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Development and Validation of a Python-based Simulation Program for Energetic and Exergetic Analysis of Heat Exchangers

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Abstract
Kaduna refining and petrochemicals company thermal power plant in Nigeria that cogenerates steam and electricity is faced with deterioration from its design output and excess fuel consumption. A simulation program for energetic and exergetic analysis of the thermal power plant was developed and validated in free and open-source literature based on the object-oriented programming language. The procedure to transform a mathematical model into a Python-based simulation program is shown. The article contains an algorithm for simulating the selected components. Herein, the simulation models of the Deaerator 1, HP Heater 1, and Condenser 1 were validated based on the literature' data. The energy and exergy analysis identified the losses, destructions, and efficiencies of the components. The validated results are graphically presented in charts. In the input interphase, the corresponding enthalpies, entropies, and the specific exergies were obtained as input data are considered. The program calculated the losses, destructions and efficiencies of the components, and the output interphases displayed the results. The results were validated by comparing it with the data of the referenced literature. It was revealed that the outputs from the program showed a very good agreement with the operational data from the literature.

Keywords — *Algorithm, deterioration, energy, exergy, Python, simulation*

I. INTRODUCTION

Thermal power plants that cogenerate steam and power energies consist of a deaerator, a high-pressure pump, a high-pressure heater, a high-pressure steam boiler, a steam turbine generator, and a water-cool condenser connected in series [1] - [3]. These plants commonly comprise heat exchangers, which are essential components whose performances significantly affect the steam and power generation. Deterioration in thermal performances of heat exchangers affects the steam and power generation and the thermal performance of a plant as a whole [4], [5]. These heat exchangers are heat transfer devices that exchange heat between two or more process fluids and are widely accepted in industrial and domestic applications. Many heat exchangers like deaerators, heaters, and condensers have been developed for thermal power plants, processing companies, transportation power systems, etc. A typical thermal power plant's thermal performance is primarily due to efficient heat transfer through the heat exchangers. Therefore, the effectiveness of these exchangers has a substantial influence on the plant's whole performance [6], [7].

A deaerator's primary function is to remove dissolved oxygen content and other corrosive gases from the boiler feed water and indeed increase the water temperature. This is accomplished using steam, which supports the deaeration process and preheating of boiler feed water [8]. The heater is also another type of heat exchanger, either low pressure (LP) heater or high pressure (HP) heater. These heaters are devices used in power plants to heat the feedwater before entering the boiler [9]. The Condenser is a heat transfer device used to condense steam from its gaseous to its liquid state by the cooling process. In this process, the steam's latent heat is given up and will transfer to the condenser coolant. Cooling water as a coolant is commonly used in many condensers. The main function is to receive exhausted steam from a steam turbine and converts it into liquid form for reuse in the boiler feedwater circuit. A typical power plant's performance can be accomplished by decreasing the thermal energy loss from Condenser [10], [11]. Kaduna Refining and Petrochemical Company (KRPC) thermal power plant cogenerates steam and electricity to smooth the entire refinery complex. The plant components like deaerators, HP heaters, and condensers, as shown in fig. 1, fig. 2, and fig. 3., are faced with the problem of deterioration from design output, which led to excess fuel consumption in the power plant. This research intends to solve these problems by designing and developing a simulation program to analyze those components, which will reveal the quantum of losses that occur in the plant and the components responsible. It will also assist the management of the company on its maintenance schedule of the plant. It's being said that to analyze the performance of an energy conversion system. It requires proprietary software [16]. This article is an attempt to refute this statement. It is proven that object-oriented programming languages can be used to develop a simulation program for analyzing an energy conversion system. The use of noble exergy analysis is essential in analyzing modern power plants.

Fig. 1: KRPC Deaerator

Fig. 2: KRPC HP Heater

Fig. 3: KRPC Condenser

Energy and exergy analysis based on first and second law of thermodynamics is a very important tool applied to analyze the performance of a thermal power plant and its components. It can quantify the sources of inefficiency, find out the location, type, and true magnitude of exergy destruction. Moreover, it can also be used to improve the performance of thermal power plants [12]. Generally, thermal power plants' performance analyses have to be done energetically and exegetically to determine more accurate results. The energy and exergy analysis technique evaluates performance and optimizes and suggests improvements to be made on the thermal power plant to achieve better performance [13], [14]. The step by step procedures of analyzing thermal power plant using exergy-based methods is described in the textbooks of [15], [16] and [17]. Qt Designer is the Qt tool or a standalone program for designing and creating graphical user interfaces (GUI) for desktop applications. It can be used to make windows, dialogs, and forms. It also allows different kind of widgets to create GUIs using on-screen forms and drag and drop based interphase [18]. Python is a popular programming language that was created by Guido van Rossum and released in 1991. It can be used on a server to create web applications, alongside software to create workflows, connect to database systems to read and modify files, handle big data, and perform complex mathematics. It can also be used for rapid prototyping or production-ready software development. Python is good because it offers multiple options and has different libraries for GUIs development [18].

Many researchers have already done much good research in energy and exergy analysis in thermal power plants and their components. Reference [19] refuted the statement that simulation of a thermodynamic system requires only proprietary software. The Authors transformed a physical model into a python-based simulation program and validated it based on literature data. The results were presented graphically in a Grassmann chart, which manifested high qualitative and quantitative conformity with literature data. A 250 MW thermal power plant's performance analysis based on exergy consideration using MATLAB calculation tool was carried out [20]. The result revealed that the boiler has the maximum exergy destruction of 490.76 MW, and the Condenser contributed to a major heat loss ratio. Reference [21] studied the simulation modeling of a 250 MW capacity coal-based power plant at different load conditions.

The simulation model of the plant was successfully done using the MATLAB calculation tool. The simulation model's satisfying results were validated by comparing the efficiencies and the consumptions at various plant load conditions under operating conditions. A sea water-cooled condenser's performance in a 660 MW steam power plant was conducted [34]. The results indicated that the cooling water temperature improvement enhances the condenser effectiveness from 0.27 to 0.48 but decreases the overall thermal efficiency from 39.85% to 38.72%. The thermal analysis of a steam surface condenser at different operating scenarios in a coal-fired power plant was assessed [23]. The results revealed that a degree Celsius changed in cooling water temperature led to a 0.59 kPa deviation of the condenser pressure, 0.36% heat rate deviation, and 33 MW unit generation in the plant's cycle. A review of thermal performance analysis of a steam surface condenser revealed that Condenser is one of the important components in a power plant. If the Condenser's thermal performance deteriorates, it affects the power generation and the entire power plant [24]. The thermodynamic analysis of a plant in Jordan revealed that the combustion chamber has the largest exergy destruction of 73%. The plant's energy and exergy efficiency decrease with an increase in the ambient temperature [25]. Reference [26] investigated a 200 MW Shahid Montazeri power plant of Isfahan using Engineering Equation Solver software. It was found that 69.8% of the total energy lost in the Condenser and 85.66% of the total exergy destroyed was found in the boiler. In a similar vein, reference [35] investigated the effect of using a different number of feedwater heaters on a 200 MW Shahid Montazeri steam cycle power plant's cycle performance. The performance study was simulated on a validated model of the plant, and the result revealed that the combustion chamber of the boiler has the maximum exergy destruction. In contrast, the energy and exergy efficiencies of the plant were 37.5% and 41.7%, respectively.

II. DESCRIPTION OF KRPC POWER PLANT

The boiler feed water from the Demineralized water unit with a temperature of 45^{0}C, pressure of 9bar, and dissolved oxygen content of 1.0ppm goes to the Deaerators where the pressure, temperature, and the dissolved oxygen content of boiler feed water (BFW) change to 2.5bar, 125^{0}C and 0.007ppm respectively. After the Deaerators, the High Pressure (HP) pumps increase the boiler feed water (BFW) pressure to 60.5bar, while temperature and dissolved oxygen content remains unchanged. The boiler feedwater (BFW) is then supplied to the Boilers through Heaters, where only the temperature is further raised to 140^{0}C. The boiler feedwater (BFW) enters the boilers through the respective economizers at a temperature of 140^{0}C and pressure of 60.5bar at 270t/hr. After the respective economizers, the boiler feed water becomes saturated and gets to the steam drum at a temperature of 185^{0}C and pressure of 52.4bar. The saturated water is separated from steam by the drum internals (horizontal separators and chevron driers). The dry steam is then superheated through the primary superheater and secondary superheater and then enters the high-pressure steam (SH) headers. A superheater steam temperature control device (spray type attemperator) is installed between the primary and secondary superheater. The steam temperature at the superheater outlet is controlled at the specified temperature of 412^{0}C and pressure of 42.5bar.

This superheated steam drives the turbo generators' prime mover (turbines) to generate power and drive other turbine pumps for pumping boiler feedwater at the required pressure. After utilizing the superheated steam (SH) in the HP pumps and the turbines, the medium pressure steam (SM) extracted from the turbines, and the HP pumps were channeled to the common header of medium pressure steam (SM). The medium pressure steam (SM) at a temperature of 300^{0}C and pressure of 16.4bar is used to drive the LP pumps and for heat exchange with boiler feed water (BFW) in the heaters. The low-pressure steam (SL) temperature of 175^{0}C and pressure of 1.44bar from the LP pumps is sent to the Deaerators for heat exchange with the boiler feedwater. Simultaneously, the heaters' condensate is also sent to the Deaerators to the make-up level of the boiler feed water (BFW). The medium pressure steam (SM) from the turbines, which were condensed under vacuum at a pressure of 18.2bar, are sending to the condensate tank (CT) via the condensate pumps (CP), and it flows back to the Demineralized unit. The process is repeated [28]. The process is depicted in fig. 4.

III. METHODOLOGY

The methodology for this research work involves the following major steps:

A. Mathematical Modeling

The KRPC heat exchangers' mathematical models were developed concerning the plant's schematic flow diagram, as shown in fig. 1. The heat exchangers of the KRPC power plant modeled are the Deaerator 1, HP Heater 1, and Condenser 1. The modeling was based on the first and second laws of thermodynamics.

(a). Energy and exergy analysis of Deaerator 1

Mass balance:

$$\dot{M}_3 + \dot{M}_1 + \dot{M}_{22} = \dot{M}_2 \quad (1)$$

Energy efficiency ($\eta_{I(De1)}$):

$$\eta_{I(De1)} = \frac{\dot{M}_2 h_2}{\dot{M}_3 h_3 + \dot{M}_1 h_1 + \dot{M}_{22} h_{22}} \quad (2)$$

Energy loss ($\dot{Q}_{L(De1)}$):

$$\dot{Q}_{L(De1)} = \left(\dot{M}_3 h_3 + \dot{M}_1 h_1 + \dot{M}_{22} h_{22}\right) - \dot{M}_2 h_2 \quad (3)$$

Nomenclature

BFW	Boiler feed water
CDT	Condensate
CW	Cooling water
CA	Combustion air
ESM	Extracted medium pressure steam
CSM	Condensed medium pressure steam
De	Deaerator
HPP	High pressure pump
LPP	Low pressure pump
He	Heater
Bo	Boiler
STG	Steam turbine generator
TC	Turbine condenser
HW	Hot well
CP	Condensate pump
CT	Condensate tank
DU	Demineralized unit
CU	Combustion unit
HEU	Heat exchange unit
KRPC	Kaduna refining and petro-chemical company
HHV	high heating value of fuel (kJ/kg)
LHV	low heating value of fuel (kJ/kg)
AAF	actual air-fuel ratio of fuel (kg of air/kg of fuel)
$\dot{E}$	Energy flow rate (kJ/s)
$\dot{E}_X$	Exergy flow rate (kJ/s)
$\dot{E}_{XD}$	Exergy destruction (kJ/s)
C_p	Specific heat capacity (kJ/kgK)
$\dot{M}$	Mass flow rate (Kg/s)
$\dot{Q}$	Rate of heat transfer to the system (kJ/s)
$\dot{Q}_L$	Rate of heat loss (kJ/s)
$\dot{W}$	Rate of work done by the system (kJ/s)
PW	Power produce by the system (kJ/s)
h	specific enthalpy (J/Kg)
s	specific entropy (J/Kg K)
P_o	Atmospheric pressure (bar)
T_o	Atmospheric Temperature (°C)

Greek letters

η_I	Energy efficiency (%)
η_{II}	Exergy efficiency (%)
ε	specific exergy (kJ/Kg)

Sub_ and superscripts

SH	High pressure steam
SM	Medium pressure steam
SL	Low pressure steam
FW	Feed water
FO	Fuel oil
F	Fuel
FG	Flue gas
A	Air
S	Steam
comb	Combustion
HP	Hot products
0	reference state

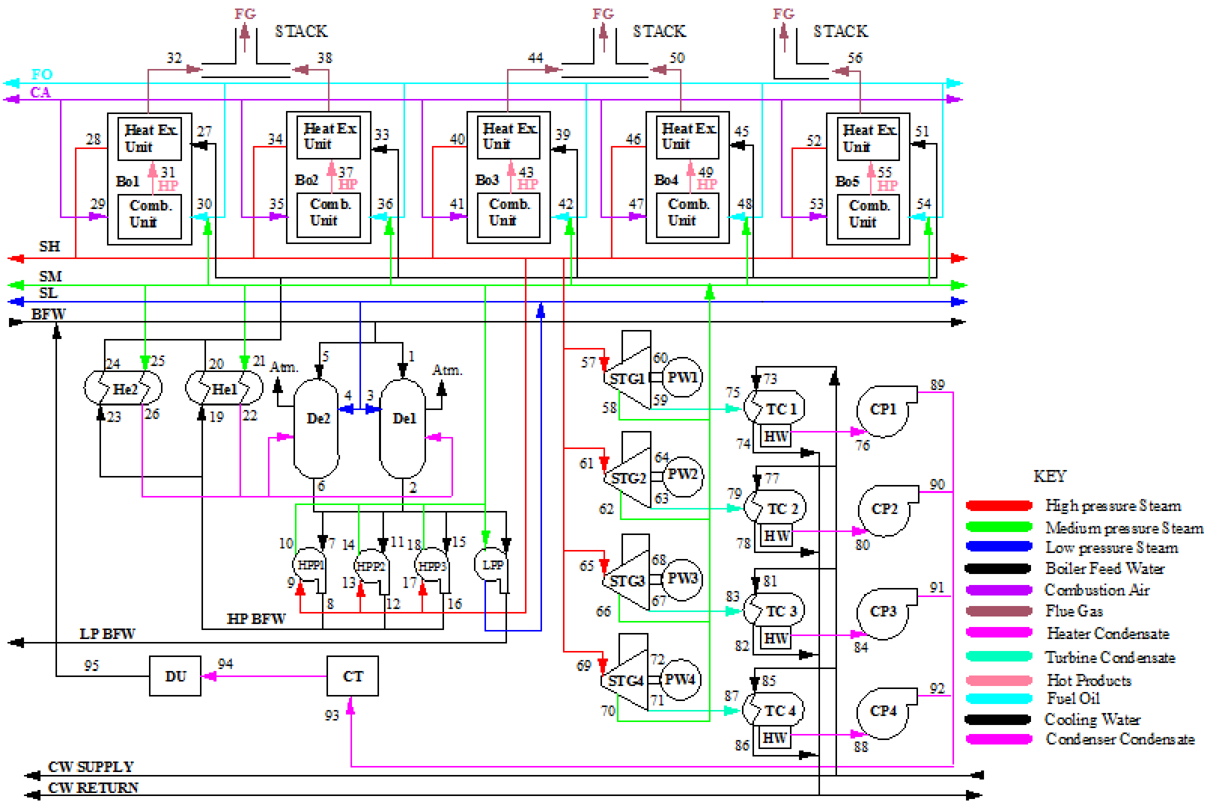

Fig. 4: Schematic flow diagram of KRPC steam power plant

The exergy efficiency of Deaerator 1 ($\eta_{II(De1)}$):

$$\eta_{II(De1)} = \frac{\dot{M}_2 \varepsilon_2}{\dot{M}_3 \varepsilon_3 + \dot{M}_1 \varepsilon_1 + \dot{M}_{22} \varepsilon_{22}} \quad (4)$$

Exergy destruction of Deaerator 1 ($\dot{E}_{XD(De1)}$):

$$\dot{E}_{XD\,(De1)} = \left(\dot{M}_3 \varepsilon_3 + \dot{M}_1 \varepsilon_1 + \dot{M}_{22} \varepsilon_{22}\right) - \dot{M}_2 \varepsilon_2 \quad (5)$$

Where:

$$\varepsilon_1 = h_1 - T_O\, s_1 \quad (6)$$
$$\varepsilon_2 = h_2 - T_O\, s_2 \quad (7)$$
$$\varepsilon_3 = h_3 - T_O\, s_3 \quad (8)$$
$$\varepsilon_{22} = h_{22} - T_O\, s_{22} \quad (9)$$

(b). Energy and exergy analysis of HP Heater

Mass balance:

$$\dot{M}_{19} + \dot{M}_{21} = \dot{M}_{20} + \dot{M}_{22} \quad (10)$$

Energy efficiency ($\eta_{I(He1)}$):

$$\eta_{I(He1)} = \frac{\dot{M}_{20} h_{20} - \dot{M}_{19} h_{19}}{\dot{M}_{21} h_{21} - \dot{M}_{22} h_{22}} \quad (11)$$

Energy loss ($\dot{Q}_{L(He1)}$):

$$\dot{Q}_{L(He1)} = (\dot{M}_{21} h_{21} + \dot{M}_{19} h_{19}) - (\dot{M}_{20} h_{20} + \dot{M}_{22} h_{22}) \quad (12)$$

The exergy efficiency of Heater 1 ($\eta_{II(He1)}$):

$$\eta_{II(He1)} = \frac{\dot{M}_{20} \varepsilon_{20} - \dot{M}_{19} \varepsilon_{19}}{\dot{M}_{21} \varepsilon_{21} - \dot{M}_{22} \varepsilon_{22}} \quad (13)$$

Exergy destruction of Heater 1 ($\dot{E}_{XD(He1)}$):

$$\dot{E}_{XD\,(He1)} = (\dot{M}_{21} \varepsilon_{21} + \dot{M}_{19} \varepsilon_{19}) - \left(\dot{M}_{20} \varepsilon_{20} + \dot{M}_{22} \varepsilon_{22}\right) \quad (14)$$

Where:

$$\varepsilon_{19} = h_{19} - T_O\, s_{19} \quad (15)$$
$$\varepsilon_{20} = h_{20} - T_O\, s_{20} \quad (16)$$
$$\varepsilon_{21} = h_{21} - T_O\, s_{21} \quad (17)$$
$$\varepsilon_{22} = h_{22} - T_O\, s_{22} \quad (18)$$

(c). Energy and exergy analysis of Condenser

Mass balance:

$$\dot{M}_{73} + \dot{M}_{75} = \dot{M}_{74} + \dot{M}_{76} \quad (19)$$

Energy efficiency ($\eta_{I(TC1)}$):

$$\eta_{I(TC1)} = \frac{\dot{M}_{74} h_{74} - \dot{M}_{73} h_{73}}{\dot{M}_{75} h_{75} - \dot{M}_{76} h_{76}} \quad (20)$$

Energy loss at Condenser1 ($\dot{Q}_{L(TC1)}$):

$$\dot{Q}_{L(TC1)} = \left(\dot{M}_{75} h_{75} + \dot{M}_{73} h_{73}\right) - \left(\dot{M}_{76} h_{76} + \dot{M}_{74} h_{74}\right) \quad (21)$$

The exergy efficiency of Condenser 1 ($\eta_{II(TC1)}$):

$$\eta_{II(TC1)} = \frac{\dot{M}_{74} \varepsilon_{74} - \dot{M}_{73} \varepsilon_{73}}{\dot{M}_{75} \varepsilon_{75} - \dot{M}_{76} \varepsilon_{76}} \quad (22)$$

Exergy destruction of Condenser 1 ($\dot{E}_{XD(TC1)}$):

$$\dot{E}_{XD\,(TC1)} = \left(\dot{M}_{75} \varepsilon_{75} + \dot{M}_{73} \varepsilon_{73}\right) - \left(\dot{M}_{76} \varepsilon_{76} + \dot{M}_{74} \varepsilon_{74}\right) \quad (23)$$

Where:

$$\varepsilon_{73} = h_{73} - T_O\, s_{73} \quad (24)$$
$$\varepsilon_{74} = h_{74} - T_O\, s_{74} \quad (25)$$
$$\varepsilon_{75} = h_{75} - T_O\, s_{75} \quad (26)$$
$$\varepsilon_{76} = h_{76} - T_O\, s_{76} \quad (27)$$

B. Programming, Simulation, and Calculation

This portion of the research outlines how a mathematical model is transformed into a running program to simulate a given process, as described in fig. 4. In this article, the input and output interphases were designed using Qt Designer software, and the source codes used are formulated according to Python's syntax. Any object-oriented programming language like Python that allows access by various objects can be used. Particularly, it is necessary to verify whether it can import different libraries and a solver that operates to solve [29]. The simulation algorithm is based on the energetic and exergetic analysis of the plant's heat exchangers, which comprises stages, as shown in fig. 5.

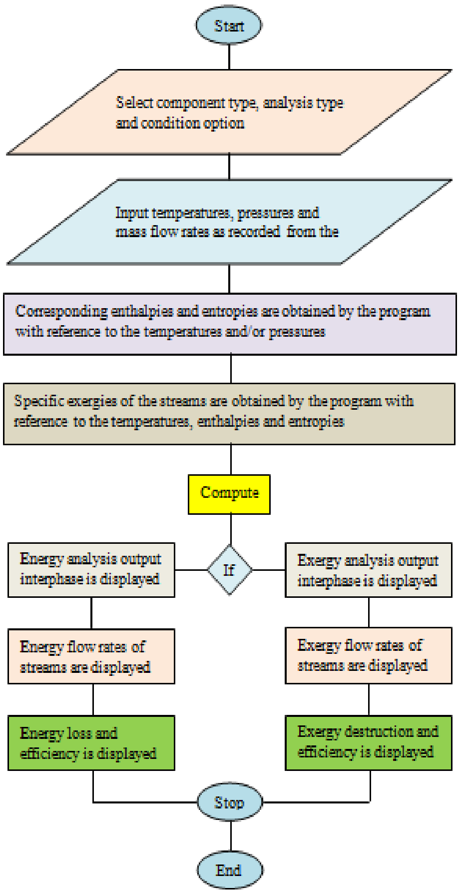

Fig. 5: Simulation algorithm for energetic and exergetic analysis of KRPC heat exchangers

The steam power plant consists of components and connections of pipes between them. In this research work, It was assumed that the components and the properties of the working fluid are steady-state during the investigation. Therefore, each component and each state is reproduced as an object with different attributes and calculation techniques. This system consists of equations based on energy and exergy perspective and attributes and states of the components.

After the necessary selections and relevant inputs are ensured, the system displays the corresponding enthalpies, entropies, and specific respective streams' exergies. When computed, the energy and exergy output interphases will display the energy loss, exergy destruction, and energy and exergy efficiencies of the selected component. Consequently, the analysis of the results will then be conducted.

C. Validation of Computer Program

After the successful simulation, the next step is to compare the simulated program's outputs data with that of plant records or with similar plants from literature. The simulation program is considered successful as the compared plants' two output values are in close agreement except small deviations that could be due to some assumptions and default values [30].

Concerning the schematic diagrams of respective thermal power plants in the literature [31], [32] and [33], the stream points of the deaerator1, Condenser1, and HP heater1 of KRPC thermal power plant as shown in fig. 1were compared with that of the deaerators, condensers, and HP heaters of the corresponding thermal power plants. The compared stream points are shown in table 1.

Table I: Corresponding stream point of the schematic diagram of KRPC plants and that of literature

Component	Stream point KRPC Plant	Stream point Literature	Stream Fluid
Deaerator	3	9a	Steam
	22	35	Water
	1	30	Water
	2	33a	Water
Condenser	75	5	Steam
	76	29	Water
	73	32	Water
	74	33	Water
HP Heater	21	15a	Steam
	22	3a	Water
	19	9a	Water
	20	10a	Water

The validation of the deaerator's simulation program was carried out concerning the literature's operational data [31]. Similarly, the Condenser's simulation program's validation was carried out with reference to the operational data in the literature [32]. And on the other hand, the validation of the HP heater's simulation program was carried out with reference to the literature's operational data [33]. The percentage variations of energy and exergy efficiencies and energy loss and exergy destruction of the components are shown in tables II, III, IV, and V. In contrast, that of the corresponding enthalpies and entropies of the temperatures and pressures of the streams are shown in Table VI.

Table II: Validation of computer program energy efficiencies of the components

Component	Energy Efficiency (%) Reference	Energy Efficiency (%) Program	% Variation
Deaerator	98.26	98.14	-0.12212
Condenser	47.0	47.49	1.042553
HP Heater	100	99.99	-0.01

Table III: Validation of computer program energy losses of the components

Component	Energy loss (MW) Reference	Energy loss (MW) Program	% Variation
Deaerator	7.8	8.3	6.41026
Condenser	6.0	6.31	5.16667
HP Heater	0.00	0.05	-

Table IV: Validation of computer program exergy efficiencies of the components

Component	Exergy Efficiency (%) Reference	Exergy Efficiency (%) Program	% Variation
Deaerator	92.15	94.04	2.05100
Condenser	24.0	23.12	-3.66667
HP Heater	80.19	80.89	0.87292

Table V: Validation of computer program exergy destructions of the components

Component	Exergy Destruction (MW) Reference	Exergy Destruction (MW) Program	% Variation
Deaerator	6.00	5.00	-16.6667
Condenser	0.6	0.69	15
HP Heater	1.889	1.856	-1.74696

Table VI: Validation of computer program stream data of the components

Component	Stream point	Stream Fluid	M (kg/s)	P (bar)	T (^{0}C)	h (kJ/kg) Reference	h (kJ/kg) Program	% Variation	s (kJ/kgK) Reference	s (kJ/kgK) Program	% Variation
Deaerator	9a	Steam	16.17	11.12	374	3207	3207.20	0.006236	7.3322	7.33223	0.000409
	35	Water	111.9	21.28	216	925	925.11	0.011892	2.4804	2.48048	0.003225
	30	Water	434.1	16.32	160	675	675.47	0.06963	1.9426	1.94262	0.00103
	33a	Water	562.2	11.12	-	783	783.106	0.013538	2.1830	2.182988	-0.00055
Condenser	5	Steam	5.55	0.09	43	2334	2334.13	0.00557	7.422	7.42203	0.000404
	29	Water	5.55	0.08	41	171.6	171.712	0.065268	0.5852	0.58564	0.075188
	32	Water	341.91	2.7	29	121.6	121.558	-0.03454	0.4228	0.42288	0.018921
	33	Water	341.91	1.5	33	138.3	138.28	-0.01446	0.4777	0.47778	0.016747
HP Heater	15a	Steam	11.39	15.23	313	3066.48	3066.13386	-0.01129	6.962	6.96077064	-0.01766
	3a	Water	11.39	10.66	183	776.68	776.334	-0.04455	2.169	2.16818	-0.03781
	9a	Water	74.93	127.52	118	495.80	495.802	0.000403	1.474	1.47401	0.000678
	10a	Water	74.93	127.52	197	843.84	843.843	0.000356	2.285	2.28501	0.000438

IV. RESULTS AND DISCUSSION

Comparisons of the components' performance parameters were made between outputs from the simulation program and outputs from the reviewed literature. The small percentage variations that were observed are presented graphically, as shown below.

A. The variation in energy efficiency

Figure 6 below shows that the chart differences are not noticeable because the percentage variation range of the components is 0.01% – 1.04%.

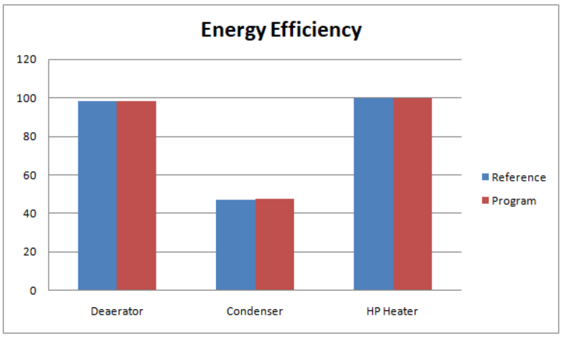

Fig. 6: Energy efficiency of reference and program

B. The variation in energy loss

Similarly, from fig. 7 below, it can be observed that the chart differences are not noticeable because the percentage variation range of the components is NIL/% - 6.4%.

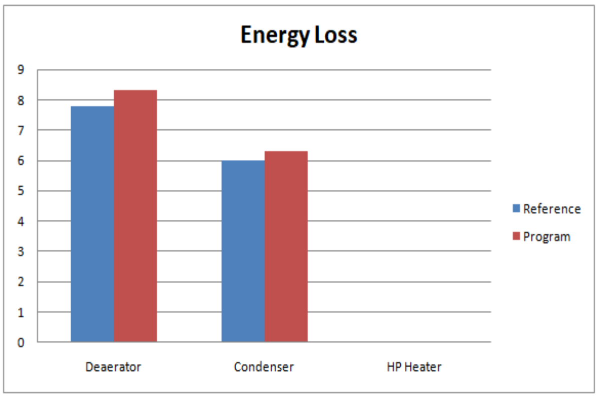

Fig. 7: Energy loss from reference and program

C. The variation in exergy efficiency

Similarly, from fig. 8 below, it can be observed that the chart differences are not noticeable because the percentage variation range of the components is 0.87% - 3.67%.

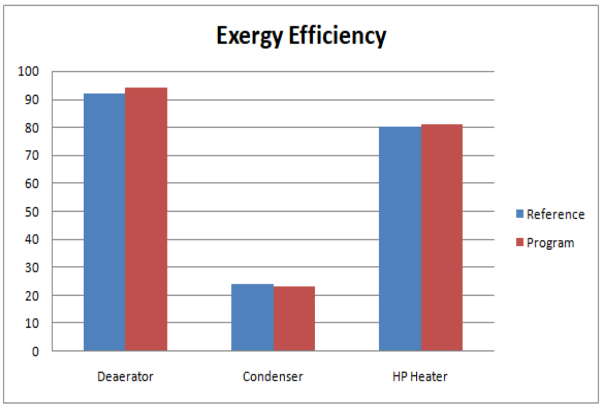

Fig. 8: Exergy efficiency of reference and program

D. The variation in exergy destruction

Similarly, from fig. 9 below, it can be observed that the chart differences are not noticeable because of the percentage variation range of the components 1.75% - 16.67%.

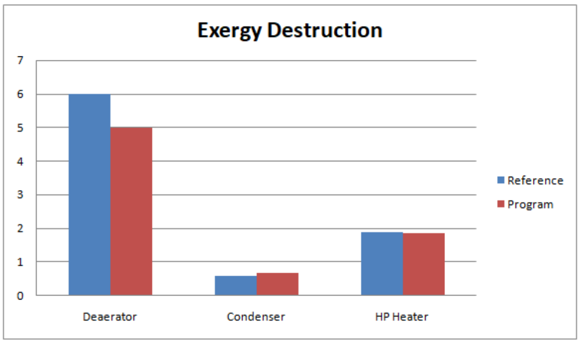

Fig. 9: Exergy destruction of reference and program

V. CONCLUSION

The article encourages the use of object-oriented programming languages to develop simulation programs, validate the program with open-source literature, and consider the noble exergy analysis for simulation of energy conversion processes. The aspects of modeling, programming, simulation, and calculation are shown in this article. The heat exchangers' mathematical model, which was further transformed into a computer program, is validated with open literature data. As shown in the charts, the validation result indicates a high degree of agreement with the literature. As a result, it is proven valid for implementation.

It is expected that the developed simulation program for analyzing the performance of the heat exchangers in the KRPC steam power plant would be practically implemented. The quantum of losses that occur during operation will be revealed, and components responsible for such losses will be identified. Consequently, the company's management will be well guided in carrying out the maintenance of components in the entire plant. It is further expected that researchers, instructors, and experts of energy science and engineering will find this research article very important in carrying out analysis of heat exchangers.

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