TECHNICAL COMPARISON AND SELECTION OF ORGANIC FLUIDS AS THE WORKING FLUID OF A BINARY CYCLE OF FLASH EVAPORATION

INSTITUTO DE INGENIERÍA UNAM

Authors: Russell Tejeda B. Uriel

Mendoza Ramirez Misael

DEA
DESALACIÓN Y ENERGÍAS ALTERNAS
INSTITUTO DE INGENIERÍA-UNAM

ABSTRACT

A binary cycle power plant uses the thermal energy from a geofluid to heat a secondary (working) fluid in a Rankine cycle to produce electricity. The choice of working fluid in the cycle and determination of optimum operating conditions to maximize power production depend on the temperature of the given geothermal resource, critical conditions of the working fluid and the cooling system (coolant mainly). The analyzed cycle is the result of the modification of a conventional binary cycle which allows achieve greater electrical power. Therefore it was necessary to evaluate different working fluids for use in binary Rankine cycles to find the best ones as a function of resource temperature, thermal efficiency and output power.

OBJECTIVES

The objective of this study was to optimize a binary organic Rankine cycle of flash evaporation for use with low-to mid-grade EGS (Enhanced Geothermal System) resources by determining the optimum working fluid and operating conditions for electric power plants. The process flow diagram used to model the cycle is shown in Figure 1.

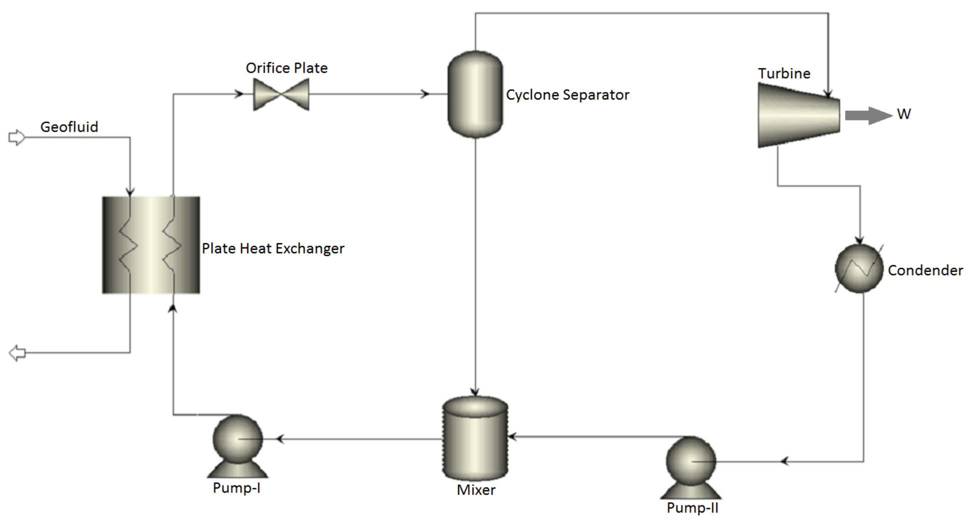
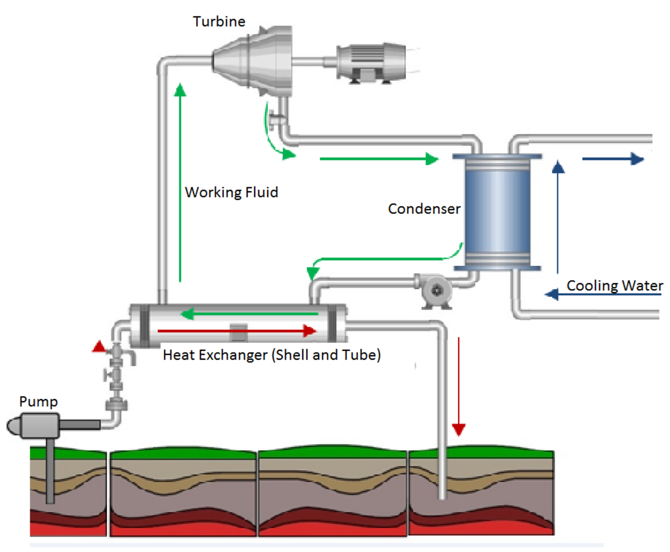


Figure 1.

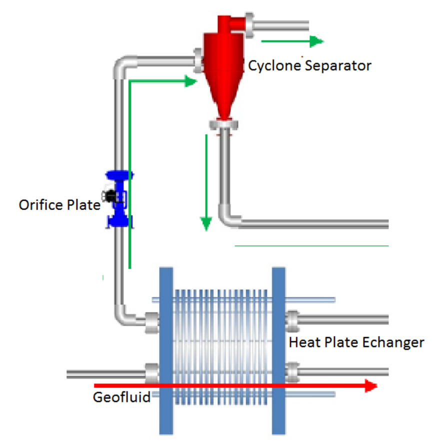
MODIFIED CYCLE BINARY vs CONVENTIONAL BINARY CYCLE

The main advantage of the binary cycle with respect to a binary plant conventional is that when using a plate heat exchanger, the efficiency of steam generation is increased, since this type of equipment allows approaches to 1°C between fluids; their losses are low which is extremely important in the utilization of geothermal energy, the space occupied by these exchangers is less and maintenance is simpler compared to shell and tube.

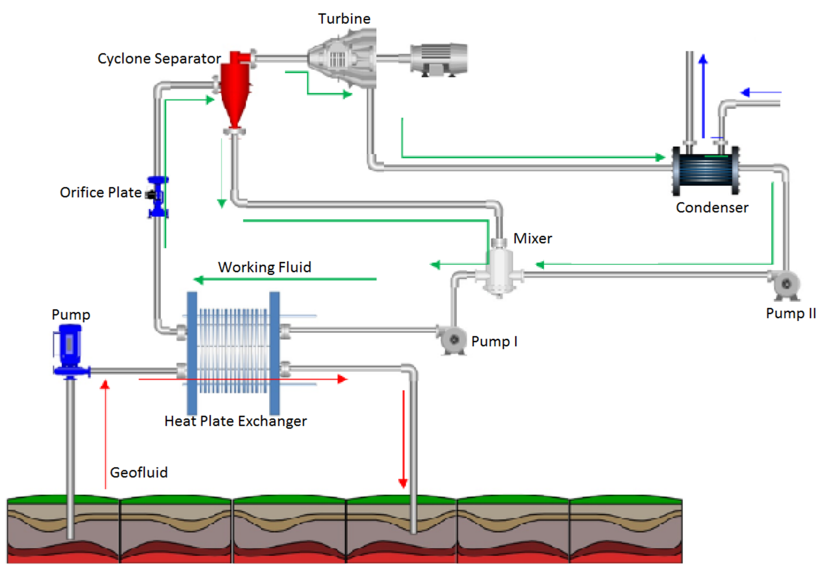
In this new system to flash evaporation with the intention to reduce the overall floor space, it is considered using a high speed turbine. This type of turbine is selected due to the characteristics of the vapor which will be taken into a consideration in this cycle. It is used a centrifugal separator because with this device 99.9% of the vapor is achieved.



Conventional Binary Cycle



Flash Evaporation System



Modified Binary Cycle

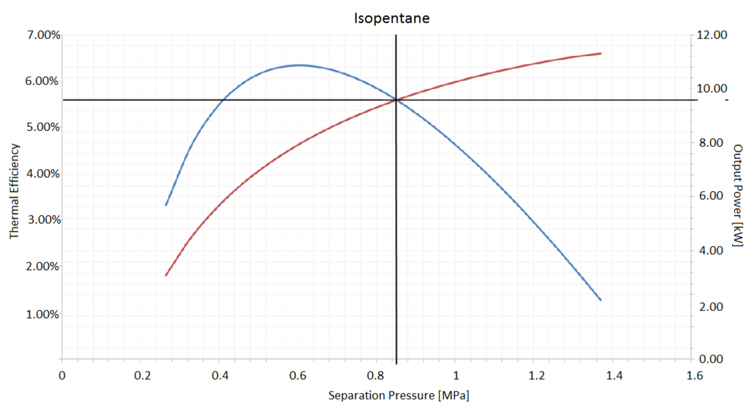
WORKING FLUID SELECTION AND PROPERTIES

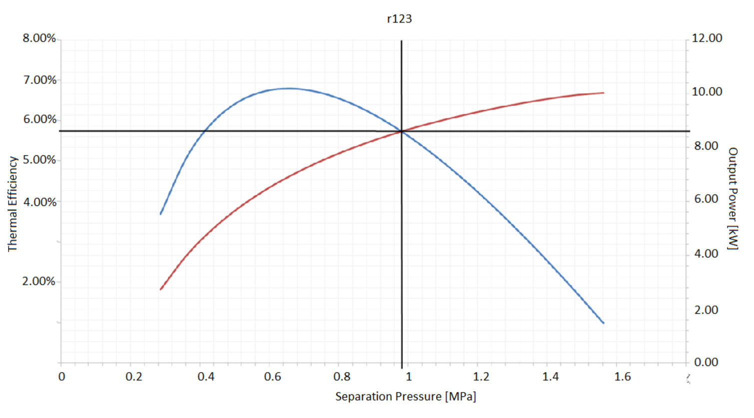
Working Fluid	Cycle Type	Critical T [°C]	Critical P [Bar]
Isopentane	Subcritical	187.3	33.8
r245fa	Subcritical	154.1	36.4
r365mfc	Subcritical	204.7	34.89
R123	Subcritical	183.94	36.62
r141b	Subcritical	208.5	45.4

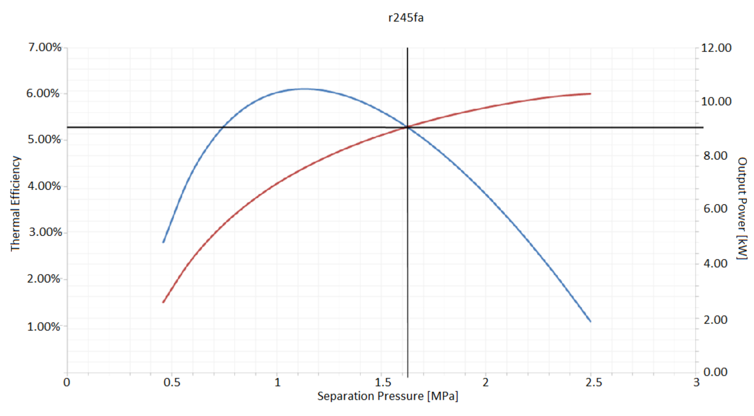
Table 1.

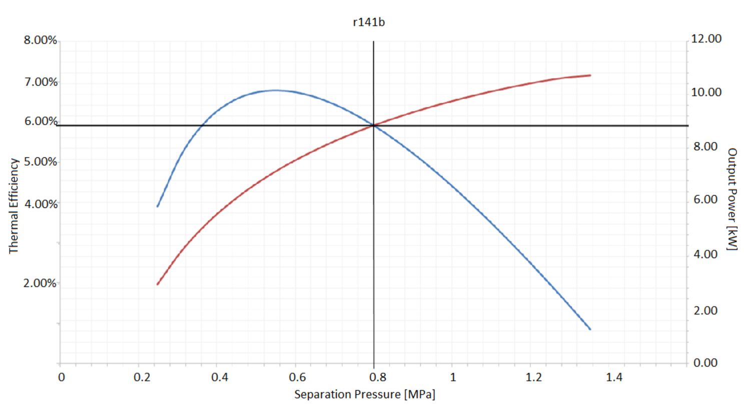
Candidate working fluids to be used in the model were selected based on the geofluid temperature and pressure in the Binary Cycle using results from a previous study on power cycles (Khalifa and Rhodes, 1985). Several organic fluids conventionally used in binary plants, along with some novel fluids and refrigerants, were studied. The working fluids and their critical temperature and pressure are shown in Table 1.

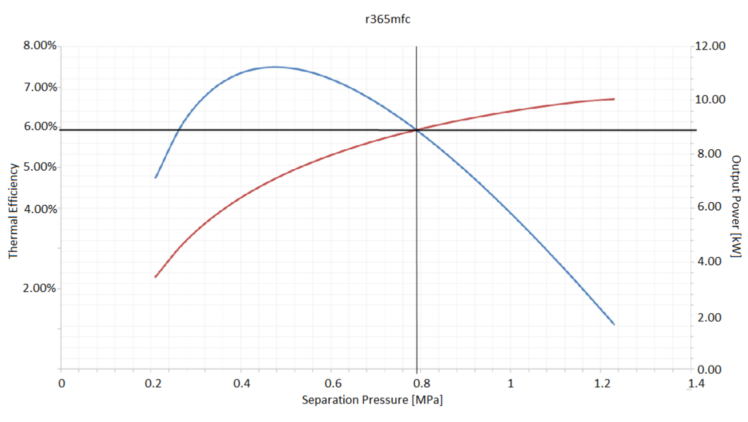
OPERATING CONDITIONS AND RESULTS





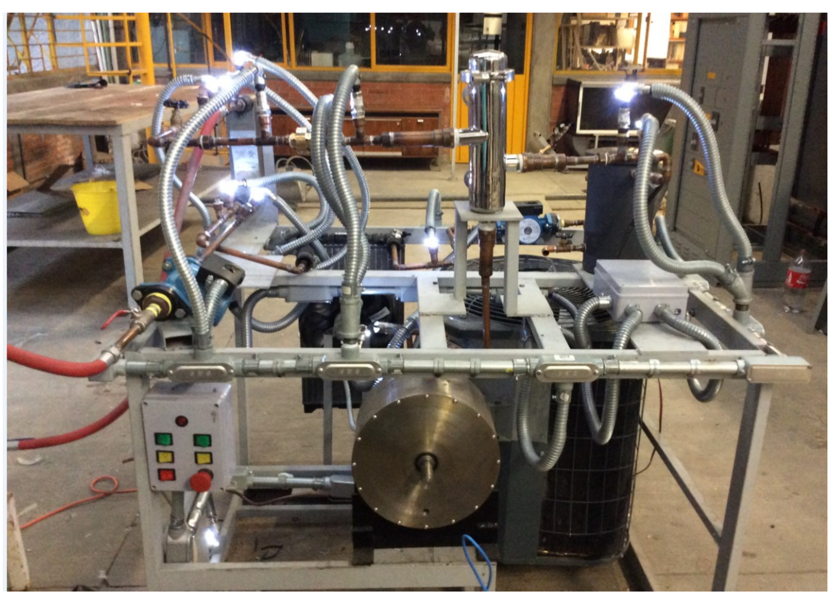






OPERATING CONDITIONS AND RESULTS

The main considerations for determining the working fluid to use, were primarily the first law of thermodynamics and the electric power generated. Of working fluids evaluated, isopentane showed better thermal performance and maximum power generation which can get better performance of the proposed system.



Preliminary laboratory prototype