12 December 1960

WELDING THEORY AND PRACTICE IN THE PEOPLE'S REPUBLIC OF CHINA

By Yu. N. Gotal'skiy

U. S. JOINT PUBLICATIONS RESEARCH SERVICE
1636 CONNECTICUT AVE., N. W.
WASHINGTON 25, D. C.

F O R E W O R D

This publication was prepared under contract by the UNITED STATES JOINT PUBLICATIONS RESEARCH SERVICE, a federal government organization established to service the translation and research needs of the various government departments.

SUBSCRIBING REPOSITORIES MAIN FILE

University of Arizona
Tucson, Arizona

University of British Columbia
Vancouver 8, Canada

State Paper Room
British Museum
London, W.C. 1, England

Center for Chinese Studies
University of California
Berkeley 4, California

University of California
Berkeley 4, California

Government Publications Room
University of California
Los Angeles 24, California

University of Chicago Library
Chicago 37, Illinois

Librarian, East Asiatic Library
Columbia University
New York 27, New York

Wason Collection
Cornell University Library
Ithaca, New York

Council on Foreign Relations
58 East 68th Street
New York 21, New York

Duke University Library
Durham, North Carolina

The Fletcher School of
Law and Diplomacy
Tufts University
Medford, Massachusetts

Harvard College Library
Cambridge 38, Massachusetts

Center for East Asian Studies
Harvard University
16 Dunster Street
Cambridge 38, Massachusetts

Harvard-Yenching Institute
Cambridge 38, Massachusetts

University of Hawaii
Honolulu 14, Hawaii

The Hoover Institution
Stanford, California

University of Illinois Library
Urbana, Illinois

Indiana University Library
Bloomington, Indiana

State University of Iowa Library
Iowa City, Iowa

Director, East Asian Institute
Columbia University
433 West 117th Street
New York 27, N. Y.

University of San Francisco
San Francisco 17, California

Librarian, School of Oriental and
African Studies
University of London
London, W.C. 1, England

Institute for Asian Studies
Marquette University
Milwaukee 3, Wisconsin

University of Michigan Library
Ann Arbor, Michigan

Michigan State University Library
East Lansing, Michigan

Continued

University of Minnesota Library
Minneapolis 14, Minnesota

Ohio State University Libraries
1858 Neil Avenue
Columbus 10, Ohio

University of Oregon Library
Eugene, Oregon

Pennsylvania Military College
Chester, Pennsylvania

University of Pittsburgh Library
Pittsburgh 13, Penna.

Princeton University Library
Princeton, New Jersey

Purdue University Libraries
Lafayette, Indiana

University of Rochester
Rochester 20, New York

Institute of Asian Studies
St. John's University Graduate School

McKissick Memorial Library
University of South Carolina
Columbia 1, South Carolina

Seton Hall University
University College
South Orange, New Jersey

University of Southern Calif.
Library
Los Angeles 7, California

University of Texas Library
Austin 12, Texas

Alderman Library
University of Virginia
Charlottesville, Virginia

Far Eastern Library
University of Washington
Seattle 5, Washington

Yale University Library
New Haven, Connecticut

Asia Library
University of Michigan
Ann Arbor, Michigan

Research Institute,
Sino-Soviet Bloc
P.O. Box 3521
Washington 7, D. C.

JPRS: 4266

CSO: 1288-S

WELDING THEORY AND PRACTICE IN THE PEOPLE'S REPUBLIC OF CHINA

[Following is the translation of an article by Yu.N. Gotal'skiy entitled "The Present State of Welding Science and Technology in the Chinese People's Republic" in Avtomaticheskaya Svarka (Automatic Welding), No 10, Kiev, October 1960, pages 82-93.]

A two-year tour of service in the Chinese People's Republic afforded the author of the present article a detailed familiarity with the present level of welding theory and practice in that country. It is nevertheless entirely conceivable that the exposition given here of several aspects of the matter will already have been outdated. The national economy of the CPR (Chinese People's Republic) is rapidly growing and expanding. For this reason it is quite possible that changes in the welding field may have occurred during the writing of this article which are not here accounted for.

The Organization of Scientific Research in the Field of Welding

By the end of 1959 there were 14 scientific research organizations in the CPR conducting studies in the welding field. Of this number, the Harbin Subsidiary (filial) of the Machinery-Construction Scientific Research Institute under the 1st CPR Machine-Building Ministry specializes wholly in this area. The rest are general-specialty institutes where welding research is being conducted by individual study teams.

Scientific research on welding in the CPR is also being carried on at nine institutions of higher learning which have specialized departments in this field. Significant work on welding is also being performed in a number of factory laboratories.

The staff membership level as well as the quantity and quality of equipment on hand at a number of scientific research institutions is such that they are already able to conduct research on welding at a modern level. Some institutions, on the other hand, have small welding teams (consisting of 8-15 persons) with an extremely meager basis for experimentation.

The Machinery-Construction Scientific Research Institute (NIIMASh -- Nauchno-Issledovatel'skiy Institut Mashinostroyeniya) under the 1st Ministry of Machine-Building, located at Peiping, is one of the major research institutions in the CPR. The Institute operates an experimental factory and four subsidiary institutions (filialy): the Shanghai Materials Subsidiary, the Shenyang Casting Subsidiary, the Wuhan Heat Treatment Subsidiary, and the Harbin Welding Subsidiary. In addition, NIIMASh has a machinery construction institute which trains personnel for NIIMASh itself.

Even apart from its subsidiary organizations, NIIMASh is concerned with an extensive complex of machinery-construction problems. Despite the fact that its subsidiaries deal with similar specialized matters, NIIMASh headquarters also operates casting, heat treatment, and welding departments.

Welding problems at NIIMASh are the province of a special bureau under the Thermal Metals Processing Division. The Bureau consists of 48 members. By 1960, the organizational structure of the Welding Bureau had become stabilized; it consisted of four specialized teams concerned with automatic and semi-automatic flux welding in a carbonic-acid gas atmosphere, shielded arc (electro-slag) welding, brazing, and equipment design. A laboratory equipped with everything necessary for the performance of experiments on all of the more widely-known types of welding has been placed at the disposal of the Welding Bureau.

The Bureau's plans for the coming years include the development of specific welding techniques for various products of the machine-building industry in accordance with manufacturers' needs. In 1959 the Bureau was conducting research on 13 topics; ten of these projects were completed in that same year, some of which found immediate application in industry.

The Welding Subsidiary of NIIMASh was founded in November 1956 with the prospect of its eventual development into an independent scientific research institute specializing in welding. For the first four years of its existence the Institute was quartered in the Harbin Polytechnic Institute building and made use of its welding department facilities. In 1960 the Institute received a new building of its own. In plans for the future, the Institute is envisioned as having four basic buildings and a number of auxiliary facilities.

As of January 1960 the Welding Subsidiary employed a staff of 192 members. Of this number, 22 were engineers, 16 were technicians, and the rest were workers, many of whom had completed their secondary education.

The organizational structure of the Welding Subsidiary is still in a state of flux. It consists of three technological laboratories (shielded arc welding, brazing, and electrical gas welding), a design bureau, and experimental workshop, as well as of a number of auxiliary and administrative offices.

Despite the lack of a sufficient experimental base, the Subsidiary collective has managed to complete a number of serious research projects.

One of the most urgent tasks faced by the Institute consists in mastering the presently known methods of welding, using these techniques for working out welding processes for specific items, and in providing technical assistance to factories. Serious attention is being devoted to the design and construction of various welding apparatus.

The Metals Institute of the CPR Academy of Sciences operates a welding bureau, which as of the start of 1960 consisted of about 30 staff members. The structure of this bureau has not yet been fully determined, and changes in accordance with the topics to be worked out. In 1959, for example, the bureau consisted of groups working in the following areas: brazing, shielded arc welding, alloyed steel welding, and special alloy welding.

The aim of this bureau is to do theoretical research on the welding and brazing of various metals. Attention will mainly be concentrated on the melting processes and heat diffusion for various metals, as well as on the problems of welding metallurgy.

At the present time the Institute's welding bureau has at its disposal a fully adequate experimental base and is housed in a good building.

The Materials Subsidiary of NIIMASh is a completely modern scientific research institution. It is concerned with the development of new machinery construction metals and materials, as well as with the investigation of both their technological and practical properties. Welding problems are handled by a special group within the technological section. This team is still a small one and is obliged to work with rather humble experimental facilities.

The basic task of the group is the testing of materials developed by the Subsidiary for their welding properties. A significant portion of the group's work has to do with working out methods of welding difficult materials (cast iron, etc.).

All of the organizations carrying on research in the field of welding organize their work in such manner as to satisfy all the various basic needs of industry. For this reason the majority of study projects are terminated, as a rule, upon the introduction of their results into industry.

As regards the nature of the research work, it may be said that it takes in almost all of the known types of welding. The thematic work plans list various problems of manual welding, automatic and semi-automatic flux welding, welding in a shield gas (helium, argon, carbon dioxide, and water vapor) atmosphere, shielded arc (electro-slag) and pressure welding, friction and ultrasonic welding, resistance welding, as well as different types of brazing, including the vibro-arc method. The results of much of this work have already been mastered by Chinese welders and are presently the subject of routine studies. There are, however, various problems which are being studied for the first time in the CPR, and are therefore the subject of preliminary laboratory investigations.

The Use of Welding in Industry

As the basic method of joining metals in various types of construction and manufacture, welding is used extensively in China's industry. Riveting is now very rarely employed. Such a wide use of welding, however, has come about fairly recently. Thus, in the majority of industries in the CPR, the greater part of the welding workload is still performed manually.

Manual welding in the CPR is on a modern level of development. All work is done with standard-quality electrodes. Most of these are manufactured by local factories and are of the same composition as the Soviet electodes OMM-5, UM-7, MEZ-04, UONI-13, etc. The utilization of imported electrodes is limited to special-purpose work, such as the welding of heat-treated and stainless steels. Welded joints have a neat appearance and are of a quality sufficient to satisfy all requirements.

Electrode-producing factories have been set up in the major industrial areas. These constitute either the old electrode workshops unified into single units, or what were formerly small mechanical plants now refurbished for electrode production. Their manufacturing facilities are equipped with old-fashioned apparatus, and production is consequently rather low. The largest of those are the Mu-tan-chiang Electrode Factory, and the Shanghai "Pinchen" and Building Ministry factories. In addition to these producers, there are a number of major machinery-construction enterprises which operate shops equipped with modern apparatus producing electrodes not only for their own needs, but for other factories as well. Among these are the Harbin Boiler Works and the Dairen Steam-Engine Factory.

Automatic flux welding is the most widespread method of mechanized welding in China. Shipbuilders were the first to employ this technique, and for this reason greatest proportion of flux welding is performed by this particular industry. At the major shipbuilding factories, all hull plating, with the exception of sectional assembly, is by this method (Fig.1). [Not reproduced here; captions follow text.]

Extensive use of this method is also made in boilermaking. Medium-pressure boiler tanks are welded in this way exclusively. In the building of high-pressure boilers, automatic flux welding is employed both in the construction of support beams used in boiler installation assembly (Figure 2), and in the making of header chambers (Figure 3). The boiler drum bottoms are also joined by means of automatic flux welding (Figure 4), although their cover plates, as will be shown below, are welded by the slag-shielded electric arc method.

Automatic flux welding is also widely used in the construction of railway cisterns (Figure 5) and other large-capacity metallic vessels (Figure 6).

A large amount of automatic flux welding is done in the construction of various types of cranes and crane-support girders, supporting beams, and other structural materials (Figure 7).

Automatic flux welding is also finding applications in other areas of industry in the CPR, although to a lesser degree. The method is being employed at the Ch'ang-ch'un Auto Works for joining the wheel rim to the hub. This operation is performed directly on the conveyor line. Steam-locomotive boilers are likewise flux-welded. Another application for this technique is in the construction of large power-transformer frames. The An-shan Metallurgical Group of Enterprises (Kombinat) restores worn rolling-mill rolls by automatic flew welding. The material used is steel 60 wire applied under a ceramic flux.

Semi-automatic flux welding is also coming into use in Chinese industry, although somewhat more slowly than the automatic method. It is mainly employed in shipbuilding (Figure 8). Recently, semi-automatic flux welding has been brought into use in the manufacture of reaction-column cover plates for chemical plants. These are in turn connected to one another by means of automatic flux welding. The column bottoms are welded on in a similar manner (Figure 9).

One of the reasons for the slow introduction of semi-automatic flux welding into Chinese industry is the inherent difficulty of guiding the electrode along the required seam area. For this reason, studies have recently begun in the CPR on the possibility of replacing semi-automatic flux welding with semi-automatic welding in a carbon dioxide shielding atmosphere. Results emerging from these studies have already served as the basis for the decision to employ the latter method in shipbuilding. Initial attempts have indicated, however, that the utilization of electrical gas welding in the shipbuilding industry is fraught with serious difficulties whose elimination will require further investigation of the method. The problem lies in the fact that air gusts along the ways, where most of the work is done, blow off the gas shield; this has the effect of producing vapor pockets in the seams.

The total volume of automatic and semi-automatic flux welding work in the industries of the CPR is still rather small. Only in isolated shipbuilding and boiler works does it attain a level of 40-50%. The cause of this lag resides in the shortage of welding equipment and materials in the Republic.

Most of the fluxes used are produced by the electrode manufacturers. Some of the major enterprises, the Harbin Boiler Works and the Dairen Shipyard for example, turn out not only their own flux, but electrode wires as well; special facilities have been set up for this purpose. There is as yet no centralized production of electrode wire or fluxes in the CPR.

The most widely used electrode wires being used in the CPR at the present time are the standard carbide (Sv-08) and manganous (Sv-08G, Sv-10G2) wires. Most of the flux employed is of the AN-348A, OSTs-45, and AN-8 type.

Beginning in the second half of 1958, the application of slag-shielded arc welding began to spread rapidly in Chinese industry. Prior to that time, the only enterprise to use this method was the Harbin Boiler Works, where it was employed for welding the longitudinal seams of thick-walled boiler drum cover plates (Figure 10). By the start of 1960 slag-shield welding was already being performed in 25. Most of the work by this method is done with the aid of plate electrodes, as in the case of the construction of cast and welded rolling-mill beds of various types (Figure 11).

Slag-shielded arc welding with plate electrodes was used in welding the frame bars of the "650" rolling mill. In shipbuilding this method is employed in welding the stems and sterns of ships under construction.

Plate-electrode slag-shielded arc welding in the CPR is so widely employed that it is used not only for straight seams, but for ring-shaped weldments as well. The latter type of welding with plate electrodes was, for example, performed in joining two castings (Figure 12) forming the funnel of a blast furnace loading apparatus. Plate electrodes were also used for welding the ring-shaped seams on the shafts of a 15000-kilowatt hydraulic turbine.

A number of factories have mastered slag-shielded arc welding by means of several electrode wires 3.0 millimeters in diameter. This method is used in the construction of a hydraulic press in which the massive components (head, traverses, column bases, etc.), formerly one-piece castings, are now made of welded rolled stock, while the one-piece forged columns, cylinders, and pressure tanks are replaced by welded castings. Multi-wire slag-shielded arc welding of straight and ring-shaped seams was mastered for this purpose (Figures 13 and 14). Maximum thickness of welded metal was 600 millimeters for straight seams and 300 millimeters for ring-shaped seams. Straight seams in 600-millimeter metals were performed by means of two A-372r assemblies placed opposite one another. Press head and traverse crosspieces, as well as other latticework components were welded by the mouth welding rod method especially mastered for this purpose.

Multi-electrode wire slag-shielded arc welding was also employed in the construction of a 72500-kilowatt hydraulic turbine shaft (Figure 15) and hydroelectric generator discs. The mouth welding rod method was mastered for welding on the stator blades in the above-mentioned hydraulic turbine. This technique is also being used in attaching the blades to the drive wheel of the turbine. Another use of the multi-electrode wire slag-shielded arc welding method is in the construction of welded-casting heads for a 1200-ton hydraulic press; wires used for this purpose are 3.0 millimeters in diameter.

Many factories in the CPR use slag-shielded arc welding in maintenance work. It has been employed, for example, in repairing the shattered piston rod of a 1-ton pile driver, reducing the diameter of overly-large drilled hole, welding back together a broken wedge setter in a 1200-ton hydraulic press, removing defects in castings, welding on rolling-mill bed lugs mistakenly omitted in the casting moulds, filling in cracks and nicks in cast-steel rolling-mill beds, etc.

Much valuable experience was gained in repairing damaged beater heads in cement factory crushers. The slag-shielded arc technique permitted the renovation of beater heads made of austenitic manganous steel (Hadfield steel) with the aid of ordinary properly coated carbide steel electrodes.

Of the other welding methods presently finding applications in Chinese industry, we might mention friction and pressure welding. The latter is already being widely used in boiler making, automobile manufacture, electronics, railway construction, apparatus manufacture, as well as in the making of measuring and cutting instruments. At the Harbin Boiler Works, all tubing in the heating-surface areas are welded by the pressure method exclusively. Friction welding has been mastered by industry to a lesser extent; it is employed only at some of the instrumental factories in the manufacture of combination drills.

The Manufacture of Welding Equipment and Apparatus

The production of welding equipment in the CPR was initiated back in 1953, at which time three Shanghai workshops were united to create the basis for an electrical equipment factory. It was not until 1956, however, that the factory began to produce welding apparatus exclusively.

The Shanghai electrical welding equipment factory is the only enterprise in the CPR specializing solely in the manufacture of welding equipment. In order to satisfy the ever-growing demand for this equipment, the factory has been obliged to constantly extend its productive base. The selection of equipment put out by the factory is also increasing from year to year. By 1957 it was manufacturing 47 types of welding machines, including pressure welders, welding generators and transformers, as well as automatic and semi-automatic flux welding apparatus.

Most of the equipment now being manufactured at the Shanghai factory is being built according to designs received from the Soviet Union (TS-17m, A-372r, ADS-1000-3, PSh-5, et al.).

Other enterprises in the CPR also produce welding equipment, but only on a single-order basis. These orders are usually issued to factories when it becomes imperative to speed-up the introduction of some particular method of welding. Such was the case, for example, in 1959 when there was an acute need to acquaint industry with slag-shielded arc welding. There are also some factories producing welding equipment on a regular basis, manual welding transformers in most cases.

Technical Training and Publication of Welding Literature

There was no specialized training of welders in the CPR prior to 1953. Engineering and technical workers in this field were former specialists in machinery construction and other vocations. At the present time there are welding departments at nine institutes. The first class of welding engineers graduated from the Harbin Polytechnic Institute in 1956. The other institutes will graduate their first classes in 1960 and later.

The training of skilled welders of medium technical qualification has been initiated at several technical schools.

Practical experience occupies an important place in the technical school training programs for welders. Each educational institution uses student labor for some type of industrial production work. Thus, the welding department of the Harbin Polytechnic Institute in its 1959 program had its students build large power transformers. Student-welders at the Peiping Polytechnic Institute produced steam boilers to be used in agriculture. All of the work connected with the organization of production is done by the students themselves.

All educational institutions in the CPR have appropriately equipped shops, or even small production workshops which also function as experimental facilities.

In addition to all this, other steps are being taken in China to satisfy the demand for engineering-technical workers. Various types of specialized training courses are held extensively.

The solution of problems in welding and in the training of specialists is facilitated by the publication of technical literature. The volume of material on welding increases from year to year. Much effort goes into the translation and publication of Soviet and other foreign works on welding. A monthly scientific-technical and industrial periodical entitled "Han-chieh" ("Welding") is published in the CPR. As of 1960 its circulation had reached eleven thousand copies.

A number of collections of papers on work performed at scientific research organizations and large factories carrying on welding operations is also being published. China's welders are showing a great interest in the achievements of welding theory and practice in the Soviet Union and other foreign countries, and are making a very determined effort at incorporating all innovations into industrial practice.

Over the eleven years since its founding, the People's Republic of China has made a gigantic stride in developing its national economy. There can be no doubt that the exceptionally hard-working people of China will progress even further. The Soviet people wholeheartedly wish them new success.

[Captions to Unreproduced Photographs]

Figure 1. Automatic flux welding of stock for ship's hull plating.

Figure 2. Automatic flux welding of support beams at the Harbin Boiler Works.

Figure 3. Automatic flux welding of header chambers at the Harbin Boiler Works.

Figure 4. Automatic flux welding of high-pressure boiler drum bottoms.

Figure 5. Railway cisterns constructed with the aid of automatic flux welding.

Figure 6. Automatic welding of large-capacity tanks.

Figure 7. Automatic flux welding of a crane girder.

Figure 8. Semi-automatic flux welding in a shipyard.

Figure 9. Automatic flux welding of reaction column bottoms.

Figure 10. Slag-shielded arc welding of longitudinal seams on thick-walled boiler cover plates.

Figure 11. Slag-shielded arc welding of a "1200" thin-plate mill.

Figure 12. Funnel of blast-furnace loading apparatus made of two castings welded together by plate-electrode slag-shielded arc welding.

Figure 13. Hydraulic press head constructed with the aid of slag-shielded arc welding.

Figure 14. Slag-shielded arc welding of a hydraulic press pressure tank.

Figure 15. Slag-shielded arc welding of 72000-kilowatt hydraulic turbine shaft.

10,106 -END-