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Design and Development of Novel Solar Concentrating Spittoon to Control the Spread of COVID-19 Virus at Public Places

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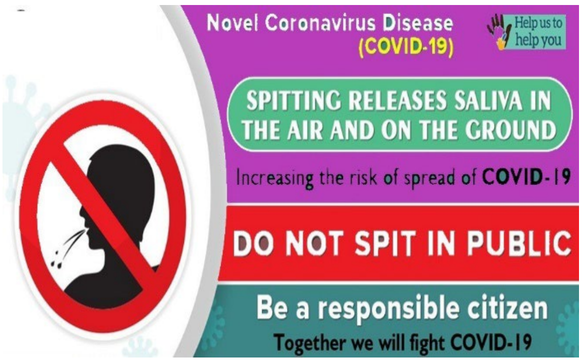
Abstract: Spitting in public places is a significant factor in spreading contagious diseases such as viral meningitis, hepatitis, and cytomegalovirus among humans. A recent study found that the novel Coronavirus is also spread via the spit of an infected person. 91.7% of patients have covid-19 detected in self-collected saliva. Many countries have emphasized stopping people from spitting in open or public places such as hospitals, parks, airports, railway stations, etc. The Coronavirus will be deactivated within one minute when it will expose to 353 K temperature. Direct concentrated sunlight has high-intensity UV rays that break down the DNA of Coronavirus and significantly reduce the spread of infection by spitting on infected persons in public places. In this regard, the present work is an attempt to design and construct a solar concentrating spittoon. This spittoon can burn spitted saliva of a person within a minute. It can generate 390 k temperature and 176 watts of heat at its receiver. At this temperature, most viruses (including Coronavirus), bacteria, and pathogens are killed or lose their ability to disease transmission. The results show that the solar concentrating spittoon performs effectively from 8.00 am to 5.00 pm daily. During this period, most people spend their time outside, such as in the park, bus stand, hospital, etc., where this solar concentrating spittoon incinerates human cough and spit within a minute. The efficiency of the solar-concentrating spittoon reached its peak for a duration of nine hours. The thermal efficiency of the receiver was found to be 80 percent, with 20 percent of the heat being dissipated to the nearby environment. It was revealed that the total efficiency was about 70 percent. Installation of this solar concentrating spittoon will help prevent the transmission of deadly contagious diseases among humans and clean the city.

Keywords: Covid-19; Heat transfer; Solar concentrator spittoon; Solar thermal energy; Thermal efficiency; Overall efficiency.

1. Introduction

Since time immemorial, smokeless tobacco has been popular in India, and its usage is on the rise despite its association with fatal diseases such as oral cancer and respiratory infectious diseases. Although a great deal is known about the dangers of smokeless tobacco chewing, tobacco is grown, developed, advertised, marketed, and sold in various parts of India to generate a substantial profit [1)]. According to a health expert, chewing tobacco products increases saliva production in the mouth. The production of saliva is followed by an intense desire to spit. Thus, tobacco smokers get used to spitting often. Until the 18th century, spitting was highly prevalent and socially acceptable throughout Europe. They believed it was impolite to suck back saliva. To prevent frequent spitting in public places, they use spittoons. Spittoons are made of pottery and were commonly used as spit containers and could be seen both inside and outside of public buildings and public houses[2)].

A person's saliva includes many bacteria, viruses, fungi, and other pathogens. Respiratory infectious illnesses, such as Influenza, TB, bronchitis, pneumonia, measles, pertussis, diphtheria, and other pathogens, as well as the newly developed Coronavirus, are transmitted by the suspended droplet of saliva in the air from an infected person's spit. There are several health risks associated with the spittle of an infected individual. Not only may it create health issues by transferring an infectious illness multiple times, but the discharge of phlegm also damages the transmission channel. Inadvertently frequent spitting has probably risen. Everywhere people can notice the term "no spitting." This is because spitting is an exceedingly uncivilized and disgusting behavior[3]. Spitting causes sputum germs to spread rapidly, particularly in busy places such as parks, train stations, and stadiums. Spit serves as a transportation container for viruses and bacteria. Intrusion of infectious viruses into the human body and subsequent dissemination may occur via several routes, such as the oral or ocular pathways, potentially leading to fatal outcomes. The oral secretion of an individual comprises a diverse array of microorganisms, including bacteria, viruses, fungus, and several pathogenic agents. In response to the emergence of the Coronavirus pandemic in recent times, legislative measures have been enacted by both federal and state governments to prohibit the act of often spitting in public areas [4]. Fig. 1. (a) and Fig. 1. (b) are shown below to give a message through pictorial representation to stop spitting for the prevention of the spread of COVID-19.



(a)

(b)

Fig. 1 (a) Stop spitting in public areas (b) Stop spitting in public areas.

2. Problem Description and Solution Strategy

The world is facing a global pandemic Coronavirus since December 2019. It is very contagious and deadly. It is a type of air-borne virus, it can remain activated for a longer interval of time (more than 24 hours) in a cold and dry environment. It can easily spread through the air and infect another healthy person from an infected host person. One major source of transmission of Coronavirus is the air spitting of an infected person in public places such as hospitals, railway stations, airports, bus stands, etc. Coronavirus is not the only pandemic; The world has already faced a pandemic of other diseases such as Influenza in 1918 and tuberculosis in 1940. These are lethal and very contagious diseases. 200 million Indians are addicted to chewing and eating smokeless tobacco products, which makes them one of the largest consumers of smokeless tobacco[5]. These consumers are used to spitting frequently in public places after eating tobacco products like pan–masala, khaini, supari gutkha, etc. Spitted saliva of a consumer is one of the major means of transmission of contagious diseases and viruses and bacteria. Now Indian central government and state government made strict laws against spitting in public places. On but another hand India is the world's third-largest producer and exporter of these smokeless tobacco products. Right now, India is facing the 3rd phase of covid-19 pandemic. Hence, it is essential to identify a hygienic solution capable of effectively decomposing and eliminating the viruses, germs, and pathogens that are communicated by the act of spitting by the user[6].

2.1. Effect of sunlight

According to virologists at the National Institute of Allergy and Infectious Diseases. Infectious diseases, such as Covid-19 and tuberculosis, have lost their stability when they came in exposure to sunlight. In dark areas where sunlight cannot reach, SARS-CoV-2 Coronavirus stays active on ordinary objects like metals, plastic, and cardboard for several days. However, it would not survive as long outside, where sunshine is present. When SARS-CoV-2 in simulated saliva was subjected to artificial sunshine, which is equal to typical day sunshine, by researchers at the National Biodefense Analysis and Countermeasures Centre. They found 90 percent of viruses were inactivated within seven minutes. This finding indicates that Coronavirus cannot survive exposure to natural sunlight and that your chance of infection is much decreased in outdoor settings[7]. Natural sun rays cannot only sterilize surfaces and prevent disease transmission but also treat disease via 'phototherapy,' a method that helped to mitigate the effects of the 1918 flu pandemic caused by the H1N1 Influenza A virus. UV light particle binds to genetic material, stopping genes from instructing cells to generate proteins. In the case of a virus, it destroyed DNA or RNA, which might prevent viruses and bacteria from replicating in their host cell.

2.2. Effect of temperature and humidity

The exact temperature and time to kill the virus cannot be predicted very accurately as it varies. It depends on various factors, such as the amount of virus that's present, the surface type, ambient humidity, etc. Most of the viruses, including Coronaviruses, might be killed entirely after exposure to temperatures of 65°C (368 K) or higher for longer than 3 minutes. For temperatures lower than 65°C (368 K). It required a longer duration than 3 minutes for the complete killing of viruses. For example, the Coronavirus may sustain more than 20 minutes when it is exposed to temperatures between 50 and 55°C (353 K to 358 K)[8]. The humidity of the environment plays an essential role in reducing the transmission of active viruses and bacteria. Many air-borne viruses are susceptible to the humidity of ambient air. Viruses are encased in an aerosol containing a lipid membrane and remain active for longer at lower relative humidity (RH) than at higher relative humidity (RH)[9]. In regions with lower humidity levels, viruses tend to be enveloped by tiny droplets, therefore prolonging their suspension and activity in the atmosphere. In an environment with elevated humidity levels, viruses get enveloped inside bigger droplets, which then descend to the ground as a result of gravitational forces acting upon the droplets. This phenomenon, known as self-weighting droplets, serves to diminish the likelihood of infection transmission. Research findings indicate that the lifespan of active viruses is around 18 hours under conditions where the ambient relative humidity is 20% and the temperature ranges from 21 to 24 degrees Celsius. The active life is reduced to 6 hours when the relative humidity is increased up to 80% at the same ambient temperature. The life of active viruses is again reduced to just 2 minutes when sunlight has been added[10].

2.3. Justification of the problem statement

In India, most people would like to chew smokeless tobacco. They can't sallow the generated saliva in the mouth by chewing tobacco because it is gross and has severe diseases such as cancer, lung infection, etc. they have to spit somewhere. This is one of the significant factors in spreading contagious diseases. Our government makes many laws and fines for indiscriminate spitting. But it is still a hectic task for the government to implement these laws on 1.37 billion people. So, the circumstances indicate that there is a critical need to get rid of this global problem like COVID-19.

2.4. Need of the Product

It is very much required to find a specific solution for this, which balances the health risk of spatter and other persons by minimizing the spread of diseases like COVID-19 etc., via spitting[11),12]. According to a recent study, Coronavirus can't stay stable for longer in sunlight. Sunlight significantly affects other viruses (including Coronavirus) and bacteria. Solar light has a powerful effect on killing viruses and bacteria on surfaces and air. Increasing temperature and humidity are also very effective in inactivating infectious viruses such as corona, tuberculosis, hepatitis, etc.[13),14]. High temperatures and humid environments are not conducive to these viruses and bacteria.

It is important to identify a resolution that addresses the maintenance of cleanliness and the prevention of disease transmission by spitting, while also taking into account the health risks associated with tobacco users and other individuals. The proposed designed product should be able to eliminate all spittle, phlegm, and other unclean bodily fluids in under a minute, along with any disease-causing viruses, germs, and pathogens.

3. Objectives

3.1. To design and fabricate a solar concentrating spittoon.

After analyzing the aforementioned research report, it has been established that it is required to develop a process that hygienically decomposes and eliminates the viruses, germs, and pathogens that are communicated by saliva. After examining various publications and research papers on the inactivation and eradication of viruses and illnesses, as well as their reaction to an increase in temperature and humidity, a method is developed to incinerate spittle by putting a solar-powered concentrator in public locations.

For the same a spittoon has to be designed. In this regard literature related to solar collector has been studied by the authors and some of them has been reported here. Hybrid Photovoltaic- air updraft solar application has been studied[15]. Ismaeel et al.[16] studied the performance of updraft air tower power plant integrated with double skin solar air heater. Solar water heater has also been studied to understand the possible design for solar spittoon[17),18]. The solar box[19] was also has been studied along with the energy management and heat storage for solar Adsorption cooling[20].

In this spittoon, collected saliva is exposed to natural sunlight at higher temperatures, up to 400 K, and in a higher humid environment, 80% RH to 90% RH. At this ambient condition, most contagious viruses, bacteria, and pathogens, including the Coronavirus, are killed or inactivated to transmit lethal disease.

The aim of the work is to design and fabricate a solar collector with the purpose of efficiently concentrating incident solar radiation. The act of expectorating saliva should result in rapid combustion. During the fabrication processes following important points are considered.

a) It should not lose heat to the surrounding.
b) Receiver temperature should be maintained at more than 373 K.
c) It should generate heat when the sun falls from a different angle.
d) It should be compact and lightweight.

4. Methodology

4.1. Assumption and Modelling

- Properties of a protein molecule are neglected.

- Saliva is assumed to be water and uniform composition.
- Variation of specific heat at constant temperature is neglected.
- Initial temperature of saliva is assumed to be the body temperature of a healthy person.

As is common knowledge, the typical individual can spit 3 ml of saliva. Saliva comprises 99% water, 1% protein molecules, and phlegm-containing viruses and bacteria[21]. Thus, the saliva's water quantity is much larger than that of another molecule. In the work, the thermal characteristics of 1% of saliva's protein molecules have been disregarded and instead the thermal properties of water at 37 degrees Celsius[22] have been examined.

4.1.1. The energy required to evaporate and burn saliva completely

$$Q = m\,C_{pw}(T_e - T_b) + mL_t \tag{1}$$

4.1.2. Power required to burn out saliva in 1 minute

For Power required to burn out saliva within one minute the following equation is used

$$P = Q/t \tag{2}$$

4.1.3. Aperture area required

The following equation is used to find the aperture area of the reflector for receiving 126 watts of Power.

$$Q = A_a I_s - q_{loss} \tag{3}$$

Here it is assumed that no heat loss from the receiver of the solar concentrator .so that the
equation became. ($qloss$ = 0)

$$Q = A_a I_s \tag{4}$$

4.2. Fabrication of solar concentrating spittoon

Our objective is to construct a solar collector in such a way that concentrates all sun rays, which fall on it. Where users spit saliva should quickly burn. During the fabrication processes following important points are considered.
a) It should not lose heat to the surrounding.
b) Receiver temperature should be maintained at more than 373 K.
c) It should generate heat when the sun falls from a different angle.
d) It should be compact and lightweight.

4.2.1. Material used for solar concentrator

a) Wood – for the construction of the frame. In reflector, rings are kept at different angles and support the whole structure of concentrating spittoon.
b) Mild Steel – mild Steel is used as a ring in all six wooden frames and is mounted with the help of a screw. Two rings are used one is the innermost ring of the smallest diameter and the other is the most giant outer ring of mild Steel.
c) Aluminum sheet – a thin aluminum sheet used in the fabrication of concentrating spittoon. Where pieces of mirror are fixed with the help of silicon glue.
d) Mirror – the mirror is taken in the process of fabrication. Small pieces are made from the mirror with the help of a glass cutter and ruler.
e) Iron: iron tubes are used in the fabrication process in form stand. Which provides support and elevation to the concentrator.

4.2.2. Materials used for the fabrication of the receiver.

Materials	Its functioning
Toughened glass	toughened glass tube with a larger diameter is used to collect the all-reflecting irradiation, which comes from the reflector. And reduce the loss of heat by convection and radiation to air.
Copper	A copper case is used for absorbing heat and conducting it efficiently to the phase-changing material, which is the filler for the copper case.
Paraffin wax	Paraffin wax is the filler material, which stores the heat from the copper case by changing its phase from solid to liquid. It helps to maintain the temperature above 333K at concentrating region when the environment is cloudy[23].

5. Fabrication and designing of solar concentrating spittoon

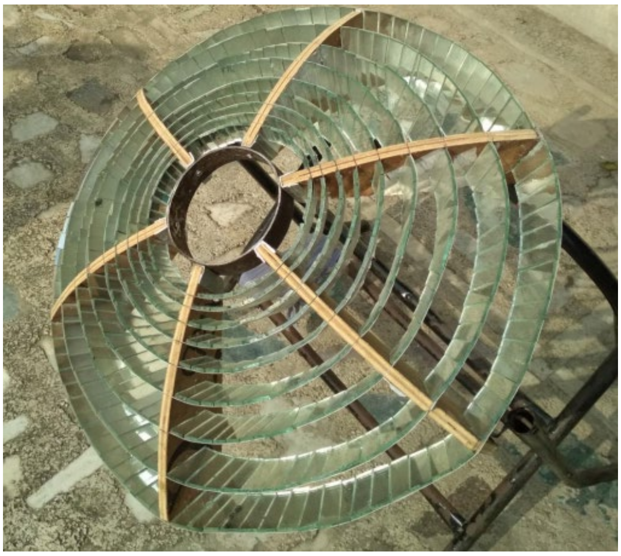


Fig. 2. Fabricated solar concentration spittoon

5.1. Design of concentrator

In this study, the receiver section is designed so that it works as parabolic trough collector so that it can reflect the incident rays around the concentrating region where PCM are installed. The reflector consists of nine concentric rings (see Fig. 2). Whose surface profile is at an angle to the sun's incident rays. Each ring surface is inclined at a distinct angle concerning the incident beam. This inclination angle decreases from the outermost reflective ring to the innermost reflective ring. This configuration gives the whole reflector a parabolic reflector form. It is common knowledge that the following equations determine the form of a parabola[24),25),26),27)] and[28)].

$$X^2 + Y^2 = 4f \tag{5}$$

5.2. Aperture area

This is the effective Area of the reflector and receiver, which is exposed to sunlight and receives energy from solar radiation. The aperture area of this solar collector is determined by the following calculation;

$$A_p = a_r - na_f \tag{6}$$

5.3. Focal length to diameter ratio

The ratio of the focal length of the concentrator to the diameter of the concentrator is denoted as *f/d*.

5.4. Rim angle

It is the total angle covered by the concentrator reflector at the focal point. The rim angle can be calculated from the below equation[29)].

$$\frac{f}{d} = \frac{1}{4}\tan(\varphi_{rm}) \tag{7}$$

5.5. Absorber area or concentrating area

It is the effective Area of the receiver where reflected light is concentrated

$$A_{ab} = \pi d_r l_r \tag{8}$$

5.6. Geometric concentration ratio

The ratio between the aperture area of the concentrator and the Area of the receiver absorbs all of the solar heat flux concentrated by the concentrating reflectors. The geometric concentration ratio is computed using;

$$CR_g = \frac{A_p}{A_{ab}} \tag{9}$$

5.7. Design calculation

Design calculations are done for solar concentrators for the burning of spitted saliva. Based on basic heat equations and equations used for the parabolic concentrator and receiver design[30),31)]. The selection of crucial independent and dependent variables, as well as the implementation of required constants from established sources, are undertaken in order to compute the daily performance of a solar concentrating spittoon. They are given below in Table 1.

Table. 1 Design specification of solar concentrator spittoon

S. no.	Parameters for design calculation	Value taken
1	Outer diameter of the concentrator	0.6 m
2	Inner diameter of the concentrator	0.13 m
3	Receiver diameter	0.06 m
4	Length of receiver	0.06 m
5	Reflectivity of reflectors (ך)	0.93
6	Transmittance (**τ**)	0.95
7	Absorptance (**α**)	0.9
8	Fraction of intercept (**i**)	0.95
9	Fraction of Area exposed to the sun (**e**)	1
10	Overall heat transfer coefficient $U = 10.45 - v + 10v0.5$ (Assume negligible velocity because the receiver is covered by concentrator)	10.45 W/m^2K
11	Solar irradiation ($\boldsymbol{I_{sn}}$)	746 watt/m^2
12	Stefan Boltzmann constant (**σ**)	5.67×10^{-8}
13	Radiative conductance (F)	0.25

5.7.1. Rate of thermal Energy available at the receiver

The thermal efficiency of the receiver depends on the amount of heat obtained by the concentration of solar irradiation and the amount of heat loss to the surrounding by conduction, convection, and radiation. Following is the fundamental equation for the rate of energy available at the receiver.

$$Q_{avail} = \{I_{sn} \times (Ap + A_{rec}) \times e \times cos(\theta_i) \times \zeta \times \alpha \times \tau \times i\} - (A_{rec} + A_{recn}) [U \times (T_{rec} - T_{amb}) + \sigma \times F \times (T_{rec}{}^4 - T_{amb}{}^4)] \tag{10}$$

5.7.2. Time taken for burning out spitted saliva

For calculating the time to burn out saliva, the fundamental equation is given below.

$$t = \frac{\text{Energy required to burn out saliva}}{\text{Rate of energy available at receiver}} \tag{11}$$

From the above calculation, it was found that this concentrator can take approximately 50 sec to burn out the saliva. So, after the spitting of 1st user, 2nd user should spit on this spittoon after 50 sec to avoid transmission of contagious diseases by spitting.

6. Results and discussion

After designing, modeling, and constructing a solar concentrating spittoon, an infrared thermometer takes readings from the energy-storing element surface (see Fig. 3), a copper container filled with paraffin wax. (Phase change material for maintaining uniform temperature and heat at saliva collecting region) readings are taken several days. Readings are taken from 6 am to 6 pm at the interval of one hour. Average reading values are considered in calculations, which are given below in Table 2. In this table, solar irradiation data are taken from https://www.nrel.gov.in.

Table 2. Recorded experimental data of temperature, irradiation, heat availability, and time to burn saliva

Time	Ambient Temperature (T_{amb}) °C	Receiver Temperature (T_{rec}) °C	Solar Irradiation (I_{irr}) (watt/m^2)	Rate of heat Available (Q_{avail}) (watt)	Time taken to burn Saliva τ (sec)
6.00 am	299	299	17	4.01	1884.3
7.00 am	300	310	119	25.12	300.95
8.00 am	301	319	646	147.1	51.4
9.00 am	308	376	778	162.33	46.57
10.00 am	311	383	867	181.9	41.56
11.00 am	313	389	883	184.26	41.03
12.00 am	313	392	913	190.32	39.72
1.00 pm	313	392	909	189.37	39.92
2.00 pm	313	392	889	184.65	40.94
3.00 pm	311	385	832	172.97	43.71
4.00 pm	311	384	723	147.58	51.23
5.00 pm	305	337	538	117.28	64.46
6.00 pm	305	305	62	14.63	516.67

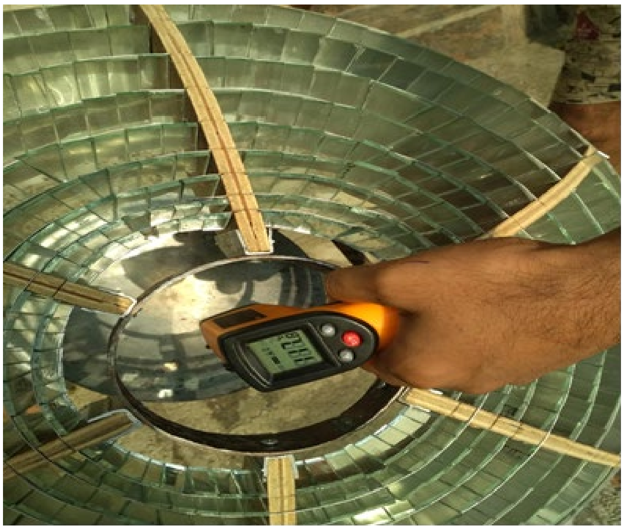


Fig. 3. Temperature at the concentrating point of the spittoon

After calculating the receiver temperature, available energy, and time is taken for burning (vaporizing) saliva from the above-collected data, it is observed that from 6.00 am to 7.00 pm temperature at the receiver is almost equal to the ambient temperature. This is because of the sun is not shining at the time of rising. So, the concentrator's reflector collects less solar irradiation from the sun. From 7.00 am to 9.00 am, the sun rises ultimately and it is on its way to getting shine at its higher intensity, so the slope of the receiver temperature graph increases. The solar intensity is high from 9.00 am to 4.00 pm so the concentrator's reflector collects a larger amount of solar irradiation. At this duration of time receiver attained its maximum temperature of that day. The observed reading from an infrared thermometer is approx. 386 K. After 4.00 pm temperature of the receiver is getting decreases. This is due to the decrease in irradiation from the sun.

The available energy of the receiver is minimum during 6.00 am to 7.00 am. The slope of available energy is positive from 7.00 am to 9.00 am. At the duration of 9.00 am to 4.00 pm, the available energy for the burning of saliva is almost uniform. After calculating available energy at the receiver, approximately 176 watts of energy is found at 386 K temperature. After 4.00 pm available energy at the receiver gets reduced.

The time duration for the burning of 3ml of spitted saliva is observed. The average duration for the burning of saliva obtained is 46 sec, between the period of 8.00 am to 5.00 pm. So, this solar concentrating spittoon is given the best performance for 9 hours. So, it can be used in public places such as a park, railway stations, etc.

6.1. Performance analysis

In this paper, performance parameters are calculated for solar concentrators, such as the optical efficiency (η_{op}) of solar concentrators, receiver efficiency ($\boldsymbol{\eta_{rec}}$), and overall efficiency (η_o). The required dependent, independent input value and constants are taken from the above calculations and tabulated in Table 1.

6.1.1. Optical or concentrator efficiency

The fraction of solar heat radiation that is incident on the receiver glass tube after reflection through reflectors is known as the optical or concentrator ratio. For the calculation of optical efficiency, the following equation has been used.

$$\eta_{op} = e.(\cos\theta_i).p.\phi \tag{12}$$

6.1.2. Receiver thermal efficiency

The thermal efficiency of the receiver can be calculated as;

$$\eta_{rec} = \tau \times \alpha - \frac{\{U \times (T_{rec} - T_{amb}) + \sigma \times F \times (T^4_{rec} - T^4_{amb})\}}{\eta_{op} \times CR_g \times I_{Sn}} \tag{13}$$

$$\boldsymbol{\eta_{rec}} = \mathbf{0.8}$$

After calculating receiver thermal efficiency, it has been found that the receiver absorbed approx. 80% of the solar heat and 20% of the heat is lost to the surrounding by convection and radiation.

6.1.3. Overall efficiency

The product of optical efficiency to receiver thermal efficiency calculates overall efficiency.

$$\boldsymbol{\eta_o} = \mathbf{0.704} \tag{14}$$

After calculation of overall efficiency, it has been found that the approx. 70% of the heat available at the receiver for burning spitted saliva over solar radiation incident on the aperture area of the solar concentrator.

7. Conclusion

This article is a comprehensive analysis of the design and manufacturing process of a solar concentrating spittoon. The mean temperature measured by the use of an infrared thermometer throughout the execution of the experimental protocol is found to be 390 K. 6 a.m. to 7 a.m., based on observations of experimental findings, the temperature and available heat of energy storage components are approximately equivalent to the ambient temperature. From 9 a.m. to 4 p.m., its temperature and available energy are 390 K and 176 W, respectively, and it maintains a constant temperature and energy level for seven hours at the receiver. By 4 p.m., its temperature decreases slightly, and after 5 p.m., the temperature and heat at the receiver reach ambient levels. Thus, it is evident that the solar concentrating spittoon functions best between 9 a.m. and 5 p.m. The efficiency of the solar-concentrating spittoon reached its peak for a duration of nine hours. The thermal efficiency of the receiver was found to be 80 percent, with 20 percent of the heat being dissipated to the nearby environment. It was revealed that the total efficiency was about 70 percent. Consequently, it may be used in public locations such as parks, zoos, buses, etc. It will aid in the prevention of the spread of COVID-19.

Nomenclature

Q	Energy required to evaporate saliva (joule).
m	Average amount of saliva spitted by a person (kg).
$\mathbf{C_{pw}}$	Specific heat of saliva (kJ/kg K).
T_b	Evaporation temperature of saliva at atmospheric pressure (k).
T_e	Body temperature of a person (K).
L_T	Latent heat of vaporization of water (KJ/Kg).
P	Power (watt).
Q	Energy (joule).
T	Time (second).
Q	Energy required to burn out saliva (watt).
A_a	Aperture area of solar concentrator reflector in(m^2).
I_S	Radiant energy received by earth surface from the sun in India (watt/m^2).
q_{loss}	Heat loss by receiver to surrounding by convection (watt).
X	Aperture plane coordinate in x- axis.
Y	Aperture plane coordinate in y- axis.
Z	Distance from the vertex of concentrator parallel to symmetry of reflector (m).
f	Focal length of concentrator (m).
d	Diameter of concentrator (m).
φ_{rm}	Rim angle.
a_r	Normal area of reflector that is exposed to sun (m^2).
n	No of wooden frame.
a_f	Area of frame that is exposed to sunlight (m^2).
d_0	Diameter of an outer ring of a reflector (m).
d_i	Diameter of an innermost ring of reflectors (m).
t	Thickness of frame (m).
l	Length of frame (m).
$\boldsymbol{A_{ab}}$	Absorber area ($\boldsymbol{m^2}$).
$\boldsymbol{d_r}$	Diameter of receiver (m).
$\boldsymbol{l_r}$	Effective length of receiver area where

flux of heat collected (m).

CR_g	Geometric concentration ratio.
A_{recn}	Area of receiver normal to incident radiation (m^2).
η_{rec}	Receiver efficiency.
η_{op}	Optical efficiency.
η_o	Overall efficiency.
I_{sn}	Normal Solar irradiation (W/m^2).
U	Overall heat transfer coefficient (W/m^2K).
σ	Stefan Boltzmann constant.
F	Radiative conductance.
e	Fraction of area exposed to the sun.
α	Absorptance.
τ	Transmittance.

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