THE DEVELOPMENT OF A MICRO DISTILLERY FOR FUEL ALCOHOL IN BRAZIL

By DEON J. L. HULETT
Deon Hulett-Industria e Gomércio Ltda, Piracicaba, Brazil

Abstract

A small cane/alcohol plant capable of producing 2 400 litres of hydrated ethanol per day, and suitable for operation by farmers is described. Farmers could become self-sufficient in liquid fuel requirements provided tractors, trucks, etc. could use alcohol as fuel. Surplus alcohol, alternatively the whole output of the plant, could be sold to Brazil's Government purchasing authority at a price which would yield an attractive return on investment.

Introduction

Brazil ranks as the world's biggest manufacturer of alcohol distilleries as well as being the world's biggest producer of alcohol.

Distilleries range in size from the very crude little cane spirit or pinga stills found along the roadside and producing, at a rate of only 10 litres/hour, what is called "caninha de fogo" which, translated literally, means "cane spirit of the fire" because that is how it is produced, to the MACRO units, producing fuel alcohol at a rate of over a million litres/day, such Usinas Da Barra and Sao Martinho.

The manufacturers of the very large fuel alcohol distilleries, such as CODISTIL, ZANINI and CONGER, consider that the minimum size of the plant which can be operated economically is the 120 000 litre/day unit. They also offer plants as small as 10 000 to 5 000 litre/day units but few of these exist because these smaller plants prove to be very expensive on a litre/day basis. They are simply scaled-down versions of the larger plants.

With the onset of the world oil crisis, serious shortages of fuel in the country and irregular supplies to the farmers and so forth, the possibility of producing an ultra simple and comparatively inexpensive distillery which could be installed easily on any farm, was investigated and it was found to be feasible provided a different technology was used. The result was the introduction of the MICRO distillery which in Brazil, is defined as a small factory producing hydrated ethyl alcohol, at a rate of less than 5 000 litres/day.

After determining the average internal consumption of fuels on the bigger farms in Brazil which could be replaced by alcohol, it was decided to design a 100 litre/hour or 2 400 litre/day distillery. This would be sufficient to meet all the requirements of most farmers and, at times, would also allow the sale of any surplus to the alcohol market. The Government, too, could use this alcohol towards reaching its proposed target of 15 billion litre/year.

It was natural, of course, to expect an immediate "anti" reaction from the big manufacturers and the Government, and the cry of "impossible" and "not viable" was soon heard! The Government refused to consider or accept the MICRO for its inclusion in the PRO-ALCOOL financial assistance scheme, so that it meant that anyone considering a MICRO would have to bear the cost himself.

In spite of the strong opposition, however, it was decided to go ahead with the concept of the MICRO in the hopes that it would, indeed, come up to expectations and prove to be of some help towards solving the country's liquid fuel crisis.

Further investigation was made into all the possible ways in which the farmer's cost of investment could be reduced without affecting the quality of the output.

Method

1. Packed columns, consisting of simple stainless steel tubes with a plastic fill, would be used instead of the very expensive bubble tray columns.
2. A deflegmator condenser, supported on the column, would obviate the need for expensive supporting structures.
3. The columns would be heated by a simple direct-fired boiler element operating at a little over atmospheric pressure, thus eliminating the need for an expensive steam generating system.
4. Wine heating would be achieved in a liquid/liquid heat exchanger, recovering the heat from the outgoing slop, thus reducing the steam requirements and therefore, the size of the boiler element. This would also reduce considerably the overall fuel requirements.
5. To provide relatively inexpensive extraction, a mill would be designed with headstocks made from standard 50 mm plate and with the roller shafts supported on roller bearings to minimise lubrication and adjustment requirements.
6. As the power estimate for the factory amounted to less than 30 kVA, it would mean that a power station would be replaced by a transformer, connected to the national supply commission. In the case of a remote installation and this power not being available, the requirements would be obtained by burning 6% of the alcohol in a small motor generator or by using a larger motor, running on well scrubbed furnace gas and burning some of the excess bagasse.
7. The control of the distillery needed to be rationalised in such a way as to ensure the necessary stability of operation without the requirements of expensive instrumentation.
8. To streamline erection procedure, as much of the plant as possible would be assembled in the workshop, minimising on-site pipe work.
9. The civil work would be simplified as much as possible and would consist, basically, of one concrete slab on which would be mounted all the fermentation tanks, distillation unit and the mill.
10. A closed cooling water circuit, which would minimise water requirements, would be designed so that the most convenient site could be chosen for the plant from the point of view of slop disposal to the fields and cane delivery to the site.

All these decisions finally brought about the creation of an extremely simple and inexpensive distillation plant which is easy to run, needing at most five people per shift to operate the complete factory. In addition to this, it brought the initial investment, per litre of capacity installed, to approximately one third of that of the bigger, very expensive units.

As feedstock, sugar cane and sweet sorgum are ideal. They conveniently supply all the fuel requirements and the excess bagasse can be used as a cattlefeed supplement. In addition to this, the distillation slop, called vinhaca in Brazil, can be used to great advantage as a fertiliser, being rich in organic matter, nitrogen, phosphates and potassium, and can be applied "untreated" to the fields.

The use of starch-based feedstock, such as maize and cassava, immediately increases the initial investment and adds to operation costs, as

(a) a more involved extraction process is required.
(b) a saccharification step has to be introduced before fermentation, and
(c) an additional source of fuel has to be found with which to operate the plant.

Description of the Process

The distillery operates as follows :

Sugar cane or sweet sorgum, is passed through the mill (A) where about 65% of the juice is extracted. This juice passes through a screen and is pumped by pump (B) to the fermentation tanks (C), where yeast is added.

The juice is fermented in these tanks for about 24 hours, where all the sugar is transformed into alcohol by the action of the yeast cells.

The fermented juice, now called wine or beer, iis pumped (D) through the liquid/liquid heat exchanger (E) to the distribution plate at the top of the stripping column (F).

The wine leaves the heat exchanger at its boiling point and percolates down the packing in the stripping column, against an upflow of steam. On reaching the base (H) of the stripping column the wine circulates in the boiler element (G), where part of the water content is converted into steam which rises up the column, against the descending wine, stripping off the alcohol vapours.

The excess wine, devoid of alcohol and now termed "slop", overflows a weir and passes through the heat exchanger, giving up its sensible heat and heating the incoming wine.

A mixture of alcohol vapour and steam passes from the top of the stripping column by means of the flegma pipe (P). This mixture of vapours rises up the rectifying column (J) against the refluxing alcohol, condensing in the deflegmator condenser (K), which is mounted at the top of the column.

In the rectifying column, the hydrated alcohol, at its minimum azeotropic boiling point, collects at the base of the condenser (K) on the alcohol collecting tray (L) where part of it is bled through the alcohol cooler (M) to the control panel (N). The rest, about 80%, overflows the tray and flows back down the packing as reflux.

The water, transferred to the rectifying column with the flegma, collects at the bottom of this column in the base (O), where the excess overflows back to the suction of the pump (D), to be mixed with the wine and pumped back to the top of the stripping column.

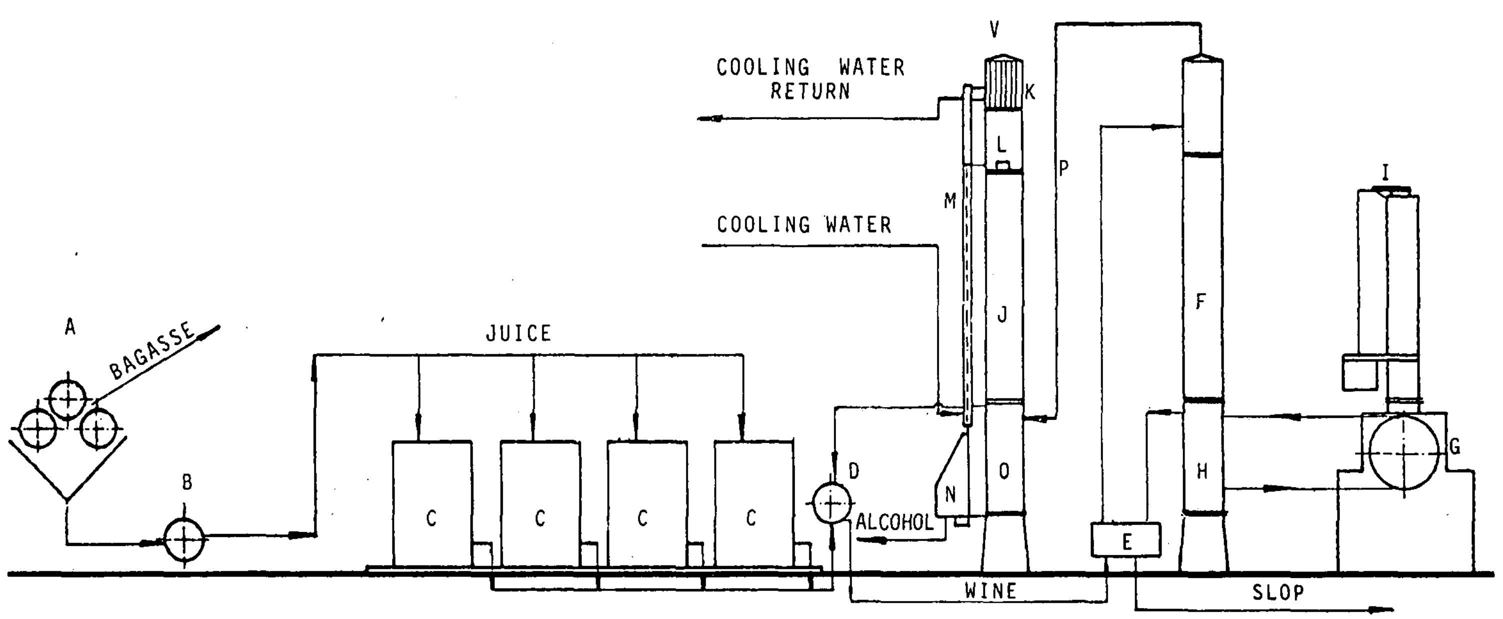
The product, alcohol, and the wine feed rate are regulated by two control valves, mounted in the control panel, and flow rates are set to provide the required capacities and alcohol quality.

At times about 10 litres of dilute alcohol are drawn off from the bottom of the rectifying column to obviate fusel oil accumulation. The fusel oil is then separated from this alcohol by further dilution with water which causes it to float to the top, from where it is skimmed off and the diluted alcohol is returned to the fermentation tanks.

Advantages of the MICRO vs the Bigger Plants

1. Decentralisation of job opportunities and a better spread of income helping to settle labour in the rural areas.
2. Considerable economy in fuel due to a reduction of the transport of both cane and alcohol.

MICRO DISTILLERY – FLOW SHEET



A MILL
B JUICE PUMP
C FERMENTATION TANKS
D WINE PUMP
E LIQUID/LIQUID HEAT EXCHANGER
F STRIPPING COLUMN
G DIRECT FIRED HEATING ELEMENT
H SLOP RESERVOIR FOR BOILER CIRCULATION
I AUTOMATIC DAMPER CONTROL
J RECTIFYING COLUMN
K DEFLEGMATOR CONDENSER
L ALCOHOL COLLECTING TRAY
M ALCOHOL COOLER
N CONTROL PANEL
O RECTIFYING COLUMN BASE
P FLEGMA TRANSFER PIPE
V VENT FOR CO_2

3. Greater national security due to decentralisation of fuel production points in the country and the resultant flexibility of production.

4. Simplicity of operation obviating the need for highly qualified personnel.

5. An investment cost per litre of alcohol of approximately one third of that of the bigger conventional plant. For the same initial investment as that of one 120 000 litre/day conventional distillery, one hundred and forty-seven (147) MICRO distilleries, producing a total of 352 000 litre/day, can be installed.

MICRO DISTILLERY COST STRUCTURE

(Data obtained from results of installation at Predregulho — SP, Brazil)

* Cruzeiros 80 = One Rand

CAPITAL COST — Cr $4 000 000*

1 Three Roller Mill — Extraction 61% — Yield 50 litres per Ton of Cane

Production per Annum 432 000 litres (2 400 ℓ/day)

Cost of Cane Cr$ 576,50 per ton* — Capacity — 48 TCPD

	Cr$/ℓ/alcohol
Cane	11,53
Chemicals	0,60
Labour	1,41
On costs (56%)	0,79
Electric power	0,46
Total variable costs	14,79
Maintenance (2% on Inv.)	0,19
Depreciation (10% on Inv.)	0,93
Insurance (1% p.a.)	0,09
Total fixed costs	1,21
Administration costs (2% on gross revenue)	0,42
Total cost per litre	16,42

	Cr$/ℓ/alcohol
Price paid by CNP/litre	20,81
Cost of production	16,42
Profit per litre	4,39
Annual Profit before tax	Cr$1 896 480
Return on Investment	47,4%
Alcohol price to consumer	27,50
Cost of production	16,42
Saving per litre	11,08
Annual Saving	Cr$4 786 560

* The above figures refer to November 1980 and reflect the real cost of cane to the farmer at Cr $576,50 per ton (or about R8 per ton) as supplied by the Institute of Sugar and Alcohol (I.A.A.). Cane prices in Brazil are incredibly low compared to South Africa. The mill door price in November 1980 was Cr $813,00 per ton, which includes the farmer's profit plus the transport cost.