THE POTENTIAL FOR ALCOHOL AS A FUEL IN SPARK IGNITION ENGINES IN TANZANIA

P D Dunn, J Clancy and G Rice,
Department of Engineering
University of Reading, Berks RG6 2AY

and

S Kawambwa,
Institute of Production Innovation, University of
Dar es Salaam, PO Box 35075, Dar es Salaam, Tanzania

ABSTRACT

As a possible contribution towards the development of Tanzanian agriculture plus national fuel self sufficiency, the potential for irrigation using pumps powered by small spark ignition engines, with ethanol as the fuel, is currently being assessed at Reading University. The ethanol can be produced on a small scale from fruit market wastes and the potential from cashew fruit waste alone is estimated as 30 to 50 million 1 of ethanol per annum, sufficient to irrigate 15,000 to 25,000 ha.

Spark ignition engines suitable for water pumping can currently be purchased. The performance including acceptable levels of water in ethanol of a single cylinder engine run on ethanol is being investigated using the minimum of modifications possible under Tanzanian conditions. This paper outlines a system suitable for Tanzanian conditions. The initial results are promising and undergoing further investigation at Reading University and the Institute of Production Innovation (IPI).

INTRODUCTION

Commercial energy use in Tanzania is currently 1,200,000 tce or 60 kg tce/cap of which 90% is imported petroleum (World Bank 1981). The cost of this imported petroleum amounts to 57% of the total export bill and this percentage is rising (South 1984). Although a very heavy drain on the economy, imported fuel represents only a small fraction (8%) (derived from Mwandosya and Luhanga 1983) of the total energy use. The remainder is largely biomass in the form of wood or its derivative charcoal. The energy problem in Tanzania is not so much that of oil replacement by renewables but the per capita increase of energy availability.

Tanzania is an agricultural economy and this sector accounts for 90% of total employment. Agriculture is not a major user of commercial energy (11% of total oil imports) but its increased availability would enable greater energy input for, eg irrigation and water lifting for cattle, and result in much improved overall productivity.

Currently there is a considerable amount of biomass in the form of fruit waste which if converted to alcohol (ethanol) would provide a locally available fuel for spark ignition engines for agricultural use. This paper describes an appropriate application for use in rural areas currently under investigation at Reading University and IPI, and identifies some of the problems.

AN OPTION FOR AGRICULTURAL DEVELOPMENT IN TANZANIA: SMALL SCALE IRRIGATION

Measures taken to improve agriculture production would:

i. Increase food production for local consumption, reducing imports and dependency on food aid.

ii. Provide jobs and reduce urban migration.

iii. Increase incomes from cash crops and exports.

The level of agricultural mechanisation in Tanzania is very low, and in the short term to increase this rapidly would have considerable implications for foreign exchange earnings and the requirements for petroleum imports.

The mechanisation of irrigation is an attractive initial option. Irrigation is not commonly practised in Tanzania and so could have an immediate wider scale impact at a lower cost. Irrigation projects particularly large scale schemes have not met with a great deal of success in Africa. Some primarily small scale schemes using ground water or lift irrigation have been successful (Carruthers 1983). This could prove to be more compatible with the average Tanzanian land holding, approx. 2 ha (Hyden 1980).

The power for lift irrigation can be met from a variety of sources. A number of systems based on renewable energy resources are currently under investigation. However, small spark ignition (SI) engines to drive lift pumps have been overlooked although they are being used for this purpose in some areas of the world (eg Guyana - Jordon 1984). The recent World Bank study on solar water pumping excluded SI systems after initial modelling showed the annual running costs to be too high (Halcrow 1983). This figure would include the cost of kerosene, an expensive imported fuel. However, a locally produced fuel based on biomass could possible substantially reduce the running costs. Ethanol produced from fruit wastes could be a suitable fuel for powering such systems.

Compression ignition (CI) engines are usually chosen in preference to SI engines for such stationary uses, primarily because of low fuel costs. In addition they have a longer life-time under similar operating conditions although their initial cost is higher. However, small spark ignition engines were previously used for stationary purposes and small boat propulsion. They are lightweight, therefore more easily transportable and so could be more readily utilised for other purposes on a farm or in a village.

Engines of this type, with magneto ignition, would seem well suited for use with hydrated alcohol. Higher compression ratios could be adopted to make use of the high octane characteristics of this fuel and to compensate for the loss of power output. Either two or four stroke cycles can be used, the former has the advantage of less moving parts (no valves) which offsets to some extent the lower efficiency with respect to the four stroke cycle. Small two stroke engines with slide valves require lubrication to be added to the fuel. The Institute of Production Innovation are currently investigating the use of castor oil, a locally available vegetable oil, for such an application.

FEEDSTOCK

The use of biomass as a fuel can lead to conflict between this application and that of food. Fruit waste is not subject to this criticism. It is widely available and there are no seasonal variations in supply.

Reliable estimates for the total waste resource in Tanzania are not available. However, IPI have estimated that 30 to 50 million litres of alcohol can be produced annually from cashew apples. Using the same parameters as those in the World Bank Solar Pumping Assessment Report, (Halcrow 1983) (a 2 hectare irrigated area at 7m head requiring 60 m^3 per day per hectare) we have estimated that this would provide sufficient fuel to irrigate 15,000 to 25,000 ha or arable farm plots.

ALCOHOL PRODUCTION

Alcohol is produced by the fermentation of an aqueous sugar solution and to make a suitable fuel must be separated from the brew by distillation. Simple distillation produces 95% ethanol/5% water which can be burnt alone in an SI engine. To blend ethanol with petrol to form gasohol, however, required 99.5% ethanol which is produced by further distilling the 95% ethanol with an entrainer. Obviously the more water that can remain in the ethanol, the lower the energy and financial costs. Engines will run on high water content, as high as 50% has been reported in Brazil, but this requires substantial modification (Brinkman 1981). The scale of production can vary from over 100,000 l/day to as little as 60 l/day (National Research Council 1983).

Economies of scale make the larger systems attractive, but this requires significant sums of capital investment and a well-organised transport system to bring the feedstock to the centralised processing plant. Transport costs are also a significant contributor to the overall cost of production. These problems could be overcome by the use of a small scale system of production based on the fruit waste in market towns or fruit farms, which would be the most appropriate scale for Tanzania. There is a lack of data on appropriate materials for small systems, as well as costs and IPI are currently developing a still of 0.5/1 hour suitable for village level use.

ADDITIONAL USES FOR ALCOHOL AS A FUEL

It is worth mentioning the additional fuel uses of alcohol suitable for Tanzanian application. In the rural context it could be used for cooking and lighting. It burns with a relatively smoke- and odour-free flame which is easily controlled. It ignites easily and is extinguished readily. It is possible to purchase a variety of simple stoves or they are easily fabricated. The latter would of course be attractive in terms of job creation although all the materials would need to be imported. To be used for lighting requires the addition of an illuminant since alcohol burns with a non-luminous flame. The illuminant could be a small quantity of kerosene, vegetable oil or animal fat.

Ethanol can also be used as a substitute oil-fired boiler fuel. Conversion trials for such boilers are under investigation in Brazil, (National Research Council 1983). Slight reductions in efficiency are reported but with lower NOx emissions than for fuel oil, although the aldehyde emissions are higher.

ALCOHOL AS AN SI ENGINE FUEL

Spark ignition engines run as well on ethanol as on petrol. In terms of emissions the situation is improved with lower NOx and CO although aldehydes may be increased (Brinkman 1981). There is no need for the addition of anti-knock lead compounds. Motor engine manufacturers modify their engines to obtain the same performance from ethanol as from petrol. For stationary engines running at constant loads and speeds these modifications may be an unnecessary expense if a slight loss of power output does not create too many problems. There is evidence to suggest that many engines tend to be over-rated for their end-use. Also in Tanzania there are not sufficient numbers of skilled personnel to undertake a large programme of major modifications.

In this context we have investigated the performance of a Briggs and Stratton single cylinder 4 stroke 2.2 kW SI engine. The engine's performance is being assessed using both absolute alcohol and alcohol with various percentages of water. The percentage of water is significant in terms of the energy requirements and cost of ethanol production.

The initial engine test results have been presented in more detail elsewhere (Kawambwa 1984). Figures 1 and 2 are representative curves of the data so far obtained. The results have been in agreement with those obtained in the literature, ie a reduction in power output matched by a corresponding increase in fuel consumption as the amount of water in the ethanol increases.

The system is currently being optimised. One minor modification that could be undertaken in Tanzania would be the enlargement of the main fuel jet to give similar power output to that using gasolene.

CONCLUSION

It would seem that there exists a potential application in Tanzania for ethanol as a fuel for driving small SI engine irrigation pump systems which would make a significant contribution to agricultural production. Work is currently in progress at Reading University to optimise the engine and pump, using only those modifications possible under Tanzanian conditions. At IPI work is being undertaken to develop an appropriate still for village level use.

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FIGURE 1: Constant throttle power-speed characteristic
Throttle position 1

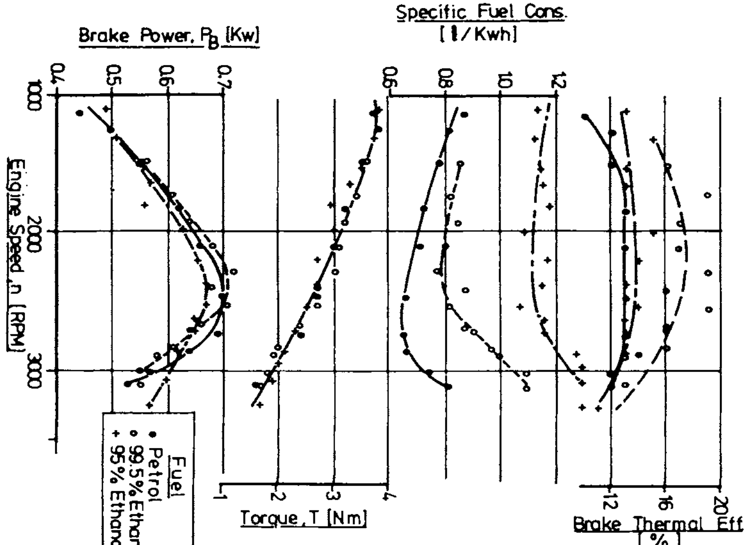

FIGURE 2