# Design of Solar dish concentration by using MATLAB program and Calculation of geometrical concentration parameters and heat transfer

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**Abstract:-**
Renewable energy sources plays an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. Energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. The goal of research is to calculate the energy, engineering characteristics of solar concentrators by writing their own equations MATLAB program and compare the theoretical results with the results of the researchers was compatible.

**Keywords:-** Solar Concentrating, Solar Geometric- optical model , Heat losses, Solar Parabolic dish, solar system Efficiency Optimization MATLAB program Function, heat transfer

## 1 -Introduction:-

Solar dish collectors form a subset of devices that are used to convert solar energy into heat such that, can be deployed for duties such as domestic water heating. The study and design of a solar collector of this type, Also this paper explains the effect of change in solar isolation and temperature and shading effect on solar panel and give the steps to track GPP [1]. For solving the heat and mass transfer problem of the mentioned technological processes (greenhouse, drying etc.) a block-oriented Matlab+Simulink1 software tool is frequently used [2]. The CSPs can be categorized into three main technologies, based on the process of collecting and concentrating solar radiation [3]: The test slope and intercept were found to be 0.387 and 0.638, respectively. The author explained that the collector's time constant is less than 1 min and the collector's acceptance angle obtained from the test is ± 0.5°, which in combination with the tracking mechanism maximum error (± 0.2°) implies that the system works continuously at almost maximum possible efficiency [4] . first establishes and optimizes a one-dimensional (1-D) theoretical model using MATLAB program to compute the receiver's major heat loss through glass envelope and then systematically analyzes the major influence factors of heat loss. With the laboratorial steady state test stand, the heat losses of both good vacuum and non-vacuum Sanle-3 receivers were surveyed by the authors. The authors' comparison shows that the original 1-D model agrees with the end-covered test while remarkably deviating from the end-exposed test. The authors also developed a 3-D model by CFD software to further investigate the different heat transfer processes of the receiver's end components [5]. The effects of the sun perturbations (solar radiation pressure and the attraction of the sun) at medium Earth orbit satellite and relation of solar radiation pressure have been investigated . Computer simulation of the equation of motion and velocity with perturbations is designed by mat lab a 7.10 where using Jacobian matrix method to increase the accuracy[6].The rotational dynamics of a small solar system body subject to solar radiation torques was investigated by Daniel J. and Sepidehsadat [7]. The scope of this paper is to look at the designing procedures and analysis of a solar thermal parabolic trough concentrator by simulation utilizing meteorological data in several parts of Malaysia. Parameters which include the aperture area, the diameter of the receiver and the working fluid may be varied to optimize the design. Aperture area is determined by considering the width and the length of the concentrator whereas the geometric concentration ratio (CR) is obtained by considering the width and diameter of the receiver [8]. reported the designed, constructed and testing of a parabolic solar steam generator works on solar energy and made concentrating collector, heat from the sun was concentrated on a black absorber located at the focus point of the reflector in which water is heated to a very high temperature to form steam. It also describes the sun tracking system unit by manual tilting of the lever at the base of the parabolic dish to capture solar energy. The whole arrangement is mounted on a hinged frame supported with a slotted lever for tilting the parabolic dish reflector to different angles so that the sun is always directed to the collector at different period of the day. On the average sunny and cloud free days, the test results gave high temperature above 200°C [9]. conducted experiments in which one-dimensional heat transfer model for the thermal analysis of the receiver subsystem was presented to reducing the optical errors. It is also useful for analysis the geometry of collector. It was shown that this model could be used to calculate a heat-loss parameter of receiver surface area to characterize the thermal behavior of the receiver. It was shown that the presented thermal analysis could be used to size the annulus gap size. The method developed in which can be used in a comprehensive design and optimization method[10]. Sangotayo. al reported numerical investigation on the enhancement of thermal performance of solar air heater having cylindrical parabolic trough solar collector with twisted tape in Ogbomoso weather conditions. Two dimensional fully developed fluid flow and heat transfer is studies. Instantaneous efficiency is finding 47.4% at optimal design parameters of 1.3m length and mass flow rate 0.036kg/s. At high value of Nusselt number, heat transfer coefficient is increase. Twisted tape in the absorber tube increase the thermal performance [11]. the mathematical and thermal modeling of the bottom layer of the solar pond, which is also known as lower convective zone(LCZ), where heat is stored. A solar pond of height 0.95m and diameter 1.25m was built at SRM University, LCZ was maintained at the salinity of 50 g/Kg for the experiment work. Nine k-type thermocouples were used for measuring the temperature of pond at various zones. Simulink tool-box from mat lab is used for simulation of LCZ. Simulated results are validated with experimental results [12]. the Mat lab based model of a Concentrating Solar Power plant (CSP), rated of 40 MW. The modeled system considers the technology of parabolic through and follows the layout of a pilot project, to be realized in the south of Italy. As that project contains also the thermal storage, the input and output temperature are well-defined. The conversion to the electrical energy is obtained by a common fossil fuel power station. Then only the primary loop of the whole system has been considered for the proposed model. The model allows to evaluate the thermal performance and the thermal efficiency of the primary loop constituting a CSP[13]. to make an optimization of their efficiency using Mat lab.The efficiency is expressed as a function of geometric and material parameters which are variable. Some of the parameters are fixed and some vary in certain ranges. The maximum value is found for efficiency which corresponds to the optimal combination of values for the variable parameters. In conclusion comparisons between are made with known values for efficiency given by solar collectors producers[14] Detailed numerical simulations of thermal and fluid-dynamic behavior of a single-pass and double-pass solar parabolic trough collector are carried out. The governing equations inside the receiver tube ,together with the energy equation in the tube walls and cover wall and the thermal analysis in the solar concentrator were solved iteratively in a segregated manner. The single-pass solar device numerical model has been carefully validated with experimental data obtained by Sandia National Laboratories .The effects of recycle at the ends on the heat transfer are studied numerically shown that the double-pass can enhance the thermal efficiency compared with the single-pass [15] now this paper support in the work of solar dish concentration, and by the mat lab program can easy find and calculation any parameters .

## 2-Theoretical part:-

### 2-1 Solar dish:-

A parabolic dish concentrates the incoming solar radiation to a point. An insulated cavity containing tubes or some other heat transfer device, is placed at this point absorbing the concentrated radiation and transferring it to a gas. Parabolic dishes must be tracked about two axes. Figure( 1) shows parabolic dish concentrators receiver at the focus.

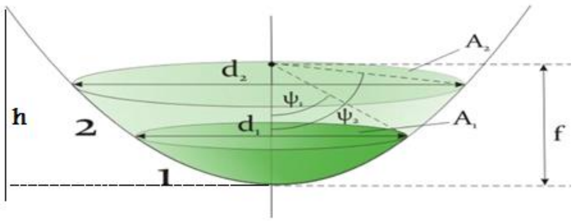


**Figure (1) Geometrical dish parameters [16]**

### 2-2 Receiver:-

The receiver of a solar dish system is the interface between the concentrator and the heats point. It has two functions:

**First**, it absorbs a large part or the radiation reflected by the collector and converts it into heat.

**Second**, it transfers the heat to the working gas of the heat engine. Important requirements for the receiver are, thus, high absorption rates and good heat transfer characteristics.

we will concentrate on receivers. In general, two types of receiver geometries could be used with parabolic dish collectors: external receivers and cavity receivers. Externals receivers are usually spherical and absorb radiation coming from different directions. Cavity receivers have an aperture through which the radiation passes [9].

### 2-3 Geometric Concentration Ratio ( $CR_g$ ):-

The area of the collector Aperture $A_a$ divided by the surface area of the receiver $A_r$ [16]

$$CR_g = \frac{A_a}{A_y} \quad \text{--------(1)}$$

The general expressions given so far for the parabola define a curve infinite in extent. Solar concentrators use a truncated portion of this curve. The extent of this truncation is usually defined in terms of the rim angle ($\psi_{rim}$) or the ratio of the focal length to aperture diameter f/d. The scale (size) of the curve is then specified in terms of a linear dimension such as the aperture diameter d or the focal length f. This is readily apparent in Figure (2) which shows various finite parabola having a common focus and the same aperture diameter [16].

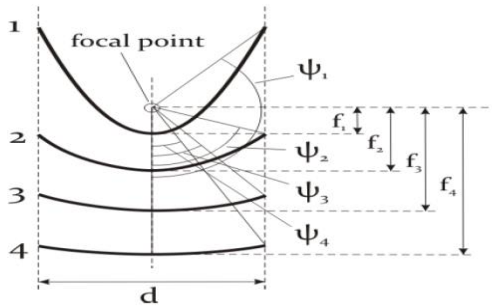


**Figure (2) Relation between the focal length and the rim angle for a constant reflector diameter [16].**

$$f = \frac{d^2}{16\,h} - - - (2)$$

In a like manner, the rim angle ( $\varphi_{rim}$) may be found in terms of the parabola dimensions:-

$$tan\,\varphi_{rim} = \frac{1}{\left(\frac{d}{8h}\right) - \left(\frac{2h}{d}\right)} - -(3)$$

where f is the focal length, d is the distance across the aperture (or opening) of the parabola as shown in Figure (2) and h is the distance from the vertex to the aperture. The cross sectional area of the space enclosed between a parabola and a line across its aperture and normal to the axis is given by this area should not be confused with the reflecting surface area of a parabolic trough or dish or their aperture areas [16 ].

$$\tan\varphi_{rim} = \frac{(f/d)}{2(f/d)^2 - \frac{1}{8}} \text{-------(4)}$$

$$\frac{f}{d} = \frac{1}{4tan(\varphi_{rim}/2)} \text{-------(5)}$$

### 2-4 Optical Energy absorbed by the receiver

To calculate the Optical Energy of receiver and heat transfer the following equation may be used .

equ $Q_{opt} = Aa\,p_{s.m}\,.\,\tau g.\,ar.\,S.\,Ia$ ----(6)

$p_{s.m}$ −specula reflectance of concentrating foil.

$\tau_g$ −transmittance of any glass envelope covering the receiver. $A_a$ −aperture a of the collector .

S- receiver shading factor (fraction of collector aperture .Not shadow by the receiver).

$I_a$-insulation incident on the collector aperture.

$a_r$-absorbance of the of the receiver

S,$a_r$,$p_{s.m}$ and $\tau_g$ are constants dependent on the materials used and the structure accuracy of the collector. These constants are nominally lumped into single constant term.

$n_{opt}$: the optical efficiency of the collector

Thus, the quantity of thermal energy produced by the solar collector is described by [15] .

$Q_{out\ 1}(v_1)= Q_{opt} - Q_{Loss1}(v_1)$ ------(7)

### 2-5 Collector Efficiency

$\eta_{collector}(v_1)=\frac{Q_{out-1}(v_1)}{Aa.Ia}$ .---------( 8)

### 2-6 Experimental work :-

we design mat lab program to calculation all parameter of concentration and receiver and heat transfer.by using all equation (1-5) we calculation the geometric concentration for any parabolic concentration . form equation (6,7) calculation the Optical Energy of receiver and by equation (8) Collector Efficiency and by using temperature inlet and outlet and dimension of receiver and other parameter speed of wind to calculation of heat transfer of system

(( **Math lab program show**))

```
d=[1.5 ;2 ;2.5 ;3 ;3.5 ;4 ;4.5 ; 5 ; 5.5 ;6 ;6.5;7; 7.5 ; 8 ;8.5 ;9 ;9.5 ;10 ;10.5 ;11 ;17 ]% (d(m)) input aperture
h=[0.2;0.25;0.3;0.35;0.4;0.45;0.5;0.55;0.6;0.65;0.7;0.75;0.8;0.85;0.9;0.95;1;1.05;1.1;1.15;2] ]% (h(m)) input depth
F=[0.703125;1;1.302083333;1.607142857; 1.9140625;2.222222222;2.53125;2.840909091;3.151041667;3.461538462;3.772321429;4.083333333;4.39453125; 4.705882353;5.017361111;5.328947368;5.640625;5.952380952;6.264204545;6.576086957;9.03125] ]% output focal lenght
k=d.^2
j=16.*h
W=(F)./(d)
L=2*(F./d).^2
G=(L)-1/8
H=W./G
S0=(pi.*(d).^2)./(4)% output surface of opening of a paraboloid
c=(8*3.14.*(F).^2)./3
M=(d./4.*F).^2
N=((1.+M).^1.5)-1
r=[0.06;0.01;0.15;0.2;0.15;0.5;0.11;0.073] %input
h=[0.02;0.25;0.25;0.3;0.3;1;0.07;0.19]% input
Sa=(3.14.*r.^2).*h
C=(S0)./(Sa)
ar=[1;1]% input
psm=[1;1] ]% (ps-m) input
Tg=[1;1] ]% input
aar=[0.99;0.9] %(αr) % input
s=[1;1] ]% input
Aa=[10.507;3.14] ]% input
la=[1064;800] ]% input
Qw=ar.*psm.*Tg.*aar.*s.*Aa.*la %(Q opt W) % input
Qk= Qw./1000 %(Q opt w) OUT PUT

Dinner=[0.17;0.17;0.17;0.17;0.17;0.17] % (D inner m) input

Douter=[0.173;0.173;0.173;0.173;0.173;0.173] %(D outer m) input

Lm=[0.2;0.2;0.2;0.2;0.2;0.2] %(L m) input
Tinner =[330;313;323;333;343;358]% (T inner k) input
Touter =[313;333;343;353;363;373]]% (T outer k)

Tair =[300;300;300;300;300;300]%(Tair K) input
Tfilm =0.5.*(Tair +Touter)%(T film K) input
V=[0.5;0.5;0.5;0.5;0.5;0.5] % wind speed
v=[5.15E-05;5.15E-05;5.15E-05;5.15E-05;5.15E-05;5.15E-05] % viscosity
Re=(V.*Douter)./v %Reynolds n
Nu=0.3.*(Re).^0.6 %Nusselt n
Kair=[0.0456;0.0456;0.0456;0.0456;0.0456;0.0456]
hw=((Kair)./(Douter)).*Nu
e=[0.5;0.5;0.5;0.5;0.5;0.5]%(ϵ)
E=4.*((0.0000000567041).*e)
P=Tair.^3
hr=E.*P
```

```
UL=1./(hw+hr).^-1 %radiation cofficient
T=(Touter+Tair)./2
Tr=T-Tair
Ar=(2*3.14.*(Douter./2).^2)+(2*3.14.*(Douter./2).*Lm)% Receiver
Qloss=Ar.*UL.*Tr % Q LOSS
psm=[1;0.8;0.8;0.8;0.8;0.8] % (ps-m) input
Tg=[1;1;1;1;1;1] % input
aar=[0.8;0.8;0.8;0.8;0.8;0.95]%( αr) input
s=[1;1;1;1;1;1] % input
Aa=[3.14;3.14;3.14;3.14;3.14;3.14] % input
la=[550;600;650;700;800;800] % input
Qw=psm.*Tg.*aar.*s.*Aa.*la %(Q opt w) output
Qk=Qw./1000 % (Q opt k w)output
Qout=Qw-Qloss %(Q out)out put
Ycollector=(Qout)./(Aa.*la)%
(η collector) efficiency . output
```

## 3 -Results and discussion :-

By using the program above we can design any concentration and calculation the parameter of heat transfer so as, now we can easy design many concentration, table (1) shows geometrical concentration parameter by using the program for many concentration.

**Table ( 1 ) show the geometrical concentration for many solar concentration.**

| **d (m)** | h(m) | **f (m)** | **f/d** | Ψ | Sa | H | Sa | C |
|---|---|---|---|---|---|---|---|---|
| 1.42 | 0.25 | 0.5041 | 0.355 | 70.308 | 0.00022 | 0.02 | 0.000226 | 7001.389 |
| 2.5 | 0.3 | 1.3020 | 0.520833 | 51.282 | 0.01836 | 0.26 | 0.018369 | 267.094 |
| 3 | 0.35 | 1.6071 | 0.535714 | 50.033 | 0.03391 | 0.27 | 0.033912 | 208.3333 |
| 3.5 | 0.4 | 1.9140 | 0.546875 | 49.134 | 0.05495 | 0.28 | 0.05495 | 175 |
| 4 | 0.45 | 2.2222 | 0.555556 | 48.455 | 0.08195 | 0.29 | 0.081954 | 153.2567 |
| 4.5 | 0.5 | 2.5312 | 0.5625 | 47.924 | 0.11539 | 0.3 | 0.115395 | 137.7551 |
| 5 | 0.55 | 2.8409 | 0.568182 | 47.498 | 0.15574 | 0.31 | 0.155744 | 126.0081 |
| 5.5 | 0.6 | 3.1510 | 0.572917 | 47.149 | 0.20347 | 0.32 | 0.203472 | 116.7052 |
| 6 | 0.65 | 3.4615 | 0.576923 | 46.85739 | 0.25905 | 0.33 | 0.25905 | 109.0909 |
| 6.5 | 0.7 | 3.7723 | 0.580357 | 46.60978 | 0.28867 | 0.34 | 0.288679 | 114.8897 |
| 7 | 0.75 | 4.0833 | 0.583333 | 46.39718 | 0.30870 | 0.35 | 0.308709 | 124.5995 |
| 7.5 | 0.8 | 4.3945 | 0.585938 | 46.21265 | 0.32962 | 0.36 | 0.329625 | 133.9592 |
| 8 | 0.85 | 4.7058 | 0.588235 | 46.05098 | 0.35144 | 0.37 | 0.351445 | 142.9529 |
| 8.5 | 0.9 | 5.0173 | 0.590278 | 45.90817 | 0.37418 | 0.38 | 0.374188 | 151.5717 |
| 9 | 0.95 | 5.3289 | 0.592105 | 45.7811 | 0.39787 | 0.39 | 0.397873 | 159.8125 |
| 9.5 | 1 | 5.6406 | 0.59375 | 45.66731 | 0.42251 | 0.4 | 0.422518 | 167.6761 |
| 10 | 1.05 | 5.9523 | 0.595238 | 45.56481 | 0.44814 | 0.41 | 0.448144 | 175.1669 |

And from study solar radiation with time and wind speed we can calculation of inlet and out let temperature for receiver with time by using the program we can calculation heat transfer and calculation the heat lose energy and useful energy for any solar system , table (2) , figure ( 3) show solar concentration with receiver to study heat transfer by measuring temperature and solar radiation , and by using the information in table (2) figure (4,5.6).

**Figure (3) show solar concentration system .**

**Table (2) show the energy lose ,useful energy and efficiency of solar concentration.**

| Q loss w | ps-m | τg | αr | S | Aa | Ia w/m$^2$ | Q opt w | Qopt k w | Q out | η collector |
|---|---|---|---|---|---|---|---|---|---|---|
| 5.301893 | 1 | 1 | 0.8 | 1 | 3.14 | 550 | 1381.6 | 1.3816 | 1376.298 | 0.79693 |
| 10.60379 | 0.8 | 1 | 0.8 | 1 | 3.14 | 600 | 1205.76 | 1.20576 | 1195.156 | 0.634372 |
| 15.90568 | 0.8 | 1 | 0.8 | 1 | 3.14 | 650 | 1306.24 | 1.30624 | 1290.334 | 0.632207 |
| 21.20757 | 0.8 | 1 | 0.8 | 1 | 3.14 | 700 | 1406.72 | 1.40672 | 1385.512 | 0.630351 |
| 26.50946 | 0.8 | 1 | 0.8 | 1 | 3.14 | 800 | 1607.68 | 1.60768 | 1581.171 | 0.629447 |
| 31.81136 | 0.8 | 1 | 0.95 | 1 | 3.14 | 850 | 2028.44 | 2.02844 | 1996.629 | 0.748081 |
| 37.11325 | 0.8 | 1 | 0.95 | 1 | 3.14 | 800 | 1909.12 | 1.90912 | 1872.007 | 0.745226 |

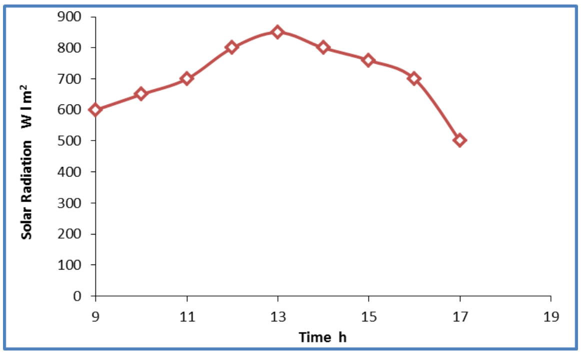


**Figure (4) illustrate solar radiation variation with time .**

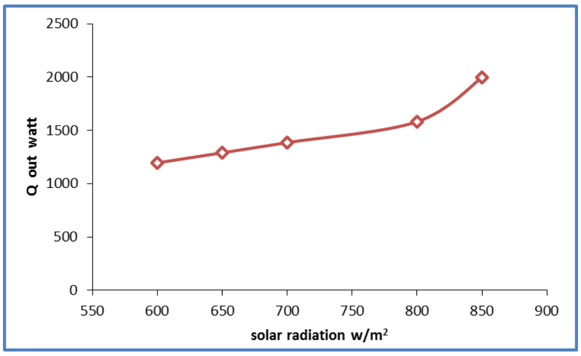


**Figure (5) illustrate solar radiation variation with output energy.**

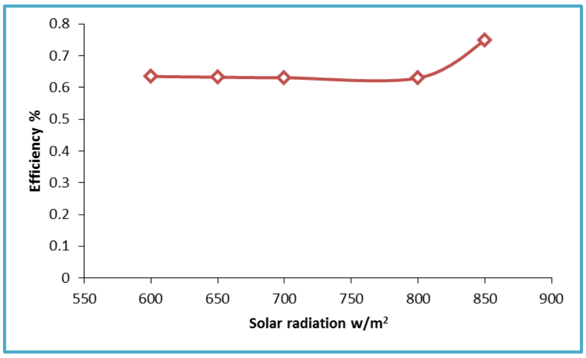


**Figure (6) illustrate solar radiation variation with efficiency.**

This theoretical results by math lab program compatible with the researchers [9,16].

## 4- Conclusion:-

This paper has highlighted to convert all parameters and equations for design solar concentration by using math lab program also as well as the heat transfer in receiver and tank by use the temperature of inlet and outlet. we plotted diagram between the parameter to study, from result of program ,By considering the optical factors and thermal analysis, the results clearly showed that there must be an equilibrium achieved between the increasing thermal losses due to the increasing aperture area, with the increasing optical losses due to the decreasing aperture area.

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# تصميم المركز الشمسي باستخدام برنامج مات لاب وحساب الخصائص الهندسية وعملية انتقال الطاقة

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**الملخص**

مصادر الطاقة المتجددة تلعب دورا هاما في توليد الكهرباء. ان مختلف مصادر الطاقة المتجددة مثل طاقة الرياح والطاقة الشمسية والطاقة الحرارية الأرضية والمحيطات الحرارية، والكتلة الحيوية يمكن استخدامها لتوليد الكهرباء وتلبية احتياجاتنا اليومية من الطاقة. من الشمس هو الخيار الأفضل لتوليد الكهرباء كما هو متوفر في كل مكان و مجانية .ان الهدف من البحث هو حساب الطاقة والخصائص الهندسية للمركزات الشمسية عن طريق كتابة المعادلات الخاصة بها ببرنامج MATLAB ومقارنة النتائج النظرية مع نتائج الباحثين حيث كانت متوافقة.

**الكلمات المفتاحية :** المركزات الشمسية , النماذج البصرية الهندسية الشمسية, الخسائر الحرارية, قطع المكافئ الشمسي الطبقي , كفاءة المنظومات الشمس , عمليات برامج مات لاب, انتقال الحرارة .