Improvement in Ocean Thermal Energy Conversion Using Solar Boosting Techniques

Gitansh Sharma[1] Abhijeet Narwal[2]
[1,2]Department of Mechanical Engineering
[1,2]ITM University, Gurgaon, India

Abstract— Ocean Thermal Energy Conversion (OTEC) is a method to generate power using the heat trapped by the ocean water due to incident solar irradiations. It utilizes the small temperature difference that exists between the warm surface water and cold deep water of the ocean. This paper describes the Solar and Wave boosting techniques that can be employed in OTEC plant to increase thermal efficiency and work output of an OTEC plant. Using the solar boosters, the OTEC cycle efficiency increases to 13%. And using the wave boosters the pump work is obtained by harnessing the energy of the wave motion of water.

Keywords: CPC, OTEC, SOTEC, Solar-Booster, Rankine-cycle.

I. INTRODUCTION

Ocean Thermal Energy Conversion is a power generation method wherein the heat energy associated with the temperature difference between warm surface water and cold deep water of ocean is converted into electricity. The study of many theoretical and experimental works reveal that closed cycle OTEC is most convenient cycle to harness ocean thermal energy. It operates on Rankine heat cycle and uses ammonia as a working fluid. The studies reveal that OTEC requires a temperature difference of minimum 20K between evaporator and condenser to effectively harness thermal energy trapped in the ocean. But the traditional OTEC plant have low thermal efficiency of about 2-3% [2] and require a large amount of pump work to pump water in and out of the OTEC system.

In this study, we will discuss various techniques or methods that can be used to increase the thermal efficiency and provide for the high pump work required to pump water in and out of the OTEC system. These technologies include solar booster technology. Solar Boosters uses solar collector to raise the temperature of warm surface water or that of a working fluid.

II. SCOPE AND AVAILABILITY OF OTEC

OTEC has a high potential as an energy source. Various studies refer that OTEC has an estimated global potential of about 30,000 - 90,000 TWh/yr. Figure 1. Shows the various sites where OTEC can be economically and effectively harnessed. The regions include the locations that are generally situated near the equator because of the higher surface temperature of ocean. These regions include south-east Asia, south India, Australia, Mexico, Cuba, etc. The regions with temperature difference of 20-25K between ocean surface water and water at 1000m depth are most suitable for OTEC plants.

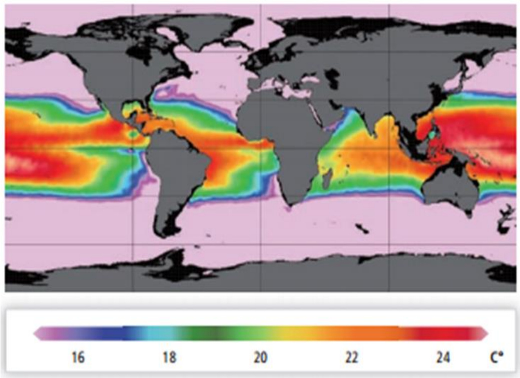

Fig. 1: World average ocean temperature differences between surface water and water at 1000m depth. [3]

III. WORKING OF OTEC

The OTEC operates on Rankine heat cycle. The OTEC uses the low pressure turbines to produce mechanical work. Figure 2 explains the working of a closed OTEC cycle. In a closed OTEC cycle the warm water from the ocean surface is drawn using a pump and is passed through the evaporator where it exchanges heat with the working fluid which gets evaporated and turns the low pressure turbine. The studies suggest that ammonia is the most suitable working fluid. The working fluid after passing through the turbine passes through the condenser where it gets condensed after exchanging heat with the cold sea water drawn from about 1000m of depth.

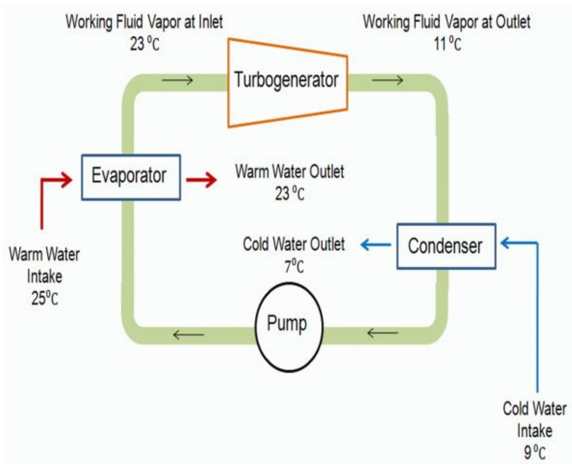

Fig. 2: Schematics diagram of traditional closed OTEC operation [3]

IV. PROBLEMS WITH TRADITIONAL OTEC

Different problems with traditional OTEC are listed below:

A. Low thermodynamic Efficiency:

– Due to small temperature difference between hot and cold water (20-25K) the thermodynamic efficiency is quiet low.

- It can be improved by using Solar boosters to raise temperature of Surface water by using solar collectors. Even High Pressure Turbines can be used.

B. High Amount of Work to pump deep water:

- Large volumes of water are required to be pumped from a depth of nearly 1000m. So, 20-40% of produced work is used as pump work to pump water in and out of OTEC system.
- The pump work can be provided using Wave and Aero generators like wave pumps and wind mills respectively.

V. SOLAR BOOSTED OTEC (SOTEC)

SOTEC uses solar collectors to raise the temperature of the surface warm water or the working fluid. This increases the temperature difference and hence the mechanical work obtained and also the thermal efficiency. As per the thermodynamics, greater the temperature difference between evaporator and condenser, greater the efficiency. Studies suggest that Solar Boosters are used to increase the temperature by 20-40K only not more than that. This is done to maintain balance between

- Cost effectiveness and efficiency
- Efficiency during day time and night

Figure3. shows the curve of efficiency of OTEC and SOTEC with the variation of temperature difference.

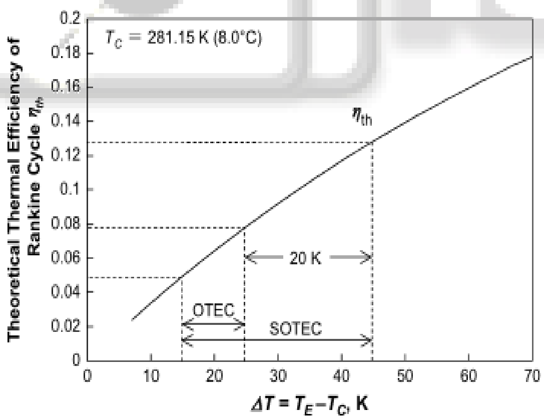

Fig. 3: Curve of efficiency of OTEC and SOTEC with the variation of temperature difference [1]

The closed SOTEC cycle is of two types direct heating SOTEC cycle and Indirect Heating SOTEC cycle. The Indirect heating technique uses solar collector to increase the temperature of the water drawn from the surface of ocean. In direct heating SOTEC system the working fluid is directly heated using solar panel after it passes evaporator. The schematics of the SOTEC have been shown in Figure 4 and Figure 5.

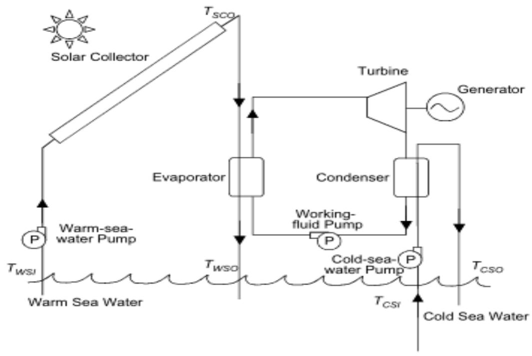

Fig. 4: Schematics of Indirect SOTEC operation [1]

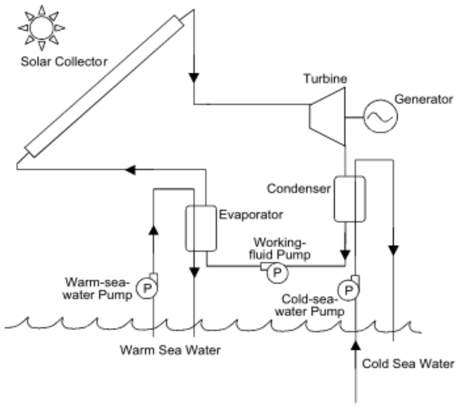

Fig. 5: Schematics of Direct SOTEC operation [1].

The schematics of SOTEC plant operation have been shown in figure 6.

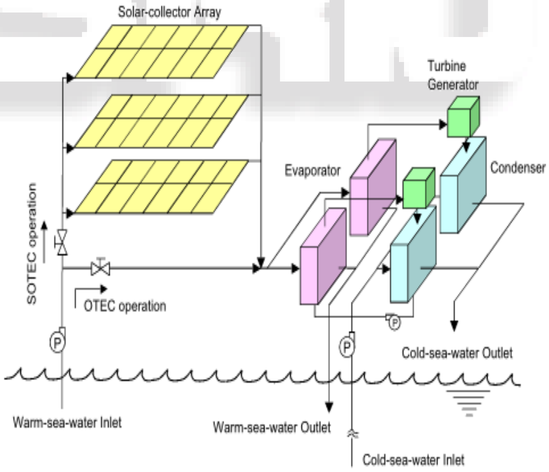

Fig. 6: Schematics of SOTEC Plant operation.

VI. ADVANTAGES OF USING SOLAR BOOSTER

- Increased Power Output
- Increased Thermal Efficiency to 13%
- Reduced Cost per KW
- Can harness SOTEC in regions where OTEC was not suitable.

VII. CONCLUSION

OTEC has a great potential that can be harnessed to meet growing energy demands. But OTEC should be incorporated with proper booster technologies to make the OTEC economical and cost effective, as alone OTEC has low efficiency and high cost of energy production. As a Hybrid OTEC plant will prove to be highly efficient, clean, renewable and continuous source of power.

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