SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1985
NSRP 0226

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1985 Ship Production Symposium
Volume II
Paper No. 1:
Overview of Panel SP-7 Welding

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 1985**	2. REPORT TYPE **N/A**	3. DATES COVERED -
4. TITLE AND SUBTITLE **The National Shipbuilding Research Program 1985 Ship Production Symposium Volume II Paper No. 1: Overview of Panel Sp-7 Welding**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230-Design Integration Tools Building 192 Room 128 9500 MacArthur Bldg Bethesda, MD 20817-5700**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**16**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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PANEL SP-7

WELDING

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Fiscal Year 1984 Overview

The Welding Panel, SP-7 completed another year of activity September 30, 1984. I believe that it can be safely said that we have had a good year and in the next few minutes, I will go over our panel activities for the year, let you know what is presently happening and give you the panel outlook for the future.

At the beginning of Fiscal Year (FY)' 1984, the SP-7 Panel had six projects in progress and seven projects approved and funded but not underway. During the course of the year, one of the projects - Evaluation of the Unimation "Apprentice" Robot - was terminated prior to completion because preliminary studies indicated that any potential benefit this equipment may have had for shipbuilding welding had been far surpassed by existing robot welding technology.

Two others of the six projects in progress were completed in FY 1984 and reports were printed and distributed. These were:

1. Out-of-Position Welding of 5000 Series Aluminum Alloys Using Pulse GMAW Power Sources.

   This project successfully demonstrated that full penetration butt welds could be made out-of-position and from one side of the plate. The welds were made with basic "off-the-shelf" welding power sources (costing less than $5,000), wire feeders, guns and accessories currently available to all U.S. shipyards. These projects were performed, utilizing the pulse welding mode of the power sources, on 5000 series aluminum alloy sheets and plates for marine applications. The welds met all specification inspection requirements for type and thickness of material; i.e. visual, radiographic and dye penetrant examination. Welding procedure qualification data was developed such that these techniques might be implemented in other shipyards *as* an improved cost effective approach to hull, superstructure, sheet metal and piping fabrication. It is also anticipated that fabricators of surface effect ships, hydrofoils and crew boats may find applications for some of the information developed.

2. Study of Fitting and Fairing Aids of U.S. Shipyards

This study was undertaken in recognition of the need for more accurate fitting in shipbuilding. Attempts to automate the higher deposition welding processes have met with limited success because the quality of fitting practiced in shipbuilding was and is not satisfactory for automatic welding without frequent operator intervention.

Inconsistent root gaps, non-parallel joint edges and uneven plate surfaces do not lend themselves to automatic welding, and many of the benefits that can be obtained as a result of automation are lost by virtue of an operator having to be in constant attendance. This fact becomes even more apparent when robots are introduced into the welding operation and it becomes immediately obvious that the quality of the weld is almost totally dependent on the quality of the fit-up.

There are at least two options to solving the problem of fitting inaccuracy as it pertains to automatic and robotic welding. The first and most obvious is to improve the accuracy and quality of fitting. This option, while perhaps not readily achievable due to a number of circumstances, is the most desirable in the long run. Robot evaluation projects at the Los Angeles Division of Todd Shipyards indicate that when the fitters were required to meet tolerances satisfactory for robot welding, the entire welding program benefitted and continued to benefit even after the robot evaluation was completed.

Contrary to how it may have sounded up to this point, this paper is not intended as a blanket indictment of fitting personnel and practices in U.S. shipyards. It is recognized that, at the very best, fitting is a difficult task. Shipbuilding materials are often less than ideal to work with, having been subjected to conditions beyond the fitter's control but which, nonetheless, become his responsibility. For example, problems 'start with the way materials are made. Stresses from rolling mills and heat treatments can cause problems during the fabrication process.

Mill tolerances are often excessive and can add up during fabrication and may result in localized stress and distortion.

Improper handling of such materials as plate, pipe, shapes and castings can have a detrimental effect on surface condition and dimensional accuracy. Incorrect and poorly performed burning and cutting operations contribute greatly to the inaccuracy of assemblies. The heat of cutting may cause shrinkage and other distortions which must be monitored and offset. Edge conditions must be held to specification or fitting and welding will be increased. Deformation also results when materials are mechanically formed on rolls and similar equipment. This causes stresses which will in turn cause distortion when the stresses are relieved by welding, cutting and heat treatments.

These problems encountered during fabrication of ship assemblies are well known and shipyards in the U.S. deal with them continually. Because these problems are shared by all shipyards, this study was initiated to document those devices and methods used by U.S. shipbuilders to combat these problems-and, where feasible, to recommend areas for improvement. The overall objective was to review the methodology for the use of fitting and fairing aids and assess the potential for improving the accuracy of fitting. This would result in reduced costs for materials, energy and labor by introducing the most advanced available techniques suitable to the individual yards. The need for greater accuracy in fitting and fairing to increase production cannot be over emphasized. This can only be achieved through the use of fitting to support welding rather than the use of welding to compensate for inaccurate fitting.

A second option, while not as desirable as improved fit-up, has become necessary to accommodate automatic and robotic welding. Due to the cyclic nature of shipbuilding and the highs and lows of employment, it is almost guaranteed that shipyards will have inexperienced burners and fitters; therefore, poor fit-UP. To compensate for this, programs are underway to develop systems that will overcome poorly fit-up weld joints. One of these, a through the arc sensing, microprocessor controlled seam tracker is the subject of an SP-7 project and will be reported on later in this meeting in a paper entitled "Tracking System for Automatic Welding".

In addition to these projects, the SP-7 panel had two other projects in progress which were initiated prior to FY 1984 and will be complete in Calendar Year (CY) 1985. One of these is entitled "Multi-Consumable Guide Electroslag Welding" (ESW) and has as its objective the development of the ESW process for joining 4" to 24" thick low carbon steel castings. Cast steel hull structural components have always presented unique problems for welding, fabrication and repair. With conventional multi-pass welding processes, the requirements for joint configuration and preparation; preheating and interpass temperature control methods; weld sequencing for distortion control and in-process dimensional checks, not only become fabrication bottlenecks but also critical welding process controlling factors.

The multi-consumable guide electroslag welding process provides an alternative to the above problems. This process can best be described as a welding technique which is based on the generation of heat by passing electrical current through molten slag. Its advantages include high deposition rate; high quality weld deposit; minimal joint preparation and fit-up and minimal angular distortion.

Even though the U.S. shipbuilding industry has used this' process, very little work has been done in the area of welding thick members. The application of the process would be directed toward the joining of rudder arms, shaft strut arms and other thick casting pieces. The electroslag welding process would significantly reduce the cost of weld fabrication and repair of these items.

Another project in progress in FY 1984 and complete in CY 1985 is entitled "Examination of Candidate Steels for High Heat Input Welding". This project has evolved as an offshoot of a much larger, earlier effort and came about in the following manner.

Modernization of shipbuilding methods and facilities which occurred during the 1970's in both foreign and U.S. shipyards, was directed toward improvements in welding technology. Higher deposition rates offered by automatic and semiautomatic processes offer substantial cost savings in many areas of shipyard welding.

Processes such as electrogas and electroslag welding of vertical side shell and bulkhead butts produce welds which offer better appearance and uniformity at substantially lower cost than manual stick electrode welding. Unfortunately, high heat input at comparatively low travel speeds adversely affects the toughness properties in both the weld and the heat affected zone

(HAZ). Charpy V-notch tests are the basis of evaluation used ABS and many other classification organizations to evaluate toughness. In view of the relatively large and increasing extent of these welds, it was felt that a more definite criteria of toughness should be established. Development of a project to establish tests other than Charpy V-notch to evaluate toughness; i.e. drop weight, dynamic tear and explosion bulge tests, entailed welding specimens of different grades and different chemical compositions of steel to be used in the testing procedure. Based on small scale impact test results, some of these steels appeared to not be significantly degraded by high heat input welding, and it was felt they would warrant full scale examination and testing. These facts became evident during previous studies made by the American Bureau of Shipping. It was recommended that these candidate steels be evaluated and subjected to a full range of weldability, nondestructive and destructive tests to determine their suitability for high heat input welding. The' benefits to be realized by shipbuilders through the use of steels that would allow the increased use of these high deposition processes were sufficient to convince the panel that the project should be undertaken. It is now complete and a report of the project will appear in the written proceedings of this Symposium.

In addition to the aforementioned projects, the Welding Panel has eight projects in progress which were initiated in FY 1984, and are still incomplete. - One of these, "Evaluate the Benefits and Determine the Feasibility of Twisted Electrode GMA and FCA Narrow Gap Welding" is sufficiently advanced such that a paper will be presented during this meeting. A second project which will be printed in the Symposium proceedings is entitled "Evaluate the Benefits of New High Strength Low Alloy (HSLA) Steels".

Three of the other six are initial efforts which are on schedule, within budget, with completion expected during CY 1985. They are:

(1) Cored Wire for Submerged Arc Welding;

(2) Benefits of Low Moisture Electrodes and

(3) Bulk Welding of High Strength Quenched and Tempered Steels.

The other three in progress are Phase II efforts of recently completed projects and are extensions of the original projects or are examinations in greater depth of the results of those projects. They are:

(1) Visual Reference Standards for Weld Surface Conditions

(2) Acceptance Standards for NDT of Welds Not Covered By Classification

(3) Tracking System for Automatic Welding.

'The preceding summary is an accurate account of the technical effort of our panel and one which we believe is effectively addressing some of the more pressing welding problems facing the U.S. shipbuilding industry.

The objectives and purpose of all of the panels that make up the National Shipbuilding Research Program are to engage in projects whose results will reduce the time and the cost of building ships. There are no written guidelines on how to do this; it is simply left up to the particular panel of industry respresentatives to determine how this can best be accomplished.

In the case of the SP-7 Panel, the collective knowledge, experience and wisdom of the panel members has been and is being utilized to develop projects that will provide the greatest measures of productivity increases and schedule reductions for the present and for the immediate future. These include application and implementation of currently available technology which provides immediate, quantifiable benefits and tend to exclude research and development of technology with only unknown or estimated benefits.

Successful completion and implementation of the projects previously described would provide immediate worthwhile benefits. For example, because of the strength and toughness required of the steel used in today's ship construction and repair, preheating is required prior to welding. This must be done to reduce the susceptibility of the weld and base material from cracking as a result of hydrogen entrapment during welding. The Welding Panel has two projects, each with a very different approach and scope of work, but whose ultimate objective is the same; the elimination of preheating prior to welding.

One of these is an evaluation of welding performed with extremely low moisture electrodes which reduces the likelihood of hydrogen pickup during the welding operation. The second involves evaluation of high strength low alloy (HSLA) steels which are not susceptible to hydrogen induced cracking and, therefore, generally do not require preheating. It is hoped that successful results from this project would allow substitution of these steels for some of those presently being used which require preheat, thereby eliminating the need for this very costly requirement. (It has been estimated that the elimination of the preheating requirement would result in a savings of one million dollars per ship on certain type Navy ships.)

Another example of evaluating and implementing existing technology with high potential for cost/schedule reduction is the previously mentioned project to further develop, refine and qualify a procedure for welding thick section carbon steel castings with the consumable guide tube electroslag welding process. A relatively recent technology breakthrough in steel manufacture shows early promise of overcoming the drawbacks of the electroslag process. It has been discovered that careful application and control of the thermo-mechanical processes involved in steel making produces steel that is not easily damaged by heat input and can be produced in the strength and toughness levels that-make it attractive for construction and repair of naval ships. The ability to use the electroslag automatic plate crawler and the consumable guide tube electroslag welding processes without limitations would make it very attractive from the shipbuilder's point of view. The SP-7 Panel has a project to begin evaluation of some of these steels; subjecting them to the full range of destructive and nondestructive tests.

These are just some of the examples of developing and implementing existing technology rather than concentrating on the exotic processes such as electron beam and laser welding. This is not to say that our intent is to deliberately ignore these processes because we believe that they are fine for some types of industrial welding. On the other hand, shipbuilding methods do not offer sufficient opportunities for utilizing these processes to provide a reasonable payback for the tremendous capital outlay for equipment, dedicated facilities, training, etc. that would be necessary to make them function.

In the case of robots, the Welding Panel is engaged in projects designed to overcome the largest single drawback to robotized shipbuilding welding; poor fit-up. Until this shortcoming is overcome or a successful means developed to compensate for it, fully automatic robotic welding will not become a reality in shipbuilding.

For the future, it is our plan to keep abreast of the everchanging technology of shipbuilding and the effect of that technology on the art and science of welding. We cannot simply concentrate on the welding processes themselves, however, but must design and plan for welding more effectively. We must encourage and insist on the application of fitting and fabrication methods that provide the quality of fit-up necessary for utilization of the highest deposition processes in the automatic and robotic modes. Work must continue in the development of materials; i.e. base materials, filler materials, fluxes, etc. that are compatible with the high deposition processes. These must be evaluated and subjected to the full range of weldability, nondestructive and destructive tests to prove their suitability for intended service. Continued emphasis is necessary on the development of the most effective and least disruptive inspection methods that will satisfy the requirements and conform to the standards of the various code-making bodies. We must continue to provide the technical requirements for a well trained work force as well as making sure that all levels of management are made and kept aware of the complexities of welding and the potential that it has to reduce costs when applied correctly and effectively.

Last but not least, continued emphasis on the application of the welding processes, methods and techniques that are known and have proven satisfactory. At the same time to keep informed as to the latest improvements in new methods and techniques for their possible application to shipbuilding welding.

Thank You.

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