

TECHNICAL SCIENCES

ASPECTS OF ETHANOL MANUFACTURE. DIFFERENT PURPOSE – DIFFERENT TECHNOLOGICAL AND ECONOMIC SOLUTIONS

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Abstract

The article analyzes the reasons that led to the almost catastrophic situation in the ethanol industry of the country. The existing structure of consumption of ethanol in the domestic market, when the lion's share of ethanol is used to produce alcoholic beverages, together with the actual monopolization of pricing policies, have led to the fact that spirits can produce significantly more volumes of ethanol than the market needs, while exports make high ethanol prices impossible. When considering the effectiveness of the introduction of new technological and technical solutions, almost never paid attention to their impact on the cost of finished products. So, domestic alcoholic beverages are capable of producing high quality rectified ethanol, but the need for it both within the country and in the world is limited. The main volumes of alcohol sales on world markets are formed at the expense of bioethanol and technical ethanol (ethanol for technical needs). At the same time, prices for them are formed taking into account competition with products of the same purpose, offered by producers of other branches of the economy. Therefore, the development of the ethanol industry is possible only by changing the main directions of its use in the production of beverages for technical and transport needs and taking into account the economic results of the implementation of technological and technical solutions.

Keywords: ethyl alcohol, rectified alcohol, technical alcohol, bioethanol (fuel ethanol), directions of use of ethyl alcohol, cost of finished products, economic effect of introduction of technological and technical solutions.

Introduction

The ethanol industry of Ukraine is in a rather difficult situation. The existing capacity of the distilleries is several times greater than the volume of consumption of ethanol within the state within the existing structure of its use. The enterprises processing the grain are set to produce high-quality rectified ethanol, the demand for which forms almost 90 percent of the needs of the domestic market. Therefore, most of the distilleries either do not work for several years, or work 2-4 weeks a year. Such non-rhythmic work leads to an increase in the cost of ethanol and makes it impossible to attract investment in the renovation of production capacities in the industry. And privatization will not change anything in this regard if the situation on the ethanol market is not changed in relation to the directions of its use.

Ethanol is used in many sectors of the economy and in everyday life. Its largest amount in the world is

used as an additive to motor fuels or their main component. In addition, significant volumes of ethanol are used for technical needs, production of alcoholic beverages, medicine, etc.

In general, there are three main areas of use of ethanol and, accordingly, three of its types as commodity products:

- ethanol rectified; used for the production of alcoholic beverages, vinegar, in some branches of the food industry, in medicine;
- ethanol technical; used in various industries as a solvent, non-freezing component, raw materials for further processing;
- bioethanol (fuel ethanol); used as a component of motor fuels or the main part.

Each of these commodity products has its sales markets, which differ from each other requirements for quality products, value characteristics, the presence of competing products of similar designation, produced

by related industries of other countries or other industries, different levels of government regulation. Currently, there is no problem of "product development" (this applies not only to ethanol), but there is a problem "to sell products with profits." In each item there are several offers from manufacturers, which allows the buyer to choose the product he needs, taking into account the requirements for the quality of goods and available to the buyer financial resources.

In view of the above, producers of ethanol as commodity products in their technological and technical solutions should take into account not only the production, but also the financial and, consequently, the implementation, the result of their implementation. The overall effect is to ensure the competitiveness of finished products both in local and international markets, thus allowing them to work stably and to consider production issues in both the short and long term.

The article deals with the peculiarities of the production of ethanol of various intended purposes and the technological solutions that are feasible for implementation in view of the specifics of the sale of finished products.

1. Rectified ethanol

As already noted, the main direction of the use of ethanol rectified is the production of alcoholic beverages: strong (vodka, whiskey, gin, absinthe, etc.), low-alcohol and in wine making. Rectified ethanol is also a raw material for the production of alcoholic vinegar, used in the confectionery industry, perfumery, medicine for the production of drugs, and as a disinfectant.

Directions of use of rectified ethanol form the basic requirement of consumers to it - the quality of ethanol, and more specifically - the minimum amount of impurities, which adversely affects the quality of products produced using ethanol rectified. At the same time, given that such products are mainly consumed directly by man as beverages or food, the main requirement is the level of contaminants content in the finished product that is safe for human health.

First of all, the efforts of producers of rectified ethanol are concentrated on the implementation of technological and technical implementation aimed at ensuring the minimum content of undesirable impurities in commodity products. Thus, according to the normative documents in force in Ukraine and in other countries of the world, the content of furfural in rectified alcohol is not allowed; producers are trying to reduce to the minimum possible content of methyl alcohol, aldehydes, components of fusel oil.

The main measures to ensure the quality of rectified ethanol are realized when it is purified from impurities in the distillery department, but some of these measures are used at the beginning of production.

The main raw material for the production of rectified ethanol of the highest quality (in Ukraine - the variety "Lux" and "Wheat tear") is grain. Other types of raw materials (molasses, food waste) are used for the production of rectified ethanol for the needs of the food industry, medicine, etc. and are not used in the production of alcoholic beverages. In Brazil, alcoholic beverages use sugar cane ethanol, but there is no such ethanol as a commodity product in the markets. Therefore, it is

advisable to consider proposals for improving the technology of production of ethanol rectified grain and their impact on the quality indices of commodity products and their value.

The specifics of the Ukrainian legislation in the field of production and circulation of ethyl ethanol (primarily rectified) was that, firstly, the producer of rectified ethanol can only be a state-owned enterprise (and in fact the Ministry of Agrarian Policy and Food is a monopolist in such production).

From the July 2021 rectified ethanol can produce by private companies, but its very short time for real competition from them to the Ukrspirt. The import of rectified ethanol into Ukraine is not legally prohibited, but in fact impossible. That is, there is no competition on the Ukrainian market of rectified ethanol and there is only one seller - the Ministry of Agrarian Policy and Food through the Ukrspirt. This allows SE Ukrspirt to establish a single unit for its subsidiaries (place of working VP) and alcoholic factories of the Ukrspirt concern (in the state of liquidation) the cost of rectified ethanol of various grades.

The lack of external competition allows Ukrainian producers of rectified alcohol to introduce innovative technologies for improving the quality of finished products, without much concern for their impact on the cost of rectified alcohol. This allows alcohol producers to meet the requirements of the quality of rectified alcohol, but it has a hidden threat to the prospects for the sale of rectified alcohol in the world markets - Ukrainian rectified alcohol in world markets (with the exception of the CIS markets) is uneconomic in value and is not realized.

The production of ethanol recovered from grain has two main technological stages:

- getting the mature beer;
- the removal of ethanol from the beer and cleaning it from the admixture with the receipt of the product of the required quality.

1.1. Improvement of the technology of obtaining beer

The main direction of improvement of the technology of obtaining mature beer is the introduction into production of osmophilic thermotolerant raisins of yeast with the implementation of a complex of technological solutions, which ensures the possibility of fermentation of highly concentrated bases and obtaining beer with high ethanol content, while providing normative indicators of the quality of mature beer and ethanol output.

The first step in the complex of such measures (without taking into account the use of quality grain) is to ensure homogeneity of grain meal. Normative characteristic of meal - passage through a sieve with a diameter of holes 1mm in percent. There was a tendency to provide a passage of 98 ... 100 percent with minimizing the size of individual particles of meal (0.5 mm, 0.3 mm, 0.25 mm). But the experience of ethanol producers in other countries and the practice of the best domestic enterprises pointed to the problem of not only the total percentage of milling pass through the 1 mm sieve (95 or 100%), but the homogeneity of the meal - let the particles be 0.9 mm, but such particles should be 100 %.

Therefore, equipment for meal (hummermilis, disintegrators, etc.) is selected taking into account the requirements for homogeneity of meal and specific electricity consumption.

The next stage is dishwashing (meal + water) and its water-heat treatment. Application in the production of osmophilic raisin yeast provides an opportunity to increase the concentration of dry matter in the mash (instead of the hydromodule 1: 3,0 ... 3,5 to work with the hydromodule 1: 2,0 ... 2,5), and the use of secondary heat sources (reflux water and backset), along with the dosage of all the required amount of alpha-amylase in the mash, provides an increase in the temperature of the mash and, accordingly, reduces the amount of acute steam needed to heat the mash to the maximum heat treatment temperature. Currently, a number of distillers operate with a temperature in the apparatus for making mash 75°C ... 78°C.

The maximum temperature of heat treatment for the action of alpha-amylase is determined in the first place in accordance with the requirement of inhibition of the life of a foreign microflora, which is introduced into production with grain and from other sources. The idea that the main requirement is the effective dilution of starch, is not entirely correct. The current technological regulations provide for the achievement of 93°C ... 95°C thawing, whereas enzyme preparations offer alpha-amylase operating in the temperature ranges of 53°C ... 55°C; 73°C ... 75°C and 93°C ... 95°C. That is, the hydrolysis of starch to dextrin can be carried out at temperatures lower than 93°C ... 95°C. The maximum possible temperatures were chosen precisely because of the possibility, if not sterilization, at least pasteurization of dipping and diluted mass.

The biology of microorganisms suggests that they can be in two forms: vegetative and spore. For the inhibition of activity, and even the complete elimination of the vegetative form, sufficient temperature is 75°C ... 80°C, and spore forms can withstand short-term heating and up to 160°C ... 170°C.

Application at thawing temperature of 93°C ... 95°C is a kind of insurance manufacturers and is not connected directly with the main purpose of this stage - the hydrolysis of starch to dextrin. Therefore, part of the distillers made attempts to reduce the temperature of thinning initially to 90°C ... 93°C, and then to 88°C ... 90°C. This makes it possible to significantly reduce the use of steam during liquefaction of mash, but is not the most desirable level. If it is possible to ensure the proper functioning of the branches of preparation of beer with a maximum temperature of 75°C ... 77°C, then you can refuse the use of thermostable alpha amylase in favor of other, cheaper enzyme preparations and reach the necessary maximum temperature due to secondary sources of heat (the ultimate goal, "When the distillery department is operating, the department of thermo-enzymes treatment should not use a spicy steam").

It is also possible to prevent the activation of the life of a foreign microflora through the use of antiseptics at the stage of cooking. The maximum allowable dose for antiseptic is calculated taking into account its

(quantity) effect primarily on yeast (reproduction, fermentation activity), as well as on the quality of rectified ethanol (the possibility of getting into the finished product and the effect on the formation of undesirable impurities). Typically, manufacturers of rectified ethanol try to work with doses of antiseptic 30 ... 60 percent of the maximum permissible, fearing their negative impact on yeast primarily. But the question of the use of antiseptics should be considered and the economy. For example, the maximum permissible dose of antiseptic is determined by its effect on yeast and does not affect the quality of ethanol (and the quality of ethanol may be greater). Ethanol is produced with the use of dry yeast, which should be periodically renewed (initially fermentation activity of dry yeast was kept for 13-15 days, now the duration of their use does not exceed 9 days, or even 5-7 days). Therefore, it is necessary to do a joint technological and economic analysis that is more appropriate: to apply an increased dose of antiseptic (without affecting the quality of ethanol) and more often update the yeast, but reduce the temperature of liquefaction, or work with the maximum possible duration of the yeast and the corresponding doses of antiseptics and the temperature of liquefaction. Here, along with technology, the process economy is also important.

The use of backset in the preparation of mash is also limited by its influence on yeast and on the quality of the finished product.

In the future, especially when diluting at reduced temperatures, the optimization is the completion of hydrolysis ("saccharification") in the fermentation apparatus in conditions that are unfavorable for the activation of the life of the foreign microflora (temperature, presence of nutrient medium, the presence of a certain amount of ethyl ethanol). Preparation of production yeast is based on the content of dry matter in the mash, which is primarily due to the need to use supplementary food (depending on the type of grain) and the need to comply with the regulatory indicators of the yeast division.

Producers of rectified ethanol are used by a periodic method of fermentation. This enables, if necessary, to adjust the fermentation process to achieve the standard maturity of the mature shoots.

1.2. Excretion of ethanol from the beer and its purification from contaminants

Treatment of the mature beer in the rectified ethanol of the required quality is carried out in the distillery department at the appropriate facility. In accordance with the features of the work of the distillery department, the work of the compartments of beer preparing is also adjusted.

For the effectiveness (both technological and economic) of the compartments of beer preparing, increasing the content of dry matter in the mash, and, accordingly, the concentration of ethanol in the mature beer is the most effective measure - "the more, the better".

However, when distilling shakes with a high concentration of ethanol, the ethanol content in the distillate from the beer column increases accordingly. For companies that operate an ethers column using the technology of hydro-leakage, this means the need to use more water with an increase in column load on the

steam portion. It is also necessary to conduct an economic calculation and find the optimal solution for the two branches.

With more or less stable work, alcohol manufacturers added to the distillery the final purification columns, fuselage, accelerating, and increased the number of contact devices in the alcohol column. At present, in the case of non-rhythmic businesses, the feasibility of such measures is questionable.

The attention should be paid to the introduction of automatic control systems for the work of the distillery department with the use of computer software and the output of the performance indicators of the distillery department on the central monitor (along with the local one). This makes it possible to react promptly to changes in the work of equipment (mostly without human intervention) and to provide a multilevel control over the work of the distillery department.

Summarizing the above, we can draw the following conclusions. For domestic producers of rectified ethanol, taking into account the ratio of directions of its use (mainly for the production of alcoholic beverages) and lack of competition in the domestic ethanol market, the key to the implementation of new technological and technical solutions is their impact on the quality of finished products, the availability of the necessary funds and the rhythm of the work of a particular company. The need for a market in rectified ethanol is largely determined by the need of the population in alcoholic beverages, especially strong, and tends to decrease. In this case, the cost of ethanol is not decisive, which leads to the actual impossibility of entering the world markets of rectified ethanol.

2. Technical ethanol

Requirements of consumers to technical ethanol differ significantly from the requirements of manufacturers of alcoholic beverages and other products of the food industry. Given that the directions of the use of technical ethanol: solvents, non-freezing components, etc. On the market there are proposals similar products of other industries (primarily petrochemicals), the main role plays the cost of ethanol and technical products and its use. In most cases, the competitor of technical ethanol is methanol from various sources (mainly from natural gas and waste from the petrochemical industry, but there is also biomethanol). Therefore, technical ethanol must be competitively priced. In many countries, especially the EU, end-users are willing to pay slightly higher costs for non-methanol products (considering the environment), but within reasonable limits.

Raw material for the production of technical ethanol may be non-standard grains, molasses and other wastes of food industries (we do not consider the issue of production of technical ethanol from non-food raw materials).

The specifics of the production of technical ethanol from grains include the following. Even if the buyer submits certain requirements for the presence of impurities in the technical ethanol (for example, manufacturers of non-freezing washing liquids for cars limit the content of aldehydes, esters and fusel oil), the ethers column in the distillery department works without hydrolysis. Therefore, the content of dry matter in the

mash (and, accordingly, the content of alcohol in the beer) is limited solely to the ability of yeast to ferment the highly concentrated mash, adhering to the normative technological parameters of the beer and the yield of ethanol per unit of raw material. Also, the maximum permissible dose of antiseptic is calculated solely by its influence on the fermentation activity of yeast (a common technological and economic calculation is similar to that given for rectified ethanol).

The amount of filtrate of backset, which can be used in the stage of cooking, as well as the multiplicity of use is limited to the production parameters of yeast. Again, it is necessary to make a comprehensive calculation again: increasing the amount of backset and its multiplicity of use can lead to more frequent updating of yeast, but reduces the use of the water of the drinking quality and the steam. And here the economy should sum up - which is more profitable in monetary terms.

In the production of technical ethanol it is expedient to introduce continuous fermentation with biomass recycling. This increases the productivity of the fermentation department and, accordingly, reduces the cost of technical ethanol.

Distillery department also has certain features. For the production of a number of grades of technical ethanol (for which there are no restrictions on the content of the main and final impurities), the ethers column is not used at all. In this case, the cost of technical ethanol (taking into account the distillation of the beer with high ethanol content) is minimal. In addition, the experience of cooperation with European consumers shows that even in one country there may be different requirements for the content of ethanol in finished products. Thus, the formulations of production of non-freezing washing liquids for cars of the two Austrian manufacturers are calculated on the content of ethanol in technical ethanol at the level of 94% and 95% vol. Reducing the content of ethanol in technical ethanol (if possible) is also a way to reduce its cost.

Normative documentation also provides for the production of absolute (dehydrated) technical ethanol with a concentration of ethanol from 99.0% vol. up to 99.99% vol.

Thus, the production of technical ethanol, unlike the rectified, aims to meet the needs of many industries to produce a wide range of products for various purposes and does not directly depend on the population. Therefore, producers can count on the long-term stable operation of their enterprises, provided that the competitiveness of both technical ethanol and products with its use is ensured. When considering the feasibility of introducing new technological and technical solutions, the determining factor is their influence on the cost of technical ethanol.

3. Bioethanol (fuel ethanol)

Bioethanol (European name) or fuel ethanol (USA) is the largest in terms of volume of production and consumption of the target species of ethanol, and these volumes grow from year to year.

World production of bioethanol in recent years is characterized by the following figures, billion liters (RFA):

2017 – 101.7

2018 - 108.4
 2019 - 111.0
 2020 - 100.0
 2021 - 103.4

The United States (55%) and Brazil (27%) together provide production of 84% of the world's bioethanol content. Among other major producers: the EU-5%, China-3%, Canada-2%, Thailand-1%, Argentina-1%, India-3%, and the rest of the world-1%.

In the US, the largest producer of bioethanol, the main raw material (over 90%) is corn, in Brazil - sugar cane. In other countries raw materials are similar.

The chain of processing sugar cane in bioethanol is easier than corn: cane - the selection of juice - the fermentation of juice - the separation of ethanol from beer - the production of finished products (strengthening and dehydration of ethanol).

In the processing of maize, the main technological and technical improvements are similar to those noted with some features. The process of obtaining beer is similar to the processing of grain into rectified and technical ethanols. At the same time, they are trying to recycle the measurements of the maximum possible concentration. Yeast producers publish commercial offers for bioethanol plants with indication of ethanol concentrations in beer, which can reach and maintain their yeast at 20-22% vol. This allows you to significantly reduce the cost of steam in the beer column when you remove the ethanol from the beer.

The fermentation department uses a continuous fermentation method; often enough, the first fermentation apparatus provides sterile air for the rapid accumulation of the necessary biomass of yeast. Widely used antiseptics.

In the processing of mature shoots into bioethanol, in addition to the beer column, an ethanol column and an installation for dehydration are used. The latter can work on the principles of azeotropic rectification (usually cyclohexane is used), using molecular sieves or membranes (pervaporation). The main criterion for choosing a unit for absolute is financial: the cost of installation, its installation and operation, the specific costs of steam and water - in general, the final cost of bioethanol.

On the market bioethanol is a direct competitor of gasoline and should have approximately the same value (taking into account different calorific value). Of course, the state in a certain way, including through coercion, affects the use of bioethanol, but only in its initial stages. In the future, the main role is played by the economic factor.

3.1 Using the new type of raw material in the bioethanol production

The main requirement for the quality of bioethanol is the water content - 0.2 - 0.3% vol. Therefore, scientists, and then producers of bioethanol turned their attention to other, except grain and cane, types of raw materials that can be used on an industrial scale.

The first such list is raw materials containing cellulose: straw, grass, waste wood industry. The idea of recycling cellulose into alcohol is not new - in the last century, factories for the processing of cellulosic raw material into technical alcohol were exploited, but they worked with the use of technology of environmentally hazardous and economically disadvantageous acid hydrolysis. Cost reduction of cellulolytic enzyme preparations made it possible to organize the processing of cellulosic raw materials into bioethanol at a new technological level corresponding to the 21st century.

In the US, there are currently 4 bioethanol production companies from cellulose with a total capacity of 314.2 million liters per year, another 3 plants (881.9 million liters per year) can process grain and cellulosic raw materials. By the way, in the United States, the term "bi-refinery of the second generation" for bioethanol manufacturers is used for the second generation, emphasizing the new level of bioethanol production technology (fuel ethanol). The technology of treatment cellulosic raw materials into bioethanol is constantly being improved in the direction of its cheapening and expansion of the raw material base. For example, the patented technology of waste wood processing industry with the parallel production of biorefinery required amount of enzyme preparations from the same raw material. Such technologies are extremely interesting for our factories, especially taking into account the Government's policy of ensuring the industrial processing of wood by domestic enterprises.

The following raw materials, which are still processed on an industrial scale, but whose volume is virtually unlimited - municipal waste (sewage). Scientists have argued for the symbiosis of microorganisms, including yeast, capable of recycling the waste water of cities into ethanol. Of course, this is a distant prospect, but 15-20 years ago they talked about the technology of industrial processing of cellulosic raw materials in bioethanol.

Conclusion

The raw material base of Ukraine, the presence of skilled personnel and their training system (universities, institute of postgraduate education) provide an opportunity for the development of ethanol production both for the needs of the domestic market and for export. Successful development of the industry is possible only with the change in the structure of domestic ethanol consumption in accordance with world trends - bioethanol, technical alcohol and then rectified alcohol, as well as taking into account economic factors in the implementation of technological and technical solutions. World alcohol markets have a certain level of prices for various types of alcohol as commodity products, and the production of alcohol within these prices creates opportunities for its export.

Technology and the economy must be inseparable, then the success in the production and realization of alcohol will be ensured.