ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

Volume 9
Issue 2
2024

OPTIMIZATION OF HEAT LOAD IN THREE-STAGE DISTILLATION OF VEGETABLE OIL MICELLES

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Abstract: The article presents methods of effective use of secondary water vapor in three-stage distillation of vegetable oil micelles, optimization of material and heat consumption of solvent vapor, water vapor and water in distillation processes. Economic efficiency was calculated as a result of efficient use of energy of secondary solvent vapors, saving of cold water consumption and introduction of energy-efficient technological line.

Keywords: distillation, condensation, temperature, heat, steam, micellar, concentration, optimization, material balance, heat balance.

One of the main tasks of the optimal development of energy complexes in the world is the economy of energy resources and increasing the efficiency of its use. In the period up to 2030, the national economy's needs for food, energy, raw materials and materials will be provided at the expense of their economy.

Masstransfer processes are considered an important part of technological processes in many industries, and the correct implementation of the process depends on energy resources, product quality and environmental protection. For this reason, it is of particular importance to find a solution to the technical and technological problems related to the production of vegetable oils that meet the requirements of international standards at minimum costs in vegetable oil factories.

Currently, hot water and water vapor are widely used for heat exchange processes in the production of cottonseed oil in the oil industry. In this case, the high temperature of hot water vapor is very important.

For the distillation of micelles in industrial enterprises, in two-, three- and multi-stage technological lines, different devices are used in terms of the principle of operation and structural conditions [2, 5]. After oil extraction, three-stage nd-1250 type micellar distillation equipment, consisting of a mixture of solvent and oil, is effectively used in enterprises. in this system, separate heat energy is used in each distiller[1].

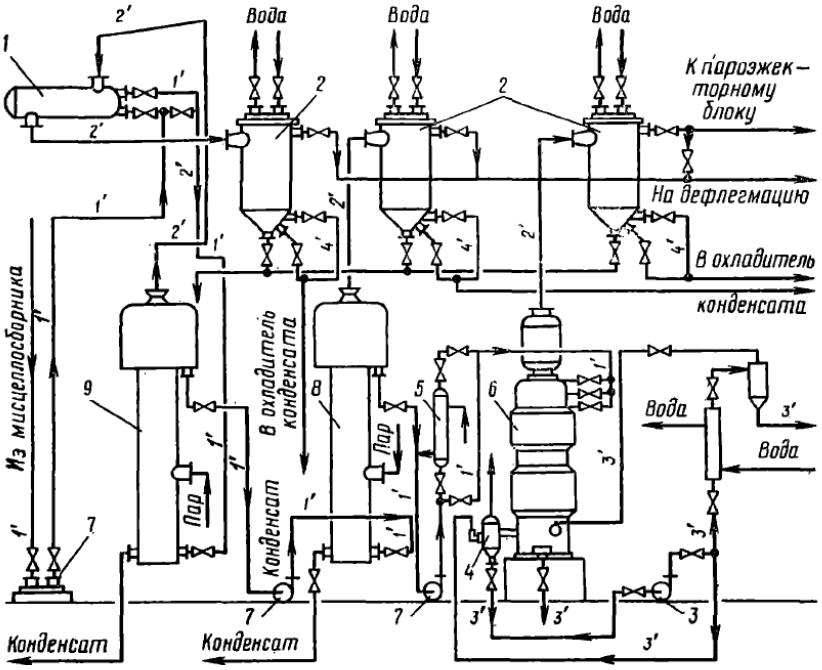

Figure 1. ND-1250 technological scheme of three-stage distillation of micelles in the extraction system. 1`-micella; 2`-solvent and water vapor 3`-oil; 4`-solvent and water; 5`-water vapor; 6`-cooling water; 7`-condensate; 8`-sediment. [9]

Devices of the first and second stages of the ND-1250 still operate under the same conditions. Depending on the features of the micelle, the water supplied to it differs in terms of steam consumption, temperature, and micelle concentration. In the third stage, water vapor is supplied in two ways, open and closed. A large amount of cold water is required to condense the secondary vapors produced during the micelle distillation process.

ND-1250 stills of the first and second stages consist of two parts, the lower part is tubular, the upper part is sent, the process is carried out under vacuum and at atmospheric pressure.

During the process, water vapor at a temperature of 180-200℃ is supplied to both stages. The temperature of the missile is 70℃ when it is sent to the first stage, and its temperature reaches 80℃ at the end of the process. in the second stage, it will be at a temperature of 80℃. Water vapor is supplied to the final distiller in two ways. The final distiller consists of four parts, a drop holder and three chambers, sprayer, curtain, deodorizer, and three different distillation methods are used: spray, curtain, and layer. After the micelle is first heated to 105-110℃ in the complete distillation process in the heat exchanger, the micelle with a concentration of 90-95% is introduced into the spray located at the top of the distiller under a pressure of 0.3 mpa. This process is carried out under vacuum. Micelles are intensively expelled from the spray zone. Intensively driven micelle drops hit the shitoki and are distributed there and flow in the form of a thin film. The leaked micelles are re-distilled under the influence of closed and open steam to the highly concentrated micellar solvent. Thus, the driving is completed, the driven oil is collected in the deodorization chamber and deodorized with open steam with a temperature of 180-200℃ and a pressure of 0.3 mpa. spotted extraction oil is heated again to 95-115 0c with closed steam [2, 5].

Hexane is used more often as a solvent to separate oil from oil in oil plants. The correct selection of the distillation process depends on the boiling point and heat capacity of hexane. Table 1 lists the properties of hexane.

Mixture of gasoline and water vapor coming out of each distiller is sent to condensers. Water vapor sent to distillers leaves the apparatus as condensate. If not enough heat is supplied to the process, the expected result will not be achieved.

the condensation process is also considered an important process, it ensures the transition of the solvent from the vapor phase to the liquid phase, and allows the reuse of the solvent during the extraction process. Condensation is the process of cooling vapors and gases with air or water, changing the aggregate state of gases and vapors, and transferring them to the liquid phase.[6]. During the condensation process, the temperature of the water entering the condenser is 20-25, the outlet temperature is 40-50.

Movement of micelles, solvent, oil, water vapor and cold water in the distillation system of the nd-1250 extraction line is shown in Fig. 1.

Currently, the production capacity of cotton seed in large oil enterprises is 400 tons per day. It is possible to calculate the material and heat calculations of distillation by working out the material calculation.

The amount of distilled solvent in the micelle can be found using the following formula.

$$Gb=Gmis(1-a1/a2) \quad (1)$$

Here, Gb - distilled steam consumption; Gmis- quantity of micelles; a1-a2- concentration of the first and second stage of micelles; [5]

List 2, [5]. Mass consumption of the micelle distillation process.

Entering the distillation stage	Tons	%	Exit from the distillation step	Tons	%
Oil G_m	22.88	14.7	Oil G_m	22.88	14.7
Solvent G_b	132.96	85.3	Amount of solvent distilled from the micelle		
			$G^1_b=G_{mis}(1-a_1/a_2)=155.84*(1-14.7/60)$	117.66	79.59
			Amount of residual solvent in the micelle		
			$G^2_b=G_b-G^1_b=132.96-117.66$	15.30	9.83
Micelle G_{mis}	155.65	100.0		155.65	100.0
Oil G_m	22.88	60.0	Oil G_m	22.88	60.0
Solvent G_b	15.25	40.0	Amount of solvent distilled from the micelle		
			$G^3_b=G^1_{mis}(1-a_2/a_3)=38.18(1-60/95)$	13.99	36.7
			Amount of residual solvent in the micelle		
			$G^4_b=G^2_b-G^3_b=15.30-14.06$	1.2	3.3
Micelle G_{mis}	38.13	100.0		38.13	100.0
Oil G_m	22.88	95	Oil G_m	22.88	95
Solvent G_b	1.2	5.0	Amount of solvent distilled from the micelle		
			G^4_b	1.2	5.0
Micelle G_{mis}	24.08	100.0		24.08	100.0

Table 1 shows the material balance of micellar distillation processes in an enterprise with a daily cotton seed production capacity of 400 tons. Where: 14.7% micelles for the first stage, 60% for the second stage and 95% for the third stage are sent to the process. As it can be seen from above, the temperature given to the micelle and its concentration play a big role in the course of the distillation process. The higher the concentration, the more complicated the distillation.

When finding the heat capacity of the micellar, it is found using the heat capacity of the oil and the solvent:

$$Cmis=Cmmm+Ceme \qquad (2);$$

Here, Cmis is the heat capacity of the micelle; Cm and Ce - heat capacity of oil and solvent; mm and me are the mass fractions of oil and solvent.

When finding the heat capacity of oil and solvent, the heat capacity is selected using the tables. In this case, the heat capacity of oil 80℃ is 0.480 kkal/kg*s, and the heat capacity of the solvent is 2.53 kJ/kg*s=0.604 kcal kg*s. At 60℃, the heat capacity of the oil is 0.465 kkal/kg*s, the heat capacity of the solvent is 2.41 kJ/kg*s=0.575 kkal/kg*s [3, 4].

List 3, [8]. Heat capacity of the micelle.

	Temperature	Fraction of oil in the micelles (%)	Heat capacity of oil (kkal/kg*°C)-(kJ/kg*C)	Fraction of solvent in the micelle (%)	Heat capacity of solvent (kkal/kg*°C)-(kJ/kg*C)	Cmis=Cmmm+Ceme (kkal/kg*°C)/(kJ/kg*C)
1	60	14.7	0.460/1.926	85.3	0.575/2.41	0.559/2.34
	70		1.968		2.47	2.39

	80		0.480/2.010		0.604/2.53	0.586/2.45
2	80	60.0	0.480/2.010	40.0	0.604/2.53	0.529/2.22
3	80	95.0	0.480/2.010	5.0	0.604/2.53	0.486/2.03
	105		0.505/2.115		0.640/2.70	0.512/2.14

In Table 3, the heat capacity of the micelle is calculated using the formula (1). heat capacities of two or more complex mixtures depend on their concentration. Due to the low heat capacity of oil, the higher the percentage of oil in the micelle, the lower the heat capacity.

$$Qmah=Gmah*Cmah*t \qquad (3);$$

Here, Qmah – mahsulotdagi issiqlik miqdori; Gmah – mahsulotning massasi; Cmah – mahsulotning issiqlik sig'imi; t – mahsulotning jarayondagi temperaturasi. [5,6].

List 4, [6,7].

	Step 1	Step 2	Step 3
Heat content of micelles (Qmis=GmisCmist) (kJ/tons)	155.65*2.34*60=21853.26	38.13*2.22*80=6771.888	24.08*2.03*80=3910.592
Heat content of solvent (Qe=GeCet) (kJ/tons)	117.66*2.53*80=23814.384	13.99*2.53*80=2831.576	1.2*2.70*105=340.2

In the process of condensing solvent vapor, water consumption for condensation is important. We calculate the water consumption for condensation using the following heat balance equation.

$$Gece(te1-te2)=Gscs(ts1-ts2) \qquad (4);$$

Here, Ge, Gs - mass consumption of solvent vapor and water; ce, cs - heat capacity of solvent vapor and water; te1, te2, ts1, ts2- initial and final temperatures of solvent vapor and water. [6,7]

We can find water consumption from formula (3)

$$Gs=Gece(te1-te2)/(cs(ts1-ts2)) \qquad (5);$$

2, 3, 4 - using the table and data, we can find the mass consumption of all three capacitors

$$Gs=Gece(te1-te2)/(cs(ts1-ts2))$$

The amount of water consumed in the 1st stage condenser-

$$Gs =117.66*2.53*(71.23-30)/(1*(40-25))=818.222$$

The amount of water consumed in the 2nd stage condenser-

$$Gs2=13.99*2.53*(80-30)/(1*(40-25))=117.98$$

The amount of water consumed in the 3rd stage condenser-

$$Gs3=1.2*2.70*(105-30)/(1*(40-25))=16.2$$

It can be seen from the mass consumption of water found in the three stages that the condensation process is inextricably linked with the consumption of water.

In conclusion, it can be seen from the stages of distillation that a lot of energy is spent on the process, and at the same time, high energy is released from the solvent during distillation. If the thermal energy of the solvent vapor generated in the distillers is used as secondary energy for various processes in the line, it has a positive effect on the reduction of water consumption and energy saving during the condensation process, thereby the cost of the product.

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