Investigation of organic impurities movement by accelerating column of alcohol which is under pressure lower than atmospheric

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ABSTRACT

Nowadays in a highly competitive market alcohol in Ukraine actual task for distillation factories is a significant reduction in the cost of finished products in the production of ethanol - rectified the highest quality. The aim of this study was: «to determine the optimal process parameters of energy-saving operation in the columns of ethanol rectification units that works under pressure lower than atmospheric with a stability production of high-quality alcohol». The movement of organic impurity in the columns of ethanol rectification units (ERU), working in energy-saving mode under pressure lower than atmospheric with aim to improve the quality of rectified spirit and increase specific output of marketable products is investigated. The most optimal technological parameters of the rectification work installation with additional columns and modes of control and regulation of this ERU were identified. The series of experiments was conducted to determine the degree of concentration and removal of organic impurity by performance booster column, which operates in vacuum. Experiments were carried out in a production condition on the gas chromatograph "Kristall 2000M".

Introduction

Nowadays in condition of fierce competition on the market of alcohol production in Ukraine and abroad the topical task before distilleries is to reduce production cost in the production of rectified spirit of the highest quality.

The first way to increase the specific output of rectified alcohol is removal it from alcohol-containing waste by incorporating distillation column (DC) in the scheme of ethanol rectification unit (ERU) according to the technology, developed at the National University of Food Technologies [1].

Recently for reduction of energy costs ethanol rectification units have been transferred to work under pressure lower than atmospheric [2,3].

Reducing the operating pressure lower than atmospheric causes a change in the coefficients of organic impurity and the coefficients of evaporation rate of ethanol, which requires adjustment of technological modes of process distilling.

The purpose of this study is to determine the optimal process parameters of distillation column operation which operates in energy-saving mode under pressure lower than atmospheric.

Research Methods

Test samples were carried out by chromatographic method on a gas chromatograph "Kristall 2000M" with a relative error of 1.2%. Studies were conducted on ethanol rectification unit Kozlivsky distillery, which operates under vacuum capacity of 4200 dal / day.

Results and discussion

Experience of its operation showed that for stable production of high-quality of commercial rectified spirit, is necessary to provide removal of it with alcohol-containing waste 1 from areas of maximum concentration as a percentage of absolute alcohol (a.a. brew), namely:

- Capacitor separator brew 2,5 – 3,0 %;
- Capacitor distillation column 1 5,0% ;
- The main fraction (MF) epuration column 6%;
- Fusel fraction 4,0%;
- Fusel spirit 1,0-1,5%;

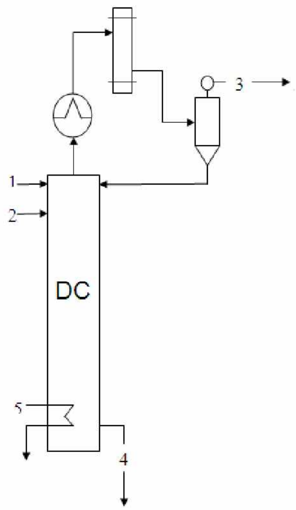

Fig. 1. The scheme of work DC

1-water; 2-supply: 3-concentrate ester-fusel (CEF); 4-cubic liquid; 5-the heating steam.

The total number of selected fractions in the production of high-quality alcohol is 18.5 - 19.5%. Outlet of these amount of alcohol-containing fractions with technological process is economically unfeasible, so we additionally introduced distillation column to the scheme BRU for concentrating and removing organic impurities of alcohol. Distillation column of Kozlivsky distillery was used as a research subject, which operates under a residual pressure at the top of the column (-4.6) m.v.st. and cubed (-2.3) m.v.st.. Technical characteristics of distillation column : Column has a 40 valve plates, diameter of columns – 1200 mm, height – 8100 mm, specific steam consumption - 2.7 kg / l. a.a. brew. To optimize the DC it is necessary to investigated the behavior of alcohol impurities at their high concentration when DC is working under vacuum. Fig. 1 shows a diagram of the DC.

Concentrating and removal of related alcohol impurities in DC that are introduced in ERU with brew.

"The degree of extraction (β)» and "the degree of concentration (α)» of related alcohol impurities depending on the efficiency hydroselection were the defied. Efficiency hydroselection was determined by the concentration of alcohol in the cubic liquid of DC at a concentration of 3.7, 3.9, 4.2, and 4.3, 4.6, 4.9, 6,0% vol. The table shows the concentration of volatile organic impurities in alcohol performance booster column at a concentration of alcohol in the cubic liquid at 3.7%, and qualitative indicators of commercial alcohol.

The concentration of volatile organic alcohol impurities by distillation column at a concentration of alcohol in a cubic liquid 3.7% vol.

Name of impurities	Zone sampling (apparent concentration of alcohol% vol.)				The degree of concentration of impurities, λ	The degree of removal of impurities, β
	Spirit (96,3%)	CEF, mg/dm³ (71,5%)	Cube DC, mg/dm³ (3,7%)	Supple column, mg/dm³ (73%)		
	1	2	3	4	$\lambda = \alpha_{CEF}/\alpha_{S.}$	$\beta = \alpha_{CEF}/\alpha_{cube}$
Acetaldehyde	0,36	365,26	3,37	144,84	2,52	42,98
Methyl acetate	traces	141,2	traces	24,55	5,75	complete
Ethyl acetate	traces	7103	traces	643,1	11,04	complete
Methanol	0,0022	0,031	0,07	0,069	0,45	0,99
Isopropanol	1,9	56,58	traces	3,67	15,42	complete
Isobutyl acetate	traces	117,7	traces	4,01	29,35	complete
N-propanol	traces	36770	2717	5116	7,19	1,88
Crotonic aldehyde	traces	33,05	traces	traces	Complete	complete
Isobutanol	traces	74900	traces	3601	20,80	complete
Izoamilatsetat	traces	505,1	traces	30,58	16,52	complete
N-butanol	traces	1015	traces	69,13	14,68	complete
Isoamyl spirit	traces	258000	7,73	12710	20,30	1644,24
N-pentanol	traces	115,5	53,04	54,16	2,13	1,02
N-hexanol	traces	578,9	traces	31,28	18,51	complete
Furfural	traces	-	traces	5,94	Complete	complete
Benzaldehyde	traces	22,71	traces	4,8	4,73	complete

The degree of concentrating and removal of organic impurities of alcohol in DC was identified on the bas's of obtained date.

Analyzing the process of separation of impurities in the performance booster column that runs under pressure lower than atmospheric, we can divide them into 2 groups varying degrees hydroselection.

The first group includes: acetaldehyde, methanol, izoamilatsetat, n-propanol, n-butanol, isopropanol, isobutyl acetate, isoamyl spirit. For their effective concentration it is necessary to maintain the concentration of alcohol in the cube DC between 3.7 ... 4.9% vol.

Group 2 includes: methyl acetate, ethyl acetate, n - pentanol, n-hexanol. For their effective concentration it is necessary to maintain the concentration of alcohol 6.0% vol.

Fig. 2 -7 shows graphs of the distribution of organic alcohol impurities depending on the degree hydroselection (concentration of alcohol in the cube DC). The next graphs are presented in the master's work.

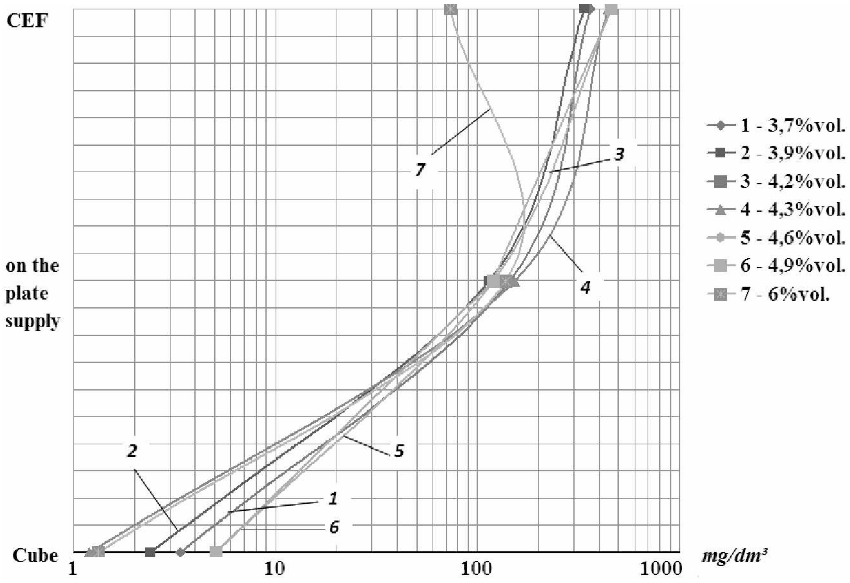

Fig.2. The concentration of acetaldehyde

The most effective concentration of acetaldehyde occurs when the concentration of alcohol in the cube PBC between 3.9 ... 4.3% vol. By increasing the concentration to 6% vol. - efficiency acetaldehyde concentration decreases times at average.

The best concentration of methanol occurs when the concentration of alcohol in the cube DC to 3.9% ob. With increasing concentration of the cube liquid to 6.0% vol. the degree of extraction and concentration of methanol decreases by almost 1.8 times.

Isopropanol is effectively removed at a concentration of cube liquid between 3.7 ... 4.9% vol.

When the concentration of alcohol from 3.7 to 3.9% vol. at concentration of n - propanol is the most effective.

When the concentration of alcohol in the cube LCD is 6% vol. removal and concentration of isoamyl alcohol is the worst. The best its removal occurs at the concentration of alcohol in the cube 3.7 ... 4.9% vol.

Ethyl acetate and methyl acetate are the most efficiently removed when the concentration of alcohol in the cube of distillation column about 6% vol.

Conclusions

Organic impurities of alcohol, which form its analytical and organoleptic properties for their degree of removal and concentration in the distillation column, with its work under vacuum (up to - 4.6 m.vod.st.) we can divid into two groups.

The first group includes, principally, intermediate impurities (n-propanol, n-butanol, isopropanol, isobutanol, izoamilatsetat), acetaldehyde and methanol, which are more effectively removed and concentrated under hydroselection that provides the concentration of alcohol in the cube of distillation column within 3 , 7 ... 4.9% vol.

The second group includes: ethyl acetate, methyl acetate, n-pentanol and n-hexanol, which are the most effectively remove and concentrated at a concentration of alcohol in the cube of distillation column at 6.0% vol., to be considered when modeling the quality parameters of commercial alcohol.

The obtained results allowed to optimize the disposal technology of rectified spirit waste of ethanol rectification units that works in energy-saving mode under pressure lower than atmospheric and to reduce their number at average from 18% to 0.3 ... 0.5% of absolute alcohol brew during stable production of high quality rectified spirit and this, in turn, increases the competitiveness of alcohol production both in domestic and foreign markets.

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