OPTIMIZATION TECHNIQUES APPLICATION IN OCEAN THERMAL ENERGY CONVERSION (OTEC)

RANADIP ROY
ASSISTANT PROFESSOR, ELECTRICAL ENGINEERING DEPARTMENT
SANAKA EDUCATIONAL TRUST'S GROUP OF INSTITUTIONS (SETGOI), DURGAPUR

Abstract

OTEC known as ocean thermal energy conversion uses the natural thermal gradient of ocean to generate power. In other words we can say the energy technology that converts solar radiation into power is known as ocean thermal energy conversion. When the sun rays falls in the ocean water then it warms the surface water more than the deep water which creates the temperature gradient in it. This temperature gradient is used to drive the power producing cycle. As long as the temperature difference between the warm water and cold water exists the generation of power takes place. To produce electricity we use a working fluid with low boiling point (e.g ammonia) or warm sea water or turn it to vapour. The expanding vapour pressure turns the turbine and produces electricity.

Keywords-ocean thermal energy conversion (OTEC),biofouling etc.

Introduction

Ocean thermal energy conversion (OTEC) generates electricity indirectly from solar energy by applying the temperature difference between the sun-warmed surface of tropical oceans and the colder deep waters from the ocean [1]. Since OTEC exploits renewable solar energy, recurring costs to generate electrical power are reduced by this plant. However, the fixed or capital costs of OTEC systems per kilowatt of generating capacity are very high because large pipelines and heat exchangers are needed to produce relatively huge amount of electricity from this technology. These high fixed costs dominate the economics of OTEC [2] to the extent that it currently cannot compete with conventional power systems, except in limited markets of the world. Considerable effort has been researched by many researchers over the past few decades to develop OTEC [3] by-products, such as fresh water, air conditioning, and mariculture, which could offset the cost penalty of the generation of electricity.

Choice of working fluid

There are many common fluids present having an appropriate boiling point, e.g. ammonia, Freon or water. Indeed, by applying a partial vacuum (i.e. lowering the pressure) the boiling point of water can be lowered to the temperature of the warm water intake from the oceans. This is the basis of the open cycle system, in which the warm water itself is act as the working fluid. Such a system provides not only power, but also provides substantial quantities of distilled water.

Environmental effects

The richness of marine life poses the problem of the term "biofouling". It also gives rise to the possibility of fish farming. Sea water from the depths of ocean water is rich in nutrients and these would be discharged near the surface around an OTEC [4] plant. This would certainly encourage the growth of algae, which in turn would attract other marine creatures higher up in the food chain. This could possibly provide a basis for the commercial fish farming. However, the total biological effects of releasing large quantities of cool water into the warmer surface environment are not yet known by the researchers.

Other Uses for OTEC Technology

OTEC systems not only produce electricity, it can also some other uses, some of which can be listed as below:
Fresh water production - The fast manufacturing growth and the population explosion all over the world results in the problem of pollution of rivers and lakes by industrialized wastes and the large amounts of sewage of the world.

On a global scale, man-made pollution of natural sources of water is becoming the single largest reason for fresh water shortfall. The only sources of water are the oceans and sea water. Their main drawback, conversely, is their high salinity present in the sea water. Consequently, it would be striking to tackle the water-shortage problem with purification of this water from the ocean. Desalination is just one of the effective potential products that could be produced using OTEC technology. Fresh water can be fashioned in open-cycle OTEC plants when the warm water is vaporized to turn the low pressure turbine of the plant [5]. Once the energy is produced the water vapor is summarized to make fresh water from the ocean.

Air conditioning and Refrigeration - Once cold water pipes are connected for an OTEC power plant, the cold water has been pushed to the surface can be used for other than being the working fluid for the condenser. Out of these, one of these uses is air habituation and refrigeration. Cold water can be used to circulate finished space heat exchangers or can be used to cool the occupied fluid within heat exchangers of the plant. This technology can be applied for hotel and home air conditioning as well as for refrigeration systems.

Aquaculture and Mari-culture -

Additional opportunity for taking advantage of OTEC plants is the use of the water pipes to harvest marine plants and animals for the purpose of food materials [6]. This proposition is still under exploration in this world.

Coldwater Agriculture - As seaside areas appropriate for OTEC [7] are in tropic regions, there is a potential to increase the overall food multiplicity within an area using the cold water instigating from the deep ocean water. It has been proposed that burying a network of cold-water pipes underground the temperature of the ground would be ideal for spring type crops like strawberries and other plants delimited to cooler climates of world.

Working

OTEC works basically by two cycle systems known as open cycle system and closed cycle system.

Closed cycle OTEC system-

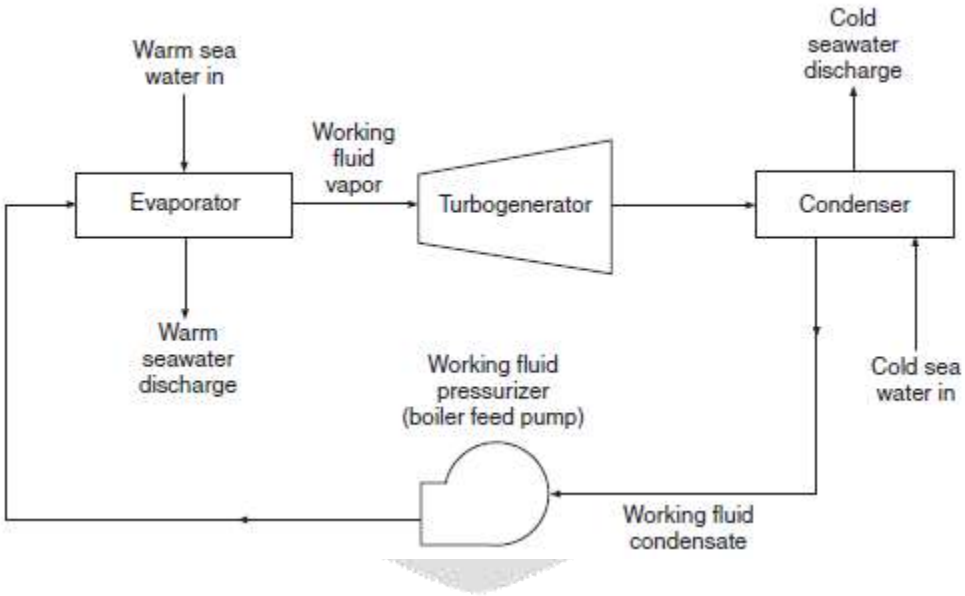

Figure 1.1

Closed cycle system has the following steps-

-The working fluid such as ammonia is vapourized by the warm sea water which flows through the heat exchanger or evaporator.

-The pressure caused by the expansion of vapour turns the turbine which is coupled to the generator that produces electricity.

-The condensation of the vapour takes place in heat exchanger or condenser by the cold seawater which is pumped from ocean by using pipes.

-The working fluid which is condensed is pumped back to the evaporator to repeat the cycle.

Open Cycle OTEC system

Open cycle OTEC system consists of following steps-

-Here the warm sea water itself act as a working fluid.
-The vapour expands through the turbine to generate electricity.
-The condensation of working fluid takes place by the heat transfer to the cold seawater thermal sink.

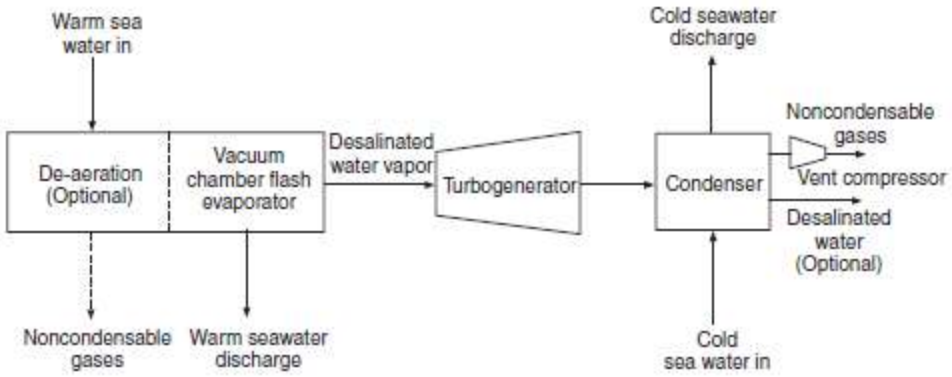

Figure 1.2

A hybrid cycle is a combination of both closed and open cycles where flash evaporator seawater is used as the closed cycle working fluid as use.

Robustness of the Optimization Scheme

The ultimate goal of algorithm is to allow rapid optimization of varying OTEC plant configurations in order to minimize capital cost.

Optimization of Operating Temperature-

Figure 1.3 shows a sample optimization curve for the evaporator operating temperature. Although algorithm optimizes both evaporator and condenser operating temperatures simultaneously, only a single parameter is shown for clarity.

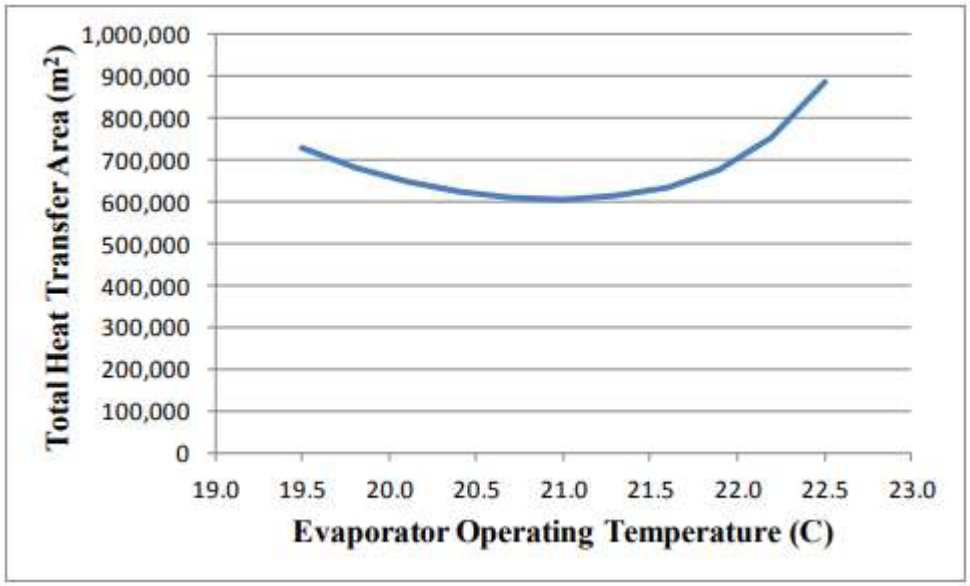

Figure 1.3 Optimization Curve for Evaporator Operating Temperature

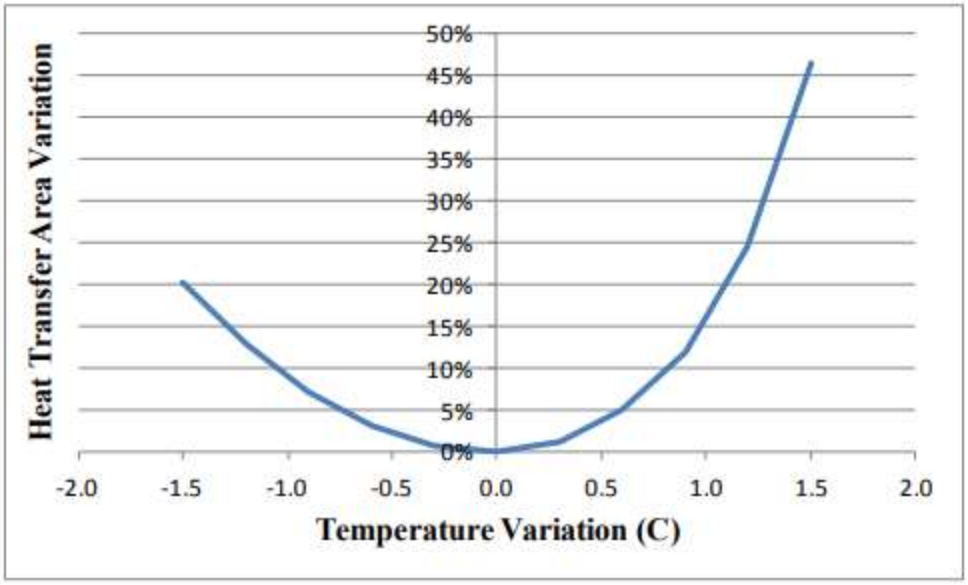

Figure 1.4 Normalized Optimization Curve for Evaporator Operating Temperature

RESULTS AND DISCUSSIONS

The curve is steeper as operating temperature increases. This trend is mirrored on condenser operating temperature optimization curves; total heat transfer area required increases more steeply as condenser operating temperature falls. In both cases, the increased sensitivity is found when the operating temperature approaches the corresponding seawater temperature. As operating temperature and seawater temperature converge, each incremental increase in operating temperature makes up a larger percentage of the remaining temperature difference with the seawater. Therefore, temperature difference falls proportionally faster as the operating temperature moves towards the seawater temperature. A faster change in temperature difference results in a faster change in heat transfer area requirements.

Advantages & Disadvantages

Advantages

OTEC uses clean, renewable, natural resources of earth. Warm surface seawater and cold water from the ocean depths replace fossil fuels to produce electricity from water of oceans. Suitably designed OTEC [8] plants will produce little or no carbon dioxide or other polluting chemicals present in the deep sea water. OTEC systems can produce fresh water as well as electricity in the world. This is a significant advantage in island areas where fresh water is limited resource. There is enough solar energy received and stored in the warm tropical ocean surface layer to provide most, if not all, of present world energy needs. The use of OTEC [9] as a source of electricity will help reduce the state's almost complete dependence on imported fossil fuels of earth.

Disadvantages

OTEC-produced electricity at present will cost more than electricity generated from fossil fuels at their current costs. These plants must be located where a difference of about 20° C occurs over the whole year. Ocean depths must be available fairly close to shore-based facilities for economic operation of mankind. Floating plant ships could provide more flexibility than others. No energy company will put money in this OTEC [10] project because it only had been tested in a very small scale. Construction of OTEC plants and lying of pipes in coastal waters may cause damage to reefs and near-shore marine ecosystems.

Conclusion

Accounting for external sources in the production and consumption of energy might eventually help the development and expand the applicability of OTEC, but in the current scenarios that have been identified herein should be considered. Conventional power plants pollute the environment more than an OTEC plant produce and the

fuel for OTEC is unlimited and free, as long as the sun heats the oceans; however, it is futile to use the arguments of various researchers to convince the financial community to invest in OTEC plants without an operational record.

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