***USE OF FLOATING SOLAR COLLECTORS IN PROCESSING ICEBERG WATER**

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ABSTRACT

A floating tracking platform equipped with parabolic collectors concentrating sunlight on photovoltaic cells is described. The unique tracking system made possible by using a floating platform allows for the construction of inexpensive low-profile concentrating collectors. The concentrating collectors would focus concentrated sunlight on a bank of photovoltaic cells. These cells must be cooled for maximum efficiency.

This type of collector, under development at the University of Arizona, could be floated next to a moored iceberg to provide waste heat for melting the ice. This combination should improve the efficiency of the photovoltaic cells and reduce the costs of ice-to-water conversion.

This coupled system would make it possible to provide both water and power to arid coastal areas.

INTRODUCTION

Using icebergs towed to desert coastal areas to supply fresh water is very intriguing. This process has been described by several researchers. Hult (1) has estimated that an Antarctic iceberg could yield 1,000 billion cubic meter of water annually.

There are many problems to iceberg utilization that need to be addressed before the technique can be employed. One of the more important ones, according to Hult (1), is how to convert the ice to fresh water at the point of use.

One obvious solution would be to use waste heat from a conventional powerplant. The heat sink provided by the melting iceberg would improve the efficiency of the conventional powerplant by an estimated 3 percent (1). The "catch 22" to this approach is that changes in powerplant design would have to be made to take full advantage of the heat sink. At this stage in development it would be very difficult to get a power company to optimize the design of a powerplant based on the availability of icebergs.

There also is the problem of transporting the waste heat from the powerplant to the iceberg. One possibility might be the use of a floating powerplant.

The Japanese are selling floating factories of various types. Perhaps a floating powerplant could be built.

The University of Arizona, in cooperation with Sunpower Systems, Inc., of Tempe, Arizona, is constructing a prototype floating solar collector. At a later date the collector will be equipped with photovoltaic cells which will be cooled by passing water behind the collection tube on which the cells are mounted.

This paper explores the possibility of mooring this type of collector system near an iceberg and using the waste heat for ice conversion.

FLOATING SOLAR COLLECTORS

History

The development of the floating solar collector evolved from research using floating covers for evaporation control. The author (2), has for many years been involved in floating covers research. In the fall of 1974 the idea of combining evaporation control with solar energy collection was first conceived and disclosures written. In the fall of 1976 the author joined with William Matlock of Sunpower Systems, Inc., in Tempe, Arizona, who had been working on the use of a land-based rotating solar collector. This collaboration resulted in development of the prototype under construction at the University of Arizona. Patents for these developments have been applied for.

Description

The efficiency of both flat plate and cylindrical and parabolic trough concentrating collectors can be improved by placing them on a rotating platform that can track the sun in an azimuth mode. The conventional altitude-tracking parabolic trough collector would then be able to track in two modes for maximum year-round efficiency. This collection efficiency has been estimated (3) to be above 80 percent. Using dual tracking the spacing of the collectors are such that only about 60 percent of the area occupied by the system is covered when the collectors are flattened at midday.

Perhaps the most interesting aspect of the floating platform is that it allows for construction of new types of simplified solar collectors built to take advantage of tracking in an azimuth mode. Parabolic troughs can be mounted rigidly to the platform adjacent to each other in a continuous cover. Tracking is done in an azimuth mode by keeping the axes of the collectors pointed at the sun. A model of this type of collector is shown in Fig. 1. The only movement in the system would be the rotation of the floating platform. One of the advantages of this system is that large four- or five-meter wide parabolic trough collectors could be built and still maintain a low profile for economy and reduced wind damage. Further protection from wind damage could be obtained by turning the system during storm periods so that the axes of the troughs are parallel to the wind. This would minimize the drag on the system.

Although the efficiency is reduced with this type of collector as compared to the dual track type, close to 100 percent of the area will be covered with

Fig. 1. Above: Sunpower Systems' dual-tracking land-based carousel.

Below: Working prototype of floating azimuth-tracking solar collector.

collectors. Thus in the middle of the day this type of collector will be producing approximately 1.5 times as much solar energy as the conventional altitude-track or dual-track system per unit area of surface occupied by the collector.

Tracking in smaller units will be done by running a chain around the periphery of the collector which passes through a gear drive connected to a reversible electric motor. A sensor operates the motor to keep the axis of the collector pointed into the sun. The hot and cold water supply lines are flexible and connect to the floating collector at its center.

On collector models large enough to melt an iceberg, tracking could be done by opposing propellers or water jets that would rotate the collector about a center pivot. It is anticipated that the central pivot point would not have to be rigid, as long as supply lines were flexible and long enough to allow for some movement.

The floating platform at the University of Arizona is inexpensively constructed out of wax-impregnated expanded polystyrene. The wax waterproofs and weatherizes while improving the strength characteristics of the foam. A modular design has been developed which greatly reduces the cost of the rotating platform. Panels of framed and cross-braced foam are attached together to cover the surface. It is envisioned that each rotating platform could be several hectares in size. These individual platforms could be moored in a cluster fashion around the iceberg after it had been beached.

Sizing

The waste heat would be transported to the iceberg in flexible, insulated tubes connected to the center of the rotating platform. It is envisioned that the top of the iceberg would be shaped to form a series of shallow basins which would be alternately filled with water containing waste heat. A small amount of cold water would be drawn off the basins for recirculation through the collection system and the rest would be transported through pipelines to shore installations for use. The temperature of this cold water would be kept just above freezing.

Once the basins were formed it should be easy to maintain them due to differential heating. Occasionally the interconnecting banks could be sprinkled with hot water to reduce their height and thus maintain the depth of the shallow basins. Thus the iceberg would be melted from the top down. The temperature of the waste water would be kept under 80 degrees centigrade to maximize electrical production from the solar cells. It is anticipated that basins would be drained when the sun was not shining to prevent refreezing, to reduce evaporation loss, and encourage nighttime condensation which would add to the total water yield from the iceberg.

Sunpower Systems, Inc. has determined that the average thermal efficiency of their 1.22 m wide polished aluminum parabolic troughs in a flat azimuth track would be 50 percent in a latitude of 32° . It is believed that this thermal efficiency can be maintained in the photovoltaic system even though 10 to 15% of the concentrated energy will be going into electrical energy due primarily to the fact that the hybrid system will be operated at lower temperatures than those Sunpower Systems used in their calculations. This hypothesis needs to be proven as soon as photovoltaic cells are installed on the

prototype collector.

For sizing purposes we will assume the 50% thermal efficiency at a latitude of 32° with an 86% sunshine factor. Under these conditions an average of $3.25 \text{ kwh/m}^2/\text{day}$ of thermal energy and $.32$ to $.48 \text{ kwh/m}^2/\text{day}$ of electrical energy would be produced.

On the average it would require about 28.62 m^2 to produce one cubic meter of melted ice per day or an annual production of 12.8 m^3 per square meter of collector per year. In order to melt a 100 m deep iceberg within a year a floating array equivalent to 7.8 times the iceberg surface would be required.

According to Hult (1) a "small" iceberg would have a volume of 100 million cubic meters. This would require a solar collector of 780 hectares in order to melt this iceberg in one year, assuming no help from direct solar radiation or sensible heat contribution from the atmosphere. The cost of construction of the solar collector would be between \$1,000,000 and \$1,500,000 per hectare. It would produce \$91,000,000 worth of power per year (based on power costs of \$0.10 per kwh).

At this rate the project could pay for itself at an 8 percent interest rate in 15 years at the \$1,000,000 per hectare cost but would require a \$.137 per kwh charge to be amortized in 15 years at 8 percent interest at the \$1,500,000 per hectare cost. This compares with a current price of approximately \$0.06 per kwh for electricity in Tucson, Arizona.

DISCUSSION AND CONCLUSIONS

This paper indicates the possible joining of two relatively untried concepts for mutual benefit of both. Either project, i.e. iceberg towing or floating solar collectors, could probably be justified on its own merits. Sea water could be used to furnish a heat sink for the solar collector and a heat source for the iceberg. There is considerable cost savings, however, for using the two concepts at the same location. There will be, in addition, a large market for power wherever large amounts of fresh water are made available.

The major added cost of floating a solar collector on the surface of the ocean versus a fresh water inland location would be wave protection and protection against corrosion due to the poor quality ocean water. It is envisioned that wave protection might be obtained by floating a wide strip of used rubber tires as a perimeter around the collector. The cost of the extra protection against waves and corrosion was not included in the cost estimates. Corrosion resistant aluminum is available. Sunpower Systems report that they have one coastal installation of polished aluminum collectors subject to salt spray that is holding up surprisingly well.

The approach described herein offers a way of obtaining large supplies of renewable water and energy. Obviously more research is needed in both iceberg utilization and floating solar collectors before large systems can be built. There will be many skeptics of the approach presented in this paper, and perhaps they may prove to be correct. However, one might ask, if this

approach won't work, what will? What other combination has the potential of producing such large amounts of water and power, at a relatively low unit cost, by using resources, icebergs and sunlight, not now being tapped by mankind?

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