Smart Mini Sanitary Pad Incinerator

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Abstract:

Normally the used sanitary pads are thrown away in the dustbins, which are non-bio degradable, thereby causing harm to the environment. 432 million pads are disposed annually in India creating a big environmental problem. With the number of pads being disposed to increase in the coming years, proper disposal of these pads is the need. Various modern electric Incinerators are equipped with large capacities and high costs for large target audience. The running costs associated with the commercial large-scale Incinerator is considerably higher and require more space for installation purpose with a consumption of 15 Amperes. The project aims at fabrication and testing of a miniature sized automatic electric Incinerator, a solution to small audience at a relatively low cost, less capacity of 5 napkins and with a power consumption of 3 Ampere only. Besides this incinerator comes with additional features of heater-auto on/off and a counter mechanism. With the safe exhaust emissions to tackle the Central Pollution Co.

Keywords: Incineration, Exhaust Emission, Automation.

I. Introduction:

[1].Incineration plants must be design to ensure that the flue gases reach the temperature of 850’C for 2 sec in order to ensure proper breakdown of toxic organic substances. [2].The combustion of plastic give rise to highly toxic pollutants. [3].Overall greenhouse gas emissions from incinerations are lower than that of landfill. [4].Auto power & thermal cut-off and automatic temperature maintenance should be there for safety of user. [5].Combustion air is drawn from the waste storage area for two reasons. First, it increases temperature at heating zone also preventing litter and odor from escaping the incinerator. It also destroys the odor by exposing it to the high temperatures in the furnace. [6].As referred from standards of CPCB (Central Pollution Control Board) for exhaust gas emission of solid waste incineration the permissible values of various exhaust gas contents are as follows

HC	24PPM
CO2	0.75%
O2	22%
CO	0.1%
NO	195PPM

II.Limitations of Prevailing Methodologies:

1.Cost: - The cost of conventional Incinerator available in market are high and it does not fulfill the demand to incinerate waste in less cost

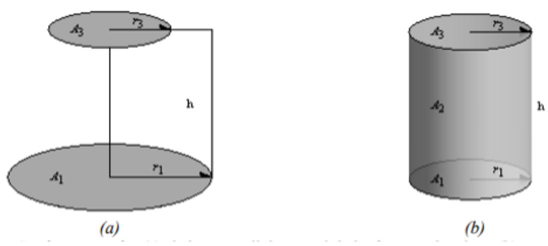
2. Size- Size plays an important role when comes to the community when the incinerator has to be installed, conventional Incinerators are high capacity industrial application based Incinerators which are employed in high end application.

3. Exhaust Emission: Exhaust which is emitted contains a foul smell with pollutant particles of ash and harmful gases.Exhaust is mostly directly released in the atmosphere without trapping particulate matter.

III. Literature Review:

Heat Required for incineration calculation Radiation

FigureCylinder Nomenclature



Let A1 be the area of base of cylinder,
A2 be the inner circular area of cylinder
A3 be the top open area of cylinder
Radiation factor
F11 = F33 = 0
F12A1 = F21A2
F13A1 = F31A3
F23A2 = F32A3
F23 = F21
F11 + F12 + F13 = 1
F21 + F22 + F23 = 1
F31 + F32 + F33 = 1
Let be the height of cylinder (L = 80mm)
Let ri be the inner radius of cylinder (ri = 38.1mm)
Ri = ri/L   Rj = rj/L
S = 1+ (1+Rj2)/Ri2
Fij = 0.5(S-(S2-4(rj/ri)2)0.5)
r1 = r2 = r
S = 1+(1+r2)/r2
Therefore, F13 = 0.5((2(0.0381)2+1)/(0.0381)2 – ((2(0.0381)2+1)/(0.0381)-4)0.5)
F13 = 0.00144741 = F31
F12 = 0.998552 = F32
F11 = F33 = 0
F23 = 0.237780 = F21
Q21 = (sigma)(area)(T24 – T14)F21(€)
Here, € = 0.6 for SS304
Therefore,
Q21 = 5.67*10-8*2π(0.0381)*(0.08)(6734 – 3034)(0.237780(0.6)
Q21 = 30.47W
Q23 = 30.47 W
Qradiation = Q21 + Q23
Qradiation = 60.94 W
Heat Required to burn 4 pads

Q1pad = Heat required to burn pad + heat required to evaporate blood
Assumptions,
Maximum material of pad is polyethylene and content of blood in one pad is 5ml
We know, Blood is 94% water
Ignition temperature of polyethylene = 3490C
Specific heat of polyethylene = 1900 J/Kg.K
Specific heat of Water = 4130 J/Kg.K
Mass of pad = 5grams
Hence,
Q1pad = Mpad*Cppad*(349-30) + Mblood*Cpwater*(100-30)
Q1pad = 31.36W   (considering 10minutes burning time)
Q4pads = 125.84W
Inner Side Convection of burning chamber
Air temperature = 225oC
Cp = 1.0027kJ/kg.K
μ = 1.467*10-5 kg/ms
K = 2.020 kW/mK
U = 0.935*10-5 m2/s
Density(d) 1.569kg/m3
α = 12.83397*10-6
Gr = 9.81(370)(0.08)3/488(0.935*10-5)2
Gr = 43.5609*106
Pr = U/α = 0.728
Ra = Gr*Pr = 31.2358*106
Nu = 0.1(GrPr)1/3 = 31.6604
Nu = hD/Kf
h = 2.020*10-2(31.6604)/(0.0762)
h = 8.3929 W/m2K
Q = hA(225-30)
Q = 59.47W
Also, Nu = 3.47 + 0.51(Ra)1/4
Nu = 41.597061
h = 11.0270
Q = 78.13W
Hence, Qiconv = 78.13W
Conduction and convection
Let Ks be the coefficient of conduction of cylinder
Let Ki be the coefficient of conduction of insulating material (Ceramic Fibre
Qcond n conv = (T1 – T2)/((1/hiAs) + (1/2πKL)ln(r2/r1) + (1/hoA))
Qcond n conv = (400-30)/((1/11.370π*0.08*0.0762) + (1/2π(0.12)(0.08))ln(0.049/0.0396) + (1/401(0.0994)(0.08)))
Qcond n conv = (400-30)/(4.5924+3.7662+4.7420*10-3+0.099822)
Qcond n conv = 43.7188W
Final Heat Required
Qtotal = Qradiation + Q4pads + Qiconv + Qcond n conv
Qtotal = 60.94 W + 125.84 W + 78.13 W + 43.7188 W
Qtotal = 308.62 W

Hence, selecting heater with 500W power Heater requirement is **500watts** as per the calculations.We also want less energy consumption therefore; we have selected **the Band type of heater.**This heater has less efficiency because area of contact for burning is less. Efficiency of the heater remains same over period of time because the material or pad indirectly coming in contact with heater. Burning time for this type of heater is less. Units consumption for this type heater is less.Incomplete burning of pad material.Cost of burning is same.Its available from 500 watts.

SS 304 Material Properties [11]

Young’s Modulus = 2*E5 MPa

Poisson’s ratio = 0.29

Tensile yield strength = 215 MPa

Ultimate Tensile strength= 505 MPa

Coefficient of thermal expansion = 1.28*E-5

6.1 Steady State Thermal Analysis

Boundary conditions

Temperature of the heating chamber

Radiation heat transfer from surface to surface

Conduction and convection

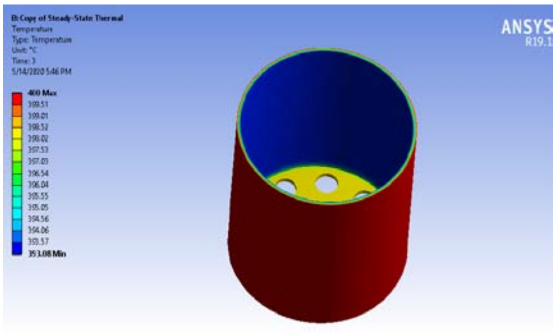


Figure 6.1 Temperature

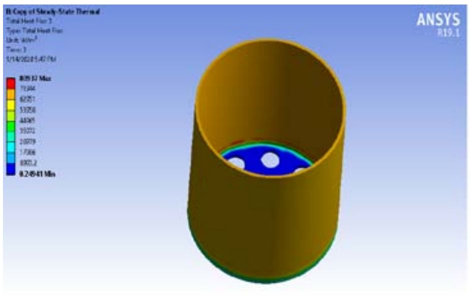


Figure 6.2 Heat Flux

As seen from temperature results the average temperature is around 396 °C which is the temperature after steady state is achieved.

Sr N.	Time [s]	Minimum [°C]	Maximum [°C]	Average [°C]
1	1	392.75	400	397.03
2	2	392.87	400	397.07
3	3	393.08	400	397.15

Table 6.1 Temperature Analysis Results

As seen in the heat flux results max heat flux is 80937 W/m2 and there is minor change in the heat flux till steady state is achieved as shown the table below.

Table 6.2 Heat Flux Analysis Results

Sr no.	Time [s]	Minimum [W/m²]	Maximum [W/m²]	Average [W/m²]
1	1	0.2427	84816	54652
2	2	0.24841	83372	53873
3	3	0.24941	80937	52558

1.2 Steady State Structural Analysis

Boundary Conditions

Temperature difference

External support to cylinder

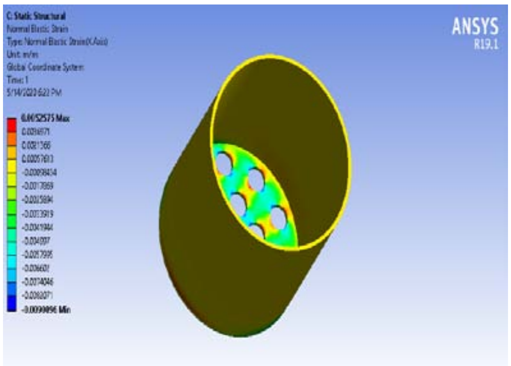


Figure 6.3 Normal Strain

$dl = \alpha\, l_o\, dt$

dl = elongation (m)

l_o = initial length (m)

dt = temperature difference (^{o}C)

$\varepsilon = \alpha\, dt$ = 1.28*E-5*400 = 5.12*10E-3

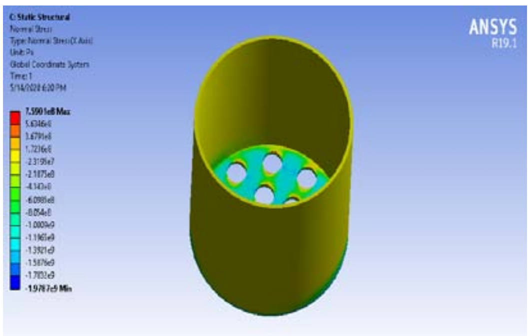


Figure 6.4 Normal Stress

$\sigma_{dt} = E\,\varepsilon$

σ_{dt} = stress due to change in temperature (Pa (N/m^2))

$\sigma_{dt} = E\,\alpha\, dt$

$= (2*10^5)*(1.283*10^{-5})*300 = 7.69*10^8$ Pa

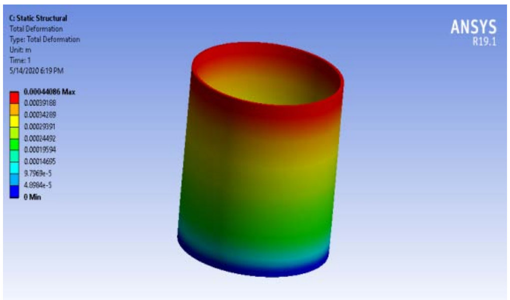


Figure 6.5 Deformation

As seen from the deformation results 0.00044 m deformation occurs due to thermal stress.

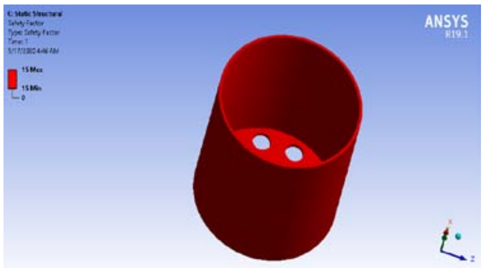


Figure 6.6 FOS

Table 6.3 Structural Analysis Result

Stress	759.01 MPa	Deformation	FOS
Strain	0.0052	0.4 mm	15

Figure 6.10 Temperature Render

IV. Proposed Work:

[1].To carry out better burning.

[2]. To reduce bad odour coming out of exhaust.

[3]. To prevent the direct escape of suspended particles into the atmosphere .

[4]. To carry out maintenance and cleaning of the incinerator with ease.

[5]. To reduce electric consumption.

[6]. To make a smart automatic machine.

[7].To filter the exhaust so as to reduce escape of pollutant gases.

[8].To have low manufacturing and running cost.

[9].To have timely output of Temperature and pad count .

Architecture Diagram of the System

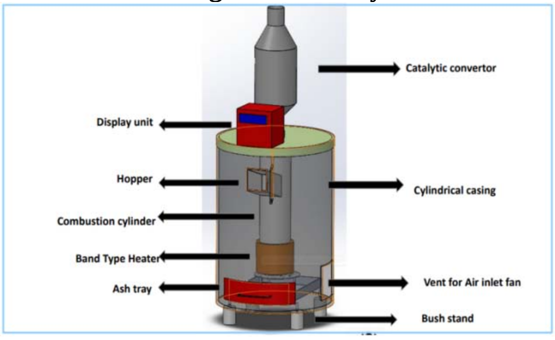


Fig . Solidworks Model

•**Hopper and Cylinder** - The inclined rectangular box made of SS304 rectangular pipe is used for guiding the pads to the combustion chamber. The Overall dimensions of the hopper are selected according to packaging constrains and opening is cut according to pad dimensions considering clearance margin.

•**Outer cylinder**- The Overall dimensions of the Cylinder dia 27.5 cm and height 37 cm . The dimension selected considering miniature size portable design of system. The function of the box is to package hopper and insulation in place.

•**Insulation**- Ceramic Fibre Insulation is been used, due to its Excellent Thermal shock resistance & High Temperature Stability.

•**Exhaust Pipe& Catalytic Converter**- The exhaust gases come out of combustion chamber goes to Particulate filter and the clean air coming out of Filter is then pass through catalytic converter . The dimensions are selected according to catalytic converter size available.

•**Electronic box**:It encloses the Electronic components . Dimensions of box are selected according to size of different electronic components.

•**Diesel Oxidation Catalytic Converter-** The diesel oxidation catalyst (DOC) owes its name to its ability to promote oxidation of exhaust gas components by oxygen.
A diesel oxidation catalyst (DOC) is an after-treatment component that is designed to convert carbon monoxide (CO) and hydrocarbons into carbon dioxide (CO2) and water. The oxidation of hydrocarbons and CO in diesel emissions can be described by the following chemical reactions:

[Hydrocarbons] + O2 = CO2 + H2O

$C_nH_{2m} + (n + m/2) O_2 = nCO_2 + mH_2O$

$2CO + O_2 = 2CO_2$

V. Implementation

Some of the objectives of our project is to reduce the electricity consumption and to make the machine smarter.

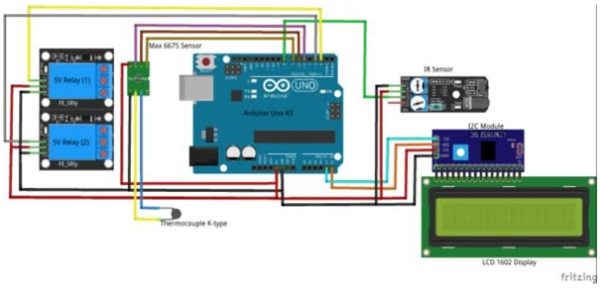
In commercially available Incinerators, napkins are stored in a machine throughout the day and machine will be turned on manually at the end of the day for any particular amount of time.

The problem with this setup is that there are possibilities of having no napkins accumulated in a day and still the machine will be turned on and also there can be a time when number of napkins will exceed the capacity of machine and there will be unburned napkins after incineration also there is no specific time known to run the machine effectively.

Our device uses an IR (infrared) sensor to count the number of pads inside a machine. IR transmitter is connected to the input door of machine and receiver is connected to the body of machine. In closed position of door, a high output is sensed at receiver, when we open the door to put a napkin the low output will be sensed at receiver and again when the door is closed the output will be high.

Hence, when there will a pulse of low and high output, counter will count 1 digit and this will give us the number of napkins inside.

When the counter counts first digit, a timer of 8 hours will be started which will make sure that the machine will be turned ON maximum after 8 hours. Now depending on the number of napkins inside the ON time of machine will be set. The ON time of machine will be determined by previous testing of how much time is required for a machine to burn 1,2,3,4,5 number of napkins respectively. If the counter counts 5 digit the machine will be turned ON irrespective of timer as the capacity of our device is 5.



VI.Future Scope

[1]. For a continuous process of incineration there can be a modification in the design of hopper where input pads while the heater is ON will be stored and then will be dropped into the burning chamber.
[2]. A mechanism can be designed to self-clean the burning chamber so the efficiency of machine will not degrade and maintenance will be reduced.
[3]. Fire safety alarm and emergency switch-off mechanism can be introduced.
[4]. Machine ergonomics can be improved for better consumer experience.

VII. Conclusion

The incinerator is designed and an entirely new machine has been fabricated and tested. This incinerator is relatively low cost, with a capacity of 5 napkins per cycle and with a power consumption of 0.55 KWh per cycle. The Manufacturing cost of the incinerator is Rs.5000/-. The incinerator uses a band type heater with a 500 Watt power rating placed around an SS304 cylindrical shell and a 12 V DC powered fan. The incinerator comes with the incredible features of heater-auto On/Off , air circulation with fan for better combustion process and a counter mechanism using IR sensor with an Arduino controller attachment all these features can be sharply controlled. A small LCD display is used to provide the temperature and counter of pads. It also has an exhaust layout that contains a particulate filter that can filter up to 1-micron size particle and a MM diesel walker catalytic converter to tackle the Central Pollution Control Board (CPCB) norms for incinerators that are implemented and a provision has been made by using naphthalene balls for eliminating the bad odour released during burning. The total power consumption of the machine will be 550 Watt and the time for a burning cycle is 25 minutes for 5 pads, and the cost of burning 5 pads per cycle is Rs.2. The machine can carry out a total of 10 cycles per day. The cumulative weight of the machine is 8 kg.

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