PRACTICAL ACTION

FINAL REPORT ON DEVELOPING LAMP FOR BIO RAW OIL

CONSULTANCY PROJECT ON BIO FUEL APPLICATIONS

Presented By:

S.R. Fernando
L.P.K. Vithanage

ABSTRACT

Energy is a basic need for mankind and is has been supplied through fossil fuels. Due to increase of crude oil prices, cost of energy has created a crisis today. In the exploring of alternatives, bio fuels have huge potential.

Therefore as engineers, it is a great opportunity to find solutions for problem that essential for the whole world. The consultancy projects we are carried with Practical Action (former Intermediate Technology Development Group), a nonprofit organization trying their best to find solutions for domestic energy requirement.

This report contains the entire process of developing a Lamp for Bio Raw Oil. The first chapter of this report gives an introduction about the project and how it was proceed with. We have done a literature survey to find the experiments that have been done similarly in the world which is explain in 2^{nd} chapter. In the 3^{rd}, the experiment and tests which are carried out is explained in detail. In the 4^{th} chapter gives force gravity testing results and final design.Also the conclusions we took at end of each experiment and how we decide our next step is described. Based on those testing's, how we proceed to change our design and other relevant details are explained. At the final, conclusions and our recommendations are elaborate.

ACKNOWLEDGEMENT

It was a golden opportunity for us to do such projects as fresh graduates. It has provided me a lot of knowledge on energy section. I'm very grateful to offer my heartfelt appreciation to the staff of Practical Action who has been kind enough to give me a proper guidance, share their knowledge and experiences & assist me in various way.
Here I would like to give my humble thank goes to the following officials help me a lot throughout this Projects.

- ***Dr Vishaka*** **,** Country director of Practical Action
- ***Mr.Upali Pannilage,*** Team Leader of Practical Action
- ***Mr.Rohitha Ananda,*** Project Manager of Practical Action
- ***Mr.Gihan Sajeew,*** Project officer of Practical Action
- ***Mr.Nameez Musafer*** **,** Project Manager of PA
- All Staff members of the Practical Action

Fernando S.R.
Vithanaage L.P.K.
Faculty of Engineering
University of Ruhuna

CHAPTER 1

1.0 INTRODUCTION

Increasing fuel cost has created an energy crisis in the world, so researches are more concern for find alternative fuel that can replace the crude oil. High fuel cost has made huge impact countries like Sri Lanka as their economy is based on crude oil. Around 60% of today electricity demand has been produced by Diesel power plants which limit extension of national electricity grid. Today national grid serves only 80% of country and rest uses Kerosene as major source for lighting.

The **aim** of this project is to develop a lamp that uses raw oil of Jatropha, Caster and Neem as the fuel. The **goal** of this is to develop a low cost lamp to the people in the rural areas where the electricity network couldn't be covered with in near future. This will be a huge help for people use Kerosene for lighting due to low cost and availability. Although the project is been mainly targeted the people of rural areas, it also acts as a stand by lamp during a power failure in other areas.

Different kinds of researches have been done in different countries to investigate the possibility to use edible and non-edible oils as fuels in lamps. Many of the researches have been successful for vegetable oils, but for oils like Jatropha, Caster and Neem successfulness is little bit doubtful.

In the process we have done a literature survey to find out what are the researches have been done related to this. Then we did experiments on capillary force, oil rise height for different raw oils, their buning properties, bio diesel properties, raw oil mix with kerosene and their performances, etc. after all these testing's we understood that raw oil can't be use for normal lamps. So our designing stage was started and realizes oil should be forced that it to be push towards the burning area. For this we had two solutions, either to use force draft or gravity force. At last we went for gravity force and then think about the safety, compactness, aesthetic and durable model.

In the final model we thought about how to adjust the flame, reflector to guide the light where we need, user friendliness, increase the intensity of light where it better than kerosene lamp and keep the soot level at minimum.

What is Jatropha?

Jatropha is a perennial shrub suited to tropical and sub-tropical climates with 50 years life span. Also it is an indigenous plant that produces wild castor beans (figure 1) and these beans contain viscous, non-edible oil, which can be used for the production of high quality soap, as a raw material for cosmetic products, as fuel for cooking and lighting and as a substitute for diesel fuel.

Jatropha starts bearing seeds after 2 years of planting. Seeds (with shell) have an oil content of 32% - 35%. About 3 kgs of seeds give 1 kg of oil. 1.05 kg of oil is required to produce 1 kg of bio-diesel.

Figure 1.1: Jatropha Fruit

Thus, the Jatropha system promotes four main aspects of development, which combine to help assure a sustainable way of life for village farmers and the land that supports them:

- Renewable energy.
- Erosion control and soil improvement.
- Poverty reduction.

The chemical analysis of Jatropha curcas oil is given in **Table 1**.

Table 1 : Chemical analysis of Jatropha curcas oil

ITEM	VALUE
Acid value	38.2
Saponification value	195.0
Iodine value	101.7
Viscosity (31°C) "Fatty acid"	40.4
Palmitic acid %	4.2
Stearic acid %	6.9
Oleic acid %	43.1
Linoleic acid %	34.3
Other acids %	1.4

Advantages of Jatropha oil

- Can be extracted through traditional expellers
- Recovery percentage will be 32 -38%
- Traditional cotton filter can be used before its use in pumping sets & tractors
- Higher flash point leads to its easier transportation, handling & storage
- Lower carbon percentage leads to smokeless exhausts in engines
- In normal conditions average consumption of jatropha oil is around 80% of diesel
- Direct use of jatropha oil in engines for agricultural purposes

CHAPTER 2

2.0 LITERATURE REVIEW

In several countries including Sri Lanka researches have been done to find out the possibility of using vegetable oil and Jatropha oil for lamps. Researches on vegetable oil have successful due to low density. But they have low potential as they are edible oil which can use as food. So huge potential is there to develop lamps for oils like Jatropha, but main discouraging factor is their high density. Also there is no report of a research on **Raw Oil** for lamp or cook stove. So I think the major factor is the very high viscosity of the raw oil.

2.1 Vegetable Oils as Fuels for Jikos and Lamps

(by Erwin Protzen, November 1997)

Some simple basic research has been conducted on burning vegetable oils using standard textile wicks. This research has been done on one hand, to find a substitute for Jatropha oil that would allow work to continue despite its scarcity, and on the other to get an understanding of vegetable oils as fuel. The cheap standard jikos and lamps, available in Tanzanian shops, all have wicks.

Experiments were done with oils from the following plants in addition to Jatropha:

- Sunflower
- Safflower
- Sesame
- Macademia
- Mexican Poppy
- Wild Borage

The findings can be summarized as follows:

- Vegetable oil is hardly transported by a wick alone. When lit, the flame needs to be very close to the oil. The shallow oil lamps of the ancient Greeks and Etrurians respected this principle.
- By placing a wick into a loosely fitting tube, transport properties are improved considerably. Standard round and flat wicks (∅ ¼", flat ½") placed in a loosely fitting tube will comfortably transport oil 4cm upwards to allow for a satisfactory adjustable flame at the top. At 6cm, transport is insufficient, to an extent that a flame cannot be sustained.
- Because of the bad transport properties of a standard textile wick, it needs, when new, to be soaked in oil for at least half an hour prior to being lit up.
- In use with vegetable oils, wicks coke up quite quickly. They form coke in the burning zone which prevents satisfactory combustion. The time taken for a wick in a tube to coke up depends on the fuel (for a ∅ ¼" wick: sunflower oil: 2 hours, wild borage, sesame, safflower and jatropha oil: 4 hours, macademia oil: 6 hours).
- It takes longer for a wick to coke up if the tube into which it is placed is wrapped with overlapping edges (wild borage, sesame, safflower and jatropha oil: 6 hours). Possibly oil transported by capillary force in the gap between the overlapping edges prolongs the life of the portion of wick in the burning zone.
- Performance improves the thicker the wick is (a tube ∅ ¼" wick in sunflower oil cokes up in 2 hours, whereas a ∅ ½" wick cokes up in 4 hours).
- The removal of coke is not difficult; it is simply knocked off the top of wick (even while it is still burning).
- The brightness of a flame on a given wick and a given setting is about the same for vegetable oil and kerosene.

- The fuel consumption for a given wick and a given setting is about the same for vegetable oil and kerosene.
- An open vegetable oil flame does not put up to wind as well as an open kerosene flame.
- A good vegetable oil for a jiko is not necessarily a good oil for a lamp.

Experiments have been conducted primarily with a very simple lamp. A Ø ¼" copper tube is cut to the length of a small glass and a Ø ¼" wick is fed into it.

The tube with the wick in it is placed into the glass which is filled with oil. Incidentally this lamp is simpler than the kerosene "kibatari". Since vegetable oil does not readily ignite, the reservoir (glass) does not need a cover. The tube with the wick simply stands in an open container with oil.

Originally it was thought that all findings made with the lamp can be transferred automatically to the jiko. This is not absolutely the case, so oils have had to be tried again in the "Butterfly" jiko once it had been modified for use with vegetable oil rather than kerosene.

Oil	Performance in Jiko	Performance in Lamp
	(Modified Butterfly)	(Ø ¼"copper tube with Ø ¼" wick dipped in oil)
Jatropha	Burns 2 hrs, smokeless	Burns 4 hrs
Wild Borage	Burns 2 hrs,	Burns 4 hrs

	smokeless	
Mexican Poppy	**?**	**Burns 2 hrs**
Sunflower	**Burns ¾hrs, smoke**	**Burns 2 hrs**
Safflower	**Burns 2 hrs, smoke**	**Burns 4 hrs**
Sesame	**Burns 2 hrs, smoke**	**Burns 4 hrs**
Macademia	**?**	**Burns 6 hrs**

2.2 Jatropha Oil and Kerosene use as fuel

By Prof. (Dr.) P.K.Bose and his other members in University of Jadavpur, India have done a research on mixing kerosene to jatropha oil to reduce viscosity and find out the best mixing blend and their conclusion is as follows.

Conclusion:

Hence we recommend that for a conventional lamp the optimum blend can be made by using 80-85% kerosene with Jatropha oil by volume basis to serve the purpose of rural requirement without any modification of the lamps for household and domestic application.

The present day applications for lighting in rural areas involve large consumption of kerosene oil. It is envisaged that with the development of blended kerosene and jatropha fuel (by mixing 80%-85% of kerosene and 20-25% jatropha oil on volume basis) shall result in considerable saving of kerosene oil in India.

Even the **raw Jatropha oil** can be used in the rural areas for illumination purpose in the "Diwali Pradeep" like form of lamps.

2.3 Lamps developed for Jatropha Oil

Lamp	Description
	First version of a very simple oil lamp from **Binga Trees Project**, at the Lake Kariba in Zimbabwe The interesting invention of the "Binga lamp" is the floating wick. It avoids the negatzve effect of the low capillary effect of the oil, because the flame burns only some mm above the surface of the oil. And if the oil is used, the wick follows its level.
	This is a test modification of an ordinary petrol lamp to be run with Jatropha oil. The tests were carried out by Erwin Protzen: On the Development of a **Prototype** Jatropha-Oil fueled Jiko and a Jatropha-Oil fueled Lamp
	In light of this and ever worsening scenario, Lantern is the only **Hope of Light** for Rural **India**. Though the lumen output of these lanterns is 10 to 20% of Electric Lamps, these can spread light in the life of people in rural India. Use of the Crude Jatropha Oil as fuel for these lanterns is more pressing than the use of it for manufacture of Biodiesel. Farmers can grow and process the seeds locally, and they can use it locally.

2.4 Jatropha projects in other countries.

Jatropha Projects been carried out in considerably high no of countries, and most of them are third world countries and following table provides few countries and their projects regarding Jatropha.

Country	Organization	Description	Time
India	KfW/AFF/NGOs	Within the frame of a big watershed development project, financed by the German development bank KfW, Jatropha was integrated into the reforestation activities. The Agro Forestry Federation took over Jatropha activities and is launching their proper projects now.	
Nepal	FAKT	FAKT, the cooperation organization of the German protestant church, finances the introduction fuel production out of Jatropha seeds, since Jatropha hedges play a big role in fencing the fields and gardens against browsing animals.	
Nicaragua	Sucher & Holzer	The Austrian Agency for Cooperation finances a big project in Nicaragua to produce plant oil methyl ester as fuel in an industrial scale. More than 1.000 ha of	since 1990

		Jatropha plantations have been already planted.	
Sénégal	ATI	ATI initiated a small Jatropha project in Senegal, were women collect the seeds of Jatropha hedges to produce oil with the Bielenberg Ram Press. This oil will be used as fuel for their flower mills or as a raw material for soap production.	since 1996
Sudan	DED	In Northern Darfur Province, in the KAEDS / IFSP project Kutum of the German Development Service, Jatropha activities have started in 2001.	since 2001

CHAPTER 3

3.0 PLIMINARY TESTS

Introduction

This chapter elaborates the testing results of the Bio Diesel and Bio Raw oil with comparing kerosene. Basically here we will provide the testing results that we have carried out to identify the properties of Bio Diesel and Bio Raw oil when it is used as a fuel for lamp. The experimental results of these testing will help for out future recommendations, design approaches and decision making in the project. In first place we have tested conventional lamps using in the villages and experiment them with the mixture of kerosene and raw oil with different blends.

3.1 Measuring the oil rise height and their burning properties

Our fist task is to measure the oil rise due to capillary force before lighting for different fuels. This will help to get an idea of fuel supply to flames during the burning. Then burning process was analyzed to compare the properties.

This height has been measured for five minute time intervals for easy comparison. In the testing we have used kerosene lamp.

Time duration - 5 minutes

Type of fuels	Height
Jatropha	3.7 cm
Kerosene	20 cm

According to this experiment there is huge difference in oil rising height. This is because the very high density of the fuel, so oil rising height is less.

3.2 Raw Oil Burning Properties

At the start

After 15 minutes

After 30 minutes

Figure 3.1: Burring of Kerosene & Jatropha

	Jatropha	Kerosene
Burning time	15 min	continuous Burning
Flame height	less than kerosene	6 cm
Soot level	less	high
Flame brightness	High	Less

The Binga lamp has been uses by certain countries such as Zimbabwe and Kenya; they have proved that it can be effectively used for any kind of raw oils. But our first testing on Binga lamp failed because it burnt out only for 30 minutes.

However, Binga lamp supposes to be a good solution due to its technology. In it, wick is floated on the oil surface and it will make burring position as close as possible to oil surface. Therefore it has two distinct advantages,

- No need of high capillary force to oil to be rise.
- As burning is closure to oil surface, it will pre heat.

Even though it is successful, is very unsafe model of lamp.

3.3 Jatropha raw oil & Kerosene mixture testing for height measurement.

Figure 3.2: Measure of oil rise height

Time duration - 5 minutes

Jatropha Percentage	Height
20%	10 cm
40%	7 cm
60%	6 cm
80%	5 cm
100%	3.7 cm

3.3 Mixture Burning Properties

The wick size of each specimen kept as half inch and oil height is same in every lamp

Jatropha & Kerosene mixture after few minutes

Figure 3.3: Burning at different mixtures

Jatropha Percentage	**Lighting time(min)**
20%	11(Wick is tight, So oil does not rise and have to be repeated)
40%	23
60%	15
80%	10
100%	10 (have to be repeated)

3.4 Mixture of Neem raw oil & Kerosene (50%)

Time duration - 5 min
Oil rise - 8 cm

Burning properties

Burning time	continuous Burning
Flame height	Kerosene > Mixture (50% Neem) > Neem or Caster
Soot level	no soot visible

3.5 Bio Diesel

Time duration - 5 minutes

Type of fuels	**Height (cm)**
Kerosene	20
Diesel	7.5
Neem	6
Caster	4.7
Coconut oil(Raw oil)	4.5

Burning properties

Type of fuels	**Burning time**	**Soot level**
Kerosene	Continuous	High
Diesel	Continuous	High
Neem	6 min	Not visible
Caster	4 min	Not visible
Coconut oil(Raw oil)	3 min	Not visible

3.6 Clay lamp testing

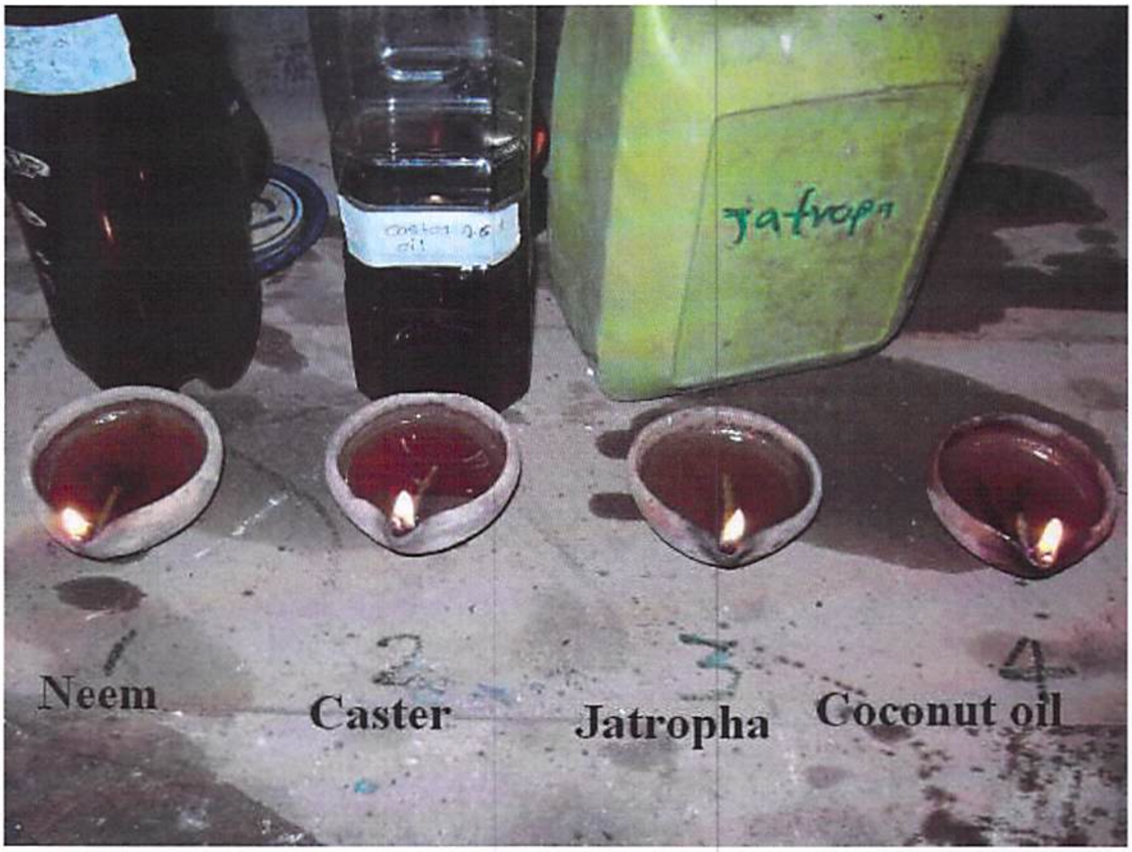


Figure 3.4: Clay lamp test

Jatropna & caster are burning along the wick and the flame tends to get smaller and smaller. But neem is good as coconut oil.

3.61 Raw oil

	Neem	**Caster**	**Jatropha**	**Coconut**
Flame height	same	same	same	same
Smoke	Not visible	Not visible	Not visible	Not visible
Burning time	Continuous burning	Continuous burning	30 min	Continuous burning
Special comments		Burn along the wick	Burn along the wick	

3.62 Bio diesel

	Neem	**Caster**	**Coconut raw oil**
Flame height	Highest	High	less
Smoke	Not visible	Not visible	Not visible
Burning time	Continuous burning	Continuous burning	Continuous burning

3.7 Summery on tests

- Capillary force is low in raw oil due to high density.
- So can't use in conventional method of lamps.
- "Binga" lamp is a possible option but safety is not enough.
- Kerosene (80%) & Oil (20%) mixture is successful for existing lamps. So any kind of conventional lamp is can light up with 80/20 mixture as normal.
- Intensity of the flame should be measured with "Lux-Meter".
- After little time un-burn carbon collects on the wick and it will disturbed the oil rising. So oil amount that dragged for burning tend to be reduce and **wick is burnt out** due to not enough oil to be burn. This was the major issue we come across in these tests.

4.0 FORCED GRAVITY MODEL

As conventional methods are not suitable, we have tried new method to over come those difficulties. Here gravity force is used to push the oil to flame, so need of capillary force. As oil container is kept above the flame surface, oil is pushed towards down side, it means to flame. So, less capillary force problem can be solved by this way.

The next step is to find maximum and minimum level differences between container and flame. This is heavily depending on the viscosity of the fluid. So, numbers of tests are carried out to measure those and the type of oils as follows,

- Caster
- Neem
- Jatropha
- Coconut oil

4.1 Gravity Model Tests

Objective of testing is to find out the level difference of oil surface and the flame where burning is continued without any disturbance. Maximum level difference has been taken when the oil is started to spill out.

Observations

- Testing was successful.
- Required oil for burning is supplied by gravity force.
- When oil level is varying, height of the flame vary.
- Soot level is varying with oil level.
- Some amount of carbon is collected.
- Wick is not burn out as previous.

In our testing's we observe that flame height and soot level is depend on the oil level difference. So it is a parameter to control the flame. Also we observe that, time to time we have to adjust the level difference when oil level changes due to burning. We can over come that if increase the diameter of the oil container.

Results

Type of Fuel	Level difference (cm)
Neem	5-9
Caster	3-5
Jatropha	1-3
Coconut	4-8

4.2 Modifications of the Model

As our experiment was successful, the model should be developed as a final product. In that we have to consider this lamp should be user friendly and any type of oil can be used. Therefore we have to analyze the level difference of each oil and determine optimum point for each. The material for wick is important when commercialize the product. So we use available common type of wick for the design. However the product should be cheap, attractive and aesthetic at the end.

For our modified design we thought to have following **added features** when compared with normal lamps.

- Any type of oil or raw oil can be used as fuel.
- Simple in design and durable.
- Eliminate were and tare parts.
- Aesthetic and compact.
- User friendliness.

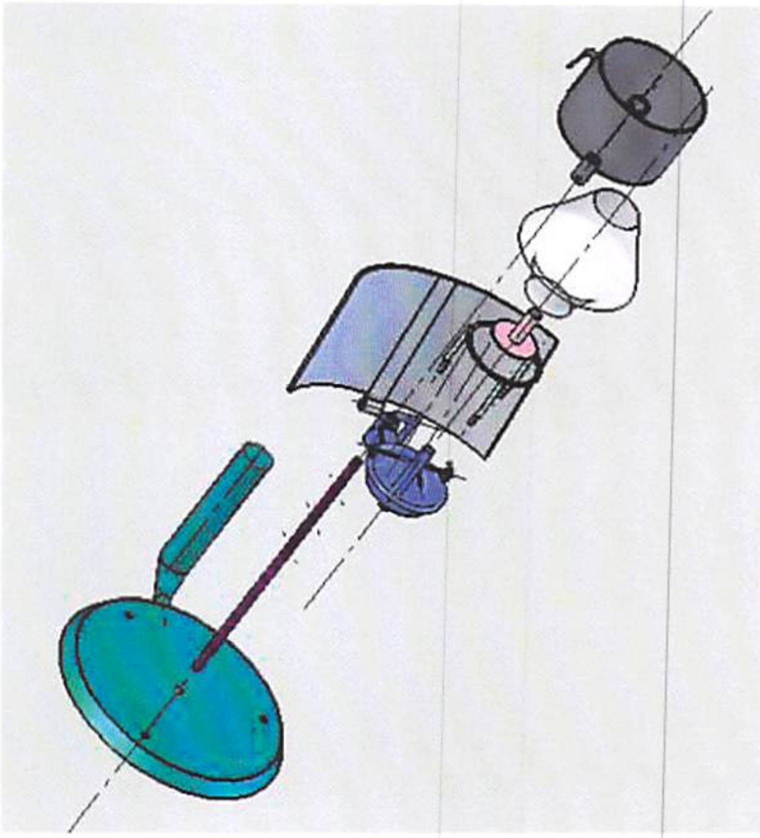
- Ability to control the flame.
- Ability to focus the light.

4.3 List of Components

- Base plate & rod -
- Oil container with top cover.
- Tap.
- Oil plate and wick holder.
- Flame controller.
- Chimney & chimney holder.
- Reflector.

Component	Purpose
Base plate & rod -	• Base plate will control the balance of the lamp. So it has built with heavy metals. • Rod helps to both container & oil plate to move up & down and hold them.
Oil container with top cover.	• Oil is kept in the container and bush at the back side help to move along the rod.
Tap.	• The flow of oil can be either stop or on by this.
Oil plate and wick holder.	• Oil plate fixes those items to rod and move along it. • At the middle, wick holding tube is fixed to oil plate and other components are kept on it.
Flame controller.	• This device is used to control the flame height, so the intensity can be changed.
Chimney & chimney holder.	• These two are kept on the oil plate. • Chimney will increase the effectiveness of the light and protect from disturbance of the wind.
Reflector.	• This will help to focus the light where we want.

4.2 Final Design



In this design we have used special features like Oil container in which the position of the oil container can be varied to alter oil level different, Chimney to improve lighting effect, flame controller to control flame height.

5.0 Conclusions

I. New design work successfully. Oil container position should be changed for different types of oil according to their viscosity.
II. Soot level is varying with the oil level difference. But in normal level difference when we compare the soot level of each, Kerosene has little bit high soot level compared to raw oils.
III. Flame height of kerosene is higher than raw oils and in comparison or brightness there is no significant difference in them.