ABSTRACT

Normally, extra neutral alcohol is produced in two stages, i.e., from fermented molasses to rectified alcohol of 96% v/v and the redistillation of rectified alcohol, after dilution, with demineralised water to remove the miscible impurities (such as aldehydes, fusel oil) in a separate distillation system comprising 4 columns, 9 condensers and 2 thermosyphon reboilers. In this conventional process, conversion of rectified alcohol to extra neutral alcohol varies between 70% to 80% or, in other words, for every litre of rectified alcohol processed for converting into extra neutral alcohol, only 0.7 to 0.8 litre is available at the cost of 3.5 to 4 kg steam per litre of extra neutral alcohol (ENA). Thus in the conventional process, the total number of columns for producing extra neutral alcohol is 7 to 8 and at a cost of 7 to 8 kg steam consumption per litre of ENA. With the development of new technology, a much finer quality of extra neutral alcohol conforming to French and German standards is obtained with 5 columns only, with the option of manufacturing ENA, high and low rum and rectified alcohol.

INTRODUCTION

Extra neutral alcohol (ENA) is produced normally in two stages wherein fermented molasses is first converted into rectified spirit in the first stage and then it is converted into ENA in the second stage. The yield in the second stage is only 70%-80% with steam consumption of around 3.5 kg to 4 kg for every litre of ENA produced. The conventional process (Paul, 1986) thus requires more distillation columns and condensers than those required in the present process in which ENA can be produced directly from fermented molasses.

MANUFACTURING PROCESS

In this process, referring to Fig.1, fermented molasses is pre-heated in the heat recovery system to a temperature of 90-92°C and introduced at the top of the degassing column which is a compound column, consisting of degassing and beer column [analyzer column]. The highly volatile impurities such as aldehydes are removed in vapour phase and directly introduced into the recovery column on 13th plate to enrich ethyl alcohol which could be drawn as product from the rectifying column. The vapour phase from the analyzer column is totally condensed in 3 sets of condensers; primary, secondary and vent, and condensate from the first and second partial condensers are fed to the hydration column directly without going through the dilution tank.
The heat recovery system consists of one tubular heat exchanger as partial condenser for the analyzer column and one plate heat exchanger for final heating of the feed wash with spent wash as heating medium. Another plate heat exchanger is provided in series to recover the waste heat from the spent wash to preheat the boiler feed water and strip off the sensible heat content from the bottom stream of the analyzer column which is the waste.

Most of the highly volatile impurities again are separated as condensate in the vent condenser and directly fed to the recovery column as liquid phase. The condensate from primary and secondary condenser is fed into the hydration column on 14th plate, where demineralised water is also introduced for dilution. At the same time, dilution ratio is controlled with respect to the quantity of impurities present in liquid phase. In this column, the more volatile component is normally condensed in the two partial condensers attached to the hydration column, and removed as impure spirit and fed to the recovery column on the 13th tray as liquid phase. In this system design, the more volatile component is not condensed but instead is fed as vapour phase on the 19th tray into the recovery column eliminating two partial condensers. Thus, this system design has saved capital cost and thermal energy.

The liquid phase at the bottom of the hydration column is free from highly volatile component and this is used as a feed to rectifying column on 17th plate out of the total 63 plates in the column. Open purged steam is introduced at the bottom of the rectifying column and the bottom product, which is water, is drained off along with some high boiling impurities. The vapour phase is condensed in a series of condensers, i.e., primary, secondary and vent. Condensate from vent condenser is directly fed to recovery column, where it is recovered as impure spirit of 96% v/v.
The entire condensate from primary and secondary is refluxed into the rectifying column and the product is withdrawn as extra neutral alcohol from 3rd and 4th plates from the top; and from 10th and 20th plates from the top, low and high rum is drawn respectively. Thus instead of 8 to 9 columns, only 4 columns, including one compound column, and 8 condensers instead of 12 condensers are needed in this system design.

This clearly indicates the saving of capital investment at the initial stage and quality product at the end, as compared with those products made by conventional method, i.e. high rum low rum and extra neutral alcohol. As per the GLC analysis in figure 2, it is clear that fusel oil is completely eliminated and all the aldehydes are removed.

The process (Paul, 1983), for production of extra neutral alcohol directly from fermented molasses, comprises preheating fermented molasses in a heat recovery system consisting of a plurality of condensers arranged in series (2, 3, 4) atop analyzer column (1), where vapour with 46% v/v ethyl alcohol leaving analyzer column (1) preheats the fermented molasses to 92°C in primary condenser (2), preheats boiler feed water in secondary condenser (3) and is finally fully condensed in vent condenser (4). Noncondensible gases and other low boiling impurities are vented to atmosphere from vent condenser (4). Preheated fermented molasses at 92°C is introduced in analyzer column (1) as shown in figure 1. Open steam is purged in the bottom of the analyzer column to provide thermal heat. Vapour leaving degassing column (1) with 42% v/v ethyl alcohol and containing highly volatile impurities of aldehydes is directly introduced, while bypassing its condensation stage, on the 13th plate of recovery column (5) to enrich in ethyl alcohol. Condensate from vent condenser (4) is refluxed as liquid feed to recovery column (5) on the 19th
plate. Vapour leaving the hydration column (6) as impure spirit with 96% v/v ethyl alcohol is made to bypass its condensation stage by directly introducing it on the 19th plate of recovery column (5), thereby saving condenser cost. Vapour leaving the recovery column (5) is totally condensed in the primary condenser (11) and secondary condenser (12) and their condensates are combined and refluxed to the recovery column (5) which is purged at its bottom with open steam to provide thermal energy. Any other feed streams containing ethyl alcohol are also fed to recovery column (5) on the 19th plate to enrich in ethyl alcohol, aldehyde and high boiling fusel oil which is decanted in the fusel oil decanter by dilution. Demineralized water preheated to 92°C is introduced in dilution ratio of 1 : 4 to hydration column (6). Condensate from the primary condenser (2) and that from secondary condenser (3) are combined and then introduced as liquid feed on 14th plate of the hydration column (6).

Recovered alcohol having 96% v/v ethyl alcohol that can be drawn as the required finished product is also introduced as liquid feed on the 14th plate from bottom of hydration column (6). Liquid leaving the hydration column (6) at the bottom with 14% v/v ethyl alcohol is introduced on the 17th plate of rectifying column (7). Dilution ratio at 1 : 4 to hydration column (6) is controlled in relation to the extent of impurities so that the spectrum of boiling points of the impurities is wider. All low boiling impurities are removed from the top of the hydration column (6) and high boiling impurities from the bottom of the hydration column (6). Steam at the bottom provides required thermal energy in the hydration column (6). The rectifying column (7) refines ethyl alcohol at the top with vapour leaving its top being totally condensed in the primary condenser (8), secondary condenser (9) and vent condenser (10). Condensates of the primary condenser (8) and the secondary condenser (9) are combined and totally refluxed to the rectifying column (7). Condensate from the vent condenser (10) mostly containing acetaldehyde is refluxed separately to the recovery column (5). The high boiling impurities containing 0.01% v/v fusel oil leave the rectifying column (7) from the bottom.

PROCESS AND PLANT EQUIPMENT

Plant for continuous production of extra neutral alcohol directly from fermented molasses (Paul, 1980) comprises:

i) A compound column (1), consisting of a degassing Column and an analyzer column (beer column) is pumped at its top with Preheated fermented molasses at 92°C in pipe line (B); An open steam pipe (S1) is connected to the column at bottom for steam purging.

ii) Vapour pipe (D) from the analyzer column (1) top is connected to a set of a primary condenser (2), a secondary condenser (3) and a vent condenser (4). Fermented wash pipe (A) is connected to primary condenser (2) for preheating the molasses wash (A) with analyzer column vapour in the primary condenser (2). Remaining uncondensed vapour leaving the primary condenser is directed to the secondary condenser (3) for condensing most of the vapour. Boiler water feed pipeline (W1) is connected to the secondary condenser to supply water as coolant. All noncondensible gases carrying impurities and highly volatile components are discharged into the atmosphere through a pipe (I) from the vent condenser (4).

iii) A pipe carrying vapour of highly volatile impurities of aldehydes leaving the degassing column (1) top, is connected to the 13th plate of the recovery column (5). Condensate pipe (H) from the vent condenser (4) and the one with other feed streams containing alcohol are joined and are connected to the recovery column (5) on the 19th plate. Recovery column (5) bottom is connected to open steamline (S2) for purging.

iv) The condensate pipe (E) of the primary condenser (2) of the analyzer column (1) is joined with that of (F) the secondary condenser (3) and the pipe (G) carrying the combined condensates is connected to the 14th plate of the hydration column (6).
v) The vapour pipe (M) from the top of the recovery column (5) is connected to its primary condenser (N1) and vent condenser N2. The condensate pipes of these condensers are joined into (K) and connected to the reflux line of the recovery column (5).

vi) Recovered alcohol as product is drawn from the recovery column (5) in pipeline (O) and also directed to the 14th plate of the hydration column (6).

vii) Open steam pipe (S2) is connected to the bottom of the recovery column (5) for purging steam.

viii) Pipe (Z) removing liquid from the bottom of the analyzer column (1) as well as the pipe (X) from the bottom of the recovery column (5) are respectively connected to spent wash and the spent lees pipelines.

ix) A vapour pipe (J) from the hydration column (6) top is connected to the 19th plate of the recovery column (5); the pipe (P) carrying the liquid from the hydration column (6) bottom is connected to the 17th plate of the rectifying column (7).

x) The vapour pipe (Q) from the rectifying column (7) top is connected to the primary condenser (8), secondary condenser (9) and vent condenser (10) all installed in series; liquid condensate pipe (R) of the primary condenser (8) and condensate pipe (S) of secondary condenser (9) are joined and connected to the rectifying column (7) reflux pipe. The condensate pipe (T) of the vent condenser (10) is separately connected to the second reflux pipeline (L) of the recovery column (5) for feeding mostly acetaldehydes.

xi) The extra neutral alcohol (ENA) product pipe (U) is connected to the 3rd and 4th plates from the top of the rectifying column (7); low rum product pipe (V) is connected to the 10th plate from the top of the rectifying column (7); high rum product pipe (W) is connected to the 20th plate from the top of the rectifying column (7). Liquid from the bottom of the rectifying column (7) is directed to the spent lees pipe (Y) as waste product. ENA thus withdrawn has conformed to the French and German specifications.

xii) The columns have been designed using tunnel cap type trays instead of bubble cap, sieve and turbo grid. This design is hence correlated with vapour rising area and not with column diameter (Panta Mitra 1963; Cross & Ryder, 1952).

xiii) The overall steam requirement in this system design has been reduced to 3.5 kg per litre ENA from 5.7 kg per litre ENA in the conventional process.

xiv) The total number of columns in this system design is reduced from 8 columns in the conventional process to 5 columns including the compound analyzer cum degassing column.

xv) Suitable instrumentation and controls are provided to control the dilution ratio in the hydration column in relation to the extent of impurities.

CONCLUSIONS

1. The conventional process of manufacturing ENA is less cost effective as it requires more columns and condensers than this process for same plant capacities.

2. Steam consumption is reduced from 5.7 kg steam per litre ENA produced in the conventional process, to 3.5 kg steam per litre ENA produced.

3. ENA produced is completely free from all aldehydes and fusel oil and it conforms to international French and German standards.
international French and German standards.

REFERENCES

Paul, B.B. (1986) Future of the Molasses Based Alcohol Distillation Industries in the Developing Countries, Bharatiya Sugar, November 13-16


PRODUCCIÓN DE ALCOHOL EXTRA NEUTRO DIRECTAMENTE A PARTIR DE MIELES FERMENTADAS

B.B. Paul
B.B. Consulting 'N' Engg. Pvt. Ltd., Mumbai (India)

RESUMEN

Normalmente el alcohol extra neutro se produce en dos etapas, es decir, de las mieles fermentadas a alcohol rectificado del 96%v/v y la redestilación del alcohol rectificado después de dilución con agua desmineralizada para eliminar las impurezas miscibles tales como aldehidos y fusel oil, en un sistema de destilación separado formado por 4 columnas, 9 condensadores y 2 rehervidores de Termosifón. En este sistema convencional, la conversión de alcohol rectificado a extra neutro varía entre 70%-80%, o en otras palabras por cada litro de alcohol rectificado procesado para convertirlo en alcohol extra neutro sólo se obtienen 0,7-0,8 litro consumiéndose 3,5-4,0 kg de vapor por litro de Alcohol Extra Neutro (AEN). Por tanto en el proceso convencional el número total de columnas para producir AEN es de 7 a 8 con el consumo de 7 a 8 kg de vapor por litro de AEN. Con el desarrollo de la nueva tecnología se puede obtener un alcohol extra neutro de mucha mayor calidad de acuerdo con las normas Francesa y Alemana solamente con 5 columnas con la opción de fabricar AEN, altas y bajas rones y alcohol rectificado.

Palabras claves: Alcohol extra neutro, destilación, mieles.
FABRICATION D’ALCOOL EXTRA-NEUTRE DIRECTEMENT DE MÉLASSES FERMENTÉES

B.B. Paul
B.B. Consulting ‘N’ Engg. Pvt. Ltd., Mumbai (India)

RÉSUMÉ

Normalement, l’alcool extra-neutre est produit en 2 étapes, c’est à dire, de mélasses fermentées à l’alcool réctifié à 96% v/v suivi de la re-distillation de l’alcool réctifié après dilution avec de l’eau déminéralisée pour enlever des impuretés solubles, (telles que des aldéhydes, fusel oil) dans un système de distillation séparé qui comprend 4 colonnes, 9 condensateurs et 2 réchauffeurs de thermosyphon. Dans ce procédé conventionnel, la conversion d’alcool réctifié en alcool extra-neutre varie entre 70% à 80%, c’est à dire, pour chaque litre d’alcool réctifié traité l’on obtient à peine 0.7 à 0.8 l d’alcool extra-neutre, au coût de 3.5 à 4 kg de vapeur par litre d’alcool Extra-Neutre (ENA). Ainsi dans le procédé conventionnel le nombre total de colonnes pour la production d’Alcool Extra-Neutre est 7 à 8 et à un coût de 7 à 8 kg de consommation de vapeur par litre de ENA. Avec le développement de la nouvelle technologie la qualité d’Alcool Extra-Neutre obtenue est bien supérieure, en accord avec les normes françaises et allemandes, utilisant seulement 5 colonnes, avec l’option de fabriquer de l’ENA, des flegmes de haute et basse densité et de l’alcool réctifié.

Mots clés : Alcool Extra-Neutre, distillation, mélasses.