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Solar-Kalina-OTEC Power Plant

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Introduction:

- Aim of this project is to ascertain the feasibility of an Ocean Thermal Energy Conversion Power Plant (OTEC) operating on Kalina Cycle (KC) in conjunction with Solar energy as primary heating source.
- Conventional OTEC operate using Organic Rankine Cycle (ORC) which utilizes temperature gradients in the sea to produce power. Kalina cycles uses Ammonia and Water mixture as a working fluid which improves system thermodynamic efficiency and provides more flexibility in various operating conditions compared to traditional ORC associated with OTEC.
- The estimated efficiency improvement of KC with comparable ORC is 10%-50%. [reference required]
- We analyse KC with solar heating using parabolic troughs.
- The estimated power output for the plant-1 with solar heating in 24 hours is 145MWh.
- The estimated power output for the plant-1 with ocean thermal heating in 24 hours is 2.4MWh.

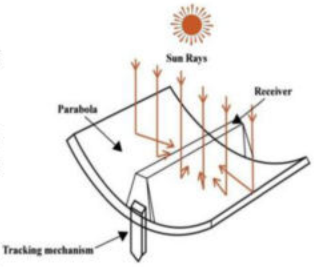

Figure 1. *Solar Trough.*

Literature:

- The KC plant comprises of a turbine, pump, boiler and condenser, separator, recuperator and a heat exchanger.
- The WF exists the recuperator to enter the heat exchanger where its diluted (~40% from ~70%) and cooled using the deep-sea water.
- The mixture is pumped again its sent to separator which separates the mixture into its two components. The excess water is sent to heat exchanger and the concentrated ammonia is ready to be pumped to the recuperator.
- For KC the mean temperature at which the heat is added is more than RC and the mean temperature where heat is rejected is lower than RC.
- High concentration of ammonia has very low condensing temperature (which can't be achieved with cold sea water).
- For a relatively lower ammonia concentration the condensation temperature of the mixture increases to a more practical operating temperature.

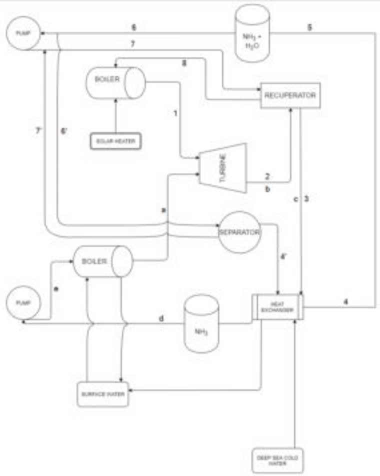

Figure 2. *Combined Power Plant.*

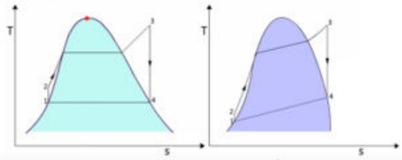

Figure 3. *T-S Diagram of RC, KC*

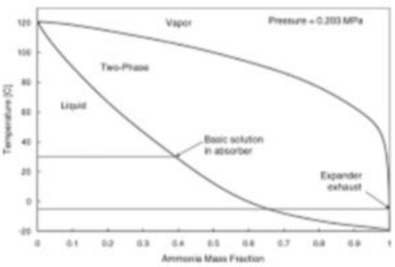

Figure 4. *Ammonia-Water Phase Diagram*

Methods:

- For the working temperatures, Euro Trough ET100/ET 150 are ideal as operating temperatures over 773K can be reached.
- For analysis Kalina Cycle – 11 is taken with the following energy equations.

Table 1. *Energy equations for KC-11*

HRVG	$\dot{Q} = \dot{m}_1 \times (h_2 - h_1)$
Separator	$\dot{m}_1 \times h_2 = \dot{m}_3 \times h_3 + \dot{m}_5 \times h_5$
Turbine	$W_t = \dot{m}_3 \times (h_3 - h_4)$
Regenerator	$\dot{m}_1 \times (h_1 - h_9) = \dot{m}_5 \times (h_5 - h_6)$
Throttle valve	$\dot{m}_6 \times h_6 = \dot{m}_{10} \times h_{10}$
Pump	$W_p = v_9 \times (p_9 - p_8)$
Efficiency	$\eta = \frac{W_t - W_p}{\dot{Q}}$

Analysis:

- For temperature range of 373-473K.
- Going by the values, we see there is a direct increase in efficiency as the temperature increases. The efficiency also depends on the pressure but after a point temperature dominates the effect.

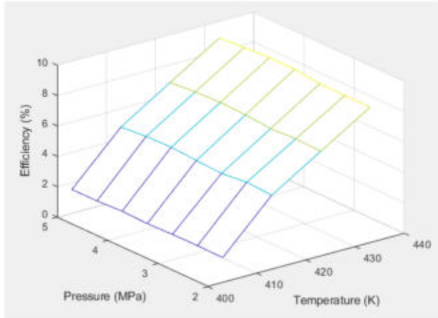

Figure 5. *Efficiency for different T and P*

- The same cycle has been used with input temperatures 788K and has had the power output of 6.5MW with efficiency 20% greater than a plant similar to this one closely studied by us. (Reference pinned below).

Results:

- Plant 1 runs for 11 output is 11*6.5MWh.
- Plant 2 runs for 11 hours, power output is 11*100kWh.
- Therefore, the combined power output is 22*(6.5+0.1) MWh which is 145.2 MWh

Conclusions:

- After carefully examining the requirements of all the individual components we can conclude and efficiencies estimated that the amalgamation of the three components works well.
- Theoretically the plant should have an output of the combined plant in 24 hours is 145MWh where as for just plant 2 it is 2.4MWh which is substantially less
- The efficiencies estimated and power output estimated suggests that the assembly of an OTEC plant has a strong potential for power generation.

Important References:

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