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PARAMETRIC ANALYSIS OF KEROSENE PRESSURE COOKER: A REVIEW APPROACH OF THEPARAMETER CALCUATION TECHNIQUES

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ABSTRACT

This paper dealt with the design and modeling of a portable kerosene pressure-cooker. The existing cookers and the problems associated with them were analyzed. The need and importance of this work were also highlighted. The design consists of three parts: the cylinder, the piping, and the frame. The analytical approaches used to find the rate of fuel burning and how heat conducted on the pan with the new design and analyze to identify the power output. Using the principles of fluid dynamics, this work is able to establish that the power of the cooker is 3.12 KW.

KEYWORDS: Kerosene Pressure-Cooker, Heat Conduction, Fluid Dynamics

1. INTRODUCTION

Household energy especially cooking energy, often accounts for a big part of the overall energy consumption in many developing countries. Wood is still the main energy source in the rural area subtropical countries; steadily rising fire wood consumption for cooking purposes results. In deforestation of large areas and creating of severe ecological problems, Smoke (Carbon monoxide) that comes out as a result of incomplete combustion of carbon poses health risk to humans and the environment, i.e. it irritates the eyes and lungs, and contributes to air pollution. Now today, in Ethiopia deforestation is not good for the environment, it becomes expedient to design and model a kerosene pressure-cooker.

A pump that would pressurize the kerosene designed. The kerosene inside is under gravitational force, if one control valve is opened, kerosene gets to the burner which is made in contour form to delay circulation initially. The pipe diameter and burners of appropriate size and dimension was used to get required velocity of jet of kerosene. Replaceable filters are used in case of stocked/blocked ones by dirt or deterioration and of usage with time to give a very fine blue steady quality flame. It determines the effect of pressure and its scattering or atomizing ability on the surface of the kerosene.

Cost considerations were also done to make the stove affordable to low income earners. the research configurations of the components were considered bearing in mind such factors as: ease of assembly, aesthetics, availability of materials and reliability. "Ifeanyichukwu Helen," [1]. The research scholar dealt with the design and construction of a portable kerosene pressure-cooker. The existing cookers and the problems associated with them were analyzed. Their design parts focused on the cylinder, piping, and the frame. The R-12 refrigerant cylinder was redesigned to suit the kerosene cylinder, since it has the desirable features for that purpose. Using the principles of fluid dynamics, this work was able to establish that the power of the cooker is 179.922KW, and that under a constant pressure of IMPa the cooker discharged and burned 1 liter of kerosene in 3.5 minutes giving out an enormous heat energy of 38.2MJ. "Moh, Kenechukwu David" [2]. Traditional cook stoves were used extensively across rural households in India. The development community across the globe comprising of governments, NGOs, civil societies and individual companies have been designing improved cook stoves to help reduce the pressure on forest resources, reduce the time spent collecting cooking fuel, decrease families' exposure to indoor air pollution and reduce climate forcing emissions.

The researcher indentified first part of the study aims to develop an understanding of traditional cooking practices with regard to fuel and cooking technology. The second part of the study looks at some of the improved cook stoves currently in the market and assesses the user experience surrounding the use of these improved cook stoves.

Despite all the concerted efforts across the public, private, and NGO sectors, improved cook stoves have not seen widespread adoption across rural India, the reasons for this non-adoption being multi fold. This paper is the result of a field research undertaken across five states in India over a period of two months. " Revati Dhoble, Sreyamsa Bairiganjan " [3]

Score-Stove TM a clean-burning cooking stove that also generates electricity was tested using a pressurized kerosene burner. The device having hot-end, cold-end and regenerator acts in a way similar to a sterling cycle generating acoustic power, which is then converted to electricity using a linear actuator. Identification of the Score-Stove performance was then evaluated while increasing the pressure of the sealed working fluid (air in this case) from atmospheric to about 1.4 bar. Technical deficiencies are documented and recommendations for improvements and future research in order to obtain wider end-user acceptance are made. LPG plays a pivotal role in the transition towards a more secure, sustainable and competitive energy model. Considering the limited fossil fuel resources, energy conservation, environmental issues, increase in the demand on LPG in near future, it is a necessary to explore the ways to further improve the thermal efficiency and the emission characteristics of the existing LPG cooking stoves. "Md Ehsan" [4] and " Jagruti R. Surange " [5].

2. DESIGN PROCEDURE AND ANALYSIS

Appearance and odor: Colorless to pale straw liquid with a characteristic odor.

Boiling range at 760 mm of Hg	: 151-301°C,
Vapor pressure	: 0.5 mm of Hg at 20°C
Density	: 810 kg/m3
Specific gravity	: 0.81
Freezing point	: 18°C
Kinematic viscosity	: 0.1765 m2/s
Solubility in water	: Insoluble

2.1 Bernoulli's Equation

Applying Bernoulli's equation between sections 1 and 2

$$\frac{P_1}{\rho g}+\frac{V_1}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2}{2g}+Z_2+h_f+h_c \quad \textbf{(1)}$$

Where $h_f = \frac{4fLV_1}{2gD_1}$ = head loss due to friction (neglected)

$h_c = \frac{0.5V_2}{2g}$ on of pipe(orifice)

$Z_1 = Z_2$

P1 = Pressure in the cylinder 104kPa

P_2 = Atmospheric pressure =101.3kpa

D_1 = Diameter of pipe (hose) = 12mm=0.012m

D_2 = Diameter of orifice = 0.3mm=0.0003m

A1 = Area of pipe (hose) =A $= \frac{\pi {D_1}^2}{4} = \frac{3.14*(0.012)^2}{4} = 1.13 * 10^{-4}\, m^2$

A_2 = Area of orifice= A $= \frac{\pi {D_1}^2}{4} = \frac{3.14*0.003^2}{4} = 7.07 * 10^{-8} m^2$

ρ = density of kerosene = 810 kg/m^3

V_1 = Velocity of kerosene in the pipe (hose)

V_2 = Velocity of kerosene at the orifice

L = Length of pipe (hose) = 1.0m

g = Acceleration due to gravity = 9.81m/s^2

∴Equation (1) becomes

$$\frac{P_1 - P_2}{\rho} = \frac{V_2 - V_1}{2} + \frac{0.5V_2}{2} \tag{2}$$

$A_1V_1 = A_2V_2;\ V_1 = \frac{A_2V_2}{A_1}$

$V_1 = \frac{{D_2}^2 V_2}{{D_1}^2} = 0.000625V_2$

Substituting the value of V_1 in equation (2)

$$\frac{104kpa - 101.3kpa}{810} = \frac{{V_2}^2 - (0.000625V_2)^2}{2} + \frac{0.5V_2}{2}$$

V_2 = 2.1m/s,

$Q=A_2V_2$

$=7.07*10^{-8}*9.07=0.14x10^{-6}\ m^3/s$

This is the volumetric flow rate of kerosene through the orifice of the burner when the pressure in the cylinder is 104kpa

The mass flow rate of kerosene becomes

$$\dot{m} = \rho * Q = 810\,\frac{\mathrm{kg}}{\mathrm{m}^3} * 0.14 * 10^{-6}\,\frac{\mathrm{m}^3}{\mathrm{s}} = 0.113 * 10^{-3}\,\frac{\mathrm{kg}}{\mathrm{s}}$$

The Frame The frame if made of steel. It has a simple function of carrying the utensil

2.2 Power Calculation

To calculate the power produced in two ways

1. Using the Mass Flow Rate

Higher heating value of kerosene from standard (=46.2MJ/Kg)

Power=heating value of kerosene × mass flow rate of kerosene

=46.2MJ/Kg×0.113×10^3KJ/s

=5.22KJ/s assuming kerosene stoves are 60% efficient

=5.2×0.60=3.12KW which is used for cooking

2. Using Volume Flow Rate

From the experiment one litter of kerosene (0.0001m^3/s)=37.5MJ

But from the calculation the volume flow rate

$Q=0.14\times10^{-6}m^3/s=?$

$= (37.5\times10^{6}\times0.14\times10^{-6})/0.001$

=5.205KJ

Power =Energy/Time

=5.205KJ/S

=5.205KW×0.60

=3.123KW

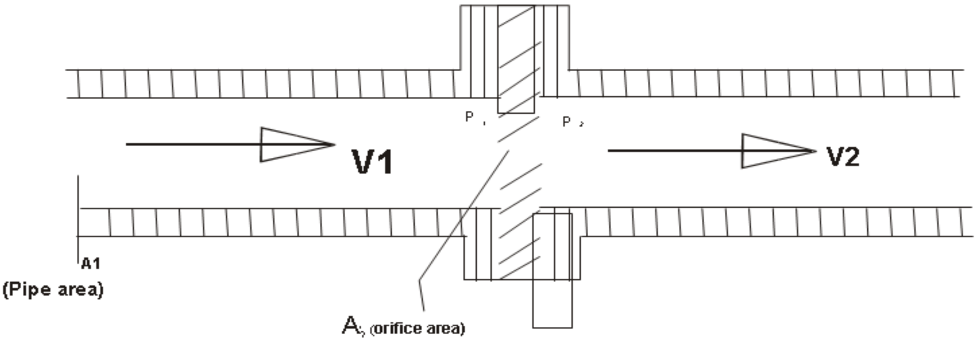


Figure 1: Line Diagram

3. RESULTS AND DISCUSSIONS

Modeling of Kerosene Stove

To model the kerosene pressure stove using ANSYS

Conductivity of clay, k=0.46w/mK

Temperature (T) =3500C

Density=810kg/m3; Diameter of stove=60cm; Thickness = 2mm

Cp=2010J/kg.K

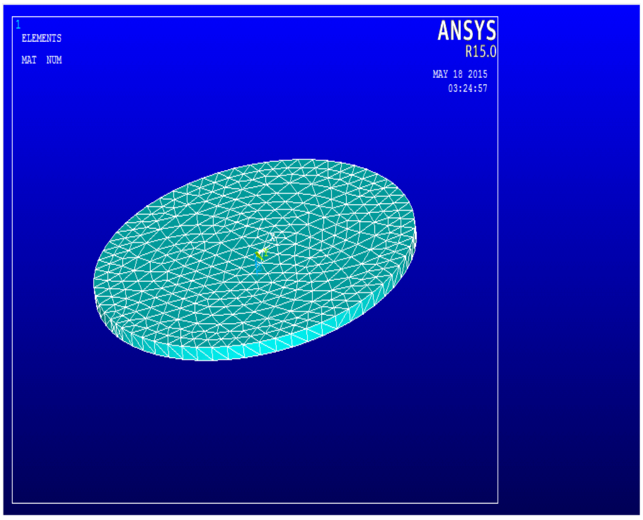
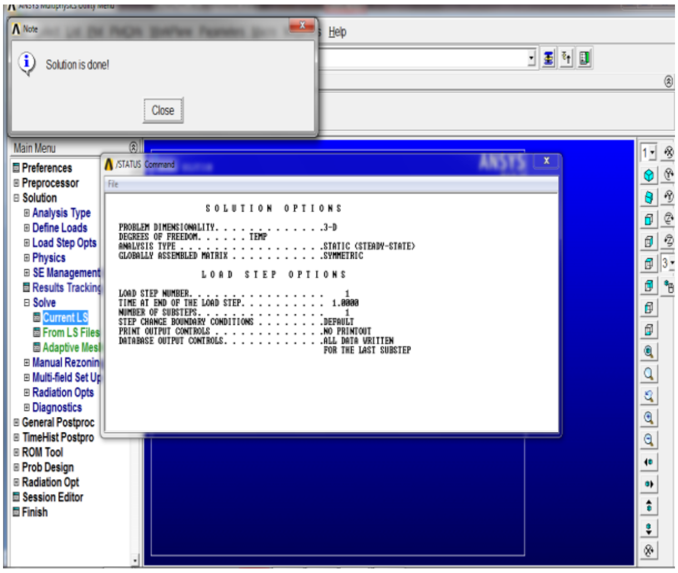


Figure 2: Meshing



Solution is done!

```
                S O L U T I O N   O P T I O N S

 PROBLEM DIMENSIONALITY. . . . . . . . . . . . .3-D
 DEGREES OF FREEDOM. . . . . . TEMP
 ANALYSIS TYPE . . . . . . . . . . . . . . . . .STATIC (STEADY-STATE)
 GLOBALLY ASSEMBLED MATRIX . . . . . . . . . . .SYMMETRIC

               L O A D   S T E P   O P T I O N S

 LOAD STEP NUMBER. . . . . . . . . . . . . . . .    1
 TIME AT END OF THE LOAD STEP. . . . . . . . . .  1.0000
 NUMBER OF SUBSTEPS. . . . . . . . . . . . . . .    1
 STEP CHANGE BOUNDARY CONDITIONS . . . . . . . .DEFAULT
 PRINT OUTPUT CONTROLS . . . . . . . . . . . . .NO PRINTOUT
 DATABASE OUTPUT CONTROLS. . . . . . . . . . . .ALL DATA WRITTEN
                                                 FOR THE LAST SUBSTEP
```

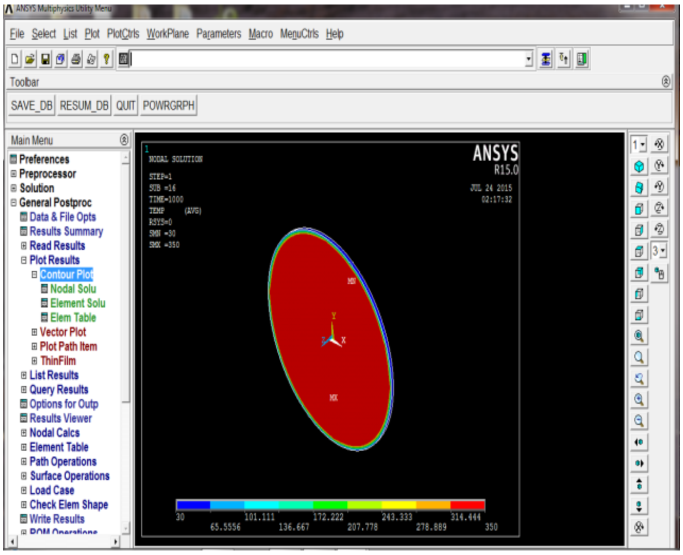
Figure 3: Solution Result

The volumetric flow rate, Q, obtained showed that the maximum quantity of kerosene that will be discharged and burnt every second, if the pressure in the cylinder is maintained at 104kPa, is $0.14\text{x}10^{-6}\text{m}^3$.

The amount of kerosene discharged at the orifice of the burner can be regulated by altering the pressure head across the pipe (hose) with the help of a control valve, (knob) fitted before the orifice of the burner.

$$\mathbf{P = \frac{ENERGY}{TIME} = 3.12KW}$$

Temperature Gradient along the Thickness

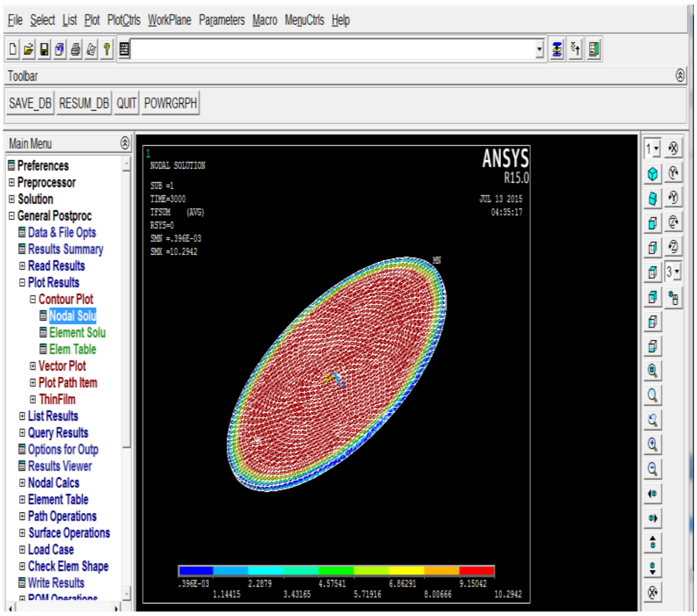


```
1
NODAL SOLUTION

STEP=1
SUB =16
TIME=1000
TEMP     (AVG)
RSYS=0
SMN =30
SMX =350
```

```
JUL 24 2015
02:17:32
```

Figure 4: Temperature Gradient



```
1
NODAL SOLUTION

SUB =1
TIME=3000
TFSUM    (AVG)
RSYS=0
SMN =.396E-03
SMX =10.2942
```

```
JUL 13 2015
04:35:17
```

Figure 5: Heat Flow along the Thickness

It is known that whenever 1 litter (0.001m3) of kerosene is burnt completely, it gives out 38.2MJ of heat energy, consequently, from calculations: 0.14x10^{-6} m^{3}/s will give out 3.12 KJ of heat energy per second thus, the power of the cooker becomes.

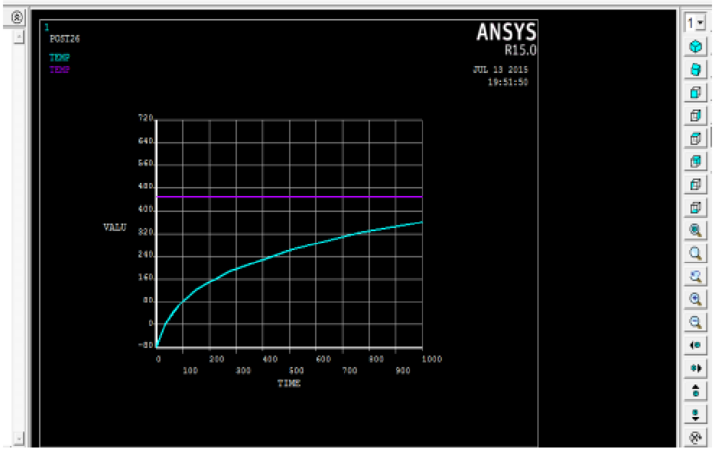


Figure 6: Temperature vs Heat Flow

4. CONCLUSIONS

This design was carried out in recognition of the present problems experienced by many Ethiopians due to irregular supply of electricity and the persistent scarcity of petroleum products. Also, the environmental and health hazards associated with firewood cooking were also taken into cognizance.

The various problems associated with the conventional kerosene stove were also highlighted, and this design is meant to overcome these problems especially the problem of sooty flame.

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