Depth and Diameter's Effect on Rim Angle of Solar Parabolic Dish Collector

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Abstract: Energy exists in numerous forms, which include heat, light, and radiation. We aim to optimise solar radiation at low, moderate, and high temperatures. Concentrating collectors, which are also, referred to as focussing collectors, capture direct radiation over a wide area and then focus it onto a small absorber area. Compared to flat-plate collectors, these collectors are more effective in producing high temperatures. The parabolic dish is what we use most often. A focussing receiver deliberately absorbs this concentrated radiation. Parabolic dish solar concentrators have recorded high operating temperatures and high conversion efficiency. The substantial opportunity for employing parabolic dish concentrators in various sectors boosts research and development. Concentrating collectors have been employed as heating technologies in numerous types and constructions in the past few decades. For estimating the intensity of a beam falling on a surface, the beam flux quantity arriving from the sun's axis must be transformed to values that are comparable and related to the surface's normal path. We aim to establish this pattern. The geometry of solar irradiation is one of the necessary factors. Different types of receivers have been studied by changing the depth and width of the parabolic dish collectors, which affects their focal point, how well they concentrate sunlight, and the temperatures they produce.

We apply several factors to a parabolic dish to calculate its different rim angles. The focal length and diameter are the parameters. The parabola's diameter and focal length vary. In addition to the amount of solar energy received, the rim angle also affects the process of creating the parabolic dish. As a consequence, the flux dispersal and geometric rearrangement are altered for each scenario. The larger value of the focussing point in the parabolic dish leads to an increase in rim angles.

Designing a parabolic collector featuring variable rim angles is the aim of the current research. The investigation examines a range of dish diameters and establishes the focus point to dish diameter ratio for every scenario during the evaluation. We employ extra precautions when choosing the right size for the reflecting materials. To achieve the least amount of deformation and strain while minimising the total mass of the dish, the dimensions of the segments and rings that hold the reflecting surface are increased.

Keywords: Parabolic Dish, Rim angle, Depth, Diameter

I. Introduction:

Radiation strikes the collector's surface in a parabolic dish collector and is reflected to the parabola's focus. The reflected light will be collected and transformed into heat (or straight into energy, as with a concentrated photovoltaic collector) if receiver is positioned at a parabolic reflector's focal point. The fundamental operations of a parabolic concentrating collector are these two major functions: reflection to a point or line and subsequent absorption by a receiver. For this kind of reflector, temperatures between 300 and 500^0 Celsius or higher would require a concentration ratio of roughly 30 to 100 or greater. When it comes to using the reflector area, parabolas are the most efficient of all the steerable concentrators. In a completely steerable parabolic, radiation losses are negligible and aperture effects are eliminated because of the absorber's small area at the focus. When the rim angle is changed, the focus point and collector depth will change, and the output will constantly vary. Parabolic trough collectors are at rim angle 90^0, while parabolic dish collectors are constructed with a focus point inside the collector that has a rim angle more than 90^0 or a focus point outside the collector that has a rim angle greater than 90^0. We can determine the ideal focal distance to attain the maximum concentration by using the actual maximum concentration ratio. The goal of the research project is to use a parabolic solar concentrator dish to concentrate the heat that the sun emits. The energy-harvesting capacity is examined by tracking the sun's movement without the use of a gear assembly to prevent mechanical losses and by utilizing a changeable diameter parabolic dish while maintaining a constant depth.

Main components of Parabolic Dish Collector:

Parabolic dish always contains four main parts:

1. Parabolic dish collector.

2. The Focus Receiver.

3. The solar tracking system.

4. Supporting structure.

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Parabolic Dish Collector

Some solar concentrators resemble the parabolic shape of a perfect concentrator by using a large number of spherically shaped mirrors held up by a truss structure. For the body of the dish, aluminum may be preferred over steel due to its low weight, cost-effectiveness, ease of manufacturing, and energy efficiency. A parabolic dish weighs less overall due to its light weight.

The Focus Receiver

The concentrator concentrates solar radiation to attain the desired temperature at the parabolic dish's focus, and the receiver is positioned to absorb energy reflected from the concentrator. The absorbing plate is frequently placed beneath the receiver's focus in order to absorb the concentrated solar thermal power, reduce the flux concentration affecting the receiver and transform it into energy that is mechanical. In order to minimize irradiation and traditional thermal losses, an aperture is positioned at the focus.

The Solar Tracking System

A solar tracking device will guide the solar dish system to follow the sun in order to collect as much energy as possible. The vast majority of solar dish systems use azimuth-elevation tracking. The primary axis of an azimuth-elevation tracking mechanism is the azimuth axis, which facilitates the rotation of the dish in a plane parallel to the ground. An azimuth axis, to which the plane is perpendicular, rotates with the mirror surface as the secondary axis, which is an elevation axis.The collector may spin left-right and up-down to these two planes; the rotations alter throughout the day and throughout the year. The Super jack rotates the parabolic dish slowly and steadily from east to west on its axis. A 36 V-Motor installed at one end of the jack controls the hydraulic arm. Sensors for solar radiation installed on the dish's aperture transmit electrical impulses to the motor, which then moves the dish until the aperture receives the most intense amount of sunlight.

Supporting Structure

Steel bars that are hollow and rectangular in shape are used to support the dish vertically. This is because it is strong, stiff, and resistant to bending from ordinary winds, as well as capable of withstanding the forces that the heating section experiences both longitudinally and cross-sectionally. The foundation of the solar water heater is a combination of angled and flat steel bars. Using flat and angle bars can provide a strong foundation for the rectangular steel bar with a vertical axis that supports the parabolic dish. Other structural components, such as stands, are also made of steel.

II. Aim and Objectives

Aim:

- To enhance the parabolic collector's efficiency.

Objectives:

- The primary objective is to raise the solar energy collection system's temperature above that of currently available systems.
- To offer the ideal depth, focal length, and rim angle—that is, the parabolic collector's geometry.
- To offer an automated tracking system with a steady rotational speed, such as 15^0 revolutions per hour or one revolution per day.
- To test the aforementioned research project to improve geometry in a range of seasonal and climatic conditions so that the system can function effectively all year long.

Design parameter of dish

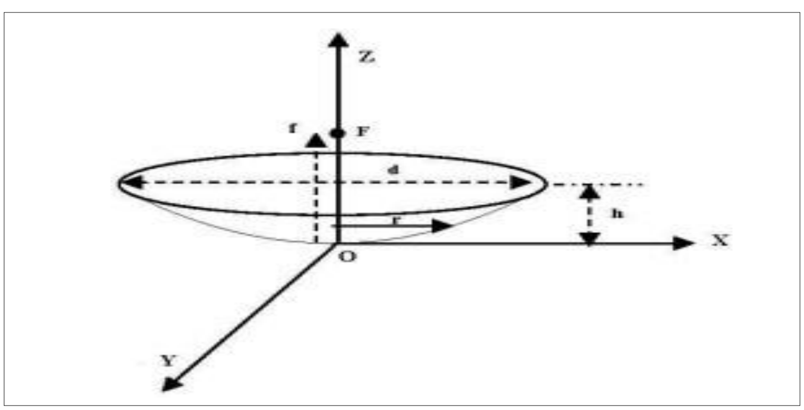

Fig1: Design parameter of dish

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Whereas, f = focal length

D = diameter of dish

Diameter of dish are taken as 600mm 700mm 600mm

h = depth of dish

Depth of dish is 175 cm

Material: Frame – Mild Steel, Heliostat - Anodize Aluminum

All the incident solar energy and the parabolic dish's structure are impacted by the rim angle. As a result, the flow distribution and geometric manipulation vary for each case. Greater values in rim angles will be obtained by the parabolic dish's imposed focus point (Fig5). The (Table1) below shows calculation of rim angle and focal point for various cases:

Depth (a)mm	**Radius(x)mm**	**Diameter (Dc)mm**	**Focal pointmm**	**Rim angle (Ø) in degree**
175	300	600	128.57	98.82 < depth
175	350	700	175	90.00 = depth
175	400	800	228.57	82.37 > depth

Table 1 Rim Angle and Focal Point for Constant Depth

Diameter (Dc) mm	**Radius (x)mm**	**Depth (a)mm**	**Focal pointmm**	**Rim angle (Ø) in degree**
800	400	150	266.7	73.3 > depth
800	400	200	200	63.54 =depth
800	400	300	133.3	22.63 < depth

Table 2 Rim Angle and Focal Point for Constant Diameter

From the above calculations (Table2), it is inferred that in constant depth case for every 100 mm diameter difference there is approximate difference of 8 degree of rim angle. Similarly, in case of constant diameter there is no consistent change in rim angle can be seen. Hence by keeping constant depth expected results can be incurred.

The following elements influence the arrangement of the parabolic dish collector.

- Concentrator aperture area sizing
- Parabolic dish focal length
- Rim angle.

Concentrator aperture area Sizing

The dish concentrator's aperture area (Ac), measured in square meters, is the total surface area that a solar concentrator uses to absorb sunlight. It is also described as the region that absorbs solar light. The amount of solar thermal energy sent to the receiver is affected by the solar concentrator's dimensions. Based on this, one may use Equation to figure out the solar dish concentrator's aperture area.

$$Ac = \frac{\pi Dc^2}{4}$$

Parabolic dish focal length

The concentrator's solar parabolic mirrors focus the sun's rays onto the receiver, where the radiation is subsequently reflected and focused at the focal point. The formula that follows can be employed to calculate the dish concentrator's length of focus(Fig2).

$$y^2 = 4fx$$

Whereas *f* is the focal length

A parabola with a finite height (fig3) is used in solar applications (Figure 3andb). The available aperture size (Dc), focal location

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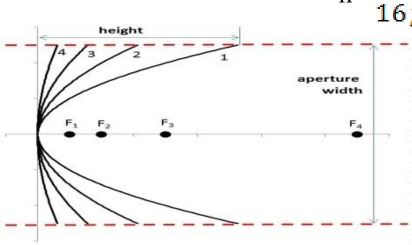
(f), or the location of the receiver, and reflector height (h) are all taken into consideration in the construction of the parabolic reflector. The equation establishes a relationship between these parameters.

$$h = \frac{Dc^2}{16f}$$



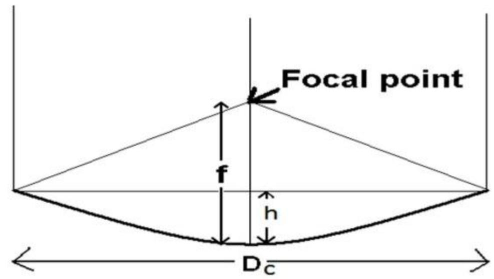


Fig. 2 Variation in focal distance of fixed aperture Fig. 3 Corresponding parabolic curvature

Rim angle

The rim angle affects both the parabolic dish's generation and the solar radiation that comes in.(Ørim). William B. Stine states that the rim angle measures the distance between the axis and the rim of the focused truncated solar parabolic collector. Fraser defines the rim angle as a measure of the parabolic concentrator's shape of the surface. The rim angle, on the other hand, is proportional to the ratio of the aperture diameter to the focal length. (f/Dc); it ranges from less than 10° to greater than 90°, and its value falls as the focus point rises..

$$Ørim = \tan^{-1}\left[\frac{8f/Dc}{16\,[f/Dc]^2 - 1}\right]$$

Working Principle

When sunlight falls on the LDR sensors (Fig4), it decreases the resistivity of the sensor and completes the driving circuit. Driving circuit gives the direction to the DC motor and linear actuator to trackthe sun position with the DC supply of the battery.

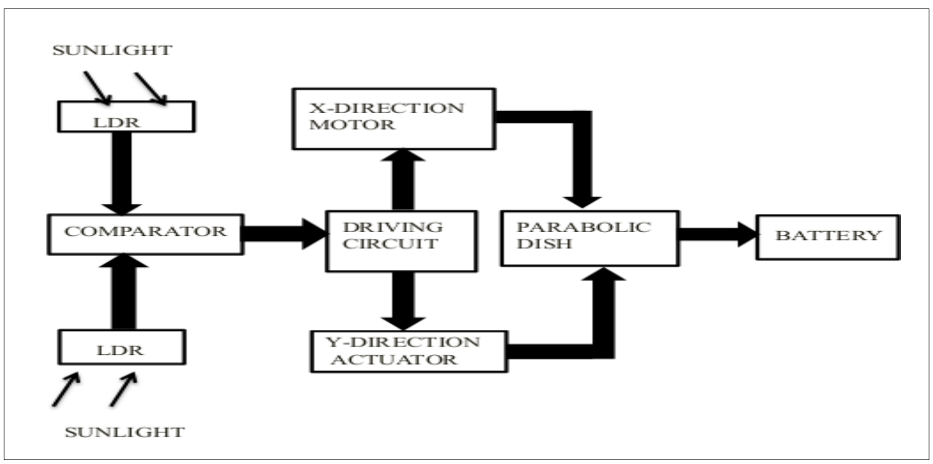
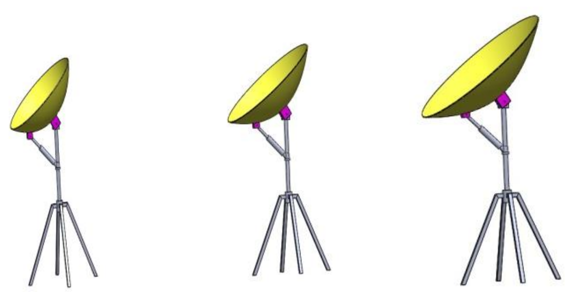


Figure 4: Block diagram of working automatic tracking system



600 mm 700 mm 800 mm

Fig. 5 Computer aided drawing of variable diameter dish

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III. Result

The greater the parabolic dish's focus point, the greater the rim angle value. Various rim angles cause changes in imaging and no-imaging diameter. Hence, there is a wide range of geometric manipulations for various situations and flux distributions. Accordingly, concentration temperature varies. At various incidence angles, bunches of solar heat flux beams from various solar elements impact each concentrator element.

IV. Conclusion

In this study the parabolic dish collector is optimized for various rim angles, focus point of different length and geometry of parabola. Design parameters are formulated for the geometry of the parabolic collector to obtain maximum output. By employing a small absorber area with a large imaging diameter, heat loss at high temperatures can be efficiently minimized. Optical concentrator reduces Heat losses and increases the useful energy gain.

The parabolic dish's focal length is determined by the rim angle. Knowing the rim angle is crucial for collecting the most amount of solar flux. Parabolic dish concentrators with rim angles close to 45°, and studies have shown that employing these values will result in the thermal efficiency and maximum concentration ratio. Rim angle up to 90°, as opposed to roughly 45° on the other dish systems, which has a greater impact on the focal point that is considerably closer to the dish. By lowering the need for great stiffness and accuracy, these effects will result in a smaller cantilever dish between the dish and the receiver. The diameter of the dish and the degree of its angle of inclination affect where the focus is and how far away it is from the dish.. However, lower the convexity reduce the amount of reflected radiation, lower the intensity of the radiation, and decrease the temperature the surrounding environment.

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