MIT SEA GRANT
FALL 1980

Quarterly Report

New Underwater Welding Techniques

The prohibitive cost of using multi-million dollar dry chambers for simple, shallow-water welding tasks has created interest in developing less expensive tools adapting surface welding techniques to the harsh marine environment. Although waterproofed welding tools have been available for decades, they are difficult to handle and produce unreliable welds. At MIT, the Sea Grant Program is supporting Professor Koichi Masubuchi of the Department of Ocean Engineering to produce handheld, fully automated "wet" welding tools that he hopes will allow even nonprofessional welders to produce more effective welds in water.

Wet welding, like surface welding, fuses two metals together with an electric arc generated between an electrode and a base metal. Although the electrode is waterproofed, vapor from water that surrounds the welding arc prohibits formation of a strong weld because the weld is quenched and the base metal is unable to heat up to the temperature of the electrode. Hydrogen and oxygen from the vapor are absorbed into the fusing metals, increasing the porosity of the deposited metal and contributing to embrittlement and hydrogen cracking. The underwater outcome -- welds with about 80 percent of the strength and 40 percent of the ductility of surface welds.

These problems, Masubuchi claims, can be diminished with a system that packages welding operations in an inexpensive dry chamber. In 1976, he and his associate, Dr. N. Kutsuma were awarded a patent for a prototype underwater stud welding gun which enclosed not only the stud to be welded but the entire welding operation.

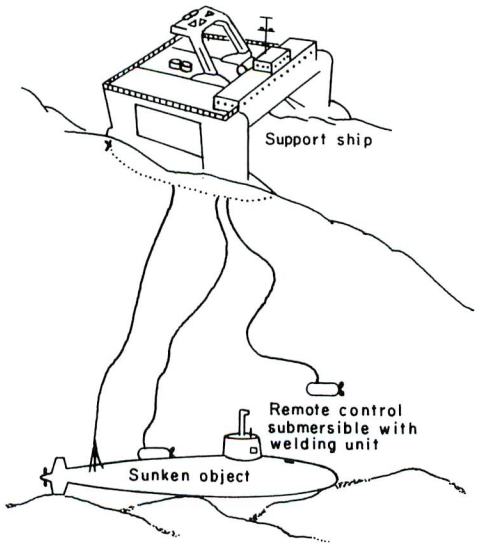

Figure 1. Lifting sunken ships in ocean salvage operations is one expected application for integrated underwater welding systems.

Because the gun was designed to be held tightly against the base metal, only a small amount of water could interfere with the welding process. An electromagnetic controller was designed to prevent any distortion of the arc under high environmental pressure. Currently Professor Masubuchi is simplifying the operation so that users need only press a button to create a proper arc length between the studs and the base metal for accurate welding.

Another automated welding method, a flux-shielded arc welding system, was developed and patented by Professor Masubuchi and Dr. C.L. Tsai in 1978. Like the stud welding gun, this tool is held tightly against the base metal and welding takes place within the gun. A vacuum pump removes the majority of the water from the weld arc and a dry flux powder, like limestone, insulates the electrode and absorbs any excess moisture.

Currently Professor Masubuchi and his students are testing the reliability of these prototype tools in a chamber simulating deep-sea conditions up to 600 psi. These tests have pointed towards new design modifications such as the use of magnets to hold the tools against the base metals in turbulent conditions.

In a parallel study, the researchers are developing "instamatic" cassettes which would allow one machine to handle many different kinds of welding operations. Cassettes for various operations would contain the pieces to be welded, and the usual variables such as arc length and flux type would be predetermined for various base metals and environmental conditions. The Sea Grant researcher feels that just as the instamatic cameras have decreased the amount of skill needed to take a good picture, instamatic cassettes will make welding significantly easier for nonprofessional welders.

Professor Masubuchi feels that his work in designing welding tools with deep-sea applications is just the "tip of the iceberg." He believes that the welding industry must first standardize today's welding procedures before cas-

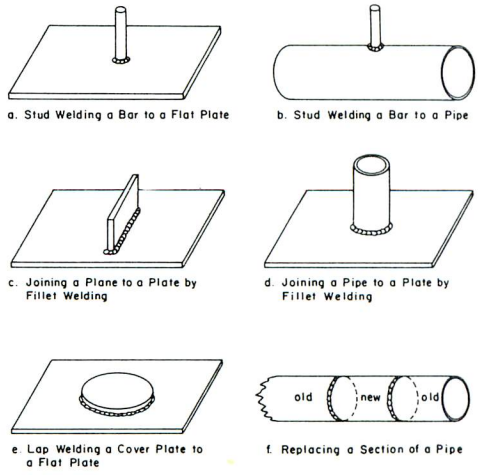

Figure 2. Several basic types of joints will be studied for welding by instamatic systems.

settes or robot welding machines can be produced.

Throughout his Sea Grant research Professor Masubuchi has acted as an industry advisor; he has served on a Welding Society subcommittee to establish underwater welding standards, and he has trained seventeen student research associates who are now working in shipyards, offshore companies, the Navy, Coast Guard, and in universities. His past research is documented in two MIT Sea Grant technical reports, "Report of Fundamental Research on Underwater Welding," and "Development of New, Improved Techniques for Underwater Welding." A third report will be available in March, 1981.

Predicting Effects Of Wastewater Discharge

As the volume of man-made wastes increases, so does the need to predict and monitor their effects on the environment. Professor Keith D. Stolzenbach of the Department of Civil Engineering and Dr. E. Eric Adams, a lecturer in the department, have been studying ocean discharges of heated water from power plants. They recently applied their work to the problem of the disposal of brine into the Gulf of Mexico.

The brine comes from caverns created by the Department of Energy in underground salt deposits in Texas and Louisiana. The caverns are being used to store large quantities of oil that could be used in the event of a cutoff of foreign oil supplies. To create the caverns, water is injected to dissolve the solid salt. The resulting brine - a highly concentrated solution of water and salt -- is pumped out and moved by pipeline to underwater disposal sites offshore in the Gulf.

To determine pre-disposal standards for the Gulf and to predict the effects of the brine on water quality and marine life, the National Oceanic and Atmospheric Administration (NOAA) is conducting environmental assessment studies. Brine is potentially toxic to marine organisms. Its high concentrations of heavy metals (copper, lead, nickel, cadmium and zinc) and salt (almost 10 times the concentration of normal Gulf seawater) can affect the migration and spawning of shrimp and other marine animals. The brine must be disposed of, since there will be too much to store. It would be too expensive to dilute it for industrial use. To predict the environmental effects, however, NOAA needed to be able to predict the distribution of the discharged brine. Through the MIT Sea Grant Program, Professor Stolzenbach and Dr. Adams have provided assistance by developing models to analyze brine distribution. Their results have been used by NOAA in studies of specific disposal sites.

To keep environmental impact to a minimum, the brine will be discharged from "diffusers" the MIT researchers helped design specifically for the brine disposal project. One diffuser has already been constructed at the first disposal site, 12 1/2 miles offshore from Bryan Mound, Texas. The diffuser consists of 34 nozzles projecting vertically from the pipeline at 59-foot intervals. Brine will be discharged from the nozzles at a high velocity to create turbulence and thus promote rapid mixing of the brine with seawater.

According to the researchers, the plume, or area covered by the discharged brine, may be divided into three regions -- the near-, intermediate- and far-field regions. Concentration of the plume decreases with distance from the diffuser. In the near field, brine is rapidly mixed with the receiving water. This mixing reduces brine concentration, in less than 100 feet from the diffuser, to within three to five parts per thousand (ppt) salt concentration of the salinity of normal Gulf seawater. In the intermediate field, plumes from individual nozzles spread along the ocean floor and merge to form one coherent plume. Little additional mixing takes place in this region. About 1,000 feet from the diffuser, the far-field regions begin. Here, the brine is further diluted and diffused by the motion of currents and natural turbulence in the water.

The worst effects of the brine will be in the near-and intermediate fields, because the brine is most concentrated there. The far-field covers the largest area and persists longer than the other regions, but NOAA predicts that the environmental effects in this region will normally be minor because of its lower concentrations (within .5 ppt above normal Gulf salinity). It is mainly under adverse conditions, such as stagnant or reversing currents, that far-field concentrations could build up and intensive environmental effects.

The near- and intermediate-field analyses are based on laboratory experiments. The far-field analysis, by contrast, is based on a mathematical model that was made into a computer simulation program in previous MIT studies. This program, called the MIT Transient Plume Model (TPM), calculated far-field concentration distribution as a function of the speed, frequency and direction of ambient currents. These variables control the shape and size of the far-field and determine whether or not there will be a buildup of excess concentration. NOAA is using the TPM program as the basis for predicting the effects of the brine. They will continuously monitor all discharge sites during and after disposal to determine the actual effects of the brine, in order to protect the Gulf's rich fishing grounds. The Sea Grant Program researchers will assist in interpretation of monitoring data and recommend any necessary changes in design and operation of the brine disposal project.

Professor Stolzenbach and Dr. Adams are continuing to

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study the near-and intermediate fields to develop more precise models of the three regions that could be applied to studies of many other kinds of pollutants, such as sewage sludge, dredge spoils, deep-sea mining wastes and high salin-ity effluents from salt-water conversion plants. The intermediate field analysis could also be useful in studies of density-driven ocean currents. All of these studies could aid efforts to effectively manage waste disposal.

Fish and Fuel: Coexistence on Georges Bank

"Fishing in general continues to be very good, even after 25 years of heavy oil development off the Louisiana coast," stated Ronald C. Lassiter, president of Zapata Corporation, which has invested heavily in both industries. Delivering the Ninth Annual MIT Sea Grant Lecture, "Georges Bank: Fish and Fuel," Lassiter said, "Our experience has definitely demonstrated that the two industries are compatible."

Although several panel members debating with Mr. Lassiter disagreed on the degree of compatibility, all shared the view of Douglas I. Foy, Executive Director of the Conservation Law Foundation. He said, "The issue is no longer, can fish and oil coexist on Georges Banks . . . they must." Foy's group has led the court battle against the lease sale. The environmental lawyer did criticize the Gulf Universities Research Consortium (GURC) study, cited frequently by Mr. Lassiter as evidence that there are only "insignificant" cumulative effects from sublethal petroleum discharges as compared to other sources of contamination or disturbance. Mr. Foy recommended that MIT and other universities undertake new "credible and responsible scientific research on the fate and effects of both oil and drilling fluids." He challenged the audience of 400, "You can improve clean-up and containment equipment and develop a monitoring system that measures damage and effects over the long term in comprehensive detail."

Fear that pollution from oil spills or drilling discharges would destroy the highly productive, unique fishery on Georges Bank has underlain the resistance to drilling in this offshore area. Minimal data is available on the fishery itself and on the effects of environmental changes of any sort. According to a lecture participant, the Canadians, who will be looking for oil on the Grand Banks, an area similar to Georges Banks, may offer a blueprint for monitoring the ultimate effects of extensive drilling activities in a rich fishing ground.

Lassiter, whose company recently purchased five sardine canneries in Maine as a base for its fisheries operations in Georges Bank, called oil spills "disasters" but "not catastrophies." And although he downplayed the effects of drilling mud, pointing out that oil companies are loathe to "waste" the expensive substance through spillage, it was generally agreed the toxicity of the chemicals that do escape requires further investigation.

From a regulatory viewpoint, Don E. Kash, Chief of the Conservation Division of the U.S. Geological Survey, noted that Survey studies had shown no negative impacts on fisheries from oil and gas activities offshore. Kash did say, however, that they frequently contact other countries, such as Canada, Norway and Britain, to keep abreast of their problems and observations. The Survey also continues to look for the "best available and safest technologies" to maintain the high performance of the U.S. offshore industry. According to Kash, government regulations have been greatly strengthened by Congressional amendments arising out of the public debate over the Georges Bank lease sale. He maintained, however, that to make regulations most effective and useful, the Survey should be allowed to enforce them within a "flexible and dynamic system," working cooperatively with industry.

Throughout the lecture it was clear that at present no one can really estimate how much, if any, oil or gas will be recovered from Georges Bank. Any exploration is an economic risk. But according to Lassiter the nation is impelled to look at and develop all available energy reserves. Our dependence on sources that could be disrupted by politics or war makes the development

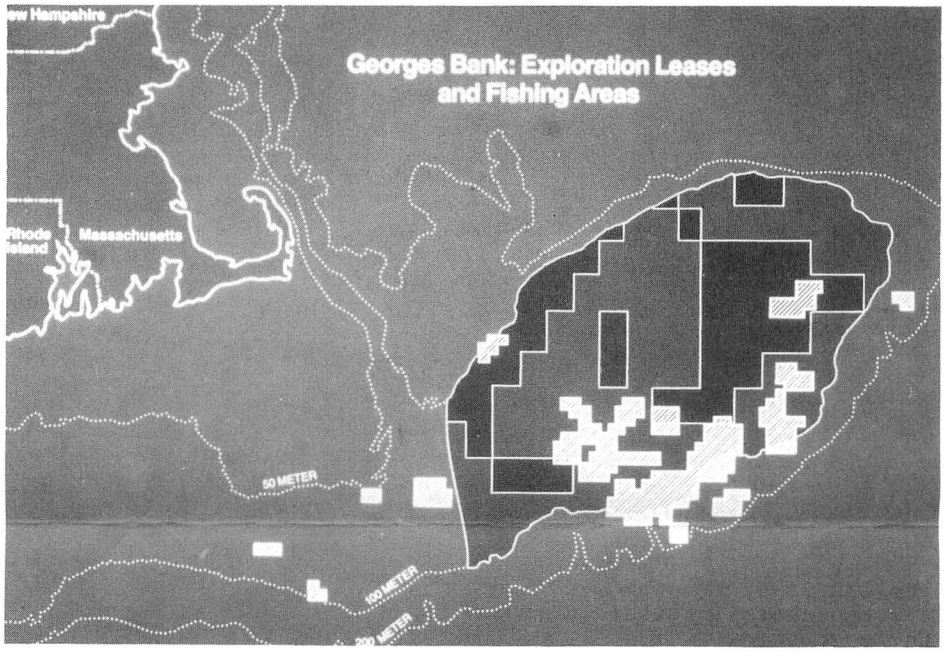

Figure 3. Georges Bank fishing areas and lease sites. Cross-hatching shows oil and gas lease areas; black areas outline heaviest fishing areas while dark grey shows sections that are more lightly fished.

question not "if" but "how." He also noted that New England fishermen, like their colleagues in the Gulf, may benefit from petroleum industry activities through improved ports, harbors and better vessel maintenance and repair facilities.

Money that goes into the national treasury from the lease bonus system will benefit the nation as a whole. This observation was made by Dr. Morris Adleman, Professor of Economics at MIT and a member of the original Georges Bank study group established by Sea Grant to look at the environmental and economic impacts on New England.

After ten years of fighting, exploration on Georges Bank will begin in the summer of 1981. The tone of this year's lecture seems to presage a new phase in which the fishing and oil industries will be looking to each other, the government and the university research community to find ways of sharing an offshore resource and of mitigating any negative effects on the health of the environment. Proceedings of the three hours of lecture, discussion, audience debate are available through the MIT Sea Grant Communications/Information office.

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Abstracts

☐ Georges Bank: Fish and Fuel Ninth Annual Sea Grant Lecture and Symposium

Proceedings from the Ninth Annual Sea Grant College Program Lecture
MITSG 81-1 36 pp.

This year's lecturer, Ronald C. Lassiter, President of the Zapata Corporation, explored many of the objections to oil drilling on Georges Bank. Panelists debating how the petroleum and fishing industries can resolve their differences included Morris A. Adelman, Professor of Economics, MIT; Douglas I. Foy, Executive Director, Conservation Law Foundation; Paul M. Jacobs, Managing Partner, Basic Development Services; and Don E. Kash, Chief, Conservation Division, U.S. Geological Survey. The moderator was Ira Dyer, Head, Department of Ocean Engineering, MIT.

☐ Cone Penetration Tests Offshore the Venezuelan Coast

Mohsen M. Baligh
Amr S. Azzouz
Robert T. Martin
MITSG 80-21 163 pp.

This report, one of a series, publishes results of an offshore soils testing research program. Using a Dutch cone and pore pressure probe, researchers gathered measurements in soils offshore Venezuela and developed theoretical and empirical correlation procedures. Information about in situ undrained stress-strain-strength behavior between test sites and soil types for which there already exists extensive information was compared. Researchers have developed improved theoretical models for interpreting the results of cone penetration and pore pressure data, and guidelines for using cone penetrometers to estimate in situ properties for foundation design.

☐ Some Federally Sponsored Research Programs for Unmanned Underwater Vehicles Opportunity Brief #18

MIT/Marine Industry Collegium
MITSG 80-5 34 pp.

This Opportunity Brief reviews research programs on unmanned underwater vehicles at MIT, the University of New Hampshire (UNH), and the Naval Ocean Systems Center (NOSC): 1) untethered search and survey vehicle (MIT); 2) free-swimming submersible using direct and supervisory control (NOSC); 3) experimental autonomous vehicle with five degrees of freedom of motion (developed by UNH, NOSC, and the U.S. Coast Guard). Telemanipulators and the theory of supervisory control are also discussed. Appendices introduce the Naval Research Lab Laminar flow vehicle and results of a workshop questionnaire to determine future vehicle capability needs.

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☐ A New Underwater Communication System Opportunity Brief #19

MIT/Marine Industry Collegium
MITSG 80-6 17 pp.

More mobile and economically efficient than tethered underwater work vehicles, untethered vehicles must transmit signals through the underwater environment. This Opportunity Brief discusses a joint acoustical telemetry communications project at MIT and Woods Hole Oceanographic Institution. Because of microprocessor advances, the system of transforming digital data to "chords" can be adapted through programmable software changes and satisfy a variety of uses which may require particular tradeoffs among key parameters of data rate, range, and error rates.

☐ Protection of Materials in the Marine Environment Opportunity Brief #20

MIT/Marine Industry Collegium
MITSG 80-7 9 pp.

Materials science research is essential to safe, economical offshore and coastal structures and ships. A collaborative presentation of the Sea Grant programs of Louisiana State University (LSU) and MIT, this Opportunity Brief discusses three aspects of LSU research in marine materials protection: longlasting antifouling marine coatings, their characterization and environmental impact; hydrogen embrittlement, including cathodic protection concentration of environmental hydrogen; and titantium-based metallic coatings. Also discussed are two LSU projects: remote sensing and interpretation of data with a TIROS satellite, and creative computer-aided ship design tools.

☐ Nondestructive Evaluation of Fiber Composites Opportunity Brief #21

MIT/Marine Industry Collegium.
MITSG 80-8 20 pp.

Increased use of fiberglass has made practical quality control vital for manufacturers, consumers, and insurers. Inherently nonhomogeneous, fiber composites can contain hard-to-detect internal flaws. This process of nondestructive thermal testing to detect fiberglass flaws involves coating the material with a cholesteric liquid crystal compound and applying heat. The temperature rise causes the crystals to change color, and anomalies in the color indicate internal flaws. This project provides quantitative interpretation of the patterns of surface temperature and underlying flaws, and mentions acoustic and ultrasonic testing.

☐ Experiments in Supervisory Control of a Computerized Vehicle for Inspecting Curved Surfaces

Tetsuichi Odahara
Thomas B. Sheridan
MITSG 80-19 47 pp.

Research in support systems for offshore resource development has resulted in new theories and applications for control systems and work vehicles. This report describes an experimental computerized vehicle for inspecting curved surfaces (such as pipelines) which simulates undersea motion. The control system uses three kinds of vehicle motion control: manual, automatic approaching, and automatic surface following. The adaptability of supervisory control concepts to undersea inspection is considered, and the report documents the difficulty of manual control and the advantage of the combined manual and automatic control system, supervisory control.