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Thermal Design Developing for Steam Power Plants by Using Concentrating Solar Power (CSP) Technologies

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ABSTRACT

The main purpose of this study is to discuss the possibility of the development of thermal power plants to produce electric power with conventional steam to work as a semi-joint system to exploit an array of solar collectors concentrated type parabolic cylindrical in processing the amount of thermal energy for steam turbine units. The effectiveness of various designs for linking Matrix complexes' solar concentration in the thermal design of the plant steam has been studied in this investigation. As a result of the use of matrix compounds, the CSP study showed the economic efficiency and environmental design of the proposed terms of the amount of savings the lowest in the amount of fuel consumed in the network. The findings show that the decrease in the amount of thermal energy and the amount of environmental pollution from carbon dioxide and nitrogen oxides which are produced in the surrounding medium.

1. INTRODUCTION

Electric power is one of the pillars upon which the modern Renaissance in various forms rests and is the artery that feeds the various social and economic activities. In recent years, most scientific research in the field of energy has focused on ways to rationalise the consumption of conventional energy sources and the preservation of the environment from pollution sources [1, 2].

As a result of this focus, means and methods for multiple uses of secondary energy sources, new energy sources, and renewable energy in the production of electric power have been developed. The findings of recent solar energy studies on the effective use of matrices complexes concentrated solar-type parabolic cylindrical in the production of electric power and thermal energy required for some industrial applications [3, 4].

The results of previous studies indicated the possibility of increasing the economic efficiency of solar power stations through the achievement of a common system for the operation of these types of stations on solar radiation energy and traditional fuels [5-7].

By which trying to exploits the thermal energy matrix of the steam turbine unit. Of course, in this case must take into account the impact of design features and specifications of the steam turbine unit, climatic conditions and the nature of weather in the site being considered on the effectiveness of the proposed design of the station similarities shared solar.

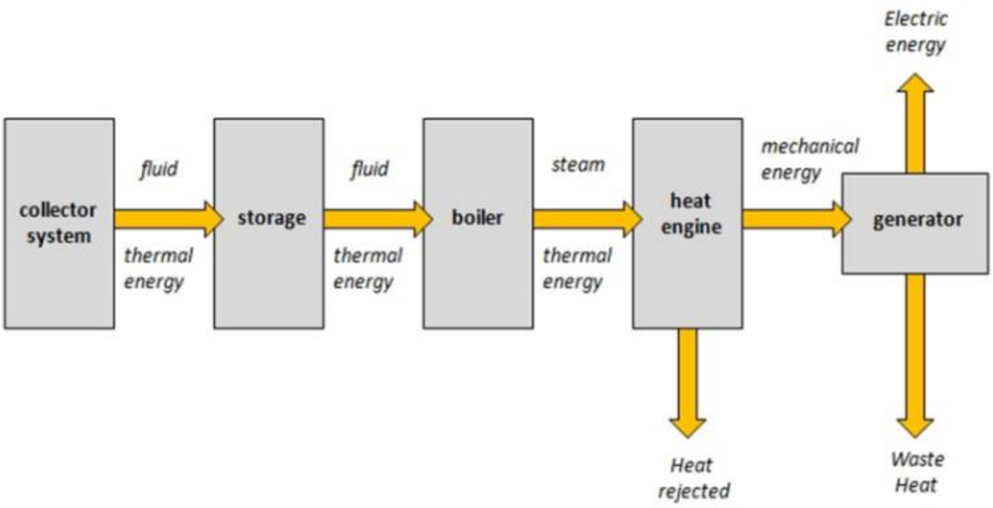

Figure 1. Schematic of a generic solar thermal power system

Concentrating solar power facilities in Earth's sunbelt regions provide a large-scale thermal or chemical fuel storage option for solar energy [8, 9]. According to Bosshard et al. [10], fundamental research themes are essential for enhancing the performance, dependability, and competitiveness of some established and new solar technologies with considerable potential for large-scale energy production. With the help of a spatially explicit model, several studies [11-16] have provided high-resolution estimates of the global potential and cost of utility-scale photovoltaic and concentrating solar power technologies. These studies also identify the best deployment strategies for reducing greenhouse gas emissions. Also, the application of thermal technologies may advance from present hybrid plants to plants with a minor degree of thermal storage and possibly even to plants with enough thermal storage to offer base load production capacity as the percentage of electricity generated by technologies rises [17-20].

The main goal of this research is to look into the possibility of developing thermal power plants to generate electric power using conventional steam in a semi-joint system that uses an array of concentrated type parabolic cylindrical solar collectors to process the amount of thermal energy for steam turbine units. Therefore, the innovation of the current study is highlighting the decrease of fuel consumption for the plant, resulting to reduce pollution by decreasing of resulted gases. The generic thermal power system is show in Figure 1.

2. BASIC DESIGN OF THE PLANT STEAM

The basic design consists of a steam boiler plant with a production capacity of 400.26 tonnes per hour and a condensing steam turbine unit with one axis and a design capacity of 150 megawatts. Figure 2 shows Schematic diagram parabolic trough solar power plant. The steam turbine operates at the elementary properties of steam (To=500 C; Po 130.4 bar). One stage to re-heat the steam in the boiler (PRH=30.53) bar (TRH=580 C) as shown in Figure 3. The expansion of the steam boiler (TSB=510 C; PSB=145.47 bar) and include six points to drain the steam from the cylinder for the purpose of a retrospective heating feed water Table 1.

Table 1. The properties of steam at various points of attrition of steam turbine

Point	1	2	3	D	4	5	k
p	29.8	16.2	9.43	4.7	2.15	0.7	0.5
TC^0	329	340	256	210	120	108	34

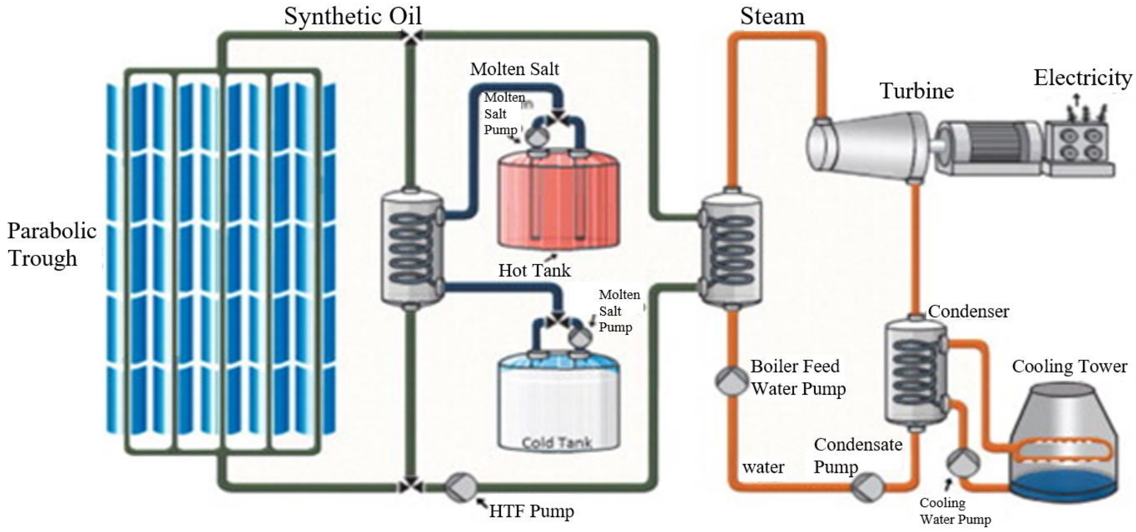

Figure 2. Schematic diagram parabolic trough solar power plant

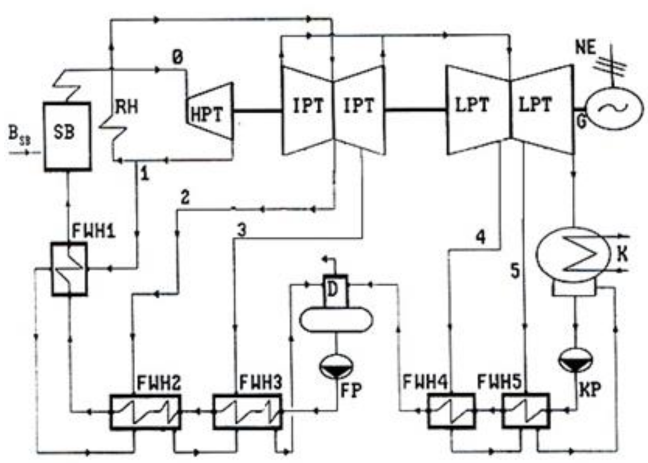

Figure 3. The basic design of the steam station

3. DESIGNS OF THE STUDIED PLANT SIMILARITIES SHARED SOLAR

The proposed design of the station resembles a solar array that contains a matrix of solar concentrated collectors of both the concentration type and solar parabolic cylindrical parts, in addition to the above-mentioned in the basic design of the steam plant. Where they are in accordance with the design of the proposed use of concentrated solar matrix complexes in the processing of the amount of thermal energy for the steam turbine unit through the heating system for water retrospective feed water.

Which led to a decline in the amount of steam from the turbine user for the purpose of heating water for retrospective compensation, and then the low rate of fuel consumption in the boiler due to the fall in the amount of steam supplier of the steam turbine unit? Where the proposed system's mode of operation is similar to the common characteristics and specifications on the design of the steam turbine unit, therefore, the study includes the following methods for the functioning of the station in the semi-common:

i. (a reserve to increase the rate of increase in the flow of steam in the final stages of the steam turbine and the amount of electrical power produced by the generator): In this way, the steam turbine unit works at the design flow rate for the amount of processed steam boiler (DO=con) and within the steam turbine is the increasing amount of steam for the process of non-extracted heating of feed water. Thereby increasing the flow rate of steam to the condenser (DK=var) and then increasing the electrical energy produced by the steam turbine (NE=var).

ii. (In the absence of a reserve to increase the power of the generator): In this way, within the steam turbine, extend the amount of steam for the process of unextracted heating of the feed water (DK=var.). In this case, the constant amount of electric energy produced is maintained (NE=con.). This leads to a lower rate of fuel consumption in the boiler.

iii. In the absence of a reserve to increase the flow rate of steam in the final stages of the steam turbine, in such a way as to reduce the amount of processed steam for the steam turbine unit by the largest amount of non-steam extracted retrospective of the heating process of water nutrition. In order to maintain the rate designed for the flow of steam in the last stage of the steam turbine (Dk=con), which leads to a decline in the amount of electricity produced (NE=var.) by the turbine unit and a decline in the rate of fuel consumption in the boiler. From the foregoing, the effectiveness of the proposed design of the plant similar to the common solar system will depend on how connected solar concentrated matrix complexes are in the thermal design of the steam plant. This is in addition to the technical limitations of the work station in the solar system, similar to the joint.

To that end, in the current study, the following proposal to link the design matrix complexes concentrated solar heating system in the retrospective of the feed water.

3.1 First studied design

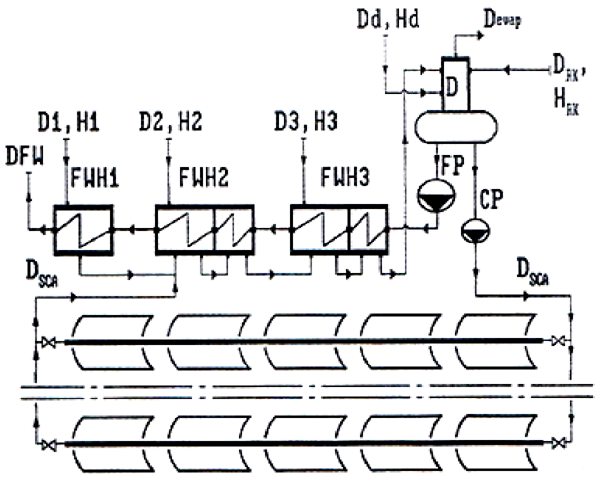

Figure 4. Design considered the first to link a matrix solar collector at the plant steam (FWH: FEED WATER HEATER, FP: FEED PUMP, CP: CIRCULATION PUMP, D: DEAERATOR)

This will be according to the suggested design (Figure 4); link matrix complexes solar concentrated with a tank of disarmament air and gases dissolved in the water feeding (D). Thus, in the case of solar radiation is processing the amount of thermal energy produced by a matrix complex, Dream Castle solar heating system to the retrospective of feed water. Which leads to a decline in the amount of steam turbine extracted from steam tanks to remove dissolved air and gases? And then either increase the power producing steam turbine unit, in the first case, the way for the operation of the station; If the first method for the operation of the station in the system is similar to a joint or lower the amount of processed steam turbine unit in the case of the other methods of joint working station solar similarities, the amount of fuel consumed to produce electricity [5].

3.2 The second studied design

As is well known when using the process of re-heating steam in the thermal design of the steam plant to be the maximum temperature of the steam turbine extracted from steam for the purpose of heating water retrospective Nutrition is located at the point of attrition after the re-heating operation directly. So as to reduce the amount of loss in the steam extracted to the process of heating retrospective and increase the effectiveness of the proposed design of the station near the joint, a design considered the first where it was in accordance with the proposed design (Figure 5), processing the amount of thermal energy produced for a matrix solar collector for concentrated heated gases II (FWH2).

Which led to a decline in the amount of steam turbine extracted from steam heaters for kinetic second (FWH2) and third (FWH3) and tank removal of dissolved air and gases. And this will depend on the amount of thermal energy in the design matrix. Concentrated solar collectors on the amount of thermal energy needed for heating the feed water heater in the heat of this second addition to the technical parameters of the functioning of the proposed design of the system is similar to a common [6, 7].

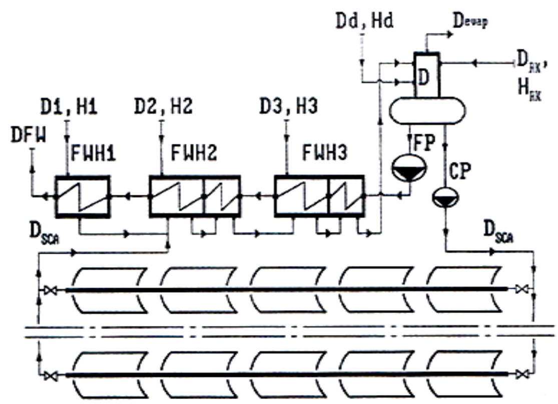

Figure 5. Design considered the second to link the *matrix compounds in the Solar steam Plant* (FWH: FEED WATER HEATER, FP: FEED PUMP, CP: CIRCULATION PUMP, D: DEAERATOR)

3.3 The third studied design

Featuring some of the designs of conventional steam stations, the high number of heaters in thermal heating systems used in the retrospective of water nutrition leads to a decline in the amount of thermal energy needed to heat the feed water and condensate in the main heated gases.

In order to increase the effectiveness of the proposed design of the station, shared similarities in the case of falling solar thermal energy design of the heated gases and when there is a large reserve to increase the flow rate of steam in the final stages of the steam turbine, have been considered second to modify the design. Where they are in accordance with the proposed design (Figure 6), processing the heat transfer fluid After his release from matrix compounds, concentrated solar to the tank removes the air and dissolved gases as well as the feed water with high pressure, taking into account the amount of loss in the steam out of the system. which, in the case of design lessons (Figure 6), results in any decrease in the amount of steam Leech Removal of heated gases in retro II (FWH2) removal and tank air and gases dissolved (D) in addition to heated gases III (FWH3) And this will depend on the amount of thermal energy available to the design matrix complexes. The concentrated solar thermal energy needed to heat the heated gases in the retrospective and the second tank to remove dissolved air and gases.

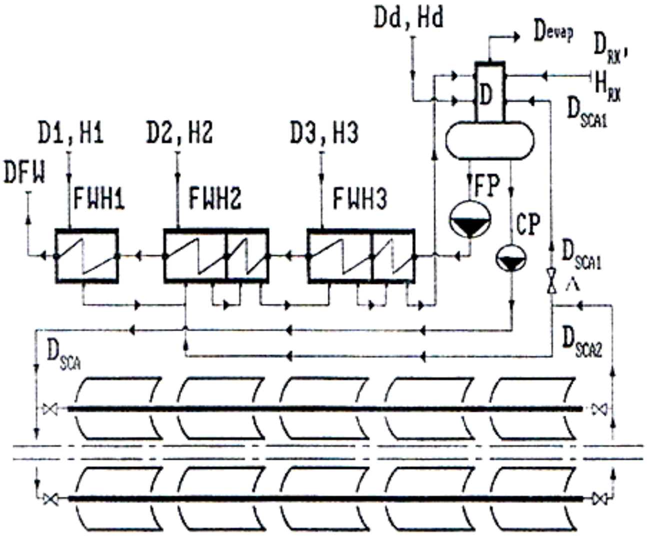

Figure 6. Design considered the third link solar matrix complexes in the plant steam (FWH: FEED WATER HEATER, FP: FEED PUMP, CP: CIRCULATION PUMP, D: DEAERATOR)

4. METHOD OF STUDYING THE EFFECTIVENESS OF THE PROPOSED DESIGNS

To study the effectiveness of using solar concentrated matrix complexes of the type of parabolic cylindrical in the thermal design of the conventional steam plants requires the expense of several different alternatives to the proposed design of the plant similar to the common solar features from each design change considered to link the matrix complexes concentrated in solar thermal design, unity turbine steam and the way the legs work in the semi-joint. In a measure of the effectiveness of maintaining the lowest level of pollution in the Central Pacific, was to study the adoption of the amount of savings in the amount of fuel consumed for the production of electricity grid as a result of the use of matrix compounds in solar thermal design of the plant steam so they can be the following relationship reflects the amount of savings in the amount of fuel consumed for the production of electric power:

$$DBST = (BSB)\ basic + \frac{3600 * DNE}{Qcv * EST} - BSBproposed \qquad (1)$$

where, *BSB* (*BSB*) is fuel consumption rate of the boiler in the basic design of the steam plant and the proposed design of the joint sub-station solar order (ton\hr); *EST* is the efficiency of the plant for the production of countervailing power, Qcv is calorific value of fuel quality (kj /kg).

DNE is amount of change in the amount of electrical power produced by steam turbine unit as a result of the use of concentrated solar array complexes (MW) and is calculated from the following relationship:

$$DNE = NE - (NE)0 \qquad (2)$$

where, *NE*, (*NE*)0 represents an electricity-producing steam turbine unit in the basic design of the plant and the proposed design of the plant is similar to the common solar order (MW).

Thus, the appropriate replacement is the one who gives the maximum value of the integration of equation (1) year-round. To undertake this study, mathematical modelling was used. The mathematical model proposed for the station in accordance with the nature of the technical and physical designs studied and the way the work station in the system is similar to the common solar, according to the methods adopted and used to conduct these types of accounts and the method of calculating the thermal design of the steam stations [5].

- Clear sky method to estimate the amount of solar radiation on the surface of the land [6].
- Method of calculating the thermal design and specifications for the design of solar collectors Concentrated parabolic cylindrical [4].

It should be noted in the study was to calculate the amount of solar radiation on the surface of the earth the adoption of the nature of weather and climatic conditions of the station site at the corner of latitude 37.78 degrees [2]. And the properties used in the approved design [4] for concentrating solar collectors.

5. RESULTS AND DISCUSSION

The effectiveness of the proposed design for the station mainly depends on the properties and specifications of the unit turbine steam. So, it has been a study to examine the effect of the method of operation of the proposed design of the system similar to a common solar (paragraph 3) on the amount of savings in the amount of fuel consumed by the relationship (1) and to determine the effectiveness of designs studied to link the matrix Complexes concentrated on solar in the thermal design of the plant, steam. The results indicate that the proposed design of the station common solar design in the case considered the first high amount of savings in the amount of spent fuel (DBST). With more virtual (LAT) in the morning (Figure 7), to be up to the maximum value at midday (LAT=12 h), dropped by the virtual g The reason for this is to increase the amount of thermal energy-producing complexes in concentrated solar arrays (QSC) as a result of the high amount of solar radiation that falls on the surface of the matrix (ETA).

Then a decline in the amount of steam from the turbine steam extraction to remove the air tank and dissolved gases. Then, as shown in Figure 7, the start value of the amount of savings in the amount of fuel consumed in the fall Increase the time with the virtual. And therefore, the high amount of the increase in the amount of electric power producing steam turbine units (DNE) according to the first proposed design for the operation of the system, similar to a common solar. Because of the decline in the amount of direct solar radiation that falls on the surface of a matrix complex, concentrated solar and the low efficiency of this matrix lead to a decline in the amount of electricity-producing steam turbine units. It is noted from Figure 7 that the efficiency of a matrix solar collector in the morning (LAT<12 h) for the operation of a matrix solar collector and a decrease in the evening (LAT>12h). The reason for this could be interpreted to be to increase the amount of solar radiation absorbed and the high temperature of the surrounding medium in the morning. And then increase the amount of thermal energy produced for a matrix solar collector by the biggest rise in the amount of heat loss to the middle of the ocean. The amount of decrease in the amount of thermal energy produced by a matrix solar collector is greater than the decline in the amount of heat loss to the middle of the ocean. It has been studying the impact of the second design considered (paragraph 2.3) and the third (paragraph 3.3) on the effectiveness of the proposed design of the plant, similar to the common solar system. As seen from Figure 8, the high amount of savings in the amount of fuel consumed (DBST) and the amount of the increase in the amount of electricity produced (DNE) compared with the design considered first (Figure 5) is due to the increase in the amount of thermal energy to the design matrix solar collectors (QSA3=21 MW; QSA2=14 MW). The decline in the amount of lost extracted steam for heating water revisionist nutrition, particularly in the second heat of the heated feed water, and the subsequent rise in the amount of work done by steam (unextracted retrospective of the heating process) within the steam turbine.

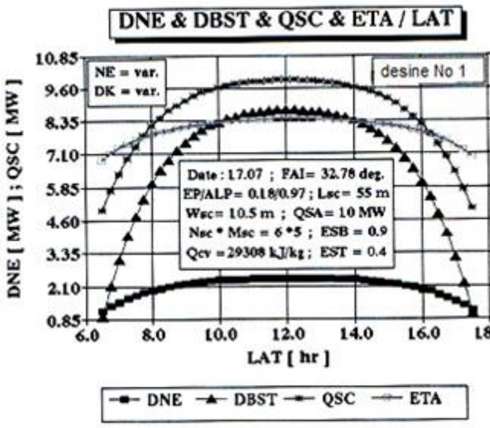

Figure 7. Relationship of the design specifications for the station with the solar time in the case of virtual design and the way that studied first for the operation of the station

As shown in Figure 8, the high effectiveness of the proposed station design was related to an increase in the amount of solar thermal energy design matrix complexes concentrated solar power. And so was studied the effect of using the second method for the operation of the proposed design of the station similarities shared solar on the amount of savings in the amount of fuel consumed (DBST). We note from Figure 9 as compared to (5) that there is closely related to the amount of savings in the amount of fuel consumed with the virtual time.

But in this case, increasing the amount of thermal energy producing compounds concentrated matrix leads to a high increase in the rate of flow of steam in the final stage of the steam turbine (DDK). And then there is the low rate of fuel consumption of the boiler as a result of the fall in the amount of steam-producing boilers in a solar system similar to the joint. In addition, as shown in Figure 9, there is a slight decrease in fuel consumption when compared to Figure 9.

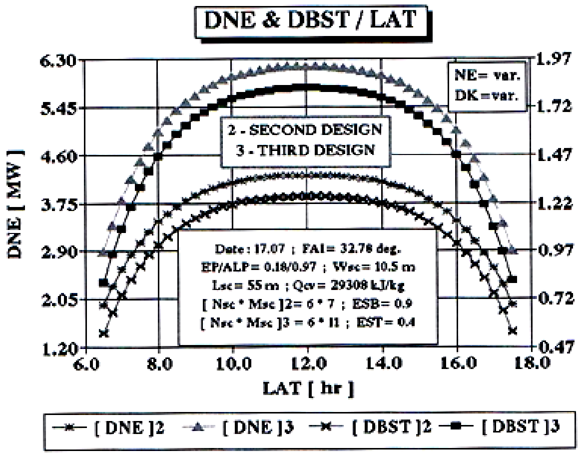

Figure 8. The relationship of the design specifications for the station with the solar time in the case of virtual designs that studied the second, third and first method of operation of the station

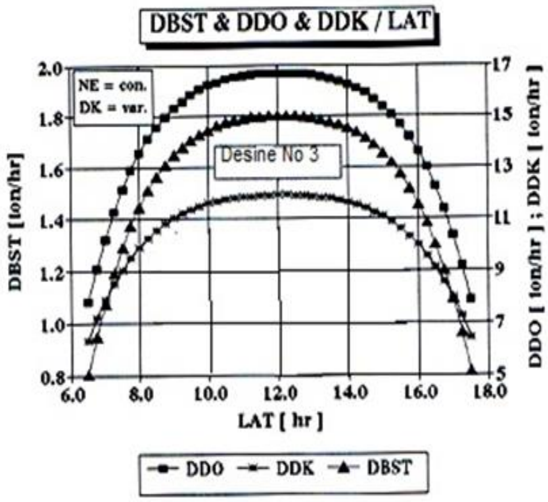

Figure 9. Relationship of the design specifications for the station with the solar time in the case of virtual design that considered the third and second method of operation of the station

The reason for this is due to the slight difference between the efficiency of the station compensated to produce electric power and the efficiency of the basic design of the plant steam {(EST)o=o.395}.

It is noted from Figure 10 that the amount of steam supplier of the steam turbine unit is greater than the amount of the increase in the rate of steam flow in the last stage of the steam turbine.

This is due to the high extracted steam to the heating process in retro heaters heat, which affects the amount of thermal energy-producing complexes concentrated solar array in accordance with the third (paragraph 3.3). The findings have shown that the impact of the use of third way for the operation of the proposed design of the plant is similar to the amount of solar saving on the amount of fuel consumed during the month (DBM) at different values of the efficiency of the plant for the production of countervailing power (EST). Where the notes of the Figure 10 show a high amount of savings in the amount of fuel consumed during the month in the summer (8, 7, 6, 5 months) compared with the winter months (2, 1.12, 11).

The reason for this could be interpreted to increase the amount of direct solar radiation that falls on the surface of concentrated solar arrays during the summer compared with the winter due to the nature of the control system used in the routing matrix of concentrated solar (Radiation centre movement about one axis elongated horizontally from the north to the south).

This, along with the sun's passage over the northern hemisphere during the summer and the weather at the site studied (the angle of latitude of 37.78 degrees). And then there is the high amount of thermal energy vector of a matrix solar collector. As a result, the amount of steam supplier of the steam turbine unit decreases which leads to a high drop in electric power producing steam turbine units during the month (DNM) and the rate of fuel consumption at the boiler.

As well as the note of the Figure 10, a high amount of savings in the amount of fuel consumed during the month with a compensatory increase in the efficiency of the plant to produce electric power. Because of the low rate of fuel consumption to produce electricity, a power station is compensatory compared with the basic design of the station. The integration was conducted throughout the year to determine the amount of savings in the amount of fuel consumed from the relationship (1) and all methods studied for the operation of the proposed design of the plant similar to the common solar at different values of the efficiency of the plant compensatory.

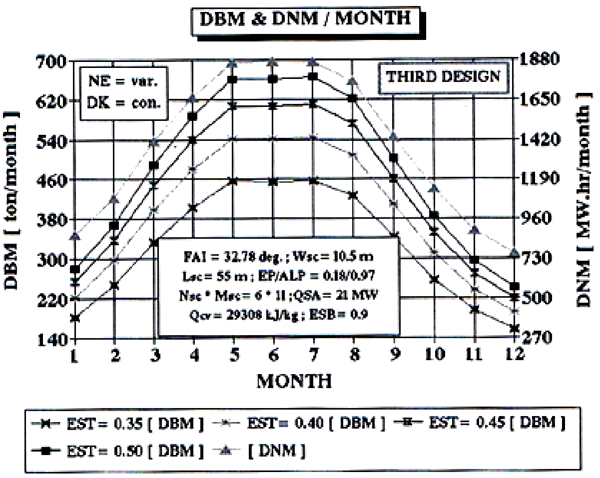

Figure 10. Relationship with the amount of savings in the amount of fuel consumed (DBM) and the amount of the decline in electrical power produced (DNM) during the month of the station and solar similarities shared different month of the year in the case of third way for the operation of the station

6. CONCLUSIONS

(1) The effectiveness of using concentrated solar array complexes of the type of parabolic cylindrical in processing the amount of thermal energy for steam turbine units through the heating system of water nutrition. Where it reached the lowest savings in the amount of fuel consumed for the production of electrical energy to the design matrix complexes concentrated solar energy, according to the amount of the decrease in thermal energy and the amount of nitrogen oxides and environmental pollution from carbon dioxide.

(2) The similarities between dependent effective solar stations are based primarily on the properties and design specifications of the steam turbine unit.

(3) The compensatory increase in the efficiency of the plant to produce electric power by 25% on the basis of the basic design of the plant steam leads to a high amount of savings in the amount of fuel consumed during the year by 22% in the case of maintaining a fixed rate for the flow of steam in the final stage of the steam turbine.

(4) There is a need for an economic study to determine the thermal properties and specifications to design the ideal matrix of solar collectors, which gives the maximum possible economic effectiveness.

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