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Efficiency Optimization Thermal Analysis and Power Output of a Modified Incinerator Plant Using Organic Rankine Cycle

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ABSTRACT

A compound of a modified incinerator system with an organic Rankine cycle (ORC) was analyzed and optimized regarding exergy and energy. This paper provides an overview of system performance considering thermal aspects in a conceptual design to understand the technical effects of the system on future energy systems; it also provides a way to increase efficiency up to an amount that did not exist before in practice by using optimization. The conceptual design uses multiple flue gas regeneration units, and R124 is used as ORC working fluid. The power plant is modeled and optimized for its thermal performance. An innovative cycle is designed to reuse the wasted heat, which makes the evaporator more efficient and increases the overall exergy efficiency of the power plant. Then, the exergy destructions and systems efficiency are observed. The results indicate that 3.19 MW output power could be generated from municipal wastes with capacity of 400 tons/day. The highest destruction of exergy for the incinerator unit and boiler were approximately 8 kW and 6.4 kW, respectively. For the primary cycle the power output capacity was almost 2.8 MW. Also, this research increased their exergy efficiency by using heating flow streams**.** The ORC cycle could not produce high power but generally improve the exergy and energy efficiency. The proposed combined cycle with flue gas reheating units and optimization increases the system output power from 3.02 to 3.19 MW. Furthermore, energy and exergy efficiency increased by 10% and 9%, respectively.

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NOMENCLATURE

Abbreviations		**Greek letters**	
Cond	Condenser unit	η	Energy efficiency
ORC	Organic Rankine cycle	ε	exergy efficiency (-)
MSW	municipal solid waste	$\dot{W}_{net}$	net power output (MW)
LHV	lower heating value (kJ/kg)	**Subscripts**	
CHP	Combined Heat and Power	*ch*	chemical
e	specific physical exergy (kJ/kg)	*D*	destruction
$\dot{E}$	the flow rate of exergy (kW)	*e*	outlet
h	specific enthalpy (J/kg)	*G*	generator
$\dot{m}$	the flow rate of mass (kg/s)	*i*	inlet
$\dot{Q}$	rate of heat transfer (kW)	*p*	product exergy (kW)
R	gas constant (kJ/kg K)	*s*	supplied exergy (kW)
s	entropy (kJ/kg K)	*t*	overall
T	temperature (K)	*j*	Outlet exergy (kW)
$\dot{W}$	power (kW)		

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1. INTRODUCTION

Over the years, humans have been disturbed by the steady increase in municipal waste generation. Municipal waste in cities and crowded areas is a significant environmental problem. Although burial or burning of these wastes is used. By using these wastes could create economic interest and decrease environmental pollution [1]. Hence, it seems that a win-win situation must be achieved to solve both problems to some extent, which many countries in the world have done by building waste incineration plants [2]. Today, an incinerator is any process in which waste burns to become harmless substances or produce energy. Many of these materials used in the combustion process and are incinerated cost much less than fossil fuels. Urban society inevitably has garbage that is increasing daily. Waste incineration is used for electricity or heat production and reduces its volume and pollution by more than 80%, which is very suitable for waste storage and disposal [3].

Electricity generation from the incineration of solid municipal waste is a proper use of such wastes; which is preservation of fossil fuel resources, leads to less pollution than the fossil fuel. In simulation software, Chen et al. [4] simulated the incineration and gasification unit of municipal waste in two reactors. The main goal is to achieve a higher heat conversion percentage and calorific value. Their results show that gas entry from the combustion chamber to the gasification chamber increases the percentage of heat conversion. Pan et al. [5] simulated a municipal waste incinerator and Organic Rankine Cycle system. They have also, reached the optimal values of the cascade supercritical CO_2 cycle. Shahnazari et al. [6] investigated the most helpful method for the thermochemical processing of MSW. Siddiqi et al. [7] estimated electricity generation via combustion of MSW along with Rankin cycle for the waste generated in Pakistan. There are various parameters for reviewing and optimizing the generated electricity from municipal waste. One of the most important parameters can be the amount of electricity generated, which can be significantly increase by changing some conditions. For example, Sajid Khan et al. [8] increased the amount of electricity generated per waste unit by integrating solar and incinerator systems. Alrobaian [9] presented an exergy, energy, and economic (3E) analysis for improving the efficiency of the incinerator plant by recycling waste heat for the feed water preheating process. Kythavone and Chaiyat [10] investigate the evaluation of an ORC and MSW incinerating for pestiferous medical waste. Escamilla-Garcia et al. [11] conducted a scientific and economic analysis of MSW incineration output power in Mexico. Mohtaram et al. [12] studied an exergy-energy efficiency analysis of an incinerator cycle coupled with a different ORC. They have reported that turbine efficiency is also raised with decreased working fluid temperature and rising inlet pressure. Sorgulu et al. [13] experimentally designed a newly developed integrated ORC plant and reached 2.3 MW electric power. Kavatia and Prajati [14] reviewed biomass-to-energy plants using vegetable waste with an ORC. Nami and Arabkoohsar [15] designed a waste-driven combined heat and power (CHP) plant via parallel Rankine and Organic Rankine cycles and improved the power output by thermodynamic analysis. Ascanio et al. [16] presented a thermal-economic analysis of the electricity generation potential by combining the Rankine cycle and MSW incineration. The main drawback of waste incineration plants is their low efficiency of production power, which requires optimization and inventing better methods to get maximum power from waste. A steam power plant that uses an organic fluid instead of water, such as hexane, etc., is called ORC [17]. The most crucial benefit of the ORC is that it requires less heat to vaporize the working fluid [18]. The most important ability of ORC technology is utilizing all waste to generate electric power. A full review of this ORC application can be found in literature [19]. There is exhaustive literature about the combined cycle and ORC technologies, different working fluids, and benefits [20]. Therefore, more information about this technology is not explained here. In general, the design of an innovative cycle, especially about ORC, using energy and exergy analysis can help increase the efficiency of energy production and optimize as much as possible, which is the main requirement of the industry.

This study analyses an incinerator CHP plant by two Rankine and ORC parallel cycles. A general exergy and energy analysis of the incinerator plant is accomplished. The innovation of this study is the concept design of cycles and multiple regeneration streams of heat for the ORC and main cycle. Also, this proposed combined cycle is optimized by a genetic algorithm, which tries to improve the system's electricity generation by optimizing output power. Waste incinerators are one of the best ways to reuse lost resources, so their strengthening plays a key role in improving the quality of urban life. Figure 1 presents a general flowchart of the steps of this research.

1. 1. Incinerator Power Plant and the Concept of Combined Power Plant

This part gives general information about incinerator power plants. Then, the regular Rankine cycle with a schematic diagram is explained, and the combined incinerator plant is introduced and explained. As shown in Figure 2, in the first step, municipal waste with an air intake stream enters the gasifier unit. The slurry ash goes down to the ash chamber and produces syngas, which penetrates the combustion chamber with the incoming airflow. The combustion product gas with water comes from pump-fed into steam generator boiler and, superheats steam

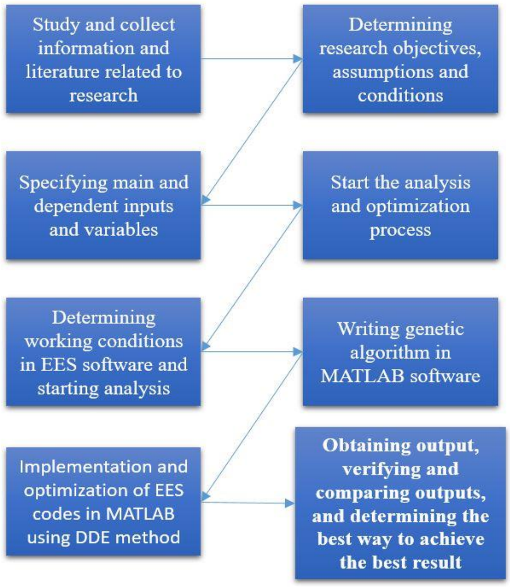


Figure 1. Steps of the research

produce, and flue gas is released from the exhaust to the air, thus superheat steam sent to the steam turbine and output power for turning on the generator is generated. Then two-phase (steam-water) fluid comes out from the steam turbine, goes to the condensing unit (that feeds with cool water from the cooling unit), and goes back to the pump.

Figure 3 shows a schematic diagram of the modified power plant. MSW and primary air initially enter the gas generator (gasifier), where syngas is produced. Complete oxidation occurs in the combustion chamber by mixing produced syngas and the air intake stream; then, syngas with high enthalpy is created. In the steam cycle, water with combustion products gas goes into the boiler to form superheat steam and then goes to the steam turbine. During the main time, the boiler's flue gas stream (8) goes into ORC. After producing power by the turbine and superheating steam, 2 phase liquid exits the turbine. Then a warm liquid stream (6a) from the steam generator turbine goes straight to the feed water tank. Water and air are used as cooling fluids (6) to cool the turbine outlet flow in the condenser. Moreover, a stream of flue released gas (11b) from the condenser and sent it to the recuperator. Two parallel cycles with similar conditions have formed this power plant, producing 3.19 MW of total output power. The ORC is the last section of the incinerator to reuse the heat output of the cycle flue gas. The waste heat from the flue gas is transferred to the organic fluid in the evaporator, and the superheated fluid goes to the turbine. After that, hot ORC liquid goes into the recuperator, gives its heat to it, and then goes to the ORC condensing unit. One flue gas stream from the recuperator enters the evaporator (11) to increase cycle thermal efficiency. At last, the waste flue gas stream exited from the exhaust. R124, as an organic working fluid, is hired in the ORC system.

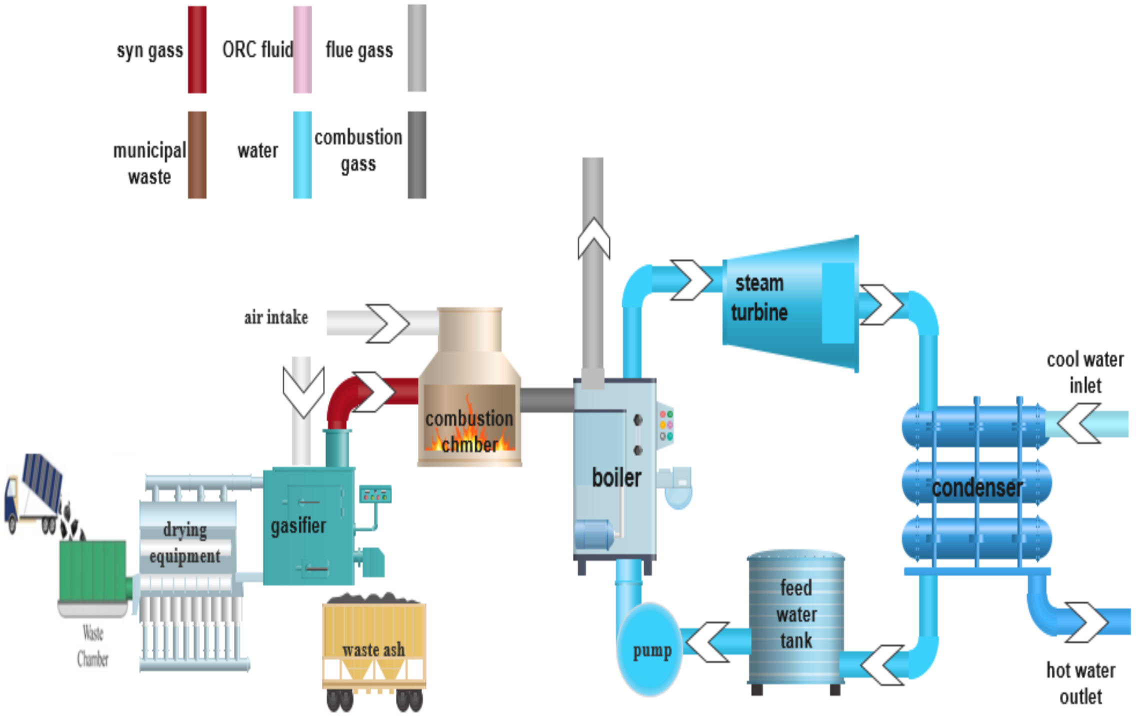


Figure 2. Schematic of the incinerator power plant [21]

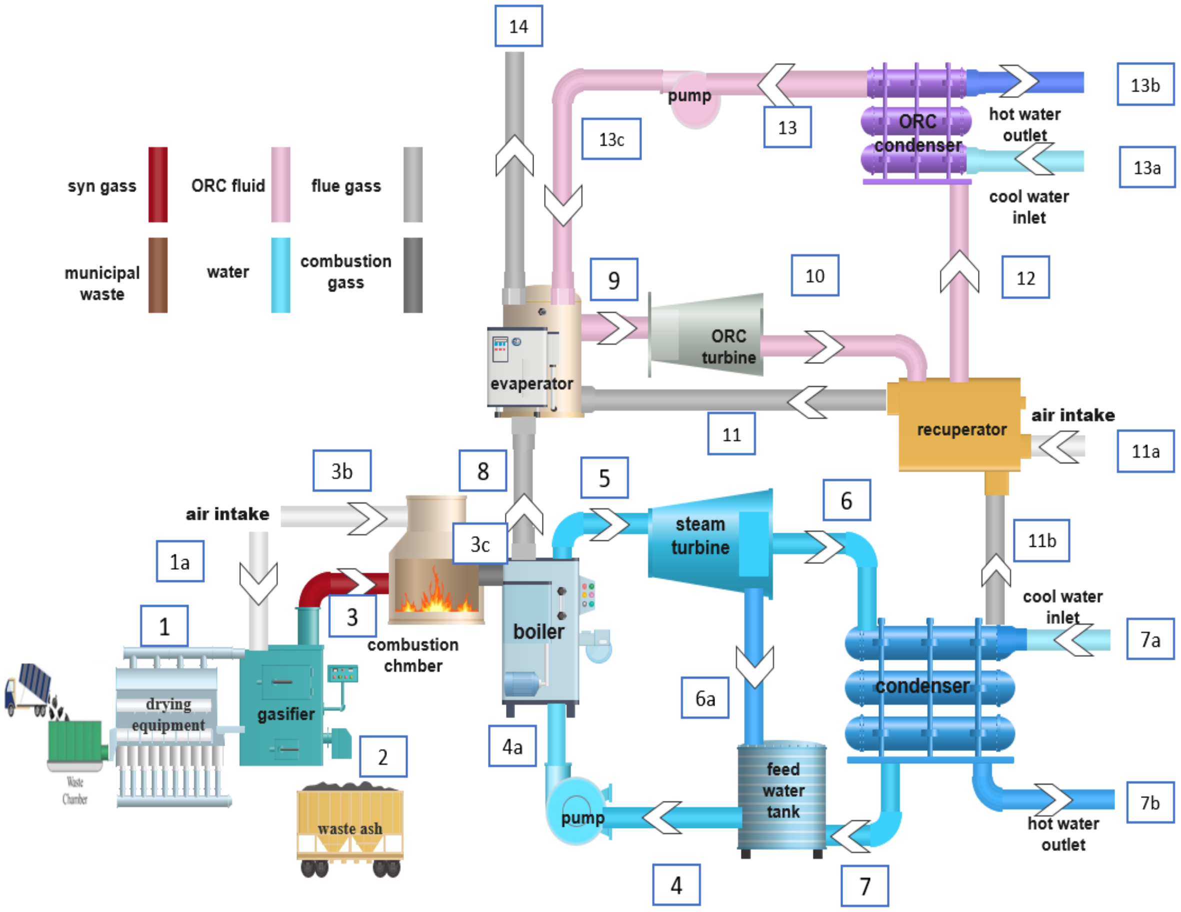


Figure 3. Schematic of the concept design of incinerator CHP-ORC plant

The system is assumed to work in Steady-state conditions for the proposed cycle, and air contents are set as 79% N_2 and 21% O_2. The pressure drop in the boiler, evaporator, and condensers is 5%. Moreover, heat transfer from the combustion chamber is equal 2%. Moreover, air and flue gases are ideal [22, 23]. All operating parameters of both cycles are inserted in Table 1.

TABLE 1. Technical properties of the combined cycle incinerator system

Item	Info./Value	Reference
Orc Working Fluid	R124	
Orc Turbine Inlet Condition/Pressure (State/MPa/°C)	Sat. Vap. /Superheat P=0.8–1.2/P=1.3-2.3 T=T Sat. /T=Tsat+5	[24]
Evaporator Pinch Point (°C)	5	
Condenser Pinch Point (°C)	3	
Msw Compositions	5.91% Ash 47.18% Carbon 6.25% Hydrogen 39.57% Oxygen 0.91% Nitrogen 0.18% Sulphur	[25]
LHV of The Waste (kJ/kg)	12,500	[25]
The Volume Percentage of Air During the Incineration Process	80%	[26]
Syngas Temperature after Combustion (°C)	1100	[27]
Temp./Pressure of the Fluid after Turbine (°C/MPa)	350/2.9	
Temp./Pressure of the Fluid After Condenser (°C/MPa)	90/0.07(Condensed)	
Temp./Pressure of the Fluid Before Boiler (°C/MPa)	290/10.1	[28]
Orc Turbine Inlet Pressure (MPa)	2-4	[29]
Orc Condenser Temperature (°C)	10	[29]
The Efficiency of Orc Turbine (%)	0.9	[29]
The Efficiency of the Pump (%)	0.85	[29]

2. ANALYSIS

This part explains the energy and exergy models of the modified incinerator power plant.

2. 1. Energy Analysis

Each part is assumed to be a control volume for analyzing the system, and an energy conservation equation is created. By following the first rule of thermodynamics, works the level of steam turbine and ORC turbine ($\dot{W}$ turbine, $\dot{W}$ORC turbine), the electric power consumed by pumps ($\dot{W}$ pump, $\dot{W}$ORC pump), the pure power of each line of the system ($\dot{W}$ cycle, $\dot{W}$ORC cycle) and total power of the system ($\dot{W}$ net) are presented as follows [30-33]:

$$\dot{W}_{\text{turbine}} = \dot{m}(h_6 - h_5) \tag{1}$$

$$\dot{W}_{\text{ORCturbine}} = \dot{m}_{ORC}(h_{10} - h_9) \tag{2}$$

$$\dot{W}_{\text{pump}} = \dot{m}(h_{4a} - h_4) \tag{3}$$

$$\dot{W}_{\text{ORC pump}} = \dot{m}_{ORC}(h_{13c} - h_{13}) \tag{4}$$

$$\dot{W}_{\text{cycle}} = (\dot{W}_{turbine} - \dot{W}_{pump}) \tag{5}$$

$$\dot{W}_{ORC\ cycle} = (\dot{W}_{ORC\ turbine} - \dot{W}_{ORC\ pump}) \tag{6}$$

$$\dot{W}_{\text{net}} = (\dot{W}_{cycle} + \dot{W}_{ORC\ cycle}) \tag{7}$$

The efficiency of the turbines and pumps are presented as follows:

$$\eta_{turbine} = \frac{(h_5-h_6)}{(h_5-h_{6s)}} \tag{8}$$

$$\eta_{pump} = \frac{(h_{4as}-h_4)}{(h_{4a}-h_4)} \tag{9}$$

$$\eta_{ORC\ turbine} = \frac{(h_{10}-h_9)}{(h_{10}-h_{9s})} \tag{10}$$

$$\eta_{ORC\ pump} = \frac{(h_{13cs}-h_{13}}{(h_{913c}-h_{13})} \tag{11}$$

The rate of heat transfer by the combustion chamber and condensing units is presented as follows:

$$\dot{Q}_{\text{heating}} = 12500kw \quad \text{(Minimum) [25]} \tag{12}$$

$$\dot{Q}_{\text{condenser}} = \dot{m}(h_6 - h_7) \tag{13}$$

$$\dot{Q}_{\text{ORCcondenser}} = \dot{m}_{ORC}(h_{13} - h_{12}) \tag{14}$$

At last energy efficiency of the system is presented as follows:

$$\eta_{total} = \frac{\dot{W}_{net}}{\dot{Q}_{\text{heating}}} \tag{15}$$

Applied equations derived for all sections of the concept incinerator power plant are inserted in Table 2.

TABLE 2. Energy equations on the parts of the modified incinerator power plant

Parts	**Equations**	**Numbers**
Incinerator	$\dot{m}_3h_3+\dot{m}_{3b}h_{3b}=\dot{m}_{3c}h_{3c}$	(16)
gasifier	$\dot{m}_1LHV+\dot{m}_{1a}h_{1a} =\dot{m}_3h_3+\dot{m}_2h_2$	(17)
Boiler	$\dot{m}_{3c}h_{3c}+\dot{m}_{4a}h_{4a}=\dot{m}_8h_8+\dot{m}_5h_5$	(18)
Turbine	$\dot{W}_{\text{Turbine}} =\dot{m}_5(h_5-h_6-h_{6a})$	(19)
Pump	$\dot{W}_{\text{Pump}} =\dot{m}_8(h_{4a}-h_4)$	(20)
Evaporator	$\dot{m}_8(h_8+h_{11}-h_{14}) = \dot{m}_9(h_9-h_{13c})$	(21)
ORC turbine	$\dot{W}_{\text{ORC Turbine}} =\dot{m}_9(h_{10}-h_9)$	(22)
ORC pump	$\dot{W}_{\text{ORC Pump}} =\dot{m}(h_{13c}-h_{13})$	(23)
Condenser	$\dot{m}_6=(h_6-h_7) = \dot{m}_{7a}(h_{7b}-h_{7a})$	(24)
ORC condenser	$\dot{m}_{12}=(h_{12}-h_{13}) = \dot{m}_{13a}(h_{13b}-h_{13a})$	(25)
Recuperator	$\dot{m}_{10}=(h_{10}-h_{12}) = \dot{m}_{11a}(h_{11b}+h_{11a}-h_{11})$	(26)

2. 2. Exergy Analysis

This paper considered only physical and chemical exergies and neglected potential and kinetic exergies. The equation of exergy balance for a converting energy system is as follows [30, 31]:

$$\sum_{in} \dot{E}_i = \sum_{out} \dot{E}_j + \dot{E}_D \tag{27}$$

In here, $\sum_{out} \dot{E}_j$ and $\sum_{in} \dot{E}_i$ are, respectively, outlet and inlet exergy, while $\dot{E}_D$ is destruction of exergy [32]. A proposed correlation by Song et al. [33] is used for effectively modeling an incinerator power plant for calculating the chemical exergy of waste as a fuel e-MSW (kJ/kg). The chemical exergy of inlet waste $\dot{E}$ MSW (kW) is explained as follows:

$$\dot{E_{MSW}} = \dot{m}_{MSW} e_{msw} \tag{28}$$

With:

$$e_{MSW}=1812.5+31.8\mathbf{A}+587.354\mathbf{H}+295.606\mathbf{C}+17.735\mathbf{N}+95.615\mathbf{S}+17.506\mathbf{O} \tag{29}$$

Here, A, H, C, N, S and, O are a mass combination of ash, hydrogen, carbon, nitrogen, sulfur, and oxygen, respectively.

Song et al. [34] also presented special exergy for ash e_{ash} (kJ/kg). So ash exergy $\dot{E}_{\text{ash}}$ (kW) is as follows:

$$\dot{E}_{ash} = \dot{m}_{ash} e_{ash} \tag{30}$$

$$e_{ash} = 0.01057T + 0.0004056T^2 - 54.44 \tag{31}$$

That T (k) is the ash temperature.

An exergy modeling of the concept incinerator system parts is presented in Table 3 [35].

2. 3. Optimization

This part uses multi-objective optimization to optimize the hybrid power plant. So, objective functions must be defined for this purpose. The

TABLE 3. Exergy equations for each part

Parts	$\dot{E}_s$	$\dot{E}_p$	Number
Incinerator	$\dot{E}_3+\dot{E}_{3b}$	$\dot{E}_{3c}$	(32)
gasifier	$\dot{E}_1+\dot{E}_{1a}$	$\dot{E}_3-\dot{E}_2$	(33)
Boiler	$\dot{E}_{3c}$	$\dot{E}_8+\dot{E}_5$	(34)
Turbine	$\dot{E}_5-\dot{E}_6-\dot{E}_{6a}$	$\dot{W}_{Turbine}$	(35)
Pump	$\dot{W}_{Pump}$	$\dot{E}_{4a}-\dot{E}_4$	(36)
Evaporator	$\dot{E}_8+\dot{E}_{11}-\dot{E}_{14}$	$\dot{E}_9-\dot{E}_{13c}$	(37)
ORC turbine	$\dot{E}_{17}-\dot{E}_{18}$	$\dot{W}_{ORC\ Turbine}$	(38)
ORC pump	$\dot{W}_{ORC\ Pump}$	$\dot{E}_{13c}-\dot{E}_{13}$	(39)
Condenser	$\dot{E}_6-\dot{E}_7-\dot{E}_{11b}$	$\dot{E}_{7b}-\dot{E}_{7a}$	(40)
ORC condenser	$\dot{E}_{12}-\dot{E}_{13}$	$\dot{E}_{13b}-\dot{E}_{13a}$	(41)
Recuperator	$\dot{E}_{10}-\dot{E}_{12}+\dot{E}_{11a}$	$\dot{E}_{11}-\dot{E}_{11b}$	(42)

objective function is the pure outlet system's power ($\dot{W}_{net}$) and the total power plant's efficiency. The equation of the objective functions is a single equation as follows [36]:

$$\text{Objective Function} = \eta_{ex} = \frac{\sum_n \dot{W}_{net}}{\dot{Ex}_f} \tag{43}$$

The method used in multi-objective optimization maximizes the 1st objective function, and naturally, the 2nd objective function is also improved. We must have specific limits, values, and reasons for all optimization cases. The limitations are inserted in Table 4.

Exergy and energy equations for all stages of the combined cycle are written down in Engineering Equations Solver (EES) software. Exergy, Energy balance equations, and applicable auxiliary equations are applied to the system components. The plant analysis is completed, the equations are entered into the Matlab software from ESS by the DDE method, the exergy destruction of the system calculating for generations and optimized by genetic algorithm.

3. RESULTS AND DISCUSSION

The results performed on the incinerator power plant are carried out in this part. Based on the obtained results, changes in exergy and energy efficiency increase the efficiency of the incinerator power plant. Table 5 shows the technical characteristics of the incinerator plant resulting from the energy analysis.

Table 6 reports the results of exergy performance in a waste incineration plant. This information determines the amount of exergy input and output and the exergy destruction of the critical parts when the incinerator operates at full load.

Figure 4 compares the exergy efficiency in different sections of the incinerator combined cycle. Incinerators and boilers have the lowest exergy efficiency in all cases, and a significant part of the exergy input to these parts is destructed.

Figure 5(a) shows the variability of the thermal efficiency of the two different designs of the modified cycle for the 6a stream (as shown in Figure 3). As the figure illustrates, the cycle's thermal efficiency rises with

TABLE 4. Limits of optimization [37, 38]

Limits	Rationale
290℃ < Boiler inlet < 330 ℃	Material temperature limit
10MPa< P_{Pump} < 13 MPa	Material pressure limit
900 ℃< Steam Turbine < 1100 ℃	Superheat temperature limitation
50 ℃ < T_{Cond} < 100 ℃	Thermal efficiency limitation

TABLE 5. Technical parameters values

Parameter (Unit)	Value
The flow rate of fuel (kg/s)	1
The heat transferred into the boiler (MW)	9.25
The flow rate of steam (kg/s)	3.08
Energy efficiency (%)	25.49
Electrical efficiency (%)	20.9

TABLE 6. The results of exergy analysis were performed at full load before optimization

Parameters (Unit)	Values
Steam generator Boiler inlet/outlet/destructed exergy (MW)	14.57/8.1/6.47
Steam Turbine inlet/outlet/destructed exergy (MW)	7.39/5.99/1.4
Condenser inlet/outlet/destructed exergy (MW)	4.17/2.2/1.97
Recuperator inlet/outlet/destructed exergy (MW)	0.561/0.56/0.001
Exergy efficiency (%)	23.69

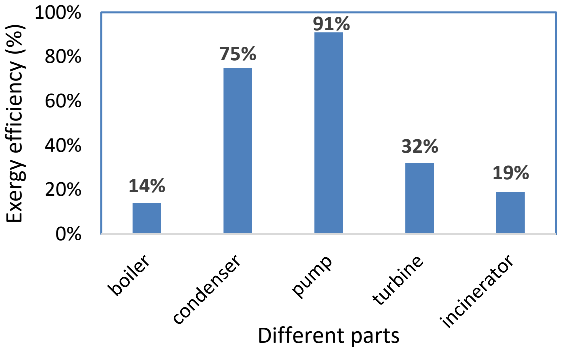
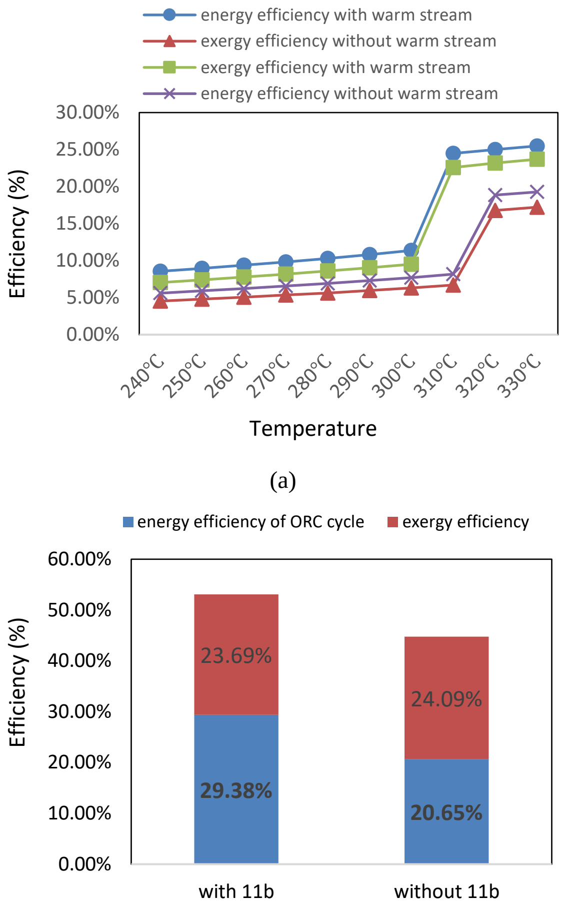


Figure 4. The exergy efficiency in different sections of the plant



(a)

(b)

Figure 5. (a) 6a stream effects on the exergy & energy efficiencyat different inlet temp (b) Effect of 11b stream in combined cycle exergy and energy efficiency

increasing boiler inlet temperature. Furthermore, the modified cycle design increases the thermal efficiency by 15% for the same two conditions. Moreover, Figure 5(b) shows the effects of the 11b stream on the exergy and energy efficiency of the combined cycle. As shown in this figure, energy efficiency increases with the existence of the 11b stream, but exergy efficiency decreases. However, total efficiency increased.

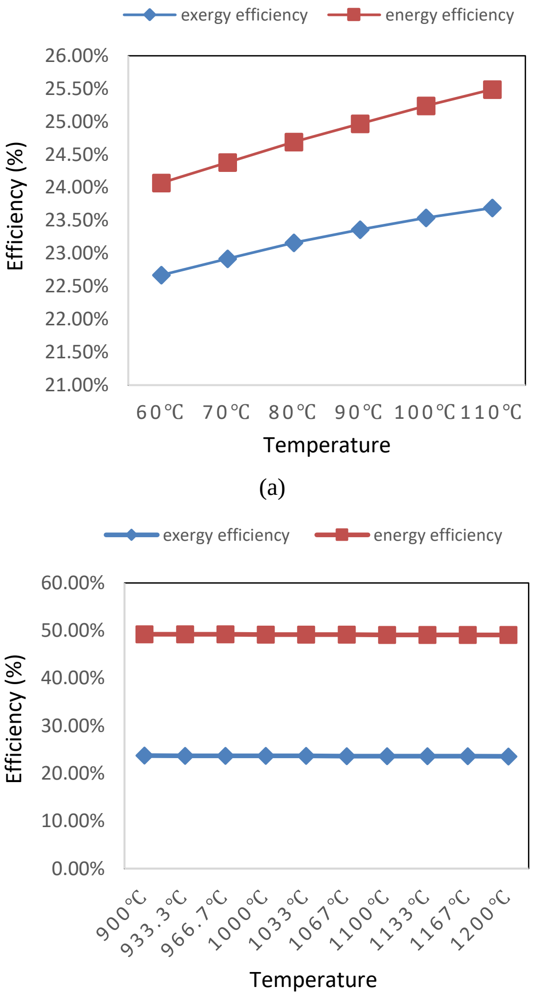
Figure 6(a) illustrates the different values of the superheater temperature change on the cycle exergy efficiency. This figure demonstrates that increasing the temperature in the evaporator (in ORC) decreases the destruction of the exergy. In other words, flows 8 and 11 increase the inlet temperature to the evaporator and the energy and exergy efficiency of the organic Rankine cycle. Figure 6(b) shows that boiler outlet temperature decrease (Not significantly) exergy efficiency and has no effects on the energy efficiency. (The temperature varies from 900 to 1200 degrees Celsius)

Figure 7 illustrates the effects of the Boiler inlet temperature from the pump station on the exergy and energy efficiency and confirms this trend by increasing the inlet temperature of the boiler from the pump, energy, and exergy efficiency increasing. In other words, 6a flows increase boiler inlet temperature and the energy and exergy efficiency of the main cycle.

3. 1. Optimization Results and Records

The optimization variables (genes) and thermal design results for the optimized incinerator combined cycle are shown in Table 7. Moreover, $\dot{W}_{net}$ is a rise from 3017 to 3186 kW.

Figure 8(a) shows an increase in the energy and exergy efficiency of the plant after and before optimization. Figure 8(b) shows the extracted plot of Matlab software and determines the plant's maximum output power calculated by a genetic algorithm. As it is clear in the figure, the maximum available output power



(a)

(b)

Figure 6. (a) Energy & Exergy efficiency in various evaporator temp (b) boiler outlet tempreture effects on the exergy and energy efficiency

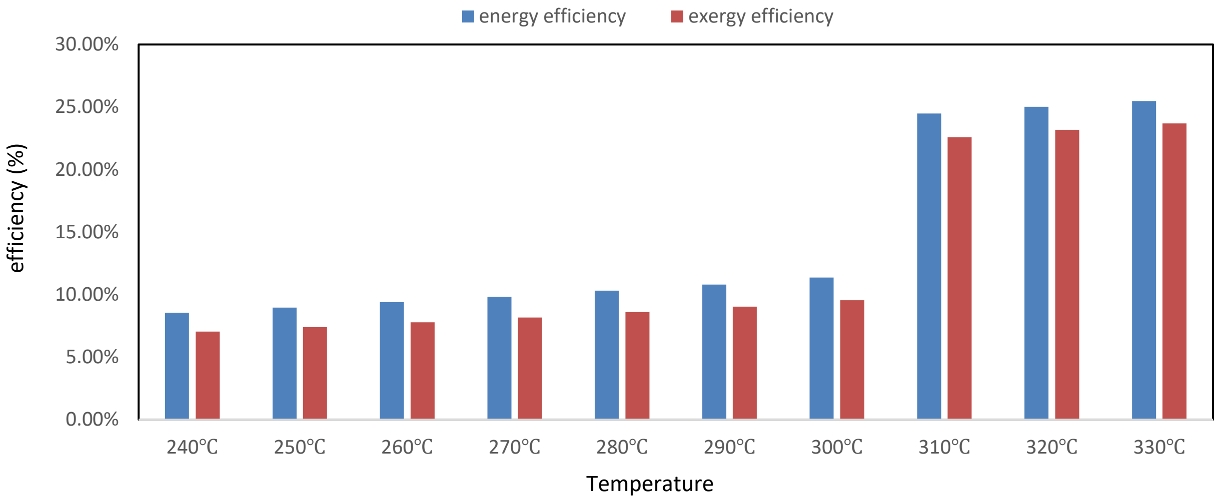


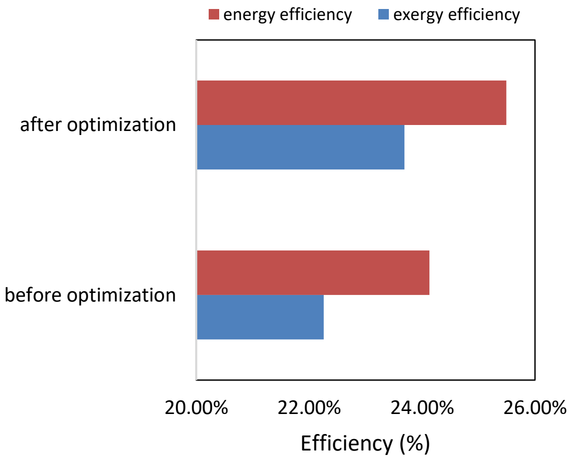
Figure 7. Boiler inlet temperature effect of energy and exergy efficiency

TABLE 7. Optimal design parameters of the CHP plant by genetic algorithm

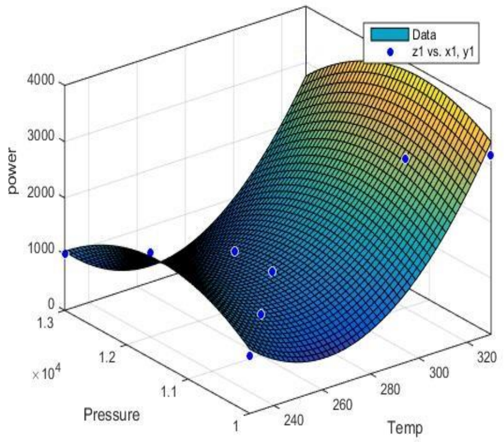
Decision variable	Value
Boiler inlet Temperature	330 ℃
Boiler inlet Pressure	10112 kPa
condenser inlet Temperature	92.06 ℃
Condenser inlet Pressure	50.14 kPa
Incinerator outlet Temperature	976.2 ℃

can be reached at a temperature of 330 degrees Celsius (input to the boiler) and a pressure of about 10 MPa.

The increase in energy efficiency and exergy compared to nami and arabkoohsar [15] research is almost the same (both 9% and 10%), although this research has reached this increase in efficiency with a simpler and naturally cheaper method. Also, this research has directly increased the amount of output power, which was mentioned in the previous research implicitly and not in a clear and specific way.



(a)



(b)

Figure 8. (a) Exergy and energy efficiency before and after optimization (b) Optimization 3D plo

4. CONCLUSION

In this paper, general analysis and optimization of the modified waste incinerator power plant were carried out and reviewed. After performing a parametric study and comparing the performance of different ORC working fluids, R124 is suggested as the best fluid from the viewpoint of exergy efficiency. Furthermore, multi-objective optimization based on genetic algorithm is applied to find the optimum point considering both exergy and energy analysis. The main factors and their effect on the objective functions have been perused. The results show that with the increase of the steam generator boiler inlet temperature, the reduction of exergy destruction can be seen. Therefore, in the system's design, a higher inlet temperature for the boiler than the pump station should be considered. On the other hand, with the increase in the output temperature of the boiler, exergy efficiency decreases, while increasing the inlet temperature of the evaporator, the destruction of exergy decreases. As a result, the design of reheating flows from other parts of the cycle (using a recuperator) and heating the evaporator as much as possible increases the superheat steam temperature and reduces exergy destruction in the organic Rankine cycle. Also, by using optimization and genetic algorithm, the best temperature and pressure were obtained to achieve the highest output power.

5. REFERENCES

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Persian Abstract

چکیده

ترکیبی از یک سیستم زباله سوز اصلاح شده بهمراه یک سیکل آلی رانکین در راستای بهبود بازدهی اگزرژی و انرژی مورد تجزیه و تحلیل و بهینه سازی قرار گرفت. این مقاله مروری بر عملکرد حرارتی سیستم در یک طراحی ابداعی برای درک اثرات فنی سیستم بر سیستم های انرژی آینده ارائه می دهد. همچنین با استفاده از بهینه سازی راهی برای افزایش بازدهی تا مقداری که قبلاً در عمل وجود نداشت، فراهم می کند. طراحی ابداعی از چندین جریان احیای گاز اتلافی استفاده می کند و از R124 به عنوان سیال عامل سیکل آلی رانکین استفاده می شود. نیروگاه برای محاسبه عملکرد حرارتی آن مدل سازی و بهینه شده است. یک چرخه مبتکرانه برای استفاده مجدد از گرمای تلف شده طراحی شده است که باعث کارآمدتر شدن و افزایش راندمان کلی اگزرژی نیروگاه شد. سپس اگزرژی تخریب شده و کارایی سیستم محاسبه گردید. نتایج نشان می‌دهد که ۳/۱۹ مگاوات توان خروجی از ٤۰۰ تن زباله شهری تولید می‌شود. بیشترین تخریب اگزرژی مربوط به واحد زباله سوز و بویلر به ترتیب با حدود ۸ کیلووات و ٦/٤ کیلووات برای سیکل رانکین اولیه با ظرفیت خروجی تقریبا ۲.۸ مگاوات است. همچنین، این تحقیق با استفاده از جریان‌های گرمایش مجدد، راندمان اگزرژی آنها را افزایش داد. سیکل آلی رانکین نمی تواند توان بالایی تولید کند اما به طور کلی اگزرژی و بهره وری انرژی را بهبود می‌بخشد. سیکل ترکیبی پیشنهادی با واحدهای گرمایش مجدد گاز دودکش و بهینه سازی، توان خروجی سیستم را از ۳.۰۲ به ۳.۱۹ مگاوات افزایش می دهد. علاوه بر این، بازده انرژی و اگزرژی به ترتیب ۱۰٪ و ۹٪ افزایش یافت.