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Exergeo-economic Optimization of a Single Effect Hybrid Solar LiBr-H_2O Absorption Chiller by GA

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Abstract: Exergeoconomic optimization of a dynamic single effect solar LiBr-H_2o absorption chiller system is performed. A model based on the energy and exergy analysis is presented. An economic model of the system is developed. As solar radiation variable is not constant in different days and months in the hot seasons of the year, the transient analysis (time dependant) is applied. The objective function based on the thermodynamic and exergeoconomic analysis is developed. The proposed single effect solar absorption cycle system includes eight decision variables is considered for optimization. A stochastic/deterministic optimization approach known as genetic algorithm is utilized as an optimization method. This approach is applied to minimize the cost of the system product.
Keywords: Single effect solar LiBr-H_2o absorption cycle, Transient modeling, exergeo-economic, GA

بهینه‌سازی اگزرژی اقتصادی یک سامانه ترکیبی جذبی LiBr-H_2O خورشیدی تک‌اثره بکمک الگوریتم ژنتیک

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چکیده: اخیراً، بمنظور استفاده از فناوری‌های پیشرفته نیروی محرکه، نیاز مبرمی به توسعه موتورهای جدید می‌باشد. بهرحال این سیستم‌ها برمبنای احتراق کار می‌کنند و بنابراین روش‌هائی موردنیاز است که بتوان بوسیله کاهش تاخیر در جرقه و یا گسترش شرایط شعله چایدار، عملکرد احتراق را بالا برد. گرچه یک کاتالیست می‌تواند موجب بروز احتراق در دمای پائین شود ولی از نظر فنی نمی‌توان کاتالیست را در محفظه احتراق نصب نمود. بنابراین روش‌های جدیدی را برای تماس کاتالیست با مخلوط سوخت و هوا موردنیاز است. پیشینه تحقیق شامل تحقیقات زیادی در زمینه اصلاح جرقه و مشخصه‌های احتراق می‌باشد. بعنوان مسثال، بهینه‌سازی موتور، ارتقادهنده جرقه و کاتالیست یکنواخت. یک راه عملی عبارت از حل کاتالیست در سوخت بطوریکه آن بطور پیوسته اضافه شود. برای تأثیر بیشتر کاتالیست باید دارای چندین معیار باشد از قبیل فعالیت خوب برای احتراق هیدروکربور و اختلاط خوب با سوخت‌های هیدروکربور در مقیاس نانومتر. نتایج نشان می‌دهد که کاتالیست نانو و قابل حلدر سوخت دارای قابلیت بیشتر جهت کاهش قابل ملاحظه تأخیر در احتراق بوده و همچنین می‌تواند شرایط شعله پایدار را در محفظه احتراق گسترش دهد.

واژه های کلیدی: نانوکاتالیست، نانواتانول و احتراق.

1. Introduction

Absorption refrigeration systems may utilize low-grade thermal energy, such as solar energy, geothermal energy and waste heat to provide cooling. Thus, absorption systems have a large potential for saving primary energy and decreasing environmental thermal pollution [1,2]. Solar absorption cooling systems have this advantage that the maximum cooling load occurs when the most solar radiation is available. Single-effect lithium bromide-water (LiBr–H2O) chiller, the most popular system in solar cooling due to its low temperature operability, has been incorporated in numerous studies including pilot projects such as Ward and Lo´f (1975) , Ward *et al*. (1978) , Bong *et al*. (1987) , Ortega (1999) , Syed *et al*. (2005) , Pe´rez (2007) and Kim (2007).

There are different methods, to evaluate performance of thermal systems. Some works have been published lately on exergitic analysis of the solar absorption chillers. Talbi *et al* utilize exergetic analysis to determine the irreversibility and exergetic efficiency of each component of single-effect lithium bromide-water (LiBr–H2O) absorption system.[3] Lee *et al* employ exergetic analysis in lithium bromide/water (LiBr/H_2O) absorption system for cooling and heating applications. Furthermore the coefficient of performance (COP) and the exergetic efficiency of the absorption system under different operating conditions such as the heat source, cooling water and supply hot water temperatures is determined.[4] Sencan *et al* calculate the input ,output and lost exergy in the lithium bromide/water (LiBr/H_2O) absorption system and consider the effect of operating conditions of system on exergetic parameters.[5] . Hourly (hour by hour sun radiation) exergy loss values due to climate of Mardin province of Turkey are calculated with the software developed in MATLAB program in Onan *et al* work [6].

Although the exergitic analysis is a powerful tool to evaluate performance of thermal systems, optimization based on exergy or any other pure thermodynamic objective functions may lead to a design with unreasonable capital cost. The thermoeconomic method is a method which considers both of the capital cost and energy inefficiency in term of money. Applying this method in pure solar systems reduces to minimizing the capital cost only because the cost of energy source is free.

Most of the solar thermal systems such as solar refrigeration system, a conventional heater is usually used in order to assist the solar collectors in absence of sufficient solar radiation. The fuel consumption of the heater depends on surface area of the solar collector, volume of the hot water storage tank and differs hour by hour. In such a system, the thermoecomomic method may be used. This method has already been applied to conventional absorption refrigeration systems [7,8]. In order to apply this method to solar systems, a dynamic model is required to calculate the fuel consumption in auxiliary heater hour by hour.

Application of dynamic modeling in optimization of solar systems has been used lately by a few researchers. Calisa [9] uses TRANSYS software to simulate the solar assisted cooling and heating system in 3 cities of Italy climates. In that paper transient sun radiation, energetic and not exergetic simulation is performed and a simple economic model is utilized. In that work design variables such as capacity of the absorption chiller and mass flow rate through solar collectors are utilized to minimize the annual simple pay back of the system .But the design parameters and each component of the chiller absorption cycle are not optimized.

In this paper, the genetic algorithm is used to optimize thermoeconomically a hybrid solar LiBr-water absorption refrigeration system. The method consists of a detailed exergy and cost analysis of the each component of the system. The analysis is carried out based on the hour by hour sun radiation. Utilizing sensivity analysis, the objective function based on the thermoeconomic analysis and its constraints is obtained. Finally the genetic algorithm (GA) is used for optimization.

2. System Description

The schematic diagram of the solar lithium bromide– water absorption cooling system is illustrated in Fig. 1. The system consists of a single effect LiBr-H_2o absorption chiller, solar system and the auxiliary heater. The absorption chiller system includes evaporator, absorber, generator, solution heat exchanger, pump and expansion valves. (Fig.2).The solar system consists of collectors, storage tank and pump.

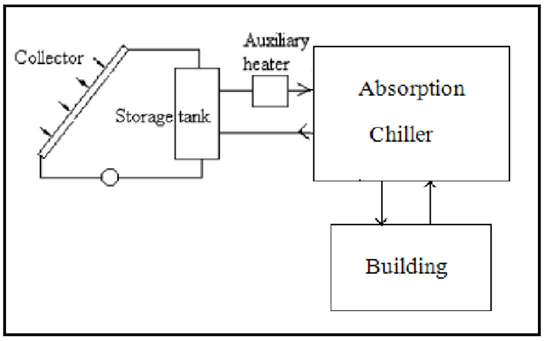

Fig. (1): schematic diagram of single effect solar LiBr-H_2o absorption chiller

Sun radiations heat which is gathered in collectors make the storage tank water to be heated. The required heat in generator of the absorption chiller is supplied by storage tank hot water .As the radiation intensity is not permanent and may not be sufficient to provide the required heat of generator, the auxiliary heater is used. The deficit of hot water is then supplied by auxiliary heater. Some assumption is considered in this system:

- The devices such as absorber, evaporator and etc work steady state.
- Pressure drops and heat losses are negligible.
- Saturated solution leaves the absorber and generator.
- There is saturated refrigerant at the condenser and evaporator outlets.
- Pump performance is isentropic.
- Expansion valves are adiabatic.

3. Governing Equations

Due to assumption that no reaction occurs in the process, the mass balance in each part of the process is expressed as:

$$\sum \dot{m}_{in} = \sum \dot{m}_{out} \qquad (1)$$

As it can be assumed that the equipments operate in steady state condition, hence:

$$\dot{Q} - \dot{W} = \sum \dot{m}_{out} \dot{h}_{out} - \sum \dot{m}_{in} \dot{h}_{in} \qquad (2)$$

Furthermore the heat transfer in each heat exchanger can be modeled as:

$$Q = UA\Delta T_{lmtd} \qquad (3)$$

4. Thermal analysis and performance of solar collector

Thermal performance of solar collector is analyzed by Hottel and Woertz method which is developed by Bliss and Whillier. It can be written as:

$$q_u = I_{t\theta} \times (\tau \times \alpha) - U_L \times (T_{pl} - T_{at}) = \frac{m}{A_{ap}} \times C_p \times (T_{co} - T_{ci}) \quad (4)$$

The total and direct radiation of the sun in different cities can be gathered from statistical related tables. The efficiency of collector can be calculated as follows:

$$\eta = (\tau \times \alpha) - \frac{U_L(T_{pl}-T_{at})}{I_{t\theta}} \quad (5)$$

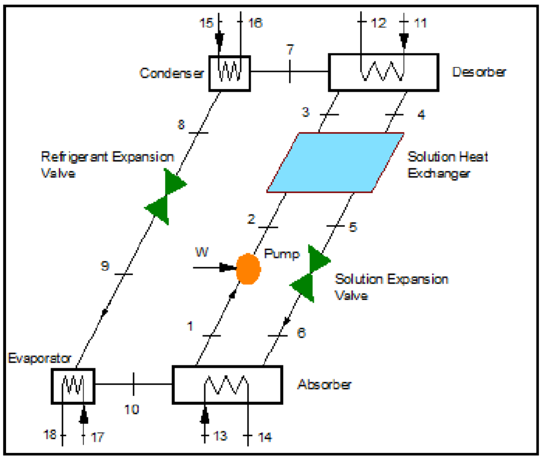

Fig. (2): diagram of single effect LiBr-H_2o absorption chiller

5. Thermal analysis and performance of Thermal Storage Tank

In this study, the hot-water storage tank is considered as a multi-nodded water tank which can be modeled by dividing it into N nodes .This model is extracted from Li and Sumathy work [10]. Defining some control functions (refer to ref [10]), the energy balance on node i (i=1 to N) can be expressed as:

$$\dot{m}_i \frac{dT_{S,i}}{dt} = \left(\frac{UA}{C_P}\right)_i \left(T_{at} - T_{St,i}\right) + F_i^C \dot{m}_{Cl}\left(T_{CO} - T_{St,i}\right) + F_i^L \dot{m}_L\left(T_{L,r} - T_{St,i}\right) + \dot{Q}_{inter} \quad (6)$$

The F_i^L and F_i^C are control functions and the $\dot{Q}_{inter}$ is the energy exchange function. Duffie and Beckman suggested UA as 11.41 W/m^2 and the convection heat transfer coefficient is considered as 0.72 W/m^{2}K.

6. Heat Balance for Auxiliary Heater

When the storage tank temperature drops below the allowable reference temperature, an auxiliary heater boosts the temperature of the hot water from the storage tank temperature to the allowable reference temperature. For this reason, the reference temperature can be considered to be exactly the minimum allowable hot water inlet temperature. The auxiliary heater capacity is calculated as follows:

$$Q_{aux} = \dot{m}_{11}.c_P.\left(T_{ref} - T_{s,1}\right) \quad (7)$$

where $\dot{m}_{11}$ is the mass flow rate used by the generator. The fraction of the total load met by non-purchased energy FNP is calculated as [11]:

$$FNP = 1 - \frac{Q_{aux}}{Q_{load}} \quad (8)$$

Where Q_{load} is exactly the same as Q_g which is the generator load.

7. Exergeo-economic Modeling

Exergeo-economics combines exergy analysis with economic constraints to provide the system designer with information which is not concluded through conventional energy and economic analysis. The detail of Exergoeconomics analysis is available in literature (Kotas, 1985;Bejan , 1995).

Considering the sub-systems of the total process of a Single effect solar LiBr-H_2o absorption cycle, the cost of exergy equations and the auxiliary equations in each sub-system can be expressed as:

1) Solar system

$$\dot{Z}_{Solar} = \dot{Z}_{cl} + \dot{Z}_{st} + \dot{Z}_{ins} \quad (9)$$

$$\dot{C}_{F,Solar} = \dot{C}_{aux} = c_{aux,solar} \times Q_{aux}{}^{TOTAL} = c_{aux} \times \left(\dot{E}_{11} - \dot{E}_{12}\right) \quad (10)$$

$$\dot{C}_{\mathrm{P,Solar}} = \dot{C}_{\mathrm{F,Solar}} + \dot{Z}_{\mathrm{Solar}} \quad (11)$$

2) Generator:

$$\dot{C}_H - \dot{C}_7 + \dot{C}_3 - \dot{C}_4 = -\dot{Z}_g - \dot{Z}_{cl} - \dot{Z}_{st} - \dot{Z}_{ins} \quad (12)$$

$$\dot{C}_{\mathrm{F}} = \dot{C}_{\mathrm{P,Solar}} = \dot{C}_{\mathrm{F,Solar}} + \dot{Z}_{\mathrm{Solar}} = \dot{Z}_{cl} + \dot{Z}_{st} + \dot{Z}_{ins} + \dot{\mathrm{C}}_{\mathrm{aux}} \quad (13)$$

$$\dot{C}_{\mathrm{P}} = \dot{C}_7 + \dot{C}_3 - \dot{C}_4 \quad (14)$$

The auxiliary equation can be extracted as:

$$\frac{\dot{m}_7(c_7e_7 - c_3e_3)}{\dot{m}_7(e_7 - c_3)} = \frac{\dot{m}_4(c_4e_4 - c_3e_3)}{\dot{m}_4(e_4 - c_3)} \quad (15)$$

Thus it can be concluded as:

$$\frac{\dot{C}_7}{\dot{m}_7(e_7 - c_3)} - \frac{(e_4 - e_7)\dot{C}_1}{\dot{m}_7(e_7 - e_3)(e_4 - e_3)} - \frac{\dot{C}_4}{\dot{m}_4(e_4 - e_3)} = \mathbf{0} \quad (16)$$

$$\mathrm{c}_H = \mathrm{c}_{11} = \mathrm{c}_{12} = \frac{\dot{Z}_{cl} + \dot{Z}_{st} + \dot{Z}_{ins} + \dot{\mathrm{C}}_{\mathrm{aux}}}{(\dot{E}_{11} - \dot{E}_{12})} \quad (17)$$

3) Absorber:

$$\dot{C}_6 + \dot{C}_{10} - \dot{C}_1 - \Delta\dot{C}_a = -\dot{Z}_a \quad (18)$$

$$\dot{C}_p = \dot{C}_1 \quad (19)$$

$$\dot{C}_F = \dot{C}_6 + \dot{C}_{10} \quad (20)$$

$$\Delta\dot{C}_a = \dot{C}_{15} - \dot{C}_{16} = -\dot{Z}_{ct} \quad (21)$$

Which $\Delta\dot{C}_a$ is the difference of the annual cost rate of inlet water and the cooling tower water. As the cost rate of waste heat in cooling tower can be assumed zero the production in absorber will be equal to annual capital cost of the cooling tower. The auxiliary equation can be expressed as:

$$\frac{\dot{C}_6}{\dot{E}_6} = \frac{\dot{C}_{10}}{\dot{E}_{10}} \quad (22)$$

$$\mathrm{c}_{14} = \mathrm{c}_{13} = \frac{(\dot{C}_{14} - \dot{C}_{13})}{(\dot{E}_{14} - \dot{E}_{13})} \quad (23)$$

4) Condenser

$$\dot{\mathrm{C}}_1 - \dot{\mathrm{C}}_2 - \Delta\dot{\mathrm{C}}_{\mathrm{c}} = -\dot{\mathrm{Z}}_{\mathrm{c}} \quad (24)$$

$$\Delta\dot{C}_c = \dot{C}_{16} - \dot{C}_{15} = -\dot{Z}_{ct} \quad (25)$$

As the cost rate of waste heat in cooling tower can be assumed zero the of production in condenser will be equal to annual capital cost of the cooling tower. The auxiliary equation can be expressed as:

$$\mathrm{c}_{15} = \mathrm{c}_{16} = \frac{(\dot{C}_{16} - \dot{C}_{15})}{(\dot{E}_{16} - \dot{E}_{15})} \quad (26)$$

5) Evaporator

$$\dot{C}_9 - \dot{C}_{10} - \dot{C}_{P,total} = -\dot{Z}_e \quad (27)$$

$$\dot{C}_{P,total} = \dot{C}_{18} - \dot{C}_{17} \quad (28)$$

$$\mathrm{c}_{17} = \mathrm{c}_{18} = \frac{(\dot{C}_{18} - \dot{C}_{17})}{(\dot{E}_{18} - \dot{E}_{17})} \quad (29)$$

6) Solution Heat Exchanger:

$$\dot{C}_4 - \dot{C}_5 + \dot{C}_3 - \dot{C}_2 = -\dot{Z}_{shx} \quad (29)$$

The auxiliary equation can be expressed as:

$$\dot{C}_4 - \frac{\dot{E}_4}{\dot{E}_5}\dot{C}_5 = \mathbf{0} \quad (30)$$

7) pump:

$$\dot{C}_E + \dot{C}_1 - \dot{C}_2 = -(\dot{Z}_{pu} + \dot{Z}_{em}) = c_{el} \times (\dot{E}_2 - \dot{E}_1) \quad (31)$$

8) Expansion Valves:

$$\dot{C}_8 = \dot{C}_9 \quad (32)$$

$\dot{C}_5 = \dot{C}_6$
(33)

9) Total System:

$$\dot{C}_{aux} + \dot{C}_{el} - \dot{C}_{P,total} = \sum \dot{Z}_k \quad (34)$$

8. Economic Model

The economic model which is considered in this work can be written as:

$$\dot{Z}_k = CRF \times OMC \times PEC_k = \dot{Z}_{PEC,k} + \dot{Z}_{OM,k} \quad (35)$$

Where CRF can be difined as:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \quad (36)$$

Which n is the operation year and i is the interest rate.

The Single effect solar LiBr-H_2o absorption cycle consists of 5 heat exchangers, 1 expansion valves and 1 pump. Based on Berhane.H [12] the purchase equipment cost (PEC) in dollar and the annual capital cost (z) of these equipments can be computed according to the costs of 2008 as:

1) Heat Exchangers:

$PEC_i = (516.612 \times A_i) + 268.45$
(37)

$\dot{Z}_i = CRF \times PEC_i$
(38)

Which subscript i can be replaced by g, c, a and e which are related to generator Condenser, absorber and evaporator respectively.

2)Pump

$$PEC_p = 630 \times W^{0.4} \quad (39)$$

$$\dot{Z}_e = CRF \times PEC_p \quad (40)$$

Berhane.H [12] suggests neglecting the expansion valve, connections and piping costs due to their considerable lower prices rather than other equipments. Due to low duty of the case study which will be introduced later the cost of cooling tower can be neglected.

The type of selected collector is conventional in Asia and Middle East. Yattra *et al* [13] suggested the cost of the some kinds of collectors. Choosing conventional single glazed flat plate collectors yields:

$PEC_{Collector} = 121 \times A_c$
(41)

The other important part of the solar system which is relatively expensive is the hot water storage tank. The Eicker *et al* [14] proposed the cost of buffer storage tank which is used in this system in Euro as:

$$PEC_{st} = 5.0127 L^{-0.1931} \quad (42)$$

Eicker *et al* [14] also suggested 12 percent of the total annual cost of collector and tank as the valves, pumps and etc cost and 5 percent as the mounting and 2 percent as maintenance costs.

9. Case Study

As case study a typical house which is studied by Florides *et al* will be considered in this paper. [15] The process simulation is run using computer codes. Sixteen independent equations are available related to mentioned mass and energy equations. There are 30 unknown parameters in the process, so 14 parameters should be assumed to solve the thermodynamic equations. The base case parameters of system are illustrated in table (1).

Table (1): The base case input variables

Variable	Base Case	Optimized Case
T_{11}	90°C	87.4°C
$T_{13} = T_{15}$	25.5°C	23°C
ε_{ShX}	0.64	0.7
ε_g	0.61	0.556
ε_a	0.45	0.552
ε_c	0.62	0.7
A_C	50	43.02
W_{st}	1500	1042

10.Dynamic Simulation of the system

The statistical data of radiation intensity which is used in this paper is extracted from Mazloumi *et al* [16] which is the climate of Ahwaz-Iran. In order to dynamic simulation of solar system the base weight of tank is assumed 1500 kg , the base area of collector 50 m^2 , the mass flow rate of generator hot water 0.197 kg/s and the T_{11} is supposed 85 ℃. Furthermore the storage tank is simulated dynamically using 3 nodes. The results shows that at the beginning and at the end of the day, the required heat is supplied only by the auxiliary heater (the FNP is equal zero) but during the day the share of the sun radiation will be increased which reach 90 percent at noun. The fig(3) shows that the temperature of tank middle node is increased at the middle hours of the day for different collector areas in May which confirms the Atmaca *et al* [17].The fig(4) illustrates the auxiliary heater load during the day in May which is decreased obviously at the middle hours of the day.

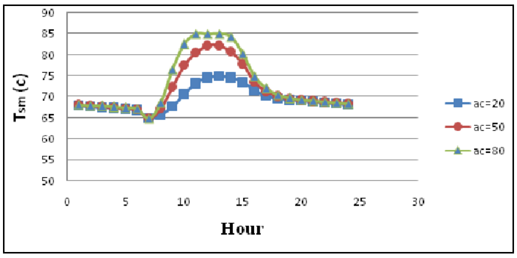

Fig.(3):The change rate of the temperature of tank middle node versus hours of day for different collector areas in May

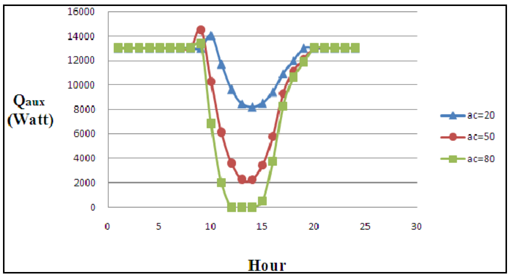

Fig.(4):The change rate of the thermal load of auxiliary heater versus hours of day for different collector areas in May

11.Optimization

The objective function is to minimize product cost rate of Single effect solar LiBr-H_2o absorption cycle system is:

$$\textbf{Minimize}\ \dot{C}_p = \dot{C}_H + \dot{C}_E + \sum \dot{Z}_k$$

The Physical constraints based on sensivity analysis which are restricting the optimization are:

$83°C < T_{11} < 100°C$

$25°C < T_{13} = T_{15} < 30°C$

$0.55 < \varepsilon_g < 0.65$

$0.4 < \varepsilon_a < 0.6$

$0.5 < \varepsilon_c < 0.7$

$0.5 < \varepsilon_{ShX} < 0.7$

$10m^2 < A_C < 100m^2$

$1000lit < W_{Tank} < 4000lit$

12.Optimization Description

Genetic algorithms were developed by John Holland in the 1960s as a means of importing the mechanisms of natural adaptation into computer algorithms and numerical optimization [18]. Algorithm starts with parent selection as the first step. In this step each individual parent has the same probability of being chosen. If the size of generated population is n, then n number of parents passes to the reproduction step, generating n offspring through a crossover strategy in which the decision variable values of the offspring fall in a range defined by the decision variable values of the parents. Some decision variable values of the offspring are also randomly mutated with a probability. The objective function values of the n offspring are then evaluated. Finally, the number of generations elapsed is compared to the established maximum number of generations. If the termination condition is met, the process stops, otherwise the surviving solutions become the starting population for the next generation.

13.Optimization Results

The results of optimization are illustrated in table (2).The results coincide with sensivity analysis except in the inlet temperature of condenser and absorber from cooling tower which has the optimized value of 23℃. Furthermore the optimized point of hot water boiler and generator hot water inlet decreases rather than base case.

Table (2): The comparison between decision variables of base case and optimized case

Variable	Base Case	Optimize d Case
T_{11}	90℃	87.4℃
$T_{13} = T_{15}$	25.5℃	23℃
$\varepsilon_{S\square X}$	0.64	0.7
ε_g	0.61	0.556
ε_a	0.45	0.552
ε_c	0.62	0.7
A_C	50	43.02
W_{st}	1500	1042

The comparison between exergetic and exergoeconimc results of the base case and optimized case tabulated in table (3).

Table (3): The comparison between exergetic and exergoeconimc results of the base case and optimized case

Specification	Base Case	Optimize d Case	Improvement (%)
Z_g($/Year-1)	740.3	626.4	15.38
Z_a($/Year-1)	226.16	255.848	13.12
Z_c($/Year-1	191.81	186.386	2.82
Z_{shx}($/Year-1)	41.29	41.61	0.7
Z_{cl}($/Year-1)	360.6	310.23	13.97
Z_{st} ($/Year-1)	90.15	62.62	13.53
Z_{total} ($/Year-1)	1541	1450	5.9
$C_{F,total}$($/Year-1)	1765	1722	2.43
$C_{P,total}$($/Year-1)	3306	3172	4.00
$C_{D,total}$($/Year-1)	4600	4021	12.58
$C_{L,total}$($/Year-1)	128.7	101.2	27.04
ε (%)	16.71	17.87	6.94
COP	0.828	0.854	3.14

14.Results and Discussions

The thermodynamic and exergetic analysis was carried over the single effect solar absorption system and the rate of exergy loss and exergy destruction in each sub-system was found. The results indicate that the exergy destruction in absorber and generator has the highest quantity because of the high temperature difference between the input and output streams of these equipments. To reach the more accurate results the dynamic analysis related to radiation of sun is done and this dynamic modeling is expanded to the other analysis and calculation of the system. The results shows that in the evening and beginning of the morning the FNP parameter reaches zero and denotes that the auxiliary heater supplies the required heat but in the morning and specially at noon the most part of the heat is supplied by generator e.g. 90 % at 14 0'clock.The temperature of the mid nod of the tank is increased at the noon which is the result of the more severe radiation of sun. Combine exergrtic analysis and economic, the exergeoconimc analysis were carried out to the system and the annual rate of fuel consumption was found. Then the effects of other system parameters on the cost rate of fuel and refrigeration production were considered (sensivity analysis) e.g. increase the area of the collectors yields the increase in absorbing the solar radiation and consequently decrease the rate of fuel cost but increase the capital cost of the system. The objective function is to minimize product cost rate of single effect solar LiBr-H_2o absorption cycle system is then constructed. Applying genetic algorithm method yields the optimal operating conditions of the system. The results of optimization coincide with sensivity analysis except in the inlet temperature of the condenser and absorber from cooling tower which has the optimized value of 23 ℃. Furthermore the optimized point of hot water boiler and generator hot water inlet is decrease rather than base case.

The optimized case shows a 5.9% decrease in total capital cost, from 1541 ($/Year) on base case to 1450 ($/Year) in optimized case. Furthermore the exergetic efficiency increases 6.94% from 16.71 to 18.87.The COP of the absorption system is improved 3.14% and finally the objective function –product cost rate- decreases from 3306 ($/Year) to 3172 ($/Year) which means 4.00 percent improvement.

15.Conclusion

Exergeoconomic optimization of a dynamic single effect solar LiBr-H_2o absorption chiller system is performed. The results show that the exergy destruction in absorber and generator has the highest quantity because of the high temperature difference between the input and output. Utilizing the exergeoconimc and genetic algorithm helps to optimize the system. In proceed case study the optimization reduces the product cost 4 percent relative to the base case which means 6.94 percent improve in efficiency of the system.

Nomenclature

$\boldsymbol{A}$	Heat Transfer Area (m^2)
c	Exergy Cost ($/Gj)
$\dot{C}$	Cost Rate ($/year)
CI	Capital Investment
COP	Coefficient of Operation
C_p	Specific Heat at Constant Pressure(Kj/Kg)
E	Exergy (Kj)
e	Specific Exergy (Kj/Kg)
E_D	Exergy Destruction(Kj)
E_L	Exergy Loss (kj)
$\dot{E}$	Rate of Exergy (Kw)
$\boldsymbol{f_k}$	Exergeoconomic Factor
F_R	Effectiveness Parameter
$\boldsymbol{FNP}$	Fraction of the Total Load met by non-Purchased Energy
$\boldsymbol{h}$	Specific Enthalpy (Kw/Kg)
$\dot{I}$	Irreversibility (KW)
i	Investment Rate
$\boldsymbol{I_{t\theta}}$	Total Amount of Sun Radiation on Collectors (Watt/m^2)
L	Tank Capacity (lit)
$\dot{\boldsymbol{m}}$	Mass Flow (Kg/s)
OMC	Operating and Maintenance Cost
$\boldsymbol{P}$	Pressure (KPa)
PEC	Purchase Equipment Cost ($)
$\boldsymbol{Q}$	Heat (Kw)
$\boldsymbol{q_U}$	Useful Absorbed Energy by Collector (Watt/m^2)
s	Specific Entropy (Kw/Kg.K)
$\boldsymbol{T}$	Temperature (℃)
T_0	Atmosphere Temperature
$\boldsymbol{T_{S,i}}$	Temperature in Storage Tank node i
$\boldsymbol{U}$	Total Heat Transfer Coefficient (Kw/$\boldsymbol{K}$.m^2)
UA	Loss Coefficient-Area Product
U_L	Heat Loss

	Coefficient($W/\boldsymbol{K}.m^2$)
$\boldsymbol{W}$	Work (Kw)
X	Saturated Quality
Y	Fraction
$\dot{Z}$	Capital Cost Rate (\$/year)
	Greeks
Δ	Difference
$\boldsymbol{\Delta T_{lmtd}}$	Log Mean Temperature Difference
ε	Exergetic Efficiency
$\boldsymbol{\tau}$	Absorption Coefficient
	Subscripts
a	Absorber
ap	Absorber Plate of Collector
at	Atmosphere (Surroundings)
aux	Auxiliary Heater
c	Condenser
ci	Inlet Stream of Collector
cl	Collector
co	Outlet Stream of Collector
ct	Cooling Tower
cw	Cooling Water
D	Destruction
e	Evaporator
el	Electricity
F	Fuel
g	Generator
in	Inlet
ins	Control Instruments
L	Loss
l	Load
load	Load
off	Disabled operation of Collector Circulation
on	Enabling Operation of Collector Circulation
out	Outlet
pl	The Sectional Area of Collector which let the Radiation pass
P	Product
pu	Pump
ref	Reference (Generator Inlet)
shx	Solution Heat Exchanger
solar	Solar System
st	Storage Tank
wb	Wet Bubble

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