martensite grade (Rumania, USSR).

Scientists of the CMEA countries pay a serious attention to the development of means and methods of NDT and the quality control in fabrication of welded structures and products. Good examples of this are the works performed in Hungary where mobile installations have been created for acoustic emission control both in the process of structure fabrication and under service conditions (Fig.3). Scientists from Poland, Rumania and the USSR have also scored appreciable successes in the field of NDT, thus providing the reliable fabrication of such important structures as spherical tanks for liquified gases, hydraulic turbine casings, etc.

Arc welding processes are the most widely spread ones in the whole world and they will continue to rank high in the near future, since the investigations being performed in this direction remain actual.

The wide application of welding in mixtures of gases, and, first of all, in two- or three-component mixtures of argon, CO_2 and oxygen, is very efficient. Such technology improves the weld formation, minimizes the metal spattering and ensures the high mechanical properties in welding of cold-resistant steels and in multipass welding of thick-walled structures. The technological peculiarities of four-component helium-based mixtures are investigated which most probably will increase the upper limits of welding current and at the same time provide good weld formation at higher welding speeds.

New efficient methods of minimizing the spattering in gas-shielded arc welding have been found. One of the methods consists in using wires, microalloyed with rare-earth elements (e.g. cerium). The method of activation of wires developed in the USSR and consisting in adding up to 5-7% of additional powdered materials into the wire alloyed with manganese and silicon should be recognized as an effective one.

The flux-cored wire welding, that ensures the high productivity and welding quality, including toughness of welds at low temperatures, has become the important type of the mechanized arc welding. The development of the new flux-cored wires considerably improved the method of automatic vertical and circumferential welding with a forced weld formation. This method is successfully used in manufacture of bodies of power-generating units of nuclear power stations, spherical tanks, position butts of pipes on routes of construction of the gas pipelines, in shipbuilding, machine industry and in other branches of industry and civil engineering.

The highly efficient process of submerged arc welding remains indispensable in manufacture of large diameter welded pipes, tanks and vessels in chemical and nuclear engineering, in shipbuilding and in fabrication of metal structures.

At present the important problems of weld formation, welding pool solidification, pore, crack and slag inclusion formation in welding using this method have been studied in the scientific centres of our countries. The modern highly mechanized production of fused and agglomerated fluxes ensuring the high welding speeds and the unique mechanical properties required, e.g., for arctic gas pipelines, has been created on this basis.

The interesting modification of submerged arc welding is a narrow-gap welding used in manufacture of thick-walled weldments mainly for the power-generating plants. Fluxes for low-alloy and high-alloy steels, developed in Czechoslovakia, allow to widely apply this method and simultaneously to considerably decrease the weldment manufacture costs.

The processes of non-consumable arc welding (pulsed, high-frequency, etc.) of sheet steels, aluminium-, titanium-based alloys and others are being developed in new directions. In the field of consumable electrode inert arc welding the unique technology has been developed in Czechoslovakia for automatic welding of impellers of powerful radial turbo-compressors (Fig.4).

The electroslag welding technology developed in the USSR is being further advanced. Lately the unique job has been performed in Czechoslovakia where this method was used for welding of frames of heavy rolling mill KVARTO 3000. Electroslag process has found its wide application in many other efficient fields, such as: manufacture of equipment for nuclear power stations, hydroelectric stations, surfacing , etc.

At present the countries-members of CMEA produce serially more than 360 grades of welding consumables and 730 grades of surfacing ones, thus satisfying the requirements of welding production. The cooperation in mutual deliveries and the specialization of production are carried out. Only in last years the welding flux-cored wires in Bulgaria, metal powders for plasma and gas surfacing, various solders, special coated electrodes, welding consumables for welding of steels for cryogenic engineering in Poland, ceramic fluxes, coated electrodes for welding of copper in Rumania, flux-cored wires for cast iron welding and underwater welding in the USSR has been developed and produced.

Among the methods of resistance welding, the flash butt welding is advancing most intensively, the USSR playing the leading role in the development of scientific fundementals of it. It will occupy one of the main places in constructing the main gas and oil pipelines. The advantages of resistance welding are most obvious in constructing the 1220-1420 or more mm dia. pipelines in the far North regions. The works of Soviet scientists and specialists of the E.O.Paton Welding Institute on creation of the pipe welding installation "Sever" (Fig.5) have become world-famed. The specialized resistance butt welding machines for mass production of welded-cast, welded-forged and other pieces with a total cross section of up to some hundred thousand square millimeters will be further developed. The USSR is the leader of standing reputation in the development and manufacture of such machines.

Other methods of resistance welding, i.e.spot, projection, seam welding, get a certain development. For example, the progressive technology and equipment for projection welding of sheet metal sieves used for preparation of condensates in power engineering have been developed in Poland. The unique system of automatic control over a process in resistance spot welding, ensuring the uniform quality of spot joints within the relatively wide range of conditions, has been developed in Czechoslovakia. The application of this system decreased the number of welded spots and increased the electrode life. Experts from GDR greatly contributed to the development of method and technology of magnetically impelled arc welding.

The integrated mechanization and automation of welding processes are used as the main means of intensification of welding production in the CMEA countries. There are considerable successes in this direction last years, this being clearly demonstrated on the example of fusion welding (Fig.6).

The new stage of welding technology automation is characterized by the application of computerized methods and equipment. The introduction of microprocessors allows not only to automate welding and accompanying processes, but to provide production with documentation, equipment diagnostics, technology control, etc.

The application of industrial robots signifies the new world-wide trend of the welded structure fabrication automation. Welding robots not only automate the multiproduct manufacture, but ensure truly automatic welding of joints of any shape at any spatial position (Fig.7,8). The efficient application of robots is provided due to program-controlled welding equipment, easy-to-adjust welding jigs, transport-orienting devices and also to the transition to flexible automated productions.

The module systems for automation and robotization (Bulgaria, GDR), the mechanized welding lines (Poland), the set of equipment of gantry and cantilever type with positioners (Rumania), the automated systems for technological preparation of welding production (Czechoslovakia) may be taken as specific examples of works performed in the field of the intergrated mechanization and automation of the welding production.

Welding equipment manufacture is being rapidly advanced in the CMEA countries (Fig.9).

Welding machines, power sources, welding process control systems, meens of integrated mechanisation and automation of welding and accompanying operations are continuously improved. The unification and unitizing of welding equipment, the intensification of welding operations by simultaneous welding of one or several workpieces with several welding devices or heads are being developed. Modern welding automatic machines are equipped with the unique tracking systems.

The new planetary welding wire feeding mechanism, which has been widely recognized in many industrial countries of the world, was developed in Bulgaria. The experts from GDR, Bulgaria and the USSR created the unified semi-automatic machine "INTERMIG/MAG" for gas-shielded arc welding on the basis of the best achievements in the field of equipment for the mechanized arc welding within the frames of cooperation (Fig.10).

The examples of other modern developments are as follows: