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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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DISTILLATION, RECTIFICATION, LOW ENERGY PROCESSES*

by

Karl Eder**

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1) Introduction

The worldwide discussion about the alarming energy situation caused a re-evaluation of the existing processes for the production of alcohol as fuel additive. The experiences which could be gained by the use of ethanol as fuel additive can be assumed to be well known. According to the present stage of technique anhydrous ethanol is used for this purpose.

The production of alcohol from carbohydrates is not an invention of our century; the processes, however, remained practically unchanged for centuries until recently. All developments on this field referred to the improvement of alcohol quality according to the particular requests of manufacturers, as alcohol has been used mainly for beverages and in the pharmaceutical industry.

During World War Two, the demand for anhydrous alcohol rose. In Germany, for example, considerable quantities as fuel additive were produced. The processes used at that time remained virtually unchanged; especially the French improved the benzene process used worldwide in this form. In this process, benzene is used as dehydrating agent. As you will know, alcohol can be distilled from aqueous solutions, only up to a concentration of 95,3 % by weight. At this concentration, the composition of the distilled and condensed liquid is equal to that of the vapour in the stills.

This "point of inflection" can be exceeded in the distillation by a trick, that means by adding a dehydrating agent. At a certain proportion of ethanol to dehydrating agent (e.g. benzene) a mixture results which has a lower boiling point. The water accumulates at the top of the column, and the dehydrated alcohol at the bottom.

A by-product, i.e. slops, influences the feasibility enormously. Whereas the slops from grain processing, especially in small distilleries, have always been used as a valuable animal feed stuff, the slops from molasses processing plants used to be wasted. Only large plants used the slops for the production of fertilisers, cyanide salts, glutamin, etc. In some plants, the slops were or still are combusted after evaporation and the heat thus produced is used partially to cover the energy demand of the distillation and evaporation. The dispersion of the non-concentrated slops on the land for beet and cane cultivation is practiced in many places. However, with increasing dimensions of alcohol production units, feasibility of these methods has to be doubted.

Now the trend goes, especially in distilleries using molasses as raw material, more and more to the method of concentrating the slops by evaporation and addition of the resulting product to feed stuff. To feed the non-concentrated slops from grain distilleries is impossible with the dimensions envisaged now (200.000 to 600.000 l alcohol per day), thus requiring a storable product.

For the production of anhydrous alcohol practically the same processes used to be applied for preparation of raw materials, distillation and waste water treatment as for the production of potable alcohol. Whilst the proceeds for potable alcohol cover roughly the input of energy, this is not the case for anhydrous alcohol used as fuel additive. The severe standards for environmental protection force to a complete disposal of waste waters and therefore to a revision of the total concept of alcohol production.

I should like to explain this fact in detail taking the production of alcohol from molasses as an example.

Principally the alcohol production is subdivided in the following steps:

1) Preparation of raw material
2) Fermentation
3) Distillation/ dehydration
4) Waste water treatment

2) Preparation of Raw Material (Molasses)

The necessity of molasses preparation depends on the quality of molasses. Whereas generally beet molasses is, apart from dilution, not treated, cane molasses requires mostly an elutriation of the sludge and its separation by decantation. On the considered plant sizes a mechanical decantation by means of centrifuges or decanters is recommendable. The additional specific energy demand, compared with beet molasses, in a well balanced energy household corresponds to that of the mechanical equipment, i.e. centrifuges and additional pumps. The energy demand for the preparation unit, however, amounts to only a small part of the total energy demand.

3) Fermentation

As you know, heat is released by fermentation, and its utilisation is the subject of quite serious research work. Principally the fermentation should be done under vacuum conditions for this purpose. However, the feasibility of such a process is not given, due to the very high energy demand for the compression of the carbon dioxide released. The main parameter for a positive energy balance will certainly be the temperature of fermentation. The aptitude of the yeast must be considered not only in the resistance against higher temperatures, but also in the capacity to do the transformation of the carbohydrates in an economical period.

For a normal fermentation, i.e. under atmospheric conditions, the so-called BDK-process, a continuous fermentation process, has proved excellently in large scale operation. The advantage of this process is the low requirements of fermentation space and a minimized demand for control work and cleaning.

The energy demand is determined by the pumps for the cooling water, supply of the sugar-containing mash to the first fermenter, discharge of the fermented mash from the last fermenter for distillation as well as energy consumption of the separator for yeast recovery.

4) Distillation

The separation of the alochol from the mash as well as its processing to anhydrous alcohol consumes the largest part of the energy necessary for the alcohol production. Of course all endeavours to reduce the energy demand were concentrated on this point. The principal consideration is that the demands on quality for power alcohol are quite different from those for potable alcohol. In power alcohol production considerably simpler apparatus can be used up to the raw-spirit stage than for potable alcohol.

Processes have been developed which afford an economical advantage enabled by the enormous sizes of the plants compared with production plants for potable spirit. Reconstructions, of course, cannot always be done in a way to accomplish optimal energy figures, otherwise these reconstructions would require gigantic investment cost.

The application of multi-pressure systems for utilization of the waste heat from one column to heat the next one was obvious.

Thus, arrangements could be elaborated which require only half the quantity of steam, compared with the benzene process, that means from about 450 kg to 250 kg per 100 l anhydrous alcohol.

With this process, the pre-dehydration column works under pressure. The vapours streaming off on the top of the pre-dehydration column are used to heat the mash column. The vapours streaming off on the top of the mash column are used to heat the dehydration column. The choice of the dehydrating agent has of course a certain influence on the energy consumption.

5) Waste Water Treatment

As already explained, the severe regulations for environmental protection force to a practically complete removal of the polluting components in the waste water. By this, the concentration of slops and the use of the produced slops concentrate as additive for feed stuff has gained more and more importance. However, it must not be forgotten that the production of the concentrate cannot be done with absence of an ulterior motive. The specifications of this slops concentrate which is used as feed stuff are such that in certain cases they influence decisively the choice of the fermentation process; in any case they determine the kind of distillation and the type of evaporator.

The fact that the concentration, even on units laid out to an optimum, requires a considerable part of the total energy demand, has led necessarily to developments enabling the combination of distillation and evaporation.

The application of mechanical vapor compressors, that means apparatus which bring the vapors resulting from the evaporation by compression to the pressure necessary to heat the evaporator, can be economical under certain conditions and under separate consideration of the evaporation station. However, with a view to the future, such an arrangement cannot be economical as soon as electrical energy has to be supplied from calorific power-stations.

6) Energy Demand

According to the actual stage of technique, for the production the figures shown in Table 1 are representative of power alcohol from molasses.

Table 1 Energy Consumption in the Production of Anhydrous Alcohol (100 % spirit) from Molasses

	Steam kg/hl	Electr. Energy kWh/hl
1. Preparation		
comprising: molasses dilution		
molasses clarification		
and sludge treatment		
pumps	20	2 kWh/h
2. Fermentation		
pumps		0.5 kWh/h
yeast separator		1.0 kWh/h
3. Distillation, Rectification, Dehydration		
pumps	250	3.5 kWh/h
4. Waste Water Treatment		
slops concentration to 65% DMS, pumps		
steam for evaporation	147	2.0 kWh/h
5. Combined Process for Slops Recovery		
distillation/ alcohol concentration/ dehydration and evaporation	350	3.5 kWh/h
6. Energy for Mechanical Vapor Compression		
mechanical compressor		16.0 kWh/h
pumps		2.0 kWh/h

7) Summary

Under the pressure of the energy situation on the one side and the rigorous demands of environmental conditions on the other side, processes for power alcohol production have been developed recently which made the use of alcohol as fuel additive discussable. The reduction of the energy demand was reached only by combined processes of distillation-dehydration and evaporation.

The development of such combined processes become possible due to the increase of capacities which were not usual hitherto in the alcohol industry.

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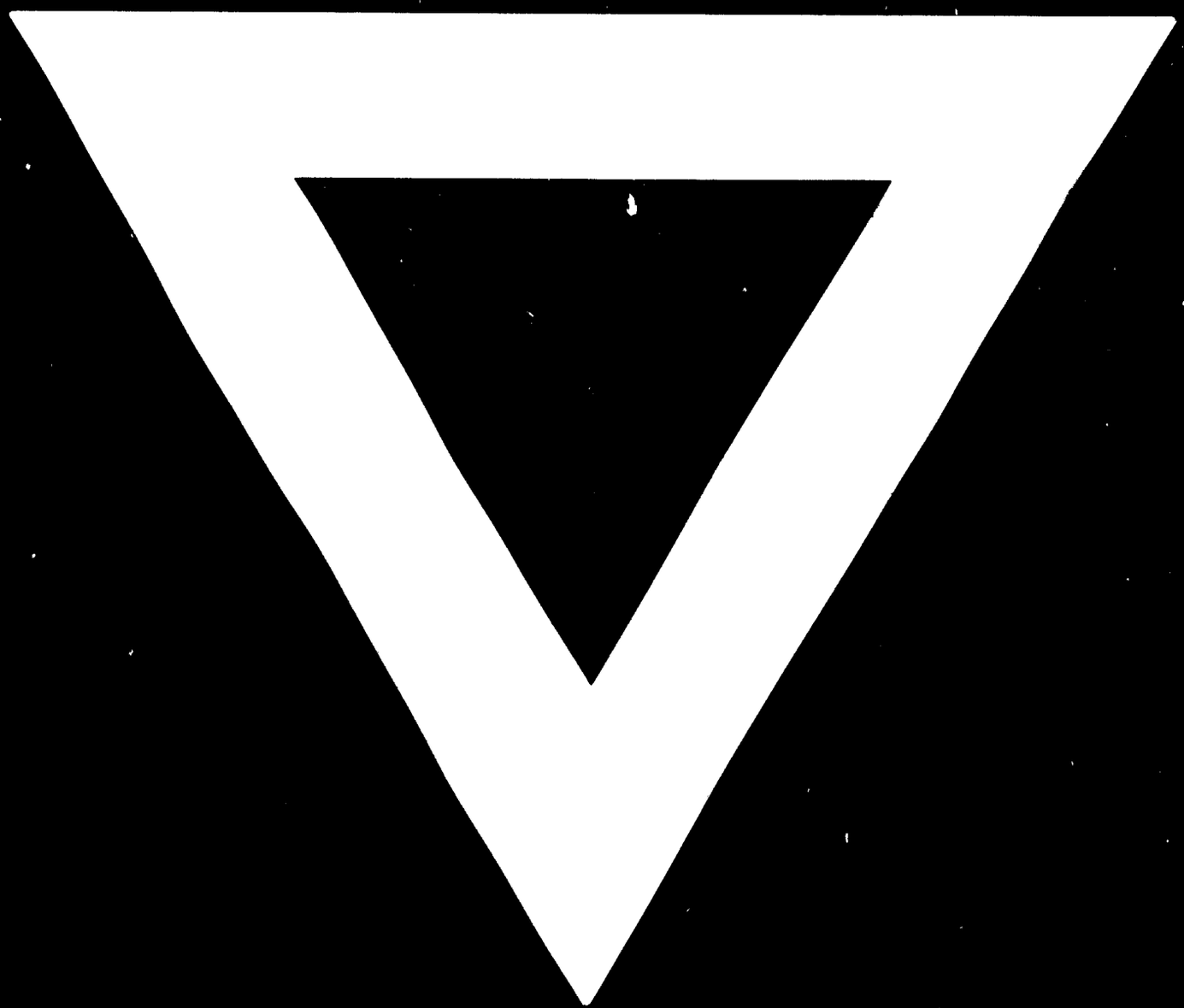

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