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Experimentation and Analysis of Cold Water Pipes In Ocean Thermal Energy Conversion

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Abstract- **Ocean Thermal Energy Conversion is one of the major sources to produce electricity by using ocean water. However, no proper implementation is being done due to various drawbacks like setup cost, expensive maintenance and also the failure of cold water pipe that is held in the ocean at a depth of 1000m. This paper deals with the experimentation and analysis of various materials for the CWP in OTEC.**

Keywords:-- **OTEC, CWP, failure, cost.**

I. INTRODUCTION

Ocean Thermal Energy Conversion can be considered as a recent advancement in power production sometimes. But this was proposed very long back by Claude (1881). This is a part of thermal engineering which is based on the temperature difference between the surface and the deep cold water.

Some studies were actually taken by many climatic and also oceanic journals. It was concluded that the OTEC can be a trendsetter in near future for producing renewable and clean energy for small and developing nations more efficiently.

However, the major drawback of this OTEC technology is the cost of fabrication of the cold water pipe that draws a large amount of water from the deep sea to the surface. This cold water pipe must be able to withstand several criteria and physical conditions such as the bending stress, temperature effects, corrosion, pressure under 1KM of the ocean.

There are two types of OTEC plants named as open and closed cycle plants. The closed cycle plant uses the working fluid as ammonia or propylene. They are actually used as they have low boiling point while we compare with water. However, the ammonia can create damages to the pipe and hence this is planned to avoid. The second type of plant was proposed by claude and this used water as working fluid. However this will increase the size of the cold water pipe as this fully works on water.

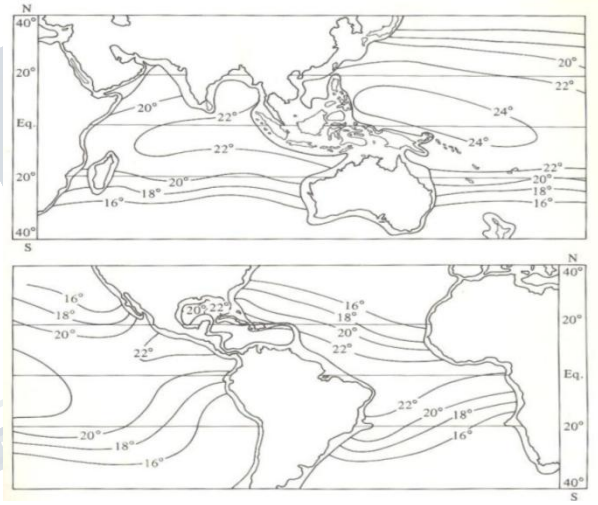

Fig. 1. Temperature difference between the surface and deep sea water in various oceans.

II. LITERATURE REVIEW

The term OTEC was first quoted by a French man named Jacques D'Arsonval in the year 1881. In 1930, a new plant was tried to be implemented at the African coast. But this was declared a failure model since it was unable to compete with the cheap hydroelectric plant. Saga University, a famous varsity in Japan had a tie up with national institute of ocean technology and Government of India to develop a 1MW mini OTEC plant in the place called as Kulashekhrapatnam, in the district of Tuticorin along the coast of Bay of Bengal. If this project is completed, then this will be the first ever power plant to produce electricity from OTEC in MW range.Sagar Shakthi is yet another project that can be a pride of the nation once if it is implemented.

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The Lockheed Martin Corporation has published its research work claiming about the materials chosen and fabrication of the Cold Water Pipe in the OTEC by means of using composites with vinyl ester resin. The size of the CWP was actually estimated to 10-20m diameter and also the length of about 1KM.

III. TECHNOLOGIES OF OTEC

The OTEC plant is actually a plant based on the ocean power and not tidal power. Thus this can be used in major parts of the sea shore provided the temperature difference between the surface and the deep cold water is 20oC.

There are 3 types of cycles are used in the OTEC plant. They are as follows.

1) Open Cycle
2) Closed cycle
3) Hybrid cycle

IV. CLOSED CYCLE

The idea of this closed cycle was first proposed by the French scientist D'Arsonval long back. The working fluid used in this cycle is found to be ammonia and propylene which is actually low boiling fluid. This will vaporize in the evaporator and the steam will run the turbine to produce electricity. Then the steam is passed through the condenser in which the steam condenses to liquid.

The main advantage of the closed cycle is this is compact and more ease to construct than comparing the open cycle. This can be constructed with the existing turbo machinery itself. The demerit is the usage of ammonia is this will cause damage to the pipe as well as the turbine.

Open Cycle

Open cycle or otherwise called as claude cycle uses the sea water as the working fluid in order to reduce the damage caused by the ammonia in closed cycle. The warm sea water is sent to the low pressure evaporator and hence the water boils there. Then, the vapor produced will produce electricity after passing through the turbine.

Hybrid Cycle

As the name itself depicts, this is a hybrid process which has the functions of both open and closed cycle. This hybrid cycle is using both water and ammonia as its working fluid. However, this is a theoretical concept and it is not practically implemented as of now. Research is going on in order to reduce the size of the CWP and thus reducing the initial cost to be invested.

However, it was concluded that the closed cycle is suitable for the coast of India. But the CWP is again still a matter of concern since this is not feasible to work under such physical conditions like temperature, pressure and also fouling.

V. EXPERIMENTATION

Various materials were used before for the manufacturing of the cold water pipe. He pioneer of this field is Lockheed Martin Corporation directly under the monitoring of US state energy department. But, the diameter of the pipe is estimated around 10-20m. The material chosen cannot be of a single material since the physical conditions of the ocean water varies with depth.

Thus, it is decided to work over the composite matrix material (i.e) Fiber Reinforced Plastics. The specimens were prepared in International Research Centre, Kalasalingam University, Virudhu Nagar, Tamil Nadu.
The material used for the preparation of specimens for test is coconut sheath. The coconut sheath is the waste of the coconut trees and it is less expensive and has all properties to make the composites. The composite formed was enriched with chromium and Aluminium particles. Thus, three different composites with different composition and enrichment were made.

Testing

The testing of the specimens was made at the same venue and the tests used were SEM, UTM, NDT and Rockwell tests. Still tests on temperatures are going on and the project is scheduled to be carried on. The results of the project will be dealt in another research paper and it will be published and filed in another occasion.

Applications Of An Otec Plant

Besides producing electricity, open cycle plants can produce desalined water that can be used for irrigation as well as drinking purpose. A closed plant can be used to treat the chemicals that can be used as a fertilizers.It can enrich the aquaculture, marine culture, the fishery industry. It can be helpful in the production of hydrogen.

VI. CONCLUSION

The demerits of the OTEC pipe were as follows.

1. The cost is high.
2. The efficiency is low.

3. The closed cycle may cause pollution on leakage.
4. Construction of a floating plant is difficult.

These issues are rectified by using these materials for the manufacture of cold water pipe.

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