

Ocean Thermal Energy Conversion

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Abstract: *A closed cycle ocean thermal energy conversion basically involves a working fluid which has a boiling point just low below ambient temperature. This fluid is then evaporated using warm sea water and then used to run turbines. This evaporated gas is then condensed using cold seawater. In this paper a study is being made to install a super heater between the evaporator and the turbine. The various consequences due to this technical advancement have been discussed taking into consideration all the components in the OTEC plant. As the energy requirement to run pumps cannot be avoided, to increase the overall efficiency of the plant an effort is being made to increase the net energy output of the turbine. This can be achieved by heating the working fluid above its saturation temperature thus increasing its enthalpy indirectly increasing the net output of the turbine. Along with a super heater a pre-heater has been installed which helps to compensate the heat losses in heat exchangers. Both the super heater and pre-heater have been developed using non-conventional energy resources and no external energy input is required. Along with this an economic study has also been made which supports the proposed idea.*

Keywords: Gradient, Desalinated, Super heater, Pre heater

I. INTRODUCTION

OTEC, Ocean Thermal Energy Conversion is an energy technology that converts solar radiation to electric power. OTEC systems use the ocean's natural thermal gradient, consequently the temperature difference between the warm surface water and the cold deep water below 800 meters by about 20 C, an OTEC system can produce a significant amount of power. The oceans are thus a vast renewable resource, with the potential to help us produce billions of watts of electric power. The cold seawater used in the OTEC process is also rich in nutrients and it can be used to culture both marine organisms and plant life near the shore or on land. The total influx of solar energy into the earth is of thousands of times as great as Mankind's total energy use. All of our coal, oil and natural gas are the result of the capture of solar energy by life of the past. There have been many projects for harnessing solar energy, but most have not been successful because they attempt to capture the energy directly. The problem with this is that huge collectors must be deployed to do this, and resulting in large costs. The idea behind OTEC is the use of all natural collectors, the sea, instead of artificial collector.

Aims and Objectives

To increase the net energy output of an OTEC closed cycle by incorporating a superheater which acts as an additional source of heat. Superheater acts as a heat exchanger which transfers direct heat from sun to the working fluid

Methodology

In the proposed design, a black metallic plate of aluminum is installed on the OTEC plant, above the water surface. This plate absorbs maximum solar radiation and gets heated up upto a temperature of 43oC. This heat is transferred to the evaporated working fluid by means of connecting rods. The outlet sea water from the evaporator is 12oC warmer than the working fluid coming out of the condenser. This fact is used to preheat the working fluid before it advances into the evaporator. This further compensates the heat loss from the heat exchangers; also it increases the working time of the OTEC plant. This preheating increases the efficiency from 3.07 to 3.11 %- a useful increase. Thus preheating provides gain both in heat absorbed and conversion efficiency. The working fluid used is propane or ammonia. Propane has Boiling point approximately 23.9oC and freezing point of 14oC, with a dew point of 7oC. In a closed cycle, the working fluid is pumped into a heat exchanger where it exchanges heat with surface water, which is at 29oC in tropical areas. After



passing through the heat exchanger, the working fluid vaporises with a dryness fraction of 97%. Superheating is a process of directly heating the saturated vapour from highest temperature source available. This additional heating occurs at constant pressure and increases the enthalpy, thus remaining vapour droplets also gets converted to vapour. Evaporator temperature is 40C less than the incoming sea water, so to improve this state of working fluid we can superheat it by 3-40C in order to reduce erosion problems in turbine. The working fluid temperature would be increased by 40C by absorption of 134 KW of heat. This increases the dryness fraction from 97% to 98%.3.1.4. Net Energy Output The net energy output depends upon the velocity with which the turbine blades rotate. This depends upon the kinetic energy of the working fluid entering the turbine. This kinetic energy of the working fluid is governed by the enthalpy of the gas. Superheating increases the temperature of the working fluid which increases its enthalpy. Thus superheating the gas indirectly increases the net energy output of the turbine. As all the other energy requirements in pumps is unavoidable, the only source of increasing the net output of the OTEC plant is to increase the gross output of the turbine. Statistical data for 1MW OTEC plant Gross output of turbine=1MW Net energy output=493KW Pump capacity (cold water) = 292KW Pump capacity (hot water) =197KW Working fluid pump capacity = 18KW Net energy output in new design Net energy output=593KW Thus 100KW of additional energy is added to the net energy output of the OTEC plant due to installation of super heaters and pre-heaters

Location of OTEC Plant

Except for closed basins, such as the Mediterranean and Red Seas, deep seawater flows from the polar regions: polar water, which represents up to 60% of all seawater, originates mainly from the Arctic for the Atlantic and North Pacific Oceans, and from the Antarctic (Weddell Sea) for all other major oceans. Therefore, T_c at a given depth, approximately below 500 m, does not vary much throughout all regions of interest for OTEC. It is also a weak function of depth, with a typical gradient of 1°C per 150 m between 500 m and 1000 m. These considerations may lead to regard T_c as nearly constant, with a value of 4°C at 1000 m. Two facts require caution, however, during the OTEC site selection process: 1) OTEC is very sensitive to any loss of thermal resource, and 2) the Cold Water Pipe is a costly plant component. Consequently, variations in T_c that appear to be small may have a drastic impact on the performance and/or the capital cost of the OTEC plant.

Co-Products of OTEC

The seawater needed for OTEC can also be used to support mariculture operations. The cold seawater contains large quantities of the nutrients required to sustain marine life. Organisms already grown in this environment include algae, seaweeds, shell fish and fin fish. The cold seawater can also be used as the chillier fluid for air-conditioning systems. In considering the economics of OTEC, it is appropriate to determine if multiple-product systems (e.g.: electricity, desalinated water, mariculture, AC systems) yield higher value by, for example, decreasing the equivalent cost of electricity. Unfortunately mariculture operations, as in the case of AC systems, can only use a relatively minute amount of the seawater required for OTEC systems. For example, the cold water available from a 1 MW OTEC plant could be used for daily exchanges of twenty-five 100m x 100m x 1m mariculture ponds, requiring at least 25 ha. Moreover, no mariculture operation requiring the use of the high-nutrient-deep-ocean water has been found to be cost effective. It is, therefore, recommended that OTEC be considered for its potential impact in the production of electricity and desalinated water and that mariculture and AC systems, based in the use of deep ocean water, be considered decoupled from OTEC.

Benefits and Drawbacks

Benefits

1. The net energy output of the plant increases by approx. 20.3% which is considerably high.
2. Suitably designed OTEC plants will produce little or no carbon dioxide or other polluting chemicals.
3. The installation of a pre-heater increases the working time constraint of the OTEC plant in a particular day.



4. The use of OTEC as a source of electricity will help reduce the state's almost complete dependence on imported fossil fuels.

Drawbacks

1. OTEC-produced electricity at present would cost more than electricity generated from fossil fuels at their current costs.
2. OTEC plants must be located where a difference of about 20° C occurs year round. Ocean depths must be available fairly close to shore-based facilities for economic operation. Floating plant ships could provide more flexibility.
3. No energy company will put money in this project because it only had been tested in a very small scale.
4. The cost of the OTEC plant increases by 21% by installation of a super heater and a pre-heater.

II. CONCLUSION

Installation of super heater and pre-heater increases the net energy output of OTEC plant. To decrease the cost of heat exchangers search for more durable Polymer heat exchangers, which are more efficient at lower cost is carried out. Also the design of metallic plate is being improved, to transfer maximum energy to the working fluid.

REFERENCES

- [1] Luis A. Vega, Economics of Ocean Thermal Energy, American Society of Civil Engineers, 1992
- [2] Dr. Hans Krock, Preliminary Analysis of Polymer Heat Exchangers
- [3] Maria Bechtel and Erik Netz, OTEC
- [4] H.P.Gupta, Solar Engineering
- [5] Ruperi Mario, OTEC in Pacific Island

