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(54) Title: INTEGRATED ETHANOL SEPARATION AND VINASSE/ SLOP CONCENTRATION USING MECHANICAL VAPOUR RECOMPRESSION

(57) Abstract: The invention relates to a process for the preparation of ethanol using mechanically compressed vapour as energy source for distillation and evaporation, wherein significantly less amount of steam energy [thermal energy] is required compared with a process not employing the process of the invention disclosed herein.

INTEGRATED ETHANOL SEPARATION AND VINASSE/ SLOP CONCENTRATION USING MECHANICAL VAPOUR RECOMPRESSION

FIELD OF THE INVENTION

The invention relates to a process for the preparation of ethanol using mechanically compressed vapour as energy source for distillation and evaporation, wherein significantly less amount of steam energy [thermal energy] is required compared with a process not employing the process of the invention disclosed herein.

BACKGROUND

Many alcoholic beverages are produced comprising one or more of the steps of: [1] producing ethanol by fermentation of a carbohydrate-rich feedstock to produce a fermented wash having concentration of about 2% to about 23% alcohol by volume [ABV]; [2] distilling the product of fermentation at elevated temperatures to produce ethanol products like rectified spirit, neutral spirit or absolute alcohol; and [3] aging the ethanol spirits until it possesses desired flavour, aroma, and colour characteristics. The commercial production of alcohol by distillation has been in widespread operation for many centuries.

The distillation is a known technique for purification of a liquid substance and involves vaporizing the substance at its boiling point, condensing the vapour and collecting the purified form as a condensate. Distillation is useful for separating a mixture when the components have different boiling points. Several kinds of distillation techniques for binary or multi-component mixtures are described and practiced in the art, for example: (1) simple, (2) vacuum or reduced pressure, (3) fractional and (4) steam distillation.

In all techniques available for distillation of ethanol from fermented wash, the consumption of steam energy per litre of ethanol produced is the critical measure for economics of the process. Presently, a typical ethanol production process consumes about 2 to about 3 kilogram of steam per litre of ethanol produced. Besides, more steam is required if the titre of ethanol in fermented wash is low. There is need of less consumption of steam per litre of ethanol consumed and the invention disclosed herein deals with a solution to the problem of high steam consumption to produce ethanol from fermented wash. The invention presented herein discloses a method of using compressed vapours for distillation having several advantages over conventional distillation methods. The invention disclosed herein also integrates the process of concentration of waste stream [also called vinasse or slop] from the distillation column [bottom stream] by using condensers that evaporate said waste stream, concentrating it with significant less amount of energy compared with the conventional methods.

BRIEF DESCRIPTION

The invention herein discloses a process for preparation of ethanol using a mechanical vapour re-compression method comprising: preheating a fermented wash forming a first stream; subjecting said first stream to a stripping column forming a first top stream and a first bottom stream; condensing said first top stream through first condenser forming a high concentration ethanol stream and a first vapour stream; solids from said bottom stream of step [b] and concentrating it in said first condenser forming a concentrated stream; compressing said first vapour stream forming a high-pressure vapour stream and providing it to said stripping a product stream, a second top stream and a second bottom stream; providing said second top stream to a second condenser forming a liquid stream and returning it to said rectifying column; recycling said second bottom stream of step [f] with said fermented wash of step [a] forming said first stream; subjecting said concentrated stream of step [d] to said second condenser forming a concentrated waste stream and a second vapour stream; and compressing said second vapour stream forming said high-pressure vapour stream and providing it to said distilling column.

DESCRIPTION OF THE DRAWING

Particular examples of methods in accordance with this invention will now be described with reference to accompanying drawing, in which:

FIGURE 1 is an exemplary plan of the invention showing several features that control the process of using mechanically re-compressed water vapour for the distillation of ethanol from a fermented wash. A fermented wash after preheating [1] is fed to a stripping column [A]. A compressed vapour stream [5] fed to the stripping column at the bottom of column where temperature is maintained at about 80 °C. This compressed vapour stream is used for the effective stripping of ethanol from said fermented wash in said stripping column. A first top stream [3] coming from said stripping column is condensed in a first condenser [C] forming a high-ethanol stream [7] that is further sent to a rectifying column [E] through a storage tank [optional] for further rectification of ethanol present said stream to get final ethanol product stream [14]. A first bottom stream [2] of said stripping column [A] is first subjected to solid-liquid separator to remove solids to form stream [6], which is concentrated in said first condenser [C] and through stream [9] in a second condenser [D] to get concentrated distillery waste stream/ concentrated syrup [11]. A first vapour stream [4] coming unit [F] leading to forming of a high-pressure vapour stream [5]. Said first vapour stream [4] is free of ethanol and is readily compressed to high-pressure vapour stream in the MVR unit [F]. Said high-pressure vapour stream [5] is used to run said stripping column [A] as well as said rectifying column [E] without need of any live steam except to turn on the system. A second top stream [12] coming from said column [E] is sent to said second condenser [D] and a second vapour stream [13] coming from said second condenser [D] is subjected to mechanical vapour re-compression unit [F] leading to forming of a high-pressure vapour stream [5]. Said second vapour stream is free of ethanol and is readily compressed to high-pressure vapour stream in the MVR unit [F]. Next, a second bottom stream [8] of said rectifying column [E] is mixed with fermented wash and recycled to recover ethanol present in it.

DETAILED DESCRIPTION

In one embodiment of the present invention, a fermented wash with ethanol concentration of between 6% to 18% by volume is obtained from yeast fermentation of a carbohydrate rich feedstock like grains, cereals, tubers, molasses, sugarcane juice or lignocellulosic materials. This wash is then preheated to about 80 ^{0}C. This preheated wash [first stream] is subjected to a stripping column to get a top ethanol rich vapour stream [first top stream]. Next, this stream is condensed and collected in a collection tank for further rectification in a rectifying column. The energy present in said first top stream is exchanged in a first condenser to the first bottom stream of said stripping column. This causes said first bottom stream to concentrate and part of it is forming a first vapour stream, which is mechanically re-compressed to generate the high-pressure vapour stream; which in turn is used for running said stripping column. Further said condensed ethanol rich stream collected in a tank is subjected to the rectification process in a rectifying column to get ethanol rich, ethanol product stream with about 90% ethanol by volume. The said rectifying column is also run on said high-pressure vapour stream generated in mechanical vapour re-compression unit that utilises low-pressure vapour streams of condensers present in the system. The second top stream of said rectifying column is condensed in a second condenser and recycled back to said rectifying column. The second condenser further concentrates first bottom stream to concentrated distillery waste/ stillage. The second vapour stream of low-pressure vapour from said second condenser is further condensed in said MVR unit to create said high-pressure vapour stream that runs the system without need of any external live steam once the system of optimally operated. Herein the said condensers are also known as evaporators as they are used to concentrate the waste streams.

In another embodiment of the disclosed invention as illustrated in FIGURE 1, this is an exemplary plan of the invention showing several features that control the process of using mechanically re-compressed water vapour for the distillation of ethanol from a fermented wash. A fermented wash after preheating [1] is fed to a stripping column [A]. A compressed vapour stream [5] fed to the stripping column at the bottom of column where temperature is maintained at about 80 °C. This compressed vapour stream is used for the effective stripping of ethanol from said fermented wash in said stripping column. A first top stream [3] coming from said stripping column is condensed in a first condenser [C] forming a high-ethanol stream [7] that is further sent to a rectifying column [E] through a storage tank [optional] for further rectification of ethanol present said stream to get final ethanol product stream [14]. A first bottom stream [2] of said stripping column [A] is first subjected to solid-liquid separator to remove solids to form stream [6], which is concentrated in said first condenser [C] and through stream [9] in a second condenser [D] to get concentrated distillery waste stream/ concentrated syrup [11]. A first vapour stream [4] coming from said condenser [C] is subjected to mechanical vapour re-compression unit [F] leading to forming of a high-pressure vapour stream [5]. Said first vapour stream [4] is free of ethanol and is readily compressed to high-pressure vapour stream in the MVR unit [F]. Said high-pressure vapour stream [5] is used to run said stripping column [A] as well as said rectifying column [E] without need of any live steam except to turn on the system. A second top stream [12] coming from said column [E] is sent to said second condenser [D] and a second vapour stream [13] coming from said second condenser [D] is subjected to mechanical vapour re-compression unit [F] leading to forming of a high-pressure vapour stream [5]. Said second vapour stream [13] is free of ethanol and is readily compressed to high-pressure vapour stream in the MVR unit [F]. Next, a second bottom stream [8] of said rectifying column [E] is mixed with fermented wash and recycled to recover ethanol present in it.

In yet another embodiment a process for producing ethanol by using recompressed vapour for distillation and rectification is disclosed, wherein steam [and hence process water] required for the whole process of preparation of ethanol is significantly less as the low-pressure steam is recovered and mechanically recompressed using a centrifugal fan or positive displacement fan. This reduced requirement of process water has several advantages like overall water requirement and consequent water treatment requirements are substantially reduced making the process economic as well as eco-friendly.

Example provided below gives wider utility of the invention without any limitations as to the variations that may be appreciated by a person skilled in the art. A non-limiting summary of various embodiments is given in the examples and tables, which demonstrate the advantageous and novel aspects of the process disclosed herein. Particular examples of processes in accordance with this invention will now be described with reference to

EXAMPLE

In one embodiment of the present invention about 595-kilo litre per day of ethanol [absolute ethanol basis] plant was operated with fermented wash containing about 15% to about 18% ethanol by volume along with congeners and solids. The fermented wash required for said process capacity was about 130 to 160 tons per hour, which was available at about 32 ^{0}C from fermentation section. This feed was preheated to about 80 ^{0}C by using available/ spare heat from other sections of the plant or from the spent wash stream obtained in the process. This preheated fermented wash along with stream coming out from rectifier bottom was fed to the stripping column to strip out the ethanol. The fresh steam was fed to the stripping column initially at the time of start-up only, and once the process was stabilized fresh steam supply disconnected. The stripping column fist top stream contains most of the ethanol present in fermented wash after distillation having about 55% to about 65% ethanol by weight. This ethanol rich stream is condensed in a first condenser and further rectified in the rectifying column to obtain ethanol products of desired compositions. The energy present in the first top stream of stripping column is transferred to the first bottom stream of said stripping column in said first condenser, leading to formation of a first vapour stream and concentrated spent wash/ stillage. The first vapour stream is further re-compressed in the MVR unit to get a high-pressure vapour stream that is used to run said stripping column in an energy efficient manner. In a similar way the rectifying column is run using said high-pressure vapour stream and a second vapour stream of a second condenser is also converted to the said high-pressure vapour stream using said MVR unit as illustrated in FIGURE 1. The mechanical vapour re-compression [MVR] unit comprises a centrifugal fan or positive displacement fan for generation of said high-pressure vapour stream from said low-pressure condenser top streams. Next, said condensed ethanol rich stream of said stripping column is further rectified in the rectifying

The rectifying column bottom stream that contains about 20% to 35% ethanol by volume is mixed with feedstock-fermented wash used in stripping column. Further, due to concerted actions of the two condensers present in the system, the spent wash/ stillage is concentrated to about 50% and the water required to create high-pressure steam in the system is also obtained from it. The conventional methods require about 1.5 to 1.8 kg of steam per litre of hydrous alcohol, whereas the method disclosed herein requires about no steam during the steady state operation of the system.

While the invention has been particularly shown and described with reference to embodiments listed in examples, it will be appreciated that several of the above disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also that various presently unforeseen and unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims. Although the invention has been described with reference to specific preferred embodiments, it is not intended to be limited thereto, rather those having ordinary skill in the art will recognize that variations and modifications may be made therein which are within the spirit of the invention and within the scope of the claims.

CLAIMS

1. A process for preparation of ethanol using a mechanical vapour re-compression method comprising:

    a. preheating a fermented wash forming a first stream;

    b. subjecting said first stream to a stripping column forming a first top stream and a first bottom stream;

    c. condensing said first top stream through first condenser forming a high concentration ethanol stream and a first vapour stream;

    d. removing solids from said first bottom stream of step [b] and concentrating it in said first condenser forming a concentrated stream;

    e. compressing said first vapour stream forming a high-pressure vapour stream in a mechanical vapour re-compression unit and providing it to said stripping column;

    f. subjecting said high ethanol stream to a rectifying column forming a product stream, a second top stream and a second bottom stream;

    g. providing said second top stream to a second condenser forming a liquid stream and returning it to said rectifying column;

    h. recycling said second bottom stream of step [f] with said fermented wash of step [a] forming said first stream;

i. subjecting said concentrated stream of step [d] to said second condenser forming a concentrated waste stream and a second vapour stream; and

j. compressing said second vapour stream forming said high-pressure vapour stream in said mechanical vapour re-compression unit and providing it to said distilling column.

2. The process of claim 1, wherein said fermented wash is preheated to about 80 °C.

3. The process of claim 1, wherein said stripping column gives said first top stream with about 30% to about 70% ethanol by weight.

4. The process of claim 1, wherein said first condenser is energized using said first top stream of said stripping column.

5. The process of claim 1, wherein said second condenser is energized using said second top stream of said rectifying column.

6. The process of claim 1, wherein said stripping column is operated using said high-pressure vapour stream.

7. The process of claim 1, wherein said rectifying column is operated using said high-pressure vapour stream.

8. The process of claim 1, wherein said high-pressure vapour stream is of water without any amount of ethanol in it.

9. The process of claim 1, wherein said mechanical vapour re-compression unit comprises a centrifugal fan or a positive displacement fan.

10. An apparatus for using mechanically recompressed vapour for the distillation of ethanol according to FIGURE 1.

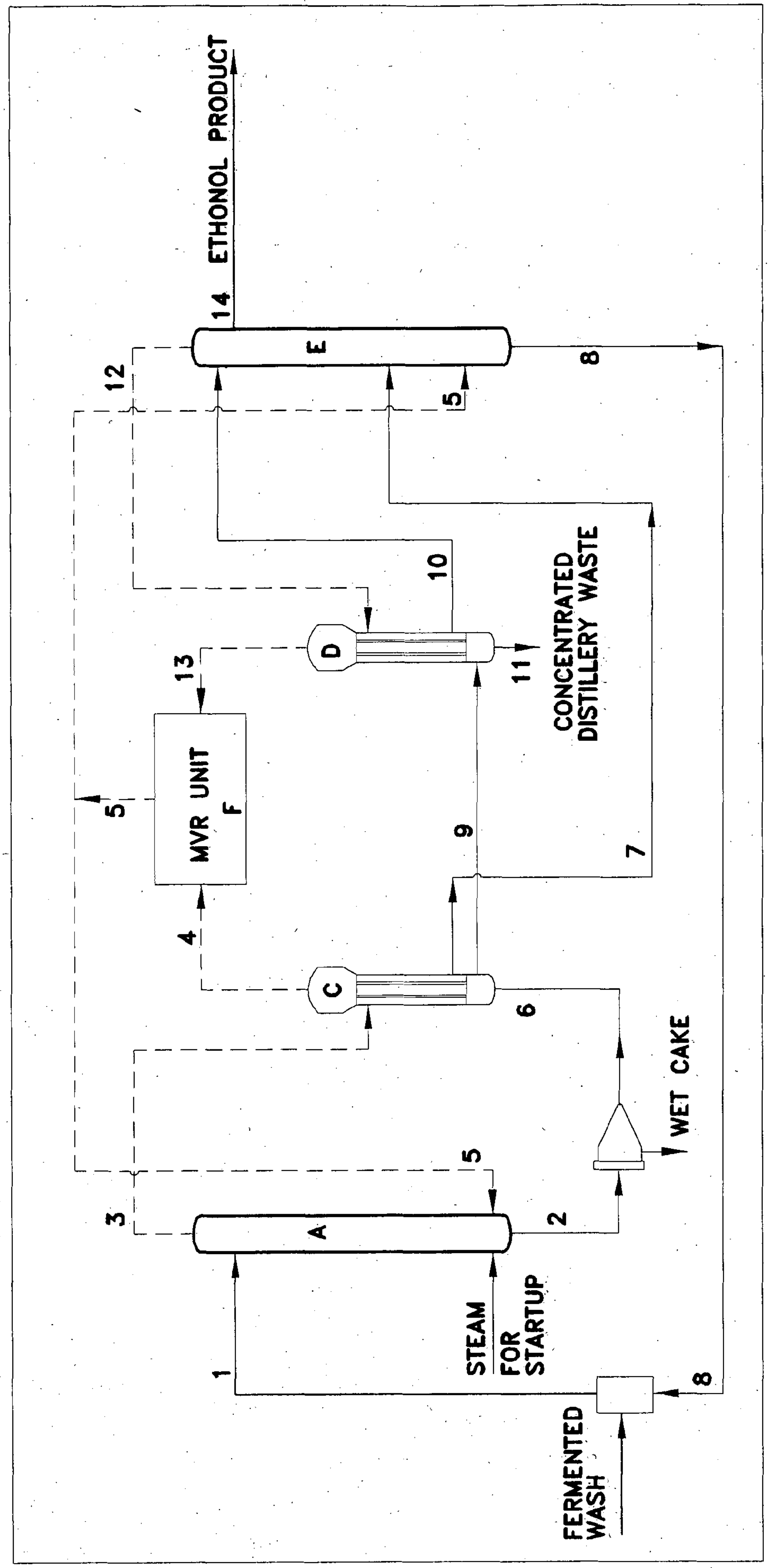
ETHONOL PRODUCT
14
E
12
5
8
10
D
13
11
CONCENTRATED DISTILLERY WASTE
MVR UNIT F
5
9
7
4
C
6
WET CAKE
5
3
A
2
STEAM FOR STARTUP
1
8
FERMENTED WASH

FIGURE 1