SCHEME OF TECHNOLOGY FOR CONGRUENT DEHYDRATION OF BIOETHANOL IN SEMI-DRY WAY

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Abstract. A method of bioethanol dehydration and a scheme for its realization are offered. The proposed method includes mash distillate rectification and simultaneous water adsorption in the pouring or downwards moving moist adsorbent layer, by feeding the mash distillate vapour flow and the flow of the adsorbent in the rectification and adsorption block, as well as the used adsorbent removing and regenerating of the adsorbent in the adsorbent regeneration unit for reuse in bioethanol dehydration. The active granular adsorbent is used as the adsorbent, which during the feeding in the rectification and adsorbing block is moistened with alcohol solution - intermediate product of the overazeotropic concentration dehydration process, and then the action of moistened adsorbent on dehydrated alcohol vapour injected in the middle of the block is provided, but the water from the used granules is separated by evaporating it in the granule regeneration block. The intermediate product of dehydration process - overazeatropic concentration alcohol solution, necessary for the moistening of adsorbent granules, is removed from the rectification and adsorption block zone, where the alcohol level of intermediate liquid is in range from 97.5 to 98.5 volume percent, by filtering intermediate liquid from the wet adsorbent granules.

Key words: congruent, bioethanol, dehydration technology, semi-dry.

Introduction

In bioethanol production, the alcohol from the water is traditionally released in three stages: distilling of the mash, rectifying of the acquired mash distillate and adsorption of residual water from the rectified alcohol.

It is known connected dehydration method of ethanol when the two processes – the alcohol rectification and water absorption - are performed simultaneously [1]. According to this technique, the powdered adsorbent by continuous flow is fed in the top of the rectifying column, where it is mixed with the phlegm. The formatted pulp through the rectifying column plates flows downwards adsorbing the water from both the liquid and vapour phase.

The used adsorbent is continuously removed from the bottom of the rectification column in the form of pulp together with lutherwater. The absolute alcohol forms on the upper plates, but below the concentration of alcohol is decreasing. At the column section, where the alcohol concentration is above the azeotropic 97.2 volume percent, only the adsorption process is running. At the lowest concentrations the both adsorption and rectification occurs. The dominant of rectification process increases, when the adsorbent gradually saturates with water.

That technique has the main disadvantage of settling the small adsorbent particles from the liquid pulp on horizontal surfaces of plates that worsens the conditions of operation and requires additional monitoring and cleaning. A certain disadvantage of the technique is also the complexity of regeneration process of adsorbent liquid pulp.

The aim is to optimize dehydration of bioethanol, reducing the energy consumption that is needed for dehydration, as well as simplifying the bioethanol dehydration technology and construction of equipment. The design of scheme of offered dehydration technology are based on studies performed in previous years and published in the proceedings of international scientific conference "Engineering for Rural Development 2010".

Materials and methods

Currently, in production of bioethanol mostly is used in Fig. 1, A mash distillate dehydration technology is shown, when in traditional rectification columns 1 the initial part of water is separated by rectifying, but the remaining part of water is adsorbed by molecular sieves 2 [2].

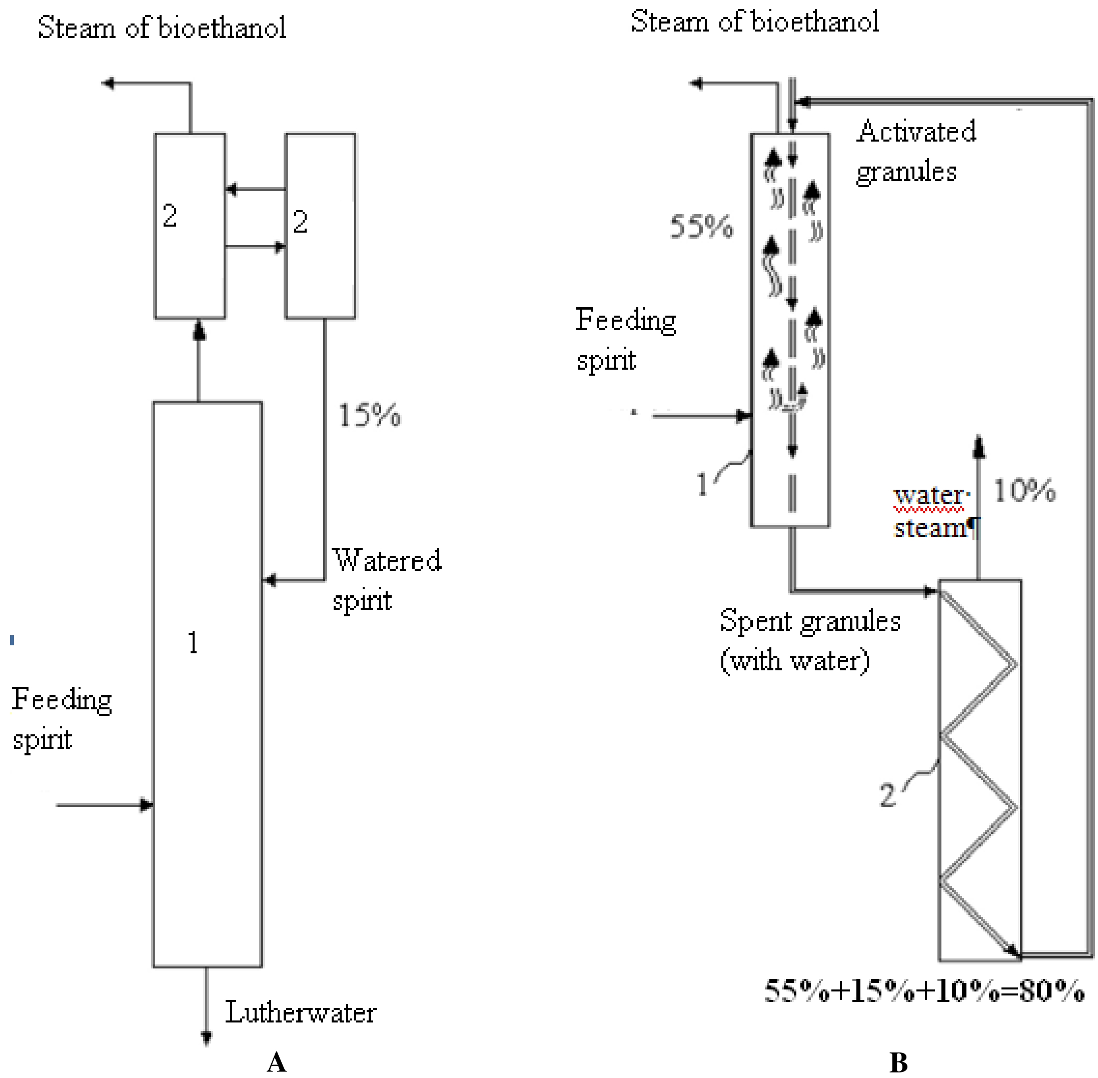

Fig. 1. **Comparison of dehydration technologies:**
A – conventional technology (1 – rectification column, 2 – molecular sieves);
B – proposed technology (1 – dehydration column, 2 – regenerator of granules)

Results and discussion

The objective is achieved by the proposed method of semi-dry congruent dehydration of bioethanol, that includes the rectification of mash distillate and the simultaneous adsorption of water in pouring or downwards moving moist adsorbent layer, when feeding in rectification and adsorbing block the mash distillate flow and the flow of the adsorbent, as well as discharging the spent adsorbent and the adsorbent regeneration in the recovery block for its re-use in dehydration of ethanol.

As an adsorbent is used the active granule form of adsorbent, that by feeding in the rectification and adsorption block, is moistened with the alcohol solution of overazeotropic concentration dehydration process intermediate product and then is provided the moistened adsorbent effect on feed in rectification and adsorption block the mash distillate vapour flow, but the bound water on spent granules is separated by evaporating it at the granules recovery block. In addition, for the moistening of adsorbent granules the needed dehydration process intermediate – overazeotropic concentration of alcohol solution is removed from the rectification and adsorption block zone where the intermediate liquid alcohol concentration is in the range from 97.5 to 98.5 volume percent, by filtering the intermediate liquid from the moist adsorbent granules. For the supplementing of the volume of intermediate liquid, part of a steam in this area is also condensed.

For the realization using principle of bioethanol semi-arid congruent dehydration establish, that the water removal from the alcohol takes place simultaneous in the way of water adsorption and rectification, free-running, in the moving down moist adsorbent granules layer, when granules layer permanently renewing, at the top of it supplying fresh, active granules, which move down gradually saturated with water are absorbed from the middle layer entered dehydration alcohol vapour, but from the bottom layer processed discharge water-saturated granules. Layer cross-sections, where the liquid phase alcohol concentration above the azeotropic 97.2 volume percent, proceed only water adsorption.

The bioethanol semi-dry congruent dehydration principle determines, that the water separation from the alcohol takes place in simultaneous water adsorption and rectification way, in pouring, downwards moving moist adsorbent granules layer, when granules layer is permanently reinstated by from the top of it supplying fresh, active granules, that in their downwards flow are gradually saturated with water by absorbing it from the dehydration alcohol vapour feed in the middle of layer, but from the bottom layer are discharged the spent, saturated with water granules. Cross-sections of the layer, where the liquid phase alcohol concentration is above the azeotropic 97.2 volume percent, proceeds only the water adsorption. In the cross-sections of the layer where the liquid phase alcohol concentration is below the azeotropic 97.2 volume percent, on the moving layer granule surfaces proceeds the mass and heat transfer that ensures also the realization of the rectification process.

In the down moving moist adsorbent layer all alcohol dehydrated process decomposes in the following areas: the top, the alcohol overazeotrope concentration zone, where occur the only water adsorption, the middle, alcohol concentration underazeotrope zone, where continue adsorption of water and begin rectification process and at the top of this zone adsorption is dominate, while the lower-rectification, the bottom, where the adsorbent granules released from the alcohol, attached to the outward surfaces of granules.

In the downstream moving moist adsorbent layer the alcohol dehydrated process is decomposed in the following zones:

- the top, the alcohol over-azeotrope concentration zone, where only the water adsorption occurs,
- the middle, alcohol concentration under-azeotrope zone, where continues the adsorption of water and starts the rectification process, whereas at the top of this zone dominates the adsorption, but in the lower part - rectification,
- the bottom, where the adsorbent granules are separated from the alcohol that is bound to the outer surface of granules.

The proposed technique based on bioethanol congruent dehydration principle, was tested in the laboratory facility, with a column size h=700 mm, d=80 mm, in which, irrespective of the small dimensions of the column, it was possible to realize the full dehydration cycle of feeding alcohol (diluted) vapour, namely, from the top of the column discharge absolute alcohol vapour, but from the bottom of the column – in the adsorbent granules fixed water, resp., the alcohol concentration range of this column was from 0 to 100 percent.

The bioethanol congruent dehydration principle application in the production technology is shown in Fig. 1, B. In the scheme are two blocks – rectification and adsorption block 1 (that is a rectification column without plates) as well as adsorbent granules regeneration block 2. Block 2 is adapted for from block 1 discharged adsorbent granules drying and redirecting in block 1 for the re-use.

From the practice of alcohol dehydration, it is known that in order to achieve high alcohol concentrations (96 to 96.5 percent) in conventional rectification, the column must contain 60 to 80 enhancement plates, which require a large equipment height [3]. For bioethanol dehydration using the proposed method, the plates are not necessary, and a column (block 1) height is less, as the concentration increases in it more effectively than in traditional rectification column.

Introduction of the offered bioethanol semi-dry congruent dehydration technique in production technology, gives such advantages as the energy savings of up to 80 percent, continuous process, simpler dehydration technology and equipment design, safer conditions for adsorbent regeneration by separating the fireproof substance - water from the granules.

Conclusions

1. The dehydration process of ethanol is optimized by reducing energy usage and simplifying bioethanol dehydration technology and equipment design.
2. The enhancement plates are not necessary using the method of congruent bioethanol dehydration.
3. The bioethanol semi-dry congruent dehydration technology allows save energy use up to 80 percent.

References

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