# Comparative study of thermal efficiency of flat spiral vs. conical spiral in a parabolic solar collector

# Estudio comparativo de eficiencia térmica de espiral plano vs. espiral cónico en un colector solar parabólico

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**Abstract**

Compare the thermal efficiency of two kind of heat by radiant energy concentrated by a parabolic solar collector. Methodology: became two spirals with 1.3 m length and diameter 3/8" copper pipe, which were controlled water flow from one step and recirculated making temperature measurements to water in container return and readings taken every 5 minutes. These coils were placed at the focal point of a parabolic solar collector of 77 cm in diameter and concavity of 6.6 cm. both proved to be very efficient in heat absorption and transmission to the water into itself, which showed greater heat loss but was the conical, although it wasn't exposed to air currents and that it had an aluminum housing. Meanwhile the flat spiral showed greater uniformity in the behavior of temperatures despite being exposed to air currents.The maximum temperature reached, at a flow rate of 0.15 l/min, was 97.5 ° C in 30 minutes from the initial temperature. Lower flows did not allow to make a reliable temperature reading since the water was going into its vapor phase

**Parabolic concentrator, Renewable energy, Solar energy, Thermal efficiency, Experimentation, Solar heat exchanger**

**Resumen**

Comparar la eficiencia térmica de dos tipos de focos receptores de energía radiante concentrada por un colector solar parabólico. Metodología: se hicieron dos espirales con 1.3 m de tubo de cobre de 3/8 de diámetro, a los cuales les fueron controlados flujo de agua de un solo paso y recirculada haciendo mediciones de temperatura al agua en el recipiente de retorno y tomado lecturas cada 5 minutos.Estos espirales fueron colocados en el punto focal de un colector solar parabólico de 77 cm de Diámetro y concavidad de 6.6 cm. Ambos mostraron ser muy eficientes en la absorción de calor y la transmisión del mismo al agua, sin embargo, el que mostró mayor pérdida de calor fue el cónico, aunque no estaba expuesto a las corrientes de aire ya que tenía una cubierta de aluminio.Mientras tanto el espiral plano mostró mayor uniformidad en el comportamiento de las temperaturas a pesar de estar expuesto a las corrientes de aire. La temperatura máxima alcanzada, a un flujo de 0.15 litros/min, fue de 97.5 °C en 30 minutos a partir de la temperatura inicial. Los flujos más bajos no permitían hacer una lectura confiable de la temperatura ya que el agua pasaba a su fase vapor.

**Concentrador parabólico, Energías renovables, Energía Solar, Eficiencia térmica, Experimentación, Intercambiador solar**

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## Introduction

Solar energy is the renewable energy, for at least the next 5 billion years, most abundant in nature in our solar system; therefore, one of the ways in which it can be channeled for its use is addressed, such as parabolic solar collectors. Throughout history, this type of energy has been used for a wide variety of uses and one of them is to integrate it into industrial processes such as the recovery of water from wastewater.

Two spirals designed and elaborated were compared, each one with its own variables, in order to be used as absorbers of solar radiation, with the purpose of verifying the thermal efficiency of each one when subjecting them to water heating tests and with the obtaining treated water for sanitary use

Solar collectors are structures designed to capture the sun's rays with the aim of transforming them into thermal energy in order to raise the temperature of a fluid or converting it to mechanical energy and transforming it into electrical energy by means of a motor.

Historically, the use of solar energy has occurred in an important way, it began with the development of a method used by Archimedes in the year 212 BC. approximately, he used the solar concentrators to burn the Roman ships by using a large concave mirror

Using solar concentrators with efficient systems of absorption and transmission of that energy in the recovery of fluids or water heating for industrial or domestic use at low cost will be a valuable contribution to mitigate the effects of environmental pollution and the high costs of the fossil fuels. Using 1.3 m 3/8 ”copper tube, two spirals were formed, one flat, Fig 1,
Clearly explain the problem to be solved and the central hypothesis.

## Development of Sections and Sections of the Article with subsequent numbering

## Hypothesis

In the comparison about the thermal efficiency between a flat spiral and a conical spiral, it is conjectured that the conical spiral will capture in a more efficient way the heat incident on the absorber, since the outer rings of the spiral are closer together.

To the parabolic they absorb heat while transmitting it to the liquid by conduction, in this way when the liquid reaches the heat concentration zone its temperature is higher than that of the environment, reducing the time required to heat the water, if at This system we add thermal insulation and a water recirculation system that is obtained at the exit of the spiral, we will have a higher performance conductor.

## Methodology

It was divided into stages: Focal length calculation, flow measurement, temperature measurement.

## Focal length calculation

A steel parabolic antenna was used which was polished and sent to chrome to have a mirror finish, Fig. 3. This already had a signal receiver insertion point established, however, it had to be calculated to confirm that it was correct. for the purposes of installing the spirals to be tested. Previously, the distance between the spiral and the concentrator was measured, calling it the real distance, which was 54.4cm. The calculation of the adequate distance that should exist between the plate and the absorber (spiral) was carried out with the following equation:

$$f = D^2/(16 * C) \tag{1}$$

Where: f = Focal length.
D = Diameter of the plate.
C = Depth or concavity of the plate.

Carrying out the measurements required for the equation, we obtain:

C= 6.6cm
D= 77cm
$f = (77)^2/\ (16 * 6.6)$
$f = 56.14cm$

The spirals were placed at the calculated focal length and it was there that the test runs were made.

## Flow determination

A container with an approximate water volume of 10L was used, in said container the recirculation pump was installed connected to the two hoses, one connected to the system and the other, which is the return one after passing through the system.

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The valves were calibrated and their positions were determined to obtain the flows at which the runs would be made.

**Determination of Temperature**

The temperature readings were made with a mercury thermometer from -10 to 110 ° C with a sensitivity of 1 ° C. A thermometer was installed in the container and another in the outlet of the water return hose.

**Variables:**

Flow: 0.2 l / min, 0.15 l / min and 0.1l / min with and without recirculation of water to the same container.

Spirals: 2
Readings: 6, one every 5 minutes
Total runs: 72

The position of the calculated focal point was adjusted, it was placed in the orientation, with respect to the sun, required depending on the spiral and the position to be evaluated.

The water began to flow through the spiral and when it reached the outlet the digital thermometer marked the measurements obtained from the water.

The readings marked at time intervals were taken, timing every 5 min until reaching 30 min. The final temperature reached in the container was taken.

To start a new cycle of measurements, the container was refilled with water at room temperature. Once the data was obtained, the emptying was done and the corresponding tables and graphs were generated.

**Results**

The temperature measurements at the different flows resulted in the flat copper spiral having a more uniform behavior with respect to the conical one. The downward temperature variations were minimal under the same weather conditions compared to the conical spiral, even when it was protected from the wind with an aluminum barrier. See graphs 1 to 10

In the flat spiral, the maximum temperature reached of the water at the outlet of the return hose was 97.5 at a flow of 0.1 l / min, see Graph 5, this recirculating the water to the same container, which was increasing the temperature of the inlet water gradually. Under the same conditions, it was not possible to measure with the conical spiral. However, with the latter at a flow of 0.2 l / min and without recirculation, a temperature of 54.9 ° C was obtained. See Graph 10. At a flow of 0.15 l / min with the same climatic conditions, the flat spiral was more efficient since it reached a temperature of 72.6 ° C vs. 32.9 ° C. See Graph 8.

**Annexes**

**Figure 1** Spiral Copper tube, Flat

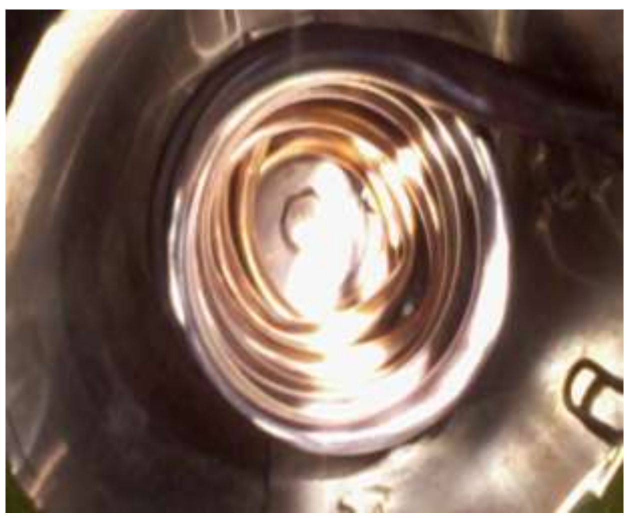

**Figure 2** Cone Shaped Copper Tube Spiral

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**Figure 3** Mirror Finished Parabolic Concentrator

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**Conclusions**

The recirculating water condition turned out to be the most recommended to achieve the best temperatures in the water. The parabolic spiral with protection was not the best option, which showed that the hypothesis was negative.

The parabolic solar radiation collector option is subject to too many climatic variables that do not allow it to have a constant behavior all year round, however, it is still a very good option when you want to reach extreme temperatures. Only in this system the thermocouple measurement was made at the focal point and 970 ° C was reached. empirically, a Pyrex glass test tube was placed with water at the focal point and instantly the water began to boil the tube to melt. More tests and new designs of solar radiation collectors are needed.

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