Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Comparative Investigation for Solar Thermal Energy Technologies System

To cite this article: Mohammed R. Al_Qasab *et al* 2019 *J. Phys.: Conf. Ser.* **1362** 012116

Comparative Investigation for Solar Thermal Energy Technologies System

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Abstract - The multiple uses of fossil fuels make them depleted in the coming years. Also, the large amount of pollution produced by the use of this fuel has made the world seriously think of environmentally familiar alternative sources of energy. Universal energy is vast and diverse energy, with the ability to cover the individual's energy needs in various fields in the coming years. The focus of this study was a parabolic dish system. There are different uses solar of parabolic dish applications that can be limited by two main groups: thermal generation and electric power generation. A thermal generation used to generate steam, solar cooking, water heating, and water distillation. The briefly objective is to review and analysis the thermal generation published by taken into considering used parabolic collector system. Also, evaluate solar dish operators in differences covering like, the composition of concentrators, the material of reflector, receiver design, parabolic dish diameter, rim angle, and focal length. These characteristics drive to entire structure possible for a parabolic dish. Finally, this article may be useful for the new research worker to consider the requirement for Thermal solar generation integrated with a parabolic dish.
Keywords: Solar Concentrating, Parabolic Dish, Solar Energy, Review, Distillation.

1. INTRODUCTION

The Archimedes (287-212 B.C.) was the initial Greek scientific recorded utilisation energy concentrated. Galen described records of stunning the striking Roman flotilla in 212 B.C. Where burned their ships by focused the solar (A.D. 130-220)[1]. In the 17th century, Athanasius Kircher (1601-1680) set fire to a heap of wood at a distance to prove the narrative of Archimedes [1]. The concentrated was supported because it could reach the highest temperatures without requiring any fuel [2]. Mouchot spearheaded producing steam has low-pressure to manage engines about 1864-1878. At the Paris Exhibition in 1878, Abel Pifre provided simple engine on solar [1]. However when in-depth testing he declared the system high costly ever to be possible the mid-20th century presented different concentrating activities. Shuman and Boys in 1912 made solar pump was utilised to rising water from the Nile [3]. Concentrating innovation had made a significant jump but stopped because of the Second World War and the next blast of minimal cost non-renewable sources. In 1977 in Shenandoah build, parabolic dishes utilised to raise the temperature for silicon-based fluid depended on steam Rankine cycle. The retention chiller worked on lithium- bromide that got from waste heat the plants. Overall thermal efficiency was 44%, take it to stand out amongst the most efficient systems at any point executed [4]. Water is a prerequisite constituent for all time on the planet. About 70 % of the surface covered by water, but just 2.5% is drinkable water, and vast numbers of it spared in polar areas [5]. Also, by bounty utilising of compound farming for agribusiness, mechanical arrival of synthetic substances misuse, underground getaway of oil, and surface overflow from construction locales divert water impure. One out of six persons on earth cannot access to safe water. Murky water and powerless sanitation administrations are the explanation behind 80% of health problem and died about 2–5 million persons each year in the world [6]. The parabolic dish concentration (PDC) is an important technique to get heat water or water purification and get fresh water from free heat source supply "Sun". The planet reached about 3.85 million EJ (Exa-joule = 10^18 J) of solar energy every year [7]. Likewise, high and mighty monthly of solar irradiance nearly (18.4 MJ m-2day-1) offered for global solar power over Iraq, it is likely to the investment it is full of the solar systems [8]. The solar distillate is a super option for all non-renewable distillation procedures. It is an innovation that is not just prepared to empty a broad scope of contaminants in just a single stage is clear, environment- friendly and cost-efficient. The outline of the parabolic dish depends on several parameters that need analysis and research in areas of interest, for instance, the material of reflector, a diameter of a parabolic dish and other settings that will study in this review article. PDC advantages are high concentration power, robust for dampness effects, an excellent thermal efficiency, long lifetime and hybrid tasks.

Additionally, most components can make in the local market. PDC give high-temperature ranges, and that is putting it in the upper concentration systems. The excellent thermal efficiency comes from the rising temperature that result give suitable applications. Accordingly, PDC will offer an economic rationale to get necessary desalinisation water, and that is maybe considered the best useful power source from renewable systems in a couple of years. From the other side, there are a few inconveniences of the PDC, the major it is tracking system and heat losses. The primary objective in this review article are different analysis designs of active solar concentration, compare study done to research description, different applications of the parabolic dish and their possible used in some country.

2. COLLECTOR COMPONENTS

The assembler points out that the total system contains a concentrator of solar radiation and a solar radiation absorption device (receiver). The concentrator part may be a refractor or reflector and have shape paraboloidal or different surface of revolution [9]. This review study is showing parabolic dish concentrator principally curved dish frame, reflective sheets, absorbing unit and solar tracking system [10]. The PDC dependably on three essential parts as shown in Fig.1:

1. Parabolic concentrator design.
2. Receiver system.
3. The tracking system.

A. PARABOLIC CONCENTRATOR DESIGN

The parabolic is the position of the points that move the same dimension from a point, and a line is fixed. Fig.2 shows that the continuous line is named the directory and the fixed point are the spot and symbolise it (F). The line is orthogonal to the directory and passes through the F concentration named the axis. The parabola tangent its axis at a point V named the vertex, which is specifically midstream between the focus and the directory. Therefore, the parabola equation is shown in equation (1) [11]:

$$y^2 = 4fx \quad (1)$$

Where (f) is the focal length , also can calculate the parabolic surface area from the equation below [3],[4]:

$$S_{area} = \frac{8\pi}{3} f^2 \{[1 + (\frac{d}{4f})^2]^{1.5} - 1\} \quad (2)$$

Where (d) is a parabolic open diameter, and parabolic aperture area is [12]:

$$A_a = \pi r^2 \quad (3)$$

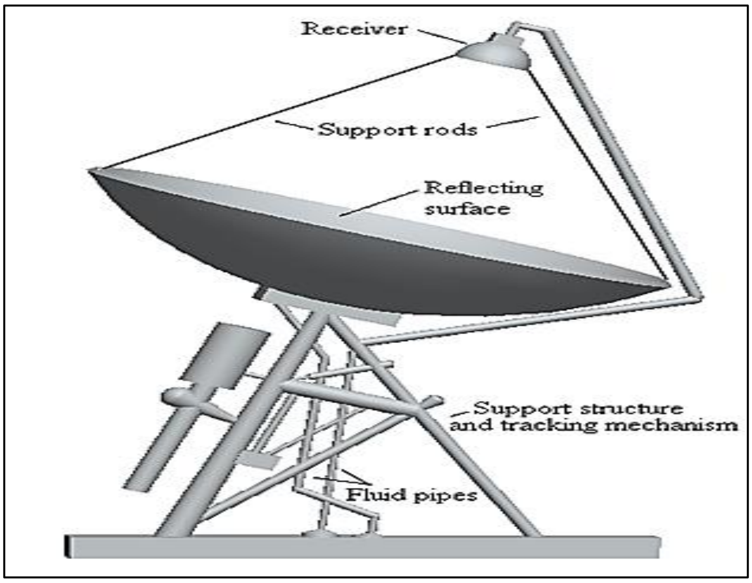

Fig.1: Parabolic Dish Concentration with Receiver [7]

Some studies change the parameter reflector form to multiple spherical mirrors bolstered by a truss structure. The solar focus location on a portable base from metallic with a counter stabiliser that was screw onto tracks. A parabolic dish made from galvanised steel material was sized 0.68 m high and 0.62 m width. That it reused from an old satellite antenna [13]. In Kafrelsheikh University, Egypt building system was a mixture of the parabolic concentrator and still collector for product salty water desalinisation. Satellite dish surface sheeted with glass mirror reflect of 4 mm thickness. The tape assembled accurately to get a correct point to concentre [14]. National Institute of Technology, India, a fabricated parabolic collector from tasty satellite dish fitted and a polished by an aluminium sheet as concentrator surface. Where the dish aperture diameter has 3.56 m, focal point measurement 1.11 m, and the aperture angle was 69° [15]. In the Coastal region, India is confronting downside regarding fresh water thus designed Parabolic Dish Solar that change over saline water into potable water [16]. Another paper was used 14-kilogram Beeswax as a phase change material (PCM) to maintain high operating temperature to provide desalinated water during the hours of the sun disappearing with PDC to check quantity distillation. The productivity of the concentrator with using beeswax was close to 62% over than the concentrator without using beeswax [17].

B. Receiver System

The receiver defines a part that fixing on focal dish point to absorb concentration of energy radiation and heat wall receiver to reach at the desired temperature[18]. Receiver retains radiant energy and utilisation it to warm operating liquid and take many designs like a convex, obscure hole or flat surface [9].

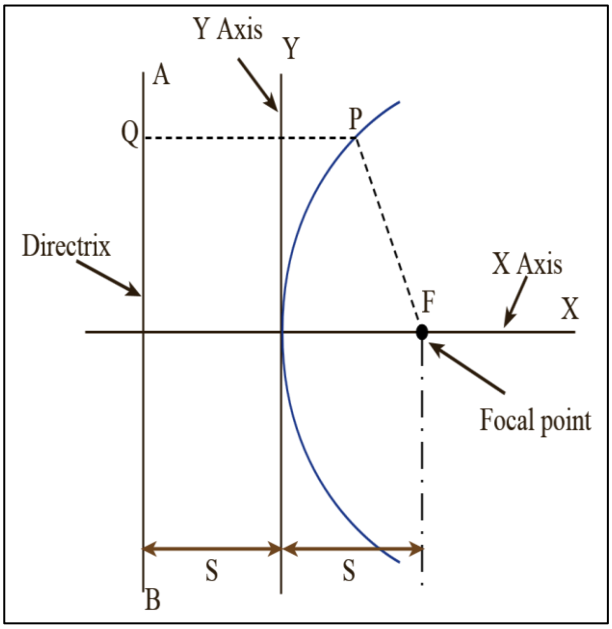

Fig. 2: The parabolic intersection [11]

Receiver's surface area symbolizes as (*Ar*), and an always it less than that of the reflector surface area that symbolizes as (*Aa*), Therefore, these characteristics are taken into account in the calculation of the concentration ratio between the incident radiation and the reflected radiation, which represents a tiny area and as a result, high temperatures can be obtained. The geometric concentration ratio depends on the proportion of the area for reflector and absorber. In this review, most of the designs that used in receivers have been catalogued of external, cavity, Tubular and Volumetrically Receivers [19]. See Table 1. We will review some of the studies carried out in this review, including, F.Wang et al. used two types for receiver ware cavity cylinder and conventional cylindrical cavity and both model made from copper tube The height 0.2 m and aperture radius 0.09 m[20]. A. Giovannelli et al. used a tubular cavity integrated with phase change material to store heat energy in the short term; The receiver is designed in a cylindrical vessel with 12 twisted tubes in a U shape inside the chassis and immersed in phase change material [21]. T.Arunkumar et al. fabricated solar still receiver from copper material and had hemispherical absorber ware placed inside it six paraffin wax ball to solar enhancement distillation [22]. A. Mawire et al. investigated cavity cylindrical as helical coil from copper are positioned on outside and inside surfaces of the cylinder [23] as shown in Figure (3-6) respectively.

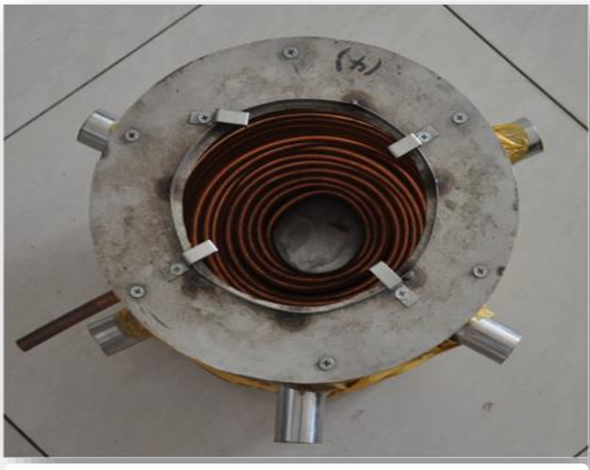

Fig. 3: Cylinder receiver cavity [22]

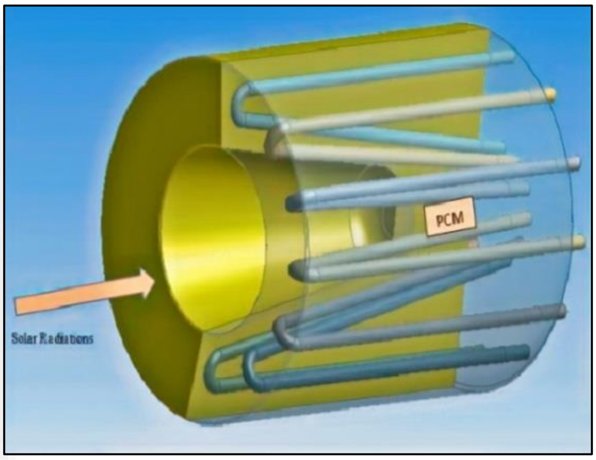

Fig. 4: Tubular cavity with phase change material[23]

Fig.5: Solar still absorber with 6 PCM balls[24]

Fig. 6: Coil cylindrical cavity receiver[25]

C. THE TRACKING SYSTEM

The principle of reflector concentration depended on the direction of beam propagation of solar radiation. This progression of advances to build up the productivity of solar systems can be considered as high significance [24]. Tracking System is an innovation that used for quite a while by researchers since this strategy permits the grouping of sun oriented vitality in an absorber material by assembling configuration pursue sun to gather the most extreme sum vitality as conceivable [25]. Two sorts for solar tracking are known one-axis and for maximum energy, dual-axis. One axis called altitude–azimuth or azimuth-elevation tracking, and the second type called equatorial or polar [26]. Designed tracking system comprises of sensor and controller with built operated monitoring circuits to push motor with control[27]. Solar dish tracking in most recent studies and different styles have some modify systems like a technique at solar cooking, which depends on gravity, offered by Badran [28]. The effect of dual-tracking on solar cooking for empirical results earned demonstrate that the temperature of the inner container achieved over than 93 C^o in a multi-day where the maximum surrounding temperature was 32 C^o [29]. Dish moving in a parallel plane to the ground so for this reason azimuth tracking consider the central axis. When plane rotates with surface and perpendicular on the azimuth axis that gives elevation tracking. The above planes show the solar track right, left, up and down rotate, during the day and throughout the year [26].

Table 1: Descriptions of various types of receivers

Type receiver	Descriptions	Ref.
External receivers	This type takes the shape of a cylinder that is composed of plates of vertical tubes. These tubes containing the operating liquids obtain the solar flux directly. The vertical tubes forward the warmed liquids to the storage. The maximum operating fluid temperature of the tubes determines the refractive point at the operating fluid temperature of the receiver. The concentration ratio and liquid temperature arrived at 1000 and 500 °C, respectively. The first heat losses are expected non-concentric, conduction, convection, radiation and reflection.	[30],[19]
Cavity receiver	In the receiver cavity, the flux receiving tube and surface located internal an insulated cavity for decreasing heat losses from the collector. The thermal losing of cavity absorber is low and in usually, thermal activity growing with a ratio of cavity side to aperture area. Besides, they supply protection to the receiver from hostile climatic conditions. Receiver cavities are using in different types of the solar thermal power plant for mid and max temperature applications.	[31]

Tubular receivers	This type of receivers consists of lines row coaxial tubes. The outer tubes get solar radiations the heat exchange fluid courses through the inner tube and leave through the annular area between the tubes. The concentration ratio and higher fluid temperature achieved are about 1.5 and 200 °C, respectively.	[20],[32]
Volumetric receivers	This receiver kind absorbs focused solar radiations out of porous structures. This one can work in surrounding light condition also in an enclosure by a transparent window.	[21]

3. THE COMPONENTS AFFECTING THE DESIGN OF THE REFLECTOR

This sub-article displays the components affecting the design of parabolic dish also the latest studies during this activity. Also, the reflector can category for significant components, which material of the reflector concentrates, the design of the reflector concentrates, focal length, solar radiation at the concentration, diameter of the dish concentration, measuring the aperture area of the concentrator, concentration ratio and rim angle [16] See Table 2.

A. SIZING THE APERTURE CONCENTRATOR AREA

Aperture area defines an overall surface area of the concentrator which solar incidents on it, also we can give another description where consider (*Aa*) as a region that gets solar radiation. The dimensions of concentrator obsession effects on the measures of solar thermal energy.

B. FOCAL LENGTH

One essential part of the parabolic reflector is a focal length that symbolises as (*f*), to guarantee that the parabolic dish works accurately, it is critical to guarantee that the transmitting component is position at a focal point so to decide this it is essential to know the focal length. In expansion to this, the *f/D* proportion is essential. As the *f/D* proportion is regularly determined alongside the measurement, the focal length can be gotten effortlessly by increasing its *f/D* proportion by the predetermined width D. [33].

The parabola's focal length find by following equation [12]:

$$\frac{f}{d} = \frac{1}{4\,tan\,(\frac{\theta\,rim}{2})} \tag{4}$$

Where (θ_{rim}) represent the dish rim angle. The rim angle has a significant effect on focal point location where the lower rim angle led to increases focal line at the same dish diameter [34]. The dish's depth found by the equation below [34]:

$$d_d = \frac{d^2}{16f} \qquad (5)$$

4. Optical Analysis

The mathematical equations used to calculate the effect of the optical and geometrical concentration ratio of the parabolic dish. Where the optical concentration ratio is defined as the ratio between the amount of solar radiation falling on the dish (I_b) and the ratio of the reflected solar radiation to the receiver (I_r) as shown in the equation below:

$$C_{RO} = \frac{I_r}{I_b} \qquad (6)$$

Table 2: The components affecting the planning of the reflector

Concentrator diameter	Concentrator aperture area	Focal length	Rim angle	Reflector material	Ref.
0.68 m	0.3312 m^2	0.55 m	35.40 ^{o}	Mirrored in an electrostatic chroming process	[13]
1 m	0.78 m^2	0.2 m	86.19 ^{o}	Glass mirror strips of 0.004m thickness	[14]
5 m	19.8 m^2	1.8 m	70 ^{o}	Chrome plated steel/brass sheets	[9]
2.88 m	6.5 m^2	1.5 m	43.8 ^{o}	The mirrors stuck on the metal surface and	[35]
2.2 m	3.8 m^2	0.75 m	16 ^{o}	Stainless steel layer with reflecting coefficient about 0.85	[36]
1.5 m	1.86 m^2	0.827 m	-	Aluminum foil with 0.5 mm thickness	[37]
1.25 m	-	0.5 m	-	Polished aluminium sheet with a thickness of 0.001 m	[38]
1.67 m	2.19 m^2	0.579 m	717^o	Glass mirror of 2mm thickness	[39]
1.5 m	1.76 m^2	0.8 m	30°	Aluminum foil	[40]
2 m	3.14 m^2	0.8 m	-	Sheet steel with reflectance of (76%)	[41]
3.25m	6.25 m^2	1.5 m	-	Mirror with reflectivity 0f 95%	[42]

3.8 m	10.28 m^2	2.26 m	45.6 °	Silvered mirror layer	[43]
3.7 m	10.75 m^2	2.233 m	45 °	Stainless steel with reflectivity 0f 67%	[6]
0.93 m	0.6792 m^2	0.303 m	74.92°	Aluminum sheet	[44]

The equation can represent the ratio of geometric focus:

$$C_{RG} = \frac{A_a}{A_r} \quad (7)$$

In addition, the maximum C_{RG} of 3D concentrator show as equation below[45]:

$$C_{R,max,3D} = \frac{1}{Sin^{2(\theta\, max)}} \quad (8)$$

Where (θ_{max}) is the half-angle subtended by the sun and is the acceptance half angle for maximum concentration ratio.

It can calculate the optical efficiency of the system where it represents the ratio between the receiving radiation of the receiver (Qabs) and the radiation reaching the dish (Qs) [8][9].

$$\eta_O = \frac{Q_{abs}}{Q_S} \quad (9)$$

Where:

$$Q_S = I_b * A_a \quad (10)$$

It can also calculate the optical efficiency of the system by knowing the properties of the material used and the amount of absorbance and its reflectivity as shown in the equation below [8][10].

$$\eta_O = \lambda\rho\tau\alpha\gamma\, cos(\theta) \quad (11)$$

Where λ is the non-shading factor, ρ is the reflection of the dish, $\tau\alpha$ is the permeability-absorption product, γ is the receiver interceptor, which is defined as the proportion of energy intercepted by the receiver to the energy reflected by the device focus parabola dish, θ is an incidence angle [46]. For the solar parabolic dish, it has dual-axis tracking, which means the incidence angle of the solar beam into the dish is zero degrees. The intercept factor is defined as the radiation portion, which will reach the receiver and estimate the value.

5. APPLICATIONS

The parabolic solar collector technologies are one of the renewable technologies that play a significant role in determining the current and future fuel issues as a result of they use the sun's heat [47]. The ray concentration could be an innovation that been utilised for quite a while by the analyst. This technique permits the convergence of solar in a focus point, that permits high solar intensity

[24]. Also, that is technology have numerous uses of the solar parabolic dish includes preparation cooking, water heating, and water desalination. Table 3 shows the many applications for PDC and comparing previous investigated [25]. At the point when the contraption added in uncovered cooking utensil mode, approximate 7 kg. of water at temperature 20 C^o was heated until the point of bubbling in 60 minutes as shown in Fig. 7, then the pot put inside the box from glass for the decreased time of bubbling at 40 minutes and the resulting efficiency for cooking expanded until 275% [28]. At other research, the gadget could rise temperature for 30kg of water from 20-50 C^o in 2½ hour. A good efficiency acquired for cooker mode was 77%, but the inclined curve for efficiency was 10.63 $W/m^2.C^o$[28]. Therefore, solar preparation technology could be the key in order to manage environmental pollution and deforestation [7].

Figure7. The cooking system mode[33]

Table 3: Dish applications

Application	Research focus	Ref.
Cooking	It is constructed, operated and tested to overcome the need for daily tracking and standing in the sun.	[25]
	An extensive survey on solar cookers and technology by using solar cooking is an essential item in order to deal with deforestation.	[7]
	A survey of various decision-making groups and user preferences for internal cooking devices in India used to formulate the evaluation matrix.	[52]
	The outlined solar cookers have various applications, such as in a hospital, large families, food stations and schools.	[53]

	The test was a convenient system in this work fabricated and tested. Higher collector effectiveness and cooking power accomplished.	[28]
	Building, development, and activity of spherical cooker by solar with a programmed sun tracking system.	[29]
Heat water	An increment in the low-stream rate of temperature at the water was attainable together with an elective trade water cycle among cool tank/collector and the hot tanks.	[48]
	The experimental stage is dependent on the style, improvement and execution qualities of the right steam age by non-following PDC system.	[49]
	For the generation of hot water that uses parabolic dish collector design for domestic applications, and the simulation of dish collector done in mat lab software.	[44]
	Low cost was concentrating solar for stream generation.	[54]
	PDC experimental with temperatures that are higher than various types of powered radiation transformation systems.	[33]
	Depended on PDC to get fresh water potable.	[41]
	Plan and improvement of a parabolic collector to warm water by solar power.	[39]
Water distillation	Design a water distillation system that converts saline water into potable water.	[16]
	Short monetary analysis for various distillation techniques to get a better result.	[5]
	Provide the advantages of solar design innovation in a world whose the utilisation of vitality by non-renewable energy sources is a genuine issue that society needs to confront.	[24]
	An innovative concentrating collector with a paraboloid dish reflector is	[55]

	present.	
	Identify the availability of alternative energy formulas related to concentrating solar collectors.	[50]
	The article showed the PDC advancements and the structure factors adjusted in various applications.	[18]
	Present a straightforward refining water system integrated with concentrating unit, paraffin wax utilised in this investigation as PCM to keep heat from the warmed water.	[40]
	Experimentally tested and results are discussed for A stand-alone triple basin solar desalination system.	[38]
	Modification of parabolic concentrator (PC) – solar still with continuous water circulation using a storage tank to enhance productivity.	[22]
	The PDC works with rising temperatures than that still solar types.	[37]
	Describe the awaited physical phenomenon correctly by using solar energy concentration.	[36]
	An experimental setup to investigate the thermal performance of a cylindrical cavity receiver for an SK-14 parabolic dish concentrator.	[23]
	Improve productivity by mixing Single slope solar still, integrated with parabolic concentrator and PCM to keep heat after sunset.	[17]
	The exchange off techniques is discussed to set up the harmony between many compelling components identified with system cost, dependability, survival, and properties.	[9]
	Offered plan and establishment of PDC, principle sun focusing authority and changed heater for bitter water desalination.	[14]

For heating water up 100 C^{o} industrialised it conceivable to accomplish with PDC model [48]. For experimental parabolic dish integrated with Helical absorber coiled from Copper, the check results were estimated 215 C^{o} with highest steam efficiency range 60% to 70% [49]. The performance of such concentrating collectors is often enhancing by correct material choice for the reflecting surface and by a decrease of assembling imperfections. By using standard tracking methodology for the dish collector, the overall values of the system are often reduced [44]. The effectiveness of solar dish concentrator expanded from 0.8 to 0.96 because of using a solar tracking system [33]. Research fields of solar collector physics, components style, material economy, energy value savings and reduction of dioxide emission into the atmosphere distillation is between 12:00-14:30 and the temperature arrived at about 146 C^o at focal point, and the water temperature is 102.7 C^{o,} and also the system is going to be more effective if the solar tracking is used [16]. Building up the concentrator solar within regions that uncovered the full daylight as a high level of the yearly direct daylight is very attractive. The Middle East measures within the inside areas that have right solar conditions compared with the other regions like (US Southwest, North Africa, Australia.) [50]. The average productivity of PDC and conventional solar still was (68, 34)% respectively, and The regular daily of fresh water was approximate (7, 3) L/m^2/day for PDC with preheating and CSS, respectively [14]. Also, solar dish concentration has more range of application like steam power, generate electric, distillation. [47],[51].

6. DISCUSSION

The solar parabolic dish characterised by a concentration of high temperature, which leads to an increase in the high thermal generation efficiency, so the primary objective of this study is to know the factors that increase the amount of efficiency and productivity of the SPD system where it depends:

1. Thermal efficiency increases when cooling the absorber's cover in water heating or desalination, but not be cost-effective.
2. Increase thermal efficiency when using change phase materials. This method was done by storing the heat and making use of the latent heat after sunset.
3. The Rim angle is an essential factor in the increase in productivity, which directly affects the determination of the focus point and the balance of the amount of light and radiation that reaches the receiver.
4. Solar tracking led to increase thermal efficiency.
5. When pre-heating the water inside the receiver or condenser vapour out from the receiver, it leads to a rise in thermal efficiency.
6. It is preferable to use high reflectivity and low absorption materials that increase the amount of radiation reflected, increasing the efficiency of the system.

7. CONCLUSION

The official purpose of these analyses is to review investigate about what the best way to install solar PDC for different applications. The investigation takes under consideration open accessible solar-based factors and very extraordinary styles. Additionally describes depicts structure factors at dishes like the material used, radiation amount incident and sizing for dish-absorber. Also, compare between geometrical parameters and affect them on collector thermal efficiencies like focal Length, concentration ratio, and rim angle. Based on solar dish style analysis, it is discovered that the optimum system performance is actively depending on rim angle, receiver area, concentration ratio and tracking system. Efficiency of solar dish system is one in all the most essential factors that show the effectiveness of the system.

Nomenclature

PCM	Phase Change Material
PCU	Power Control Unit
PLC	Programmable Logic Controller
PDC	Parabolic dish Collector
CSP	Concentration Solar Parabolic

CSS	Conventional solar still
Ar	Receiver surface area (m^2)
Aa	Reflector surface area (m^2)
f	Focal length (m)
Tw	Water temperature (C^o)
Tair	Air temperature (C^o)
Toc	Cover temperature (C^o)
C_{RO}	Optical Concentration Ratio
C_{RG}	Geometrical Concentration Ratio
η_O	Optical efficiency
d_d	Depth diameter of the parabolic dish
I_b	Direct solar radiation
I_r	Absorbent solar radiation by the receiver

8. REFERENCES

[1]. A. B. Meinel and M. P. Meinel, “Applied solar energy: an introduction,” *NASA STI/Recon Tech. Rep. A*, vol. 77, 1977.
[2]. J. R. Howell, R. B. Bannerot, and G. C. Vliet, *Solar-thermal energy systems: analysis and design*. Mcgraw-Hill College, 1982.
[3]. L. C. Spencer, “A comprehensive review of small solar-powered heat engines: part I. A history of solar-powered devices up to 1950,” *Sol. Energy*, vol. 43, no. 4, pp. 197–210, 1989.
[4]. W. B. Stine and R. W. Harrigan, “Solar energy fundamentals and design,” 1985.
[5]. H. Manchanda and M. Kumar, “Study of water desalination techniques and a review on active solar distillation methods,” *Environ. Prog. Sustain. Energy*, vol. 37, no. 1, pp. 444–464, 2018.
[6]. R. Affandi, C. K. Gan, M. Ruddin, and A. Ghani, “Development of Design Parameters for the Concentrator of Parabolic Dish (PD) Based Concentrating Solar Power (CSP) under Malaysia Environment,” *J. Appl. Sci. Agric.*, vol. 9, no. 11, pp. 42–48, 2014.
[7]. E. Cuce and P. M. Cuce, “A comprehensive review on solar cookers,” *Appl. Energy*, vol. 102, pp. 1399–1421, 2013.
[8]. M. T. Y. Tadros and M. A. M. Mustafa, “Estimation of the Global Horizontal Solar Radiation in Iraq,” *Int. J. Emerg. Technol. Adv. Eng.*, vol. 4, no. 8, pp. 587–605, 2014.
[9]. N. D. Kaushika, “Viability aspects of paraboloidal dish solar collector systems,” *Renew. Energy*, vol. 3, no. 6–7, pp. 787–793, 1993.
[10]. H. Hijazi, O. Mokhiamar, and O. Elsamni, “Mechanical design of a low cost parabolic solar dish concentrator,” *Alexandria Eng. J.*, vol. 55, no. 1, pp. 1–11, 2016.
[11]. F. M. Mohamed, A. S. Jassim, Y. H. Mahmood, and M. A. K. Ahmed, “Design and Study of Portable Solar Dish Concentrator,” *Int. J. Recent Res. Rev.*, vol. III, no. September, pp. 52–59, 2012.
[12]. A. Z. Hafez, A. Soliman, K. A. El-Metwally, and I. M. Ismail, “Solar parabolic dish Stirling engine system design, simulation, and thermal analysis,” *Energy Convers. Manag.*, vol. 126, no. August 2016, pp. 60–75, 2016.
[13]. G. O. Prado, L. G. M. Vieira, and J. J. R. Damasceno, “Solar dish concentrator for desalting water,” *Sol. Energy*, 2016.

[14]. Z. M. Omara and M. A. Eltawil, “Hybrid of solar dish concentrator, new boiler and simple solar collector for brackish water desalination,” *Desalination,* 2013.
[15]. M. Eswaramoorthy, S. Shanmugam, and A. R. Veerappan, “Experimental Study on Solar Parabolic Dish Thermoelectric Generator,” vol. 3, pp. 62–66, 2013.
[16]. R. Bhosale, G. Ambekar, S. Bhagat, A. Shaikh, M. Engineering, and D. I. T. Pimpri, “‘ Water Distillation System using Parabolic Dish Solar Collector ,’” pp. 2359–2363, 2017.
[17]. A. Kuhe and A. O. Edeoja, “Distillate yield improvement using a parabolic dish reflector coupled single slope basin solar still with thermal energy storage using beeswax,” no. 28, pp. 137–146, 2016.
[18]. A. Z. Hafez, A. Soliman, K. A. El-metwally, and I. M. Ismail, “Design analysis factors and speci fi cations of solar dish technologies for different systems and applications,” *Renew. Sustain. Energy Rev.*, vol. 67, pp. 1019–1036, 2017.
[19]. Y. Shuai, X. L. Xia, and H. P. Tan, “Radiation performance of dish solar concentrator/cavity receiver systems,” *Sol. Energy,* vol. 82, no. 1, pp. 13–21, 2008.
[20]. F. Wang, R. Lin, B. Liu, H. Tan, and Y. Shuai, “Optical efficiency analysis of cylindrical cavity receiver with bottom surface convex,” *Sol. Energy,* vol. 90, no. February 2015, pp. 195–204, 2013.
[21]. A. Giovannelli and M. A. Bashir, “Development of a solar cavity receiver with a short-term storage system,” *Energy Procedia,* vol. 136, pp. 258–263, 2017.
[22]. T. Arunkumar *et al.*, “Experimental study on a parabolic concentrator assisted solar desalting system,” *Energy Convers. Manag.*, vol. 105, no. 4, pp. 665–674, 2015.
[23]. A. Mawire and S. H. Taole, “Experimental energy and exergy performance of a solar receiver for a domestic parabolic dish concentrator for teaching purposes,” *Energy Sustain. Dev.*, vol. 19, no. 1, pp. 162–169, 2014.
[24]. F. V. Barbosa, J. L. Afonso, F. B. Rodrigues, and J. C. F. Teixeira, “Development of a solar concentrator with tracking system,” *Mech. Sci.*, vol. 7, no. 2, pp. 233–245, 2016.
[25]. M. S. Al-Soud, E. Abdallah, A. Akayleh, S. Abdallah, and E. S. Hrayshat, “A Parabolic solar cooker with automatic two axes sun tracking system,” *Appl. Energy*, vol. 87, no. 2, pp. 463–470, 2010.
[26]. H. Mousazadeh, A. Keyhani, A. Javadi, H. Mobli, K. Abrinia, and A. Sharifi, “A review of principle and sun-tracking methods for maximizing solar systems output,” *Renew. Sustain. Energy Rev.*, vol. 13, no. 8, pp. 1800–1818, 2009.
[27]. F. M. Mohamed and A. S. Jassim, “Design and study of two axis tracking system,” vol. 17, no. 4, 2012.
[28]. A. A. Badran, I. A. Yousef, N. K. Joudeh, R. Al Hamad, H. Halawa, and H. K. Hassouneh, “Portable solar cooker and water heater,” *Energy Convers. Manag.*, vol. 51, no. 8, pp. 1605–1609, 2010.
[29]. R. Abu-Malouh, S. Abdallah, and I. M. Muslih, “Design, construction and operation of spherical solar cooker with automatic sun tracking system,” *Energy Convers. Manag.*, vol. 52, no. 1, pp. 615–620, 2011.
[30]. P. Dutta, “High temperature solar receiver and thermal storage systems,” *Appl. Therm. Eng.*, vol. 124, no. June, pp. 624–632, 2017.
[31]. U. Pelay, L. Luo, Y. Fan, D. Stitou, and M. Rood, “Thermal energy storage systems for concentrated solar power plants,” *Renew. Sustain. Energy Rev.*, vol. 79, no. March 2016, pp. 82–100, 2017.
[32]. [32] R. Karimi, T. T. Gheinani, and V. Madadi Avargani, “A detailed mathematical model for thermal performance analysis of a cylindrical cavity receiver in a solar parabolic dish collector system,” *Renew. Energy,* vol. 125, pp. 768–782, 2018.
[33]. M. A. Ahmed and S. H. Abbas, “Construction and operation of solar energy dish for water heating,” *Baghdad Sci. J.*, vol. 14, no. 4, pp. 797–800, 2017.
[34]. Y. H. Mahmood and M. K. Ghaffar, “Design of Solar dish concentration by using MATLAB program and Calculation of geometrical concentration parameters and heat transfer,” vol. 20, pp. 101–106, 2015.

[35]. V. Madadi, T. Tavakoli, and A. Rahimi, "First and second thermodynamic law analyses applied to a solar dish collector," *J. Non-Equilibrium Thermodyn.*, vol. 39, no. 4, pp. 183–197, 2014.

[36]. a R. El Ouederni, M. Ben Salah, F. Askri, M. Ben Nasrallah, and F. Aloui, "Experimental study of a parabolic solar concentrator," *Rev. des Energies Renouvelables*, vol. 12, no. September 2015, pp. 395–404, 2009.

[37]. H. G. Hameed, "EXPERIMENTAL STUDY FOR PRODUCTIVITY ENHANCEMENT OF A PARABOLIC SOLAR," vol. 4, no. 2, 2011.

[38]. K. Srithar, T. Rajaseenivasan, N. Karthik, M. Periyannan, and M. Gowtham, "Stand alone triple basin solar desalination system with cover cooling and parabolic dish concentrator," *Renew. Energy*, vol. 90, pp. 157–165, 2016.

[39]. I. L. Mohammed, "Design and Development of a Parabolic Dish Solar Water Heater," *Int. J. Eng. Res. Appl.*, vol. 2, no. 4, pp. 822–830, 2012.

[40]. M. T. Chaichan, K. I. Abaas, and H. A. Kazem, "Design and assessment of solar concentrator distillating system using phase change materials (PCM) suitable for desertic weathers," *Desalin. Water Treat.*, vol. 57, no. 32, pp. 14897–14907, 2016.

[41]. A. H. Mohammad, H. A. Yasser, and A. H. Hassan, "Journal of college of education ……..…….… 2015," no. 3, pp. 103–112, 2015.

[42]. Y. H. Mahmood, A. S. Jassim, and F. N. Hamed, "Design and fabrication of Solar dish array and study it characterization," vol. 22, no. 11, pp. 2–6, 2017.

[43]. S. R. Pavlović, E. Bellos, V. P. Stefanović, C. Tzivanidis, and Z. M. Stamenković, "Design, simulation, and optimization of a solar dish collector with spiral-coil thermal absorber," *Therm. Sci.*, vol. 20, no. 4, pp. 1387–1397, 2016.

[44]. P. G. Scholar, "Design and Simulation of Parabolic Dish Collector for Hot Water Generation," no. 9, pp. 20–24, 2015.

[45]. F. Report, "DLR - Institut für Technische Thermodynamik - AQUA-CSP Concentrating Solar Power for Seawater Desalination."

[46]. [46] S. Y. Wu, L. Xiao, Y. Cao, and Y. R. Li, "A parabolic dish/AMTEC solar thermal power system and its performance evaluation," *Appl. Energy*, vol. 87, no. 2, pp. 452–462, 2010.

[47]. D. A. Baharoon, H. A. Rahman, W. Z. W. Omar, and S. O. Fadhl, "Historical development of concentrating solar power technologies to generate clean electricity efficiently – A review," *Renew. Sustain. Energy Rev.*, vol. 41, pp. 996–1027, 2015.

[48]. Yaseen Hamid Mahmood, Rafea Abdullah Munef, and Ayoub Abdulwahid Bazzaz, "Modulating a Solar Parabolic Dish to Produce Boiled Water," *J. Environ. Sci. Eng. A*, vol. 4, no. 5, pp. 225–232, 2015.

[49]. V. Sakhare, "Experimental Analysis of Parabolic Solar Dish with Copper Helical coil Receiver," vol. 1, no. 8, pp. 199–204, 2014.

[50]. C. Paper, "a Literature Review of Concentrating Solar Collector Studies in the Middle," no. January, 2016.

[51]. H. L. Zhang, J. Baeyens, J. Degrève, and G. Cacères, "Concentrated solar power plants: Review and design methodology," *Renew. Sustain. Energy Rev.*, vol. 22, pp. 466–481, 2013.

[52]. S. D. Pohekar and M. Ramachandran, "Multi-criteria evaluation of cooking devices with special reference to utility of parabolic solar cooker (PSC) in India," *Energy*, vol. 31, no. 8–9, pp. 1215–1227, 2006.

[53]. K. Schwarzer and M. E. Vieira da Silva, "Solar cooking system with or without heat storage for families and institutions," *Sol. Energy*, vol. 75, no. 1, pp. 35–41, 2003.

[54]. J. Dascomb, "Low-cost concentrating solar collector for stream generation (Thsis)," p. 85, 2009.

[55]. E. Bellos, C. Tzivanidis, and K. A. Antonopoulos, "Design and simulation of a new solar paraboloid dish collector."

[56]. Pb Agus Ristono*,"Design Of Reliable And Efficient Manchester Carry Chain Adder Based 8-Bit Alu For High Speed Applications",Journal Of VLSI Circuits And Systems, 1 (01), 1-4,2019

[57]. NHK K. ISMAIL*,"Estimation Of Reliability Of D Flip-Flops Using Mc Analysis", Journal of VLSI Circuits And Systems 1 (01), 10-12,2019.