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MINI-OTEC PERFORMS AS EXPECTED OFF HAWAII
NO POTENTIAL PROBLEMS MATERIALIZED

Second Deployment Planned

Mini-OTEC, the world’s first Ocean Thermal Energy Conversion demonstration plant, has accomplished its original mission by generating 50 kilowatts of electricity for several months to prove that the 100-year-old concept works. During three and a half months of operation (500 hours total, 102 hours continuous), Mini-OTEC has performed as its designers expected without encountering any of the seawater hurdles predicted for such plants.

Lockheed Project Manager Delbert N. Burwell said that OTEC “unknowns” have become “knowns”. Some of the possible hurdles could have been biofouling of the heat exchangers; gas (carbon dioxide) entrapped in the cold water brought up from great depths, possibly affecting the efficiency of the seawater pumps; and debris both of animal life and of inorganic materials clogging the warm-water and cold-water inlet screens.

Potential biofouling was controlled by continuously injecting minute amounts of chlorine (less than one-tenth part per million parts of water) into the seawater flow, and is most likely responsible for the absence of biofouling-slime buildup in the Alfa-Laval titanium plate-type heat exchangers. However, questions still remain regarding the amount of biofouling present in the ocean water brought up from great depths, though experiments have indicated that little or none exists.

Inlet-screen fouling, estimated before startup at around seven pounds per day, turned out to be non-existent.

Pressure fluctuations in the ammonia loops, predicted by some OTEC researchers, did not materialize. The seawater surge tank built into the seawater inlet system helped to stabilize the flow rate.

The seawater design temperature differential was 36.5°F. The actual temperature differential was slightly greater.

Power consumption was slightly higher than predicted for the plant equipment and the deck lights, but was lower for the hotel lights, the air compressor, and the chlorination systems.

The primary control system used for Mini-OTEC operations was the constant-evaporator-flow mode. This mode was previously tested on a small scale by Alfa-

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MINI-OTEC PERFORMS AS EXPECTED OFF HAWAII: NO POTENTIAL PROBLEMS MATERIALIZED

(continued from Page 1)

Laval, and proved to be successful for reliable hands-off operation of Mini-OTEC. The constant-reservoir-level control mode was tested only once, but hands-off operation could not be maintained. Based on this experience, future control systems for plate heat exchangers should provide a constant flow to the evaporator.

The average gross electrical output during testing was 48.7 kW, with a maximum of 53 kW and a minimum of 47 kW. The table entitled Power Summary appearing in this issue compares the design condition to actual test values. In the case of the test values, some measurements were combined readings. The typical net output obtained was about 12 kW, compared to a design range of 10 to 15 kW.

Reams of performance data remain to be analyzed and reduced, but it can be safely said that the plant performed essentially as predicted.

Second Deployment Awaits Funding

The plant was shut down in November 1979 only because the allocated operating funds had been expended and most of the test objectives had been achieved. Mini-OTEC was moved from its operational site off the Kona Coast of Hawaii to Honolulu in November. The cold-water pipe was left in place at the site tethered to a marking buoy. It will be reconnected to the OTEC barge for the second phase of testing probably in late spring or early summer of this year. Funding is expected to be borne primarily by DOE.

<table>
<thead>
<tr>
<th>Components</th>
<th>Nominal Value (kW)</th>
<th>Maximum Value (kW)</th>
<th>Typical Test Value (kW)</th>
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<tr>
<td>Generator Gross Output</td>
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<td>-</td>
<td>53.0</td>
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<tr>
<td>Cold Water Pump</td>
<td>11.9</td>
<td>13.6</td>
<td>14.3</td>
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<td>9.4</td>
<td>10.7</td>
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<td>Reflux Pump</td>
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<tr>
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</tr>
<tr>
<td>Net</td>
<td>10.0</td>
<td>15.0</td>
<td>18.2</td>
</tr>
</tbody>
</table>

POWER SUMMARY OF FIRST MINI-OTEC DEPLOYMENT

OCEAN ENERGY COUNCIL EXPANDS

Recent open meetings in Washington hosted by the Ocean Energy Council (OEC) have been attended by over 100 persons, indicating the increasing popularity of this organization inside the OTEC/ocean energy community. The bi-monthly meetings are open to both members and non-members. Membership in the OEC has now risen to over fifty individuals and organizations representing virtually all areas of the international OTEC community: industry, government, researchers, utilities, users, and legal and financial interests. Corporate/Organizational memberships include Ashland Development, Devco International, Global Marine, Lockheed, J. Ray McDermott, the National Marine Engineers Beneficial Association, Simpex Wire and Cable, the Solar Energy Research Institute, Solaramco, the Trane Company, TRW, and Westinghouse Electric.

An advisory board and action committees are being formed to further the aims and activities of the advocacy organization. Further information can be obtained by writing to the Ocean Energy Council, Box 57198, Washington DC 20037, or from the editor of this publication.

SERI COMPLETES NEW OTEC FILM

One of the recent major efforts of the Ocean Systems Branch of the Solar Energy Research Institute of Golden, Colorado to disseminate information to the public has been the production of a twelve-minute film on OTEC. The project, headed by Don Petty of SERI, was completed with the cooperation of DOE, industry, and other representatives of the OTEC community. The footage includes coverage of Mini-OTEC, OTEC-1, and general educational information on OTEC technology and commercial readiness.

6TH OTEC MEETING PROCEEDINGS ARE NOW ON THE WAY

A recent letter from Gordon L. Dugger, Chairman of the Sixth OTEC Conference held last June, advises that the Conference Proceedings have been “at long last” delivered to DOE for approval, printing, and mailing. The Proceedings are expected to be in the mail to all attendees on or before March 10th, 1980.
NAVAL RESEARCH IN UNRELATED FIELD MAY LEAD TO BREAKTHROUGH IN OTEC BIOFOULING CONTROL

First surfacing at the MTS meeting in New Orleans last October, research by the US Navy's Civil Engineering Laboratory (CEL) at Port Hueneme, California may lead to inexpensive control of biofouling on OTEC heat exchangers.

A miniature thermal-ocean-current sensor developed by a project at CEL and initially funded by the Naval Facilities Engineering Command and the Naval Ocean Research and Development Activity uses low-voltage electricity to completely eliminate biofouling.

The current sensor was developed to provide a system for measuring deep ocean currents which would replace present techniques that are cumbersome, costly, and frequently inefficient, especially when used for long periods.

The device, which is two inches long and a quarter-inch in diameter, is based on a principle that has been known in the laboratory for some time. When four metallic films are heated by an electric current, the flow of water past them causes heat loss. The speed and direction of the flow can then be determined by the change in temperature in each of the four films. Practical application, however, depends on the fabrication of a watertight package that would not leak and lose calibration as a result of a short circuit and would not deteriorate as a result of biofouling.

Working with platinum, an inert metal, CEL engineers led by Theodore Kretschmer devised a means of using a laser in a high-speed computer-controlled process to cut the platinum into four film resistors only half an inch long and only 0.1 micron thick.

The four films are deposited on a hollow cylindrical alumina ceramic substrate and then covered with a special plastic coating that provides complete insulation and waterproofing. On top of this an outer layer of platinum is placed to protect the plastic coating. This exterior platinum layer provides the key to the anti-fouling.

The platinum becomes an anode in an electrochemical cell. With the stainless-steel mounting shaft serving as the cathode, a slight electrical current is impressed on the platinum anode. Chlorine is formed on the platinum surface and through hydrolysis forms hypochlorite, a powerful anti-foulant.

A sensor protected in this manner has been exposed in sea water for as long as five months with no biofouling detected. By comparison, a standard sensor recovered from the ocean after just 16 days was found to have a 70% speed-measuring error due to severe fouling by marine growth.

Since only a small electric current is required for the anti-fouling process, energy consumption is minimized. It is estimated that a D-size lithium cell has sufficient energy to keep more than 20 sensors strung along a cable free of fouling for one year.

Since the chemicals generated by this technique affect only the platinum surface there is no environmental hazard. It was also found in the tests that when the electric current was turned off, the fouling buildup which ensued was completely removed when the current was turned on again.

Additional details of this new development will be provided in a paper at the Offshore Technology Conference in Houston in early May.

COUSTEAU SOCIETY MOVING ITS HEADQUARTERS TO VIRGINIA

The Cousteau Society, an avid supporter of all forms of ocean energy (see the October 1979 issue of OE), has announced that it will move its base of operations to the Norfolk-Hampton Roads area of Virginia. In co-operation with the community of Norfolk, the Society will establish a Cousteau Center to house its activities and serve as a staging area for expeditions of the research ship Calypso.

At present, the Society operates from three locations: New York, Los Angeles, and the Marseilles/Monaco area. Operations in those areas will be reduced, and most of their activities will be transferred to the new Cousteau Center.

Captain Cousteau said: "Our members, now numbering over 160,000, will be more effectively served by this facility."

The many scientific and governmental facilities in the Hampton Roads area, as well as its coastal location, attracted the Society to this new site.

[Editor's note: Readers will find interesting an extensive interview with James Schlesinger, former head of DOE, in the March issue of Calypso Log, the quarterly publication of The Cousteau Society Incorporated, 777 Third Avenue, New York, New York 10017.]

BIBLIOGRAPHY ON OCEAN ENERGY IN PREPARATION

A bibliography on ocean energy is being prepared by the American Society of Civil Engineers as a specific goal of the ASCE's year-old Task Committee on Ocean Energy. It is currently in the final stages of publication, and has been broken down into four major areas: wave energy, tidal energy, salinity gradients, and ocean temperature gradients/OTEC.

Further information may be obtained from the Committee's chairman, Dr. Y. C. Kim, Department of Civil Engineering, California State University, Los Angeles, California 90032, (213) 224-2520.

WAVE ENERGY

SOLAR OCEAN ENERGY TODAY POWERS 1,000 HOMES IN JAPAN

Right now, as you read this, ocean energy is supplying electricity to about 1,000 homes in Japan.

A generator aboard the Japanese demonstration plant Kaimai off the northern coast of Japan in Tsurouka is powered by wave action (see the June 1979 issue of OE). This is the first practical use of wave energy anywhere in the world.

The output of the 80-meter-long test plant is in the thousand-kilowatt range. Electricity is transferred to the distribution grid of the Tohoku Electric Power Company. The United States, Britain, and other countries also participated in the project.

PUBLICATIONS AVAILABLE

- Qualification of Aluminum for OTEC Heat Exchangers, by F. L. LaQue of Argonne National Laboratory, Argonne, Illinois, 32 pages, is available as ANL/OTEC-BCM-003 for $6 paper copy and $3.50 microfiche from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

PATENT ISSUED FOR WAVE POWER GENERATION

Patent Number 4,172,689, with six claims, was issued in late 1979 to Ivar Thorsheim of Norway for "a device deriving power from the energy of moving water waves".
TIIDAL POWER

BAY OF FUNDY TIDAL PROJECT FINALLY UNDER WAY

After many years of contemplation (see the June 1979 issue of OE), the harnessing of one of the world's greatest tidal-energy resources has been initially funded and is scheduled to begin operation in 1983.

The Tidal Power Corporation of Nova Scotia has awarded a $15 million (Canadian dollars) contract to Dominion Bridge-Sulzer Incorporated of Montreal to build a hydroelectric turbine as part of a power-demonstration project in the Bay of Fundy.

The 23-foot-diameter turbine will generate 20,000 kilowatts of electricity at the mouth of the Annapolis River in western Nova Scotia. Tides in the Annapolis basin rise and fall about 15 feet.

The Canadian Government will contribute $25 million to the project. The total cost is estimated at between $43 million and $47 million.

Full-scale harnessing of the tides in the Bay of Fundy would yield about four million kilowatts of electricity—double the amount of power generated by oil- and coal-fired power plants in the province. George Baker, executive vice-president of Tidal Power, says that New Brunswick and New England could receive any surplus electricity.

LOCKHEED OPENS OFFSHORE OFFICE IN HOUSTON

Lockheed Missiles and Space Company has opened a branch office in Houston for its Offshore Systems and Services organization. The Houston office will enable Lockheed personnel to work closely with the petroleum industry and related offshore construction firms. In addition to its long-term history of OTEC work, Lockheed is also involved in deep-ocean mining, oil-spill cleanup, and submersibles, among other oceanographic projects.

TAIWAN REPORTED AS IDEAL OTEC SITE

A report has recently been received by OE from Professor T. Y. Chou of the Institute of Oceanography of the National Taiwan University in Taipei, Taiwan, regarding the ocean-thermal resources of that nation.

The eastern coast of Taiwan—the fastest growing industrial nation in the world based on its GNP in recent years—is described as "most suitable" as an OTEC site in the report, entitled "Characteristics of the Kurushio Current and Their Variations in the Surrounding Seas of Taiwan". Temperatures of the surface reach 28°C in summer and 25°C in winter, with temperatures at depths of 800 to 900 meters ranging from 4°C to 5°C. These delta-Ts are comparable to those of areas currently under study for OTEC demonstration plants, including Hawaii, Puerto Rico, and the United States Gulf Coast.

Personnel of Southwestern Engineering Company, a subcontractor to TRW for OTEC-1, threading the titanium tubing for the condensor.