NICKEL-CADMIUM

The NiCd is a matured electrochemistry, in which the positive electrode is made of cadmium and the negative electrode of nickel hydroxide. The two electrodes are separated by Nylon separators and placed in potassium hydroxide electrolyte in a stainless steel casing. With a sealed cell and half the weight of the conventional Pb-acid, the NiCd battery has been used to power most rechargeable consumer applications. It has a longer deep-cycle life and is more temperature tolerant than the Pb-acid battery. However, this electrochemistry has a memory effect (explained later), which degrades the capacity if not used for a long time. Moreover, cadmium has recently come under environmental regulatory scrutiny.

NICKEL-METALHYDRIDE

NiMH is an extension of the NiCd technology and offers an improvement in energy density over that in NiCd. The major construction difference is that the anode is made of a metal hydride. This eliminates the environmental concerns of cadmium. Another performance improvement is that it has a negligiblememory effect. NiMH, however, is less capable of delivering high peak power, has a high self-discharge rate, and is susceptible to damage due to overcharging. Compared to NiCd, NiMH is expensive at present, although the price is expected to drop significantly in the future. This expectation s based on current development programs targeted for largescale application of this technology in electric vehicles.

LITHIUM-ION

The Li-ion technology is a new development, which offers three times the energy density over that of Pb-acid. Such a large improvement in energy density comes from lithium's low atomic weight of 6.9 vs. 207 for lead. Moreover, Li-ion has a higher cell voltage, 3.5 V vs. 2.0 V for Pb-acid and 1.2 V for other electro-chemistries. This requires fewer cells in series for a given battery voltage, thus reducing the manufacturing cost.

On the negative side, the lithium electrode reacts with any liquid electrolyte, creating a sort of passivation film. Every time the cell is discharged and then charged, the lithium is stripped away, a free metal surface is exposed to the electrolyte, and a new film is formed.

This is compensated for by using thick electrodes or else the battery life would be shortened. For this reason, Li-ion is more expensive than Ni-Cd.

LITHIUM-POLYMER

This is a lithium battery with solid polymer electrolytes. It is constructed with a film of metallic lithium bonded to a thin layer of solid polymer electrolyte. The solid polymer enhances the cell's specific energy by acting as both the electrolyte and the separator. Moreover, the metal in solid electrolyte reacts less than it does with a liquid electrolyte.

RAMA UNIVERSITY

www.ramauniversity.ac.in

FACULTY OF ENGINEERING & TECHNOLOGY

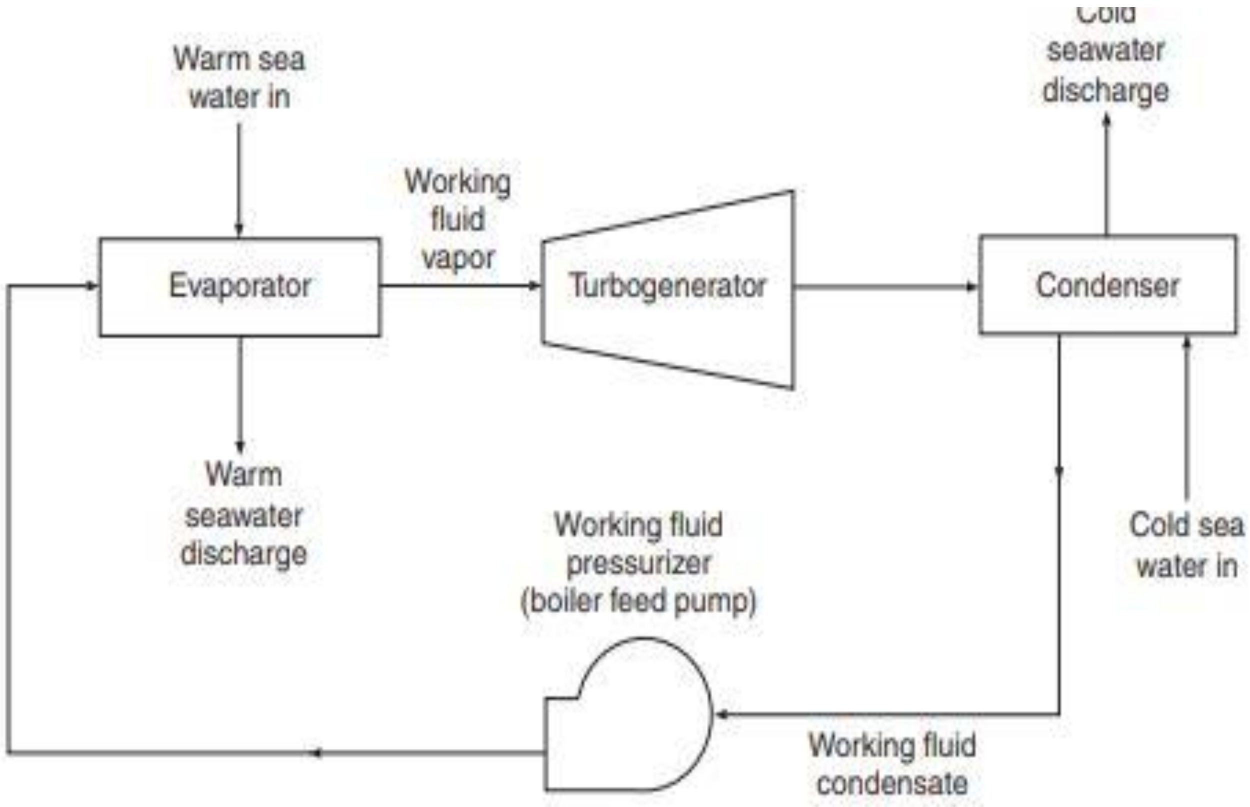
OTEC

Ocean thermal energy conversion (OTEC) generates electricity indirectly from solar energy by harnessing the temperature difference between the sun-warmed surface of tropical oceans and the colder deep waters. A significant fraction of solar radiation incident on the ocean is retained by seawater in tropical regions, resulting in average year-round surface temperatures of about 283C. Deep, cold water, meanwhile, forms at higher latitudes and descends to flow along the seafloor toward the equator. The warm surface layer, which extends to depths of about 100}200m, is separated from the deep cold water by a thermocline. The temperature difference, T, between the surface and thousand-meter depth ranges from 10 to 253C, with larger differences occurring in equatorial and tropical waters, as depicted in Figure . T establishes the limits of the performance of OTEC power cycles; the rule-ofthumb is that a differential of about 203C is necessary to sustain viable operation of an OTEC facility. Since OTEC exploits renewable solar energy, recurring costs to generate electrical power are minimal. 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 modest amounts of electricity. These high fixed costs dominate the economics of OTEC to the extent that it currently cannot compete with conventional power systems, except in limited niche markets. Considerable effort has been expended over the past two decades to develop OTEC by-products, such as fresh water, air conditioning, and mariculture, that could offset the cost penalty of electricity generation.

Closed Cycle OTEC

D’Arsonval’s original concept employed a pure working fluid that would evaporate at the temperature of warm sea water. The vapor would subsequently expand and do work before being condensed by the cold sea water. This series of steps would be repeated continuously with the same working fluid, whose flow path and thermodynamic process representation constituted closed loops } hence, the name ‘closed cycle.’ The specific process adopted for closed cycle OTEC is the Rankine, or vapor power, cycle. Figure is a simplified schematic diagram of a closed cycle OTEC system. The principal components are the heat exchangers, turbogenerator, and seawater supply system, which, although not shown, accounts for most of the parasitic power consumption and a significant fraction of the capital expense. Also not included are ancillary devices such as separators to remove residual liquid downstream of the evaporator and subsystems to hold and supply working fluid lost through leaks or contamination. In this system, heat transfer from warm surface sea water occurs in the evaporator, producing a saturated vapor from the working fluid. Electricity.

is generated when this gas expands to lower pressure through the turbine. Latent heat is transferred from the vapor to the cold sea water in the condenser and the resulting liquid is pressurized with a pump to repeat the cycle. The success of the Rankine cycle is a consequence of more energy being recovered when the vapor expands through the turbine than is consumed in re-pressurizing the liquid. In conventional (e.g., combustion) Rankine systems, this yields net electrical power. For OTEC, however, the remaining balance may be reduced substantially by an amount needed to pump large volumes of sea water through the heat exchangers.



Irreversibilities in the turbo machinery and heat exchangers reduce cycle efficiency below the Carnot value. Irreversibilities in the heat exchangers occur when energy is transferred over a large temperature difference. It is important, therefore, to select a working fluid that will undergo the desired phase changes at temperatures established by the surface and deep sea water.