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Development Of Improved Lanterns For Rural Areas

Anil K. Rajvanshi and Sudhir Kumar

Nimbkar Agricultural Research Institute (NARI),
Phaltan 415 523 Maharashtra, (India).

ABSTRACT

An improved kerosene lantern called "Noorie" has been designed and developed. It is a pressurised mantle lantern. It produces light output of 1250-1300 lumens (equivalent to that from a 100 W light bulb). The lantern is a multifuel one, which can also run on ethyl alcohol, producing similar light output. It is superior to the existing pressurised kerosene lantern ("Petromax") available in the market. It produces light output equivalent to that from Petromax lamps but with only 60% of the kerosene consumption and about one-third the pressure used in them. Besides providing light, Noorie lantern also doubles up as a cooking device. It is estimated that the lantern will cost Rs. 125. Details of its development and test results are outlined below.

I. THE PROBLEM

Around 80% of the rural households in India (80 million) use only hurricane kerosene lanterns for lighting. With unreliable electricity supply, even the remaining 20% of the households use kerosene lighting occasionally. There are guesstimates that close to 100 million such lanterns exist in the country.

Despite the proud claim by the Government that majority of states have 100% of their villages electrified, the sad fact still remains that in these villages only 15-20% of the households have electricity. With past dismal record of State Electricity Boards and a shortfall of 10,000 MW generating capacity in the 7th National Plan, it is safe to assume that kerosene lantern will continue to play a very important role in rural lighting well into the 21st century.

Thus, around 60% of the total kerosene consumption (3.6 million tonnes/year) in the country is used for lighting purposes. Out of this, 51% is in rural areas alone. India imports about Rs.13,000 million worth of kerosene every year and there are estimates that by the year 2000 A.D. this number may increase rather than decrease.

Even after paying such a heavy price, the quality of light from the hurricane lantern is abysmal. It produces light from the glow of a yellow flame, which is equivalent to about one-tenth of that from a 60 W light bulb. There is another type of lantern called "Petromax" used in the country. This is a pressurised lantern where the incandescence of a rare earth mantle produces the light. Table 1 gives the comparison of these lighting devices. It is therefore evident that there is a need to develop a lantern which is very efficient, safe, convenient to use, cheap and which gives light equivalent to that from a 100 W bulb. Besides, the new lantern should also run on alternative fuels like ethanol, which can be a renewable replacement for kerosene as a lighting fuel.

Table 1: Comparison of Existing Kerosene Lanterns

Lantern	Initial cost Rs	Light output lumens (lm)	Advantages	Disadvantages
Hurricane	36	65-70 (Equivalent to few candles)	Cheap, simple to light; handy; portable; can withstand 40 kmph wind.	Very poor light output; problems of charring of wick and necessity of trimming and cleaning it; frequent glass breakage; poor construction.
Petromax	250-300	1300	Good light output; portable; sturdy construction.	Costly; heavy and tall; frequent breaking of mantles because of poor construction; difficult to light and requires alcohol to initiate lighting; tank pressure of 1.5-2 kg/cm^2(g) and hence prone to tank bursting; noisy; frequent cleaning of nozzle required thereby increasing inconvenience; frequent pumping (almost every half hour) required.

II. THE SOLUTION

A new and efficient lantern running either on kerosene or ethanol has been developed and tested. It has been christened "Noorie".

It is a pressurised mantle lantern. It produces light by heating thermoluminescent mantles to temperatures in excess of 1000°C. Such pressurised lanterns (Petromax type) work on the principle of evaporation of kerosene in a preheated fuel tube, mixing of this kerosene vapour (kerogas) with air and the mixture being combusted to produce high flame temperatures. The kerogas ensues from a fine nozzle and the air-fuel mixing is effected near it. The kerogas flame heats the mantle which produces light and subsequently provides the heat to the fuel tube for further kerogas formation. Figure 1 shows the Noorie lanterns.

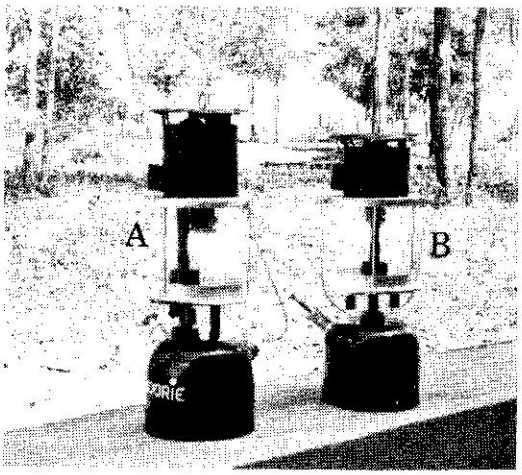

Fig. 1: Noorie Lanterns A) Kerosene B) Alcohol

In designing and developing this lantern, the main considerations were:

1. The fuel consumption should be lower than that in the existing Petromax lantern.
2. It should produce light equivalent to that from a 100 W light bulb and that its efficiency should be higher than that of Petromax.
3. It should be very easy to light. In the existing Petromax lantern, the lighting arrangement requires alcohol fuel. Since most consumers do not have access to alcohol fuel, they light the lantern by heating the fuel tube by rags dipped in kerosene which makes the glass chimney extremely dirty thereby reducing the light output considerably. This also necessitates frequent removal of glass chimney for cleaning, which leads to more frequent damage to mantle.
4. It should give an indication to the user when to start pressurising the lantern. In Petromax lantern there is no way of knowing when the fuel tube is heated up. Thus many a times the lantern is pressurised prematurely, which results in liquid kerosene jet coming out of nozzle. This excess kerosene produces extremely sooty flame thereby making the mantle black and sooty and glass chimney dirty.
5. It should run on low tank pressures [of the order of 0.3-0.5 kg/cm^2 (g)]. Existing Petromax lanterns run on 1.5-2 kg/cm^2 (g) pressures, thereby increasing the hazard of fuel tank bursting.
6. It should have a self-cleaning mechanism of the nozzle. In the Petromax lantern, the cleaning of nozzle is by a fine pin supported by an elaborate cam mechanism. This cam mechanism increases the cost of the lantern and also provides a place from where the high pressure kerogas can leak.
7. It should be easily affordable and very convenient to use. It should also be small and light in weight.
8. It should be able to run on renewable fuels like ethanol.

All the above problems were solved by designing a completely new lantern*. The main components of the design were:

a) Proper air-fuel mixing arrangement.

b) Ability for self-cleaning of the nozzle.

c) Optimum fuel tube sizing for better heat transfer.

d) Extremely simple and convenient initial lighting arrangement.

e) Use of lightweight and sturdy materials of construction.

III. TEST RESULTS

1. **Light output:** Light output measurements on Noorie kerosene and alcohol lanterns were conducted with the help of a standard Luxmeter and a Brodhum Photometer. All the photometric measurements were carried out relative to a calibrated 100 W light bulb.

   The results of these tests are shown in Table 2.

   The assumptions made in this are:

   a) Total cost of getting an electric connection for two points together with wiring is Rs. 400.

   b) Electricity cost is Re. 1/KWhr.

   c) Number of bulbs fusing are 4/yr with cost of each bulb being Rs. 7.

   d) Fluorescent tube fixtures cost Rs. 125 each.

   e) Noorie kerosene and alcohol lanterns are priced at Rs. 125 each.

* Patent pending.

Table 2: Comparison of Various Light Sources

Light source (fuel)	Light output lumens (lm)	Fuel consumption	Efficacy (lm/W)	Initial cost (Rs)	Light output/unit cost (lm/Rs/day)
100 W incand-escent bulb (electricity)	1340	100 W	13.4	400	2436
Noorie (kerosene)	1253	41 gms/hr (494.5 W)	2.53	125	2278
Noorie (alcohol)	1270	65 gms/hr of 93% (v/v) (450 W)	2.82	125	1206
Hurricane (kerosene)	68	16 gms/hr (193 W)	0.35	36	440
Petromax (kerosene)	1300	65 gms/hr (784 W)	1.66	250	1480
Fluorescent tube, 40 W (electricity)	2400	40 W	60.00	650	8856

f) Kerosene cost is Rs. 2.30/l.

g) Alcohol cost is Rs. 3/l for 95% (v/v) alcohol.

h) Cost of mantle replacement and minor repairs is Rs. 2/month.

i) Thermoluminescent mantle life is 100 hours.

j) Interest rate is 12% p.a.

k) Lighting is to be provided for 4 hours/day.

It is easily seen from the Table that Noorie kerosene lantern is nearly as cost effective as a 100 W light bulb. Besides it is 1.5 times more efficient than the existing Petromax lantern. From Table 2 it is also evident that fluorescent lighting is the most efficient and cost effective. However, where there is no electricity, Noorie lanterns can provide excellent lighting.

The Noorie alcohol lantern can run on alcohol concentrations of 80% (v/v) and above. From the table it is also clear that its efficacy is highest among all the liquid fuel lamps. With cheap and easily available alcohol it can provide a very cost effective lighting. It is envisaged that kerosene will be replaced by alcohol (a renewable fuel). Besides, alcohol is a very clean fuel and burns without soot and hence absolutely no cleaning of nozzle is required. Complete development of technology for producing alcohol from sweet sorghum using solar energy for distillation has been developed at NARI [Publication No. NARI-ALC-1 (1989)]. A 5000 litres/day (lpd) mini distillery will supply all the lighting energy requirements for 9000 families, with a provision of having two Noorie lanterns per household running for 4 hours/day. Calculations show that use of alcohol instead of kerosene for lighting will also save the country about Rs. 15,000-20,000 million in foreign exchange, by 2000 A.D.

2. **Cooking tests:** Noorie lantern also doubles up as a cooking stove. By removing the top cover and placing a utensil over the chimney, cooking is effected by flue gases. The heat of flue gases is completely wasted in Petromax lanterns. Tests conducted show that 0.4 l of water in a covered pot is boiled in 25 minutes. Also 100 gms of rice and 100 gms of dal can be cooked easily in 25 and 60 minutes respectively. The flue gas temperatures are about 500°C and the boiling-water efficiency is 18-20%.

3. **Size of Noorie lanterns:** The Noorie kerosene lantern is 35 cm tall and weighs 1.5 kg, while Noorie alcohol lantern is 33 cm tall and also weighs 1.5 kg. However, the Petromax is 40 cm tall and weighs 2.1 kg. The tank in Noorie lantern holds 500 gms kerosene which lasts for nearly three days at 4 hours/day use.

4. **Overall lighting efficacy:** Comparison of overall efficacy of a light bulb and that of kerosene/alcohol

mantle light reveals interesting results. The overall **power plant-to-light** efficacy of a vacuum electric light bulb (100 W) is 3.75 lm/W. This includes power plant efficiency of 35%, power transmission efficiency of 80% and lamp efficacy of 13.4 lm/W. The existing Noorie kerosene and alcohol lanterns have efficacies of 2.53 and 2.82 lm/W respectively. With better thermoluminescent materials, the liquid fuel lamps can have efficacies surpassing those of the electric bulbs. Hence, efficiencies of liquid fuel lighting will be at par or even exceed those of electric lighting.

5. **Cost of Noorie lantern:** Costing analysis reveals that Noorie lantern will cost Rs. 125.

IV. ONGOING RESEARCH AND DEVELOPMENT

Development of Noorie lantern is the first step in improving lighting for rural India. Efforts are underway for manufacturing it on a large scale. However, in any new product development, a continuous process of R&D takes place. Consequently, the following is being proposed or is underway.

1. **Mantle material:** Present mantle life of 100 hours should be increased by at least 5 to 6 times. Hence high temperature-stable materials with a low thermal mass like ceramic cloth are being investigated as substrates for thermoluminescent salts.
2. **Use of cheaper and better materials** of construction are being explored. These materials should be non-corrosive, long lasting and lightweight. Besides, the materials used in pump and non-return valve in the present lanterns deteriorate quite rapidly. Neoprene gaskets and teflon materials are being explored for this purpose.
3. Preliminary results indicate that it is possible to have an efficient **alcohol lantern which will be non-pressurised**. Efforts are underway to develop it further.
4. **New thermoluminescent salts:** Efforts are also underway to identify new materials which will produce light at lower flame temperatures (<1000°C). This will increase the efficiency of lighting since it will work at even lower pressures and hence will result in low fuel consumption.

V. CONCLUSIONS AND RECOMMENDATIONS

An extremely efficient and cost effective lantern called Noorie has been developed for rural areas. It is a multifuel one and can run either on kerosene or ethyl alcohol. However, in order for it to make a substantial contribution towards rural lighting, the following are recommended.

1. Use of improved lanterns should be encouraged and liberal tax laws should be enacted for their large scale production and deployment.
2. Alcohol production should be increased and excise laws liberalised so that it is easily available for lighting purposes. Replacement of kerosene by alcohol will save the country about Rs. 20,000 million in foreign exchange by 2000 A.D.
3. As a national plan, a norm of provision of two improved lanterns per household should be established. This should form a part of minimum needs program in IRDP schemes.

Finally it should be pointed out that a national program which envisages giving a minimum of two lanterns per household, will cause kerosene consumption to increase. However, the social benefits and in turn economic benefits to the rural households by better light far outweigh the concerns of increased kerosene consumption, especially when the choice is between excellent light and complete darkness. The subject of rural lighting therefore should be approached from this point of view.

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For further information on this technology, please contact Dr. A.K. Rajvanshi, Director at the above address.

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