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Effect of working fluid on the ORC cycle performance of the ocean thermal energy conversion system

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Abstract. Ocean Thermal Energy Conversion system utilizes shallow seawater as the heat source and deep seawater as the cold source, achieving energy conversion at low temperatures and small temperature differences. To improve the efficiency of the OTEC system, this paper focuses on the working fluid side, based on the closed Organic Rankine Cycle, to analyse and select common low boiling point organic working fluids suitable for the OTEC system. Two of them are combined to form new mixed fluids with different component types and ratios. The impact of different types of mixed fluids on system performance is studied. Results show that M31 mixed working fluid has higher power generation efficiency, lower operation pressure and the best economical. Peak η_{OTEC} is 6.43. Compared with pure fluids, using mixed fluids greatly reduces the power consumption and the frictional resistance loss. The R245fa/R245ca (0.3/0.7) mixed working fluid has the smallest power consumption among all its component allocation ratios, with a deep seawater pump consuming 5.085kW, accounting for only 3.3% of that when using pure R245ca. Compared to pure fluids, mixed fluids have higher net output power. So, M31 can be selected as the most suitable working fluids for OTEC system among M1 to M36.

1. Introduction

Ocean Thermal Energy Conversion (OTEC) can utilize the temperature difference between shallow and deep seawater to output electricity. Ocean thermal energy is a renewable energy source with huge reserves, efficiently using of that possesses major strategic significance in ocean development far from the coast [1,2]. The cycle efficiency of OTEC directly determines the economy of the ocean development and utilization rate of local consumption of renewable energy [3]. Therefore, how to improve the cycle efficiency of the OTEC cycle has been an international research hot topic [4,5,6]. Enhancing the efficiency of OTEC cycle can usually be investigated in terms of both the system topology and working fluids. Currently, Organic Rankine cycle (ORC) is widely utilized in OTEC projects, which is an important foundation of OTEC technology [7,8]. So, this paper focuses on effects of working fluids on the performance of the OTEC system based on the ORC cycle.

Scholars have conducted in-depth research to explore the selection of working fluids with better OTEC system performance. Stoecher et al. [9] conducted a study on ammonia, R134a and R22, and compared their respective system cycle efficiency. In the result, the OTEC system utilizing ammonia acquire the highest efficiency and economy. Wu et al. [10] took R227ea/ammonia mixture as the

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research object and determined that when the mass fraction of R227ea was 0.15, the thermal efficiency of the system could reach the maximum. Yang et al. [11] evaluated two mixture working fluids of R717/R32 and R717/R1234YF and compared them with pure R717. Results showed that R717/R32 with mass fraction ratios of 0.21/0.79 had the maximum net power outputs, which was higher than pure R717 by 18.9%, in thermodynamic improvement.

From existing research, it can be seen that scholars' exploration of working fluids has gradually shifted from pure fluids to mixed fluids. This is because that the mixed fluid has a variable temperature phase transition, which can better exchange heat with heat sources and cold sources and reduce irreversible losses, thereby, to improve system efficiency. However, existing literatures have a narrow selection of component working fluids to form the mixed working fluid. Besides, the method of pairing working fluids is incomplete. In order to overcome the above problems, this paper analyzes and screens the common low boiling organic working fluids used in OTEC systems from three perspectives: range of condensation and evaporation temperature, environmental protection and system operation pressure, to form different mixed working fluids in proportion. Then, this paper carries out thermodynamic analysis and calculation to study the cycle characteristics of different mixed working substances to provide help for the future research on the utilization of OTEC system.

2. Analysis of the OTEC system based on ORC

2.1. OTEC system cycle process

The OTEC system based on ORC is shown in the figure 1. When the system is operating, the low boiling point working fluid absorbs heat from shallow seawater in the evaporator, transforming from liquid to gas. Then, the working fluid enters the turbine to expand, driving the turbine to rotate as well as driving the generator to output electricity. After expanding, the gaseous working fluid enters the condenser and exchanges heat with the deep cold seawater lifted up by the cold water pump, cooled from the gaseous state to the liquid state. Subsequently, the refrigerant pump repressurizes the liquid working fluid and sends it into the evaporator to complete the thermodynamic cycle. Usually, the cold seawater heated at the outlet of the condenser can be used for the development of comprehensive utilization fields such as deep-sea purified water, mineralized liquid, refined salt, and seawater air conditioning.

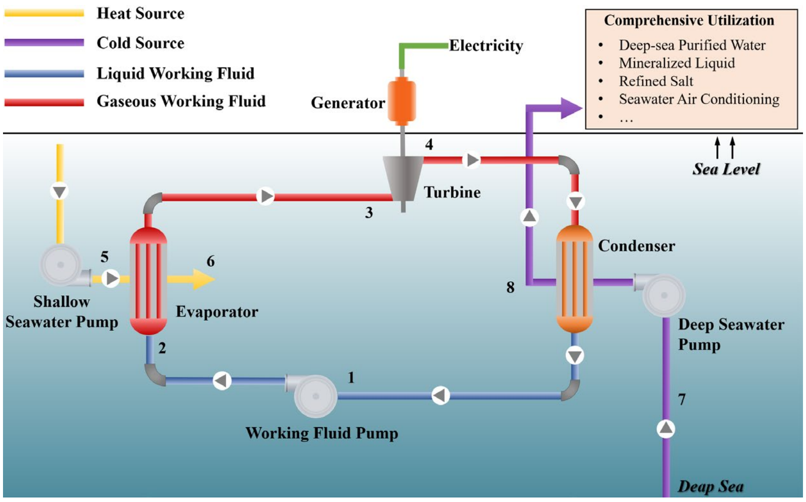

Figure 1. Topology diagram of the OTEC System.

2.2. Theoretical model

In developing the theoretical model, the following assumptions were made:

(1) It is assumed that the OTEC system is well insulated. Except for the evaporator and the condenser, other components have no heat exchange with the external environment.

(2) The working fluid operates in the ORC in an ideal state with no resistance losses.
(3) The mixture of working fluids is uniform.

The OTEC cycle begins from point 1 (figure 1). The power Wp required for rising the pressure from P1 (condenser outlet)to P2 (evaporation inlet) is equal to:

$$W_p = m \cdot \eta_p \cdot \left(h_{2,isentropy} - h_1 \right) \tag{1}$$

Where m is the mass flow rate in the OTEC system; η_p represents the isentropic pump efficiency. h stands for specific enthalpy of the work fluid. Subscripts of 1 and 2 are represent corresponding state points.

The heat absorbed by the working fluid in the evaporator (Q_h) is:

$$Q_\mathrm{h} = m \cdot \left(h_3 - h_2 \right) \tag{2}$$

Due to the expansion of the working fluid, the output power of the turbine (W_t) is:

$$W_\mathrm{t} = m \cdot \eta_\mathrm{t} \cdot \left(h_{4,isentropy} - h_3 \right) \tag{3}$$

Where η_t represents the isentropic turbine efficiency.

The heat dissipated by the working fluid in the condenser (Q_c) is:

$$Q_\mathrm{c} = m \cdot \left(h_4 - h_1 \right) \tag{4}$$

OTEC system power generation efficiency (η) is calculated as:

$$\eta = \frac{W_t - W_p}{Q_h} \tag{5}$$

Frictional resistance loss to lift deep seawater can be calculated as:

$$h_f = \lambda \frac{l}{d} \frac{V^2}{2g} \tag{6}$$

$$p_f = \rho g h_f = \lambda \frac{l}{d} \frac{\rho V^2}{2} \tag{7}$$

Where, p_f is pressure loss of fluids, Pa. h_f is head loss of fluids, m. l represents pipe length, m. d is pipe diameter, m. g is equal to 9.81m/s2. ρ stands for fluid density, kg/m3. V represents fluid velocity, m/s. λ stands for frictional resistance coefficient which can be calculated based on the table 1.

Table 1. λ of circular tube.

Flow pattern	Re	Resistance zone	λ
Laminar flow	<2000	/	$\lambda = \frac{64}{\mathrm{Re}}$
Critical flow	2000-4000	/	$\lambda = 0.0025\,\mathrm{Re}^{1/3}$
		$V < 11\frac{\nu}{K}$	$\lambda = \frac{0.3164}{\mathrm{Re}^{0.25}}$
Turbulence flow	>4000	$11\frac{\nu}{K} < V < 445\frac{\nu}{K}$	$\lambda = 0.11[\frac{K}{d} + (\frac{86}{\mathrm{Re}})^{0.25}]$
		$V > 445\frac{\nu}{K}$	$\lambda = 0.11(\frac{K}{d})^{0.25}$

Where, Re is Reynolds number. ν represents kinematic viscosity of fluid, m^2/s. K is equal to 0.046mm, when fluid flows in steel pipes.

In this paper, the shallow seawater pump and deep seawater pump are considered to work to overcome the loss of frictional resistance when lifting seawater. Therefore, the power consumption of them can be calculated as follow:

$$W_{p,ss} = \frac{m \cdot p_f}{\rho_{seawater}} \tag{8}$$

$$W_{p,ds} = \frac{m \cdot p_f}{\rho_{seawater}} \tag{9}$$

Where, $W_{p,ss}$ represents power consumption of shallow seawater pump, W. $W_{p,ds}$ stands for power consumption of deep seawater pump, W.

3. Selection of working fluid for the OTEC system

In the context of the utilization of ocean temperature difference energy for power generation, shallow seawater is used as a heat source for the system at 25-30°C and deep seawater is used as a cold source for the system at 5-8°C. The selected system working fluid should meet the following conditions:

(1) The evaporation temperature of the working fluid is lower than the temperature of the heat source, the condensation temperature is higher than the temperature of the cold source. Furthermore, the critical temperature should be higher than the temperature of the heat source.

(2) From the perspective of environmental impact, organic compounds with zero ozone depletion potential (ODP) and low global warming potential (GWP) should be selected as alternative component working fluids.

(3) The selected system working fluid should not have a high operating pressure within the operating temperature range to avoid the possibility of system component leakage and reduced system safety. At the same time, high operating pressure will greatly increase the economic costs in practical engineering.

Based on the above principles, analysis and screening are conducted on common low boiling point organic working fluids used in the OTEC system, and 9 organic compounds that can be used as mixed working fluid components are obtained: R152a, R600a, R600, R601a, R601, R134a, R227ea, R245fa and R245ca. Table 2 lists the basic physical properties and safety and environmental protection of these 9 organic working fluids. The physical property data of the working fluid comes from the physical property software REFPROP 9.1 which is developed by the National Institute of Standards Technology (NIST) in the United States. ODP, GWP, and safety and environmental protection data are sourced from literature. Combining the above 9 organic working fluids in pairs to form M1-M36, a total of 36 mixed working fluids, as shown in table 3.

Table 2. Basic Physical Properties and Safety and Environmental Protection of Pure Organic Compounds.

Working Fluid	T_{cr} (°C)	P_{cr} (MPa)	T_{NBP} (°C)	ODP	GWP
ODP=0，GWP<5000，low toxicity, but flammable					
R152a	113.25	4.517	-24.0	0	124
R600a	134.66	3.629	-11.7	0	0.1
R600	151.95	3.796	-0.5	0	20
R601a	187.25	3.378	27.8	0	<1
R601	196.55	3.370	36.1	0	<1
ODP=0，GWP<5000, low toxicity, and non-flammable					
R134a	101.05	4.059	-26.1	0	1300
R227ea	101.75	2.925	-16.34	0	3220
R245fa	154.01	3.651	15.1	0	950
R245ca	174.42	3.925	25.13	0	—

Table 3. Alternative mixed working fluids.

Component Number	Low Critical Temperature Components	High Critical Temperature Components	Low Critical Temperature Components		High Critical Temperature Components		Standard Boiling Point Difference
			Critical Temperature	Standard Boiling Point	Critical Temperature	Standard Boiling Point	
			℃	℃	℃	℃	℃
M1	R134a	R227ea	101.05	-26.10	101.75	-16.34	9.76
M2	R134a	R152a	101.05	-26.10	113.25	-24.00	2.10
M3	R134a	R600a	101.05	-26.10	134.66	-11.70	14.40
M4	R134a	R600	101.05	-26.10	151.95	-0.50	25.60
M5	R134a	R245fa	101.05	-26.10	154.01	15.10	41.20
M6	R134a	R245ca	101.05	-26.10	174.42	25.13	51.23
M7	R134a	R601a	101.05	-26.10	187.25	27.80	53.90
M8	R134a	R601	101.05	-26.10	196.55	36.10	62.20
M9	R227ea	R152a	101.75	-16.34	113.25	-24.00	7.66
M10	R227ea	R600a	101.75	-16.34	134.66	-11.70	4.64
M11	R227ea	R600	101.75	-16.34	151.95	-0.50	15.84
M12	R227ea	R245fa	101.75	-16.34	154.01	15.10	31.44
M13	R227ea	R245ca	101.75	-16.34	174.42	25.13	41.47
M14	R227ea	R601a	101.75	-16.34	187.25	27.80	44.14
M15	R227ea	R601	101.75	-16.34	196.55	36.10	52.44
M16	R152a	R600a	113.25	-24.00	134.66	-11.70	12.30
M17	R152a	R600	113.25	-24.00	151.95	-0.50	23.50
M18	R152a	R245fa	113.25	-24.00	154.01	15.10	39.10
M19	R152a	R245ca	113.25	-24.00	174.42	25.13	49.13
M20	R152a	R601a	113.25	-24.00	187.25	27.80	51.80
M21	R152a	R601	113.25	-24.00	196.55	36.10	60.10
M22	R600a	R600	134.66	-11.70	151.95	-0.50	11.20
M23	R600a	R245fa	134.66	-11.70	154.01	15.10	26.80
M24	R600a	R245ca	134.66	-11.70	174.42	25.13	36.83
M25	R600a	R601a	134.66	-11.70	187.25	27.80	39.50
M26	R600a	R601	134.66	-11.70	196.55	36.10	47.80
M27	R600	R245fa	151.95	-0.50	154.01	15.10	15.60
M28	R600	R245ca	151.95	-0.50	174.42	25.13	25.63
M29	R600	R601a	151.95	-0.50	187.25	27.80	28.30
M30	R600	R601	151.95	-0.50	196.55	36.10	36.60
M31	R245fa	R245ca	154.01	15.10	174.42	25.13	10.03
M32	R245fa	R601a	154.01	15.10	187.25	27.80	12.70
M33	R245fa	R601	154.01	15.10	196.55	36.10	21.00
M34	R245ca	R601a	174.42	25.13	187.25	27.80	2.67
M35	R245ca	R601	174.42	25.13	196.55	36.10	10.97
M36	R601a	R601	187.25	27.80	196.55	36.10	8.30

4. Thermodynamic analysis for the OTEC system

4.1. System performance analysis of mixed working fluids in ORC

36 kinds of mixed working fluids are selected to calculate and analyse under the same temperature conditions of heat and cold sources. Same temperature conditions are shown in table 4. Each mixed working fluid is mixed in the proportions of 0.1/0.9, 0.2/0.8, 0.3/0.7, 0.4/0.6, 0.5/0.5, 0.6/0.4, 0.7/0.3, 0.8/0.2, and 0.9/0.1, respectively. The calculation results of the system's power generation efficiency are shown in table 5. Among the results, mixed working fluids such as M4-M8, M13- M15, M19-

M21, M23-M24, and M26 are not considered due to excessive temperature slip during the condensation process within this temperature range, resulting in high turbine outlet temperature and pressure so the system cannot complete normal thermodynamic cycles.

Table 4. Thermodynamic calculation parameters.

Parameters	Value
Inlet temperature of heat source (shallow seawater) T_5/°C	28
Inlet temperature of cold source (deep seawater)T_7/°C	5.5
Evaporator outlet superheat dT_g/°C	1
Narrow point temperature difference in evaporator dT_{gd}/°C	1.5
Condenser outlet subcooling dT_c/°C	0.5
Narrow point temperature difference in condenser dT_{cd}/°C	0.5
Terminal temperature difference in condenser dT_{cin}/°C	0.5
Turbine efficiency η_t	0.8
Pump efficiency η_p	0.75
Net output power W_{net}/kW	300

Table 5. Power generation efficiency of various mixed working fluids (%).

Component Number	0.1/0.9	0.2/0.8	0.3/0.7	0.4/0.6	0.5/0.5	0.6/0.4	0.7/0.3	0.8/0.2	0.9/0.1
M1	4.22	4.18	4.21	4.26	4.33	4.39	4.44	4.49	4.52
M2	4.61	4.61	4.60	4.59	4.58	4.57	4.57	4.52	4.54
M3	2.51	1.52	1.20	1.36	1.92	2.80	3.85	4.49	4.26
M9	4.58	4.55	4.52	4.49	4.47	4.44	4.42	4.40	4.40
M10	3.92	3.43	3.12	3.00	3.09	3.41	3.94	4.42	4.09
M11	4.33	4.07	3.84	3.66	3.55	3.54	3.65	3.92	4.27
M12	3.26	2.50	2.10	1.98	2.08	2.37	2.83	3.40	3.97
M16	3.14	2.68	2.75	3.13	3.67	4.20	4.53	4.56	4.48
M17	3.07	2.39	2.21	2.36	2.74	3.27	3.83	4.29	4.54
M18	1.98	1.26	1.19	1.44	1.87	2.39	2.96	3.53	4.09
M22	4.53	4.45	4.40	4.37	4.35	4.36	4.39	4.43	4.50
M25	3.04	2.13	1.64	1.45	1.48	1.73	2.17	2.79	3.60
M27	2.97	3.43	4.04	4.44	4.59	4.61	4.59	4.58	4.59
M28	1.73	2.07	2.85	3.62	4.16	4.45	4.57	4.61	4.62
M29	3.87	3.38	3.10	2.99	3.00	3.13	3.36	3.69	4.11
M30	3.36	2.59	2.14	1.94	1.94	2.12	2.48	3.00	3.71
M31	4.48	4.39	4.36	4.36	4.40	4.45	4.51	4.56	4.61
M32	3.93	3.51	3.32	3.33	3.52	3.87	4.30	4.60	4.56
M33	3.81	3.25	2.94	2.85	2.95	3.24	3.70	4.24	4.59
M34	4.29	4.11	4.07	4.16	4.33	4.53	4.63	4.47	4.21
M35	4.21	3.93	3.81	3.83	3.97	4.20	4.47	4.63	4.61
M36	4.60	4.56	4.53	4.51	4.50	4.51	4.53	4.56	4.60

For the OTEC system, power generation efficiency is undoubtedly key parameter to measure system performance. In the actual process, the mixing fluid will not be mixed uniformly as in the ideal conditions. So this requires that, when the proportion of the components of the mixing fluid is changed, the change of power generation efficiency should not be too large, otherwise it will affect the overall performance of the OTEC system. Therefore, six mixed working fluids (M1, M2, M9, M22, M31, M36) are selected at first. These working fluids obtain same commonalities:1. power generation efficiency of these mixed fluids are totally greater than 4.15% with various components. 2. the difference in peak and valley power generation efficiency do not exceed 0.35%. Figure 2 shows the variation characteristic of the power generation efficiency. It can be found that M36, M31, M22 and M1 decrease firstly and then increase with the increase of low critical temperature components, while M2 and M9 keep decreasing. It should be noted that M1 has the highest fluctuation in power generation efficiency with component changes among these six mixed working fluids, which can deteriorate system performance in actual operation, and therefore cannot be used as an alternative working fluid.

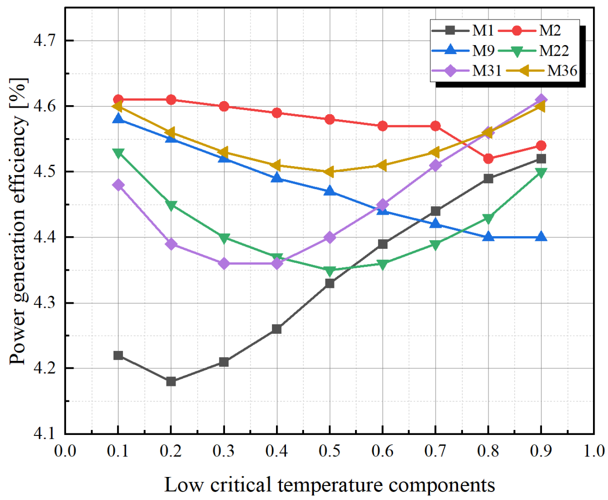

Figure 2. Characteristics of power generation efficiency.

Figure 3 and figure 4 show the variation characteristic of mass flow rate of cold source and heat source. For the OTEC system, excessive mass flow rate of cold source and heat source can greatly increase the frictional resistance loss of the fluid, thereby increasing the power consumption of shallow and deep-water pumps, especially when lifting seawater from deep sea areas (greater than 1000m). Therefore, M2 is not suitable as an alternative working fluid of the OTEC system. Conversely, M22 and M31 have lower mass flow rate of cold source and heat source compared with other mixed fluids, which can be selected as alternative working fluids. Figure 5 and figure 6 show the variation characteristic of evaporation pressure, and condensation pressure. In practical processes, either too high or too low system operating pressure can pose a risk of leakage, so the optimal operating pressure for the OTEC system is around 1 atmospheric pressure. The evaporation pressure of M31 is between 100 to150kPa, and the condensation pressure is between 50 to 70kPa. Among all alternative working fluids, the operating pressure of M31 is closest to 1 atmospheric pressure.

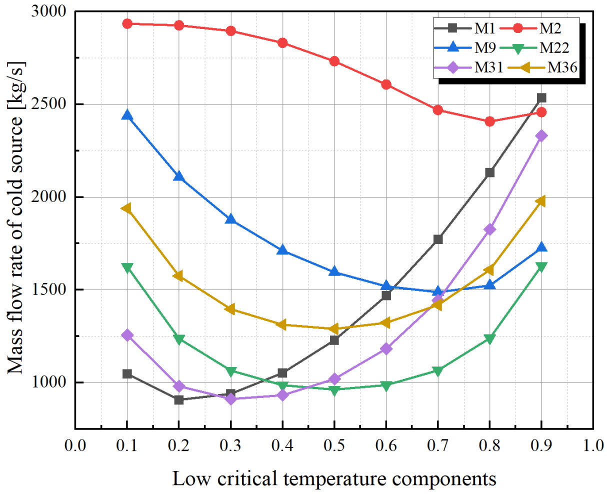

Figure 3. Characteristics of mass flow rate of cold source.

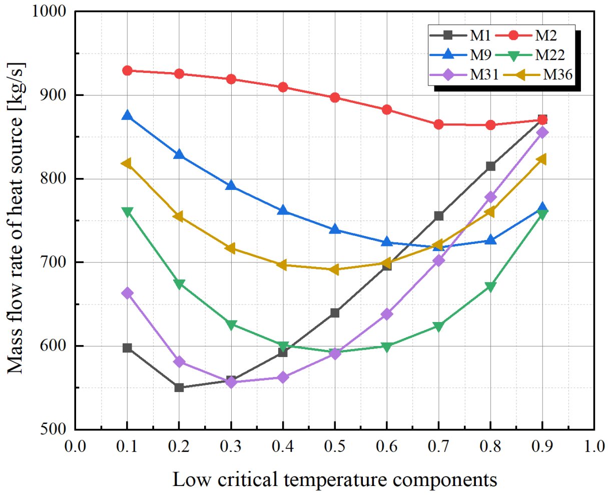

Figure 4. Characteristics of mass flow rate of heat source.

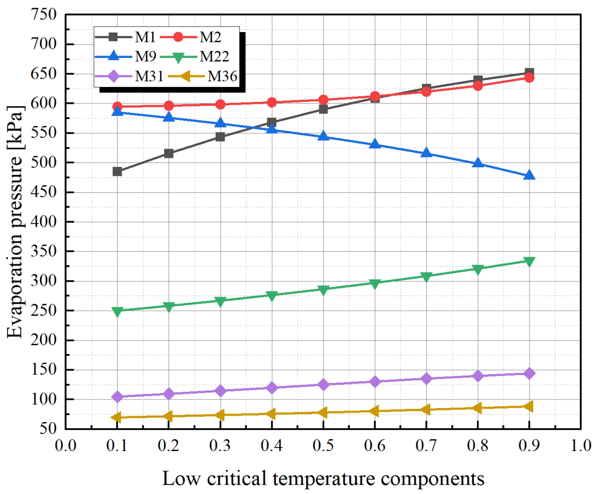

Figure 5. Characteristics of evaporation pressure.

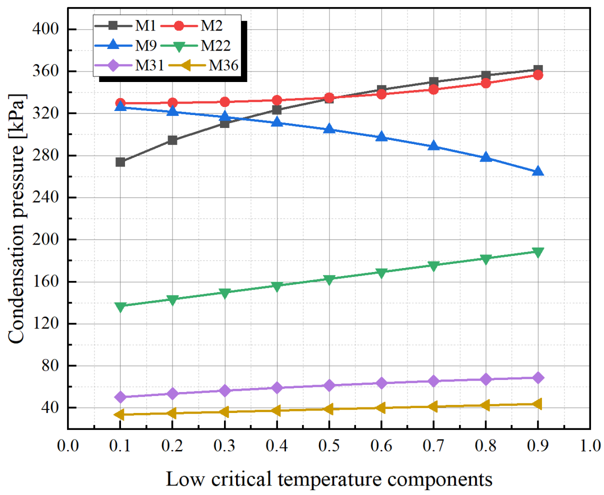

Figure 6. Characteristics of condensation pressure.

The energy consumption for deep seawater enhancement is relatively large in the entire OTEC system. Therefore, while the power generation efficiency is not significantly different, the amount of cold source flow required by the system will directly affect the efficiency and economy of the OTEC system. The energy consumed by the deep-sea water uplift is a large part of the energy consumption of the whole OTEC system, so when there is not much difference in the efficiency of the power generation, the size of the required cold source flow of the system will have a direct impact on the high efficiency and economy of the system. In order to more intuitively demonstrate the impact of different working fluids on the overall efficiency and economy of the OTEC system, this article proposes a new economic indicators η_{OTEC}. η_{OTEC} is calculated as follow:

$$\eta_{OTEC} = \frac{W_t}{W_p + W_{p,ss} + W_{p,ds}} \tag{10}$$

Economic indicators η_{OTEC} focuses on the proportion of output electricity power and input electricity power of the entire OTEC system. Figure 7 shows the variation characteristic of new indicator parameter η_{OTEC}. It can be found that M31 (0.3/0.7) has the highest η_{OTEC}, which is 6.43. This means when 100kW power is supplied to drive pumps in the OTEC system, we can get 643kW electricity power output. Furthermore, η_{OTEC} is all greater than 6, in the 0.25 to 0.4 range. The result suggests that when the component ratios fluctuate around the peak point (0.3), η_{OTEC} of the M31 is maintained at the highest levels. Therefore, M31 is clearly selected as the best working fluid among M1 to M36.

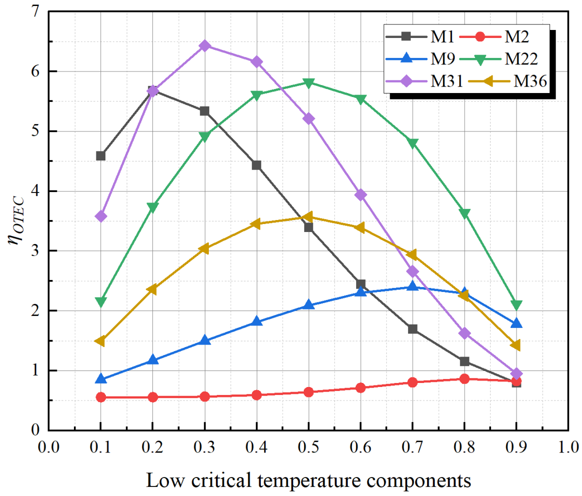

Figure 7. Characteristics of η_{OTEC}.

In summary, through the thermodynamic analysis and calculation of 36 kinds of mixed working fluids made of different component ratios, it can be obtained that the mixed working fluid of M31 (R245fa/R245ca) has higher power generation efficiency, lower system operation pressure and the best economical, which can be used as alternative working fluid in the OTEC system.

4.2. Comparative analysis of mixed and pure working fluids

Compared to the pure work mass, the mixed work mass is better able to exchange heat with the heat source and cold source at small temperature differences due to the temperature slip during the phase change process in the context of ocean temperature difference energy utilisation. T-s diagrams of the system cycle are shown in figure 8 and figure 9 for pure working fluid (R245ca) and mixed working fluid of R245fa/R245ca (0.3/0.7).

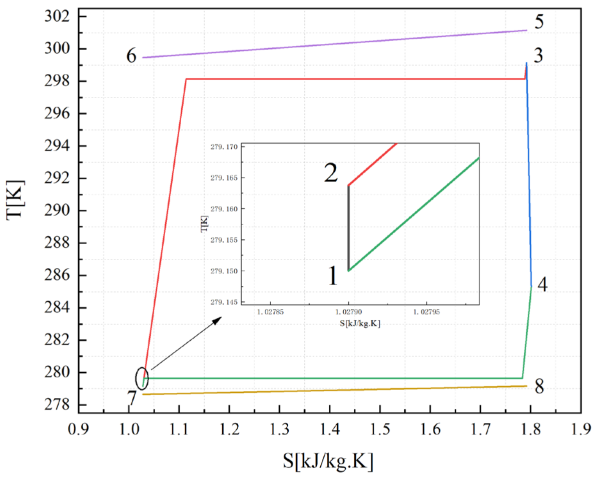

Figure 8. T-s diagram of R245ca.

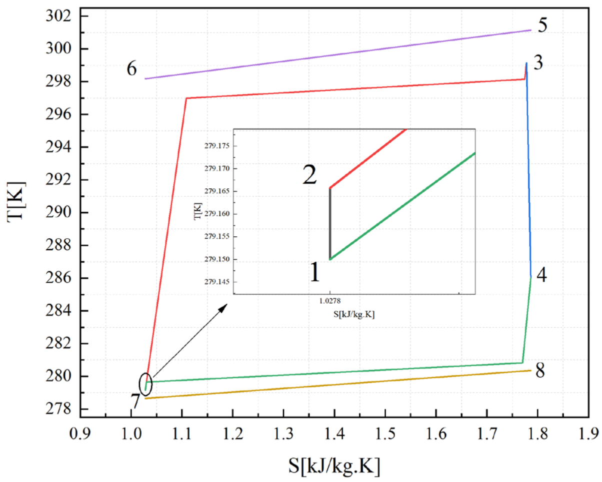

Figure 9. T-s diagram of R245fa/R245ca (0.3/0.7).

As can be seen from figure 8 and figure 9, when the heat source inlet temperatures are both equal to 28.0°C, the heat source outlet temperature is 26.3°C with R245ca while the heat source outlet temperature is 25.0°C with R245fa/R245ca (0.3/0.7). When the inlet temperatures of the cold source are both equal to 5.5°C, the outlet temperature of the cold source is 6.0°C with R245ca while the outlet temperature of the heat source is 7.2°C with R245fa/R245ca (0.3/0.7). Obaviously, mixed working fluid can better exchange heat with the heat or cold source than pure media due to the temperature shift of the phase change.

Based on analysing and calculating the performance of the ORC system (figure 2 to figure 6), the performance difference between the mixed and pure working fluids in the whole OTEC system is further analysed by taking the mixed working fluids of M31 (R245fa/R245ca) as an example, considering the power consumption of the shallow seawater pump and the deep seawater lifting pump. The relevant parameters of heat source and cold source are shown in the table 6.

Table 6. Calculation parameters of heat source and cold source side.

Parameters	Value
Heat source (shallow seawater) pipe diameter (D_h)/m	0.4
Heat source (shallow seawater) pipe length (L_h)/m	10
Cold source (deep seawater) pipe diameter (D_c)/m	0.6
Cold source (deep seawater) pipe length (L_c)/m	1000

The power consumption pumps of the shallow and deep seawater are mainly worked to overcome the flow resistance. The pressure drops and power consumption on the heat and cold source side are shown in figure 10 and figure 11. As can be seen from these figures, the choice of mixed working fluid compared to pure working fluid, the resistance loss decreases so the power consumption is also greatly reduced. R245fa/R245ca with component ratio of 0.3/0.7 acquire the smallest power consumption among all component ratios. The consume power of deep seawater pumps of this component ratio is 5.085kW, accounting for only 3.3% of the power consumption of pure working fluid of R245ca.

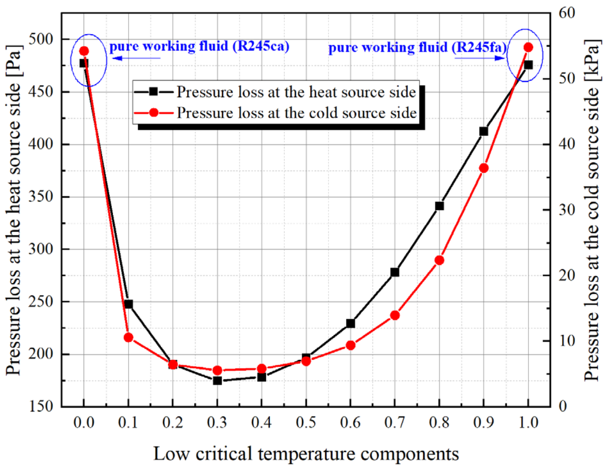

Figure 10. Pressure loss.

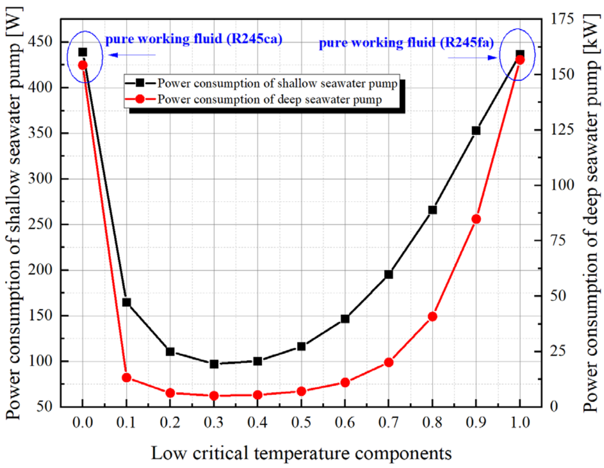

Figure 11. Power consumption.

Different from traditional thermal cycle systems, the OTEC system does not need mineral resources or electricity to heat the working fluid. Besides, all cold and heat sources are natural primary energy, which is clean and free, and also inexhaustible. This means that as long as pumps of shallow and deep seawater are provided with enough power, the whole ocean thermoelectric power generation system can continuously output electricity. It is a measure of the performance of the OTEC system to exchange the minimum pump power consumption for the maximum net output power of the whole system. The power consumption of pumps, turbine output power and net output power of the mixed working fluid of R245fa/R245ca(0.3/0.7) and pure working fluid are shown in table 7.

Table 7. Power consumption and power output of different work fluid.

Working fluid	Power consumption of shallow	Power consumption of deep seawater	Power consumption of working	Turbine output power /kW	Net output power /kW

	seawater /kW	/kW	fluid /kW		
R245ca	0.439	154.31	1.45	301.45	145.251
R245fa	0.437	156.719	2.26	302.26	142.844
R245fa/R245ca（0.3/0.7）	0.097	5.085	1.73	301.73	294.818

5. Conclusion

(1) In this paper, a mixed working fluid screening method suitable for the OTEC system is proposed, by fully considering the background of the ocean thermal energy conversion. Nine kinds of organic working fluids are freely combined in pairs to obtain a total of 36 new mixed working fluids (M1-M36).

(2) M31 (R245fa/R245ca) mixed working fluid has the higher power generation efficiency, lower operation pressure and the best economical, compared with M1, M2, M9, M22 and M36. Peak η_{OTEC} of M31can reach 6.43. Obviously, M31 can be selected as the most suitable working fluids for OTEC system among M1 to M36.

(3) Compared with pure working fluid, the use of mixed working fluid can improve the overall efficiency and economy of the OTEC system. The power consumption of the deep seawater pump using M31 is 5.085kW, which only accounts for 3.3% of the power consumption when using pure working fluid R245ca. In addition, the net output power of M31 mixed working fluid reaches 294.818kW, while that of pure working fluid R245ca is only 145.251 kW.

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