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«Intensification of heat removal in diabatic columns »

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Problem statement

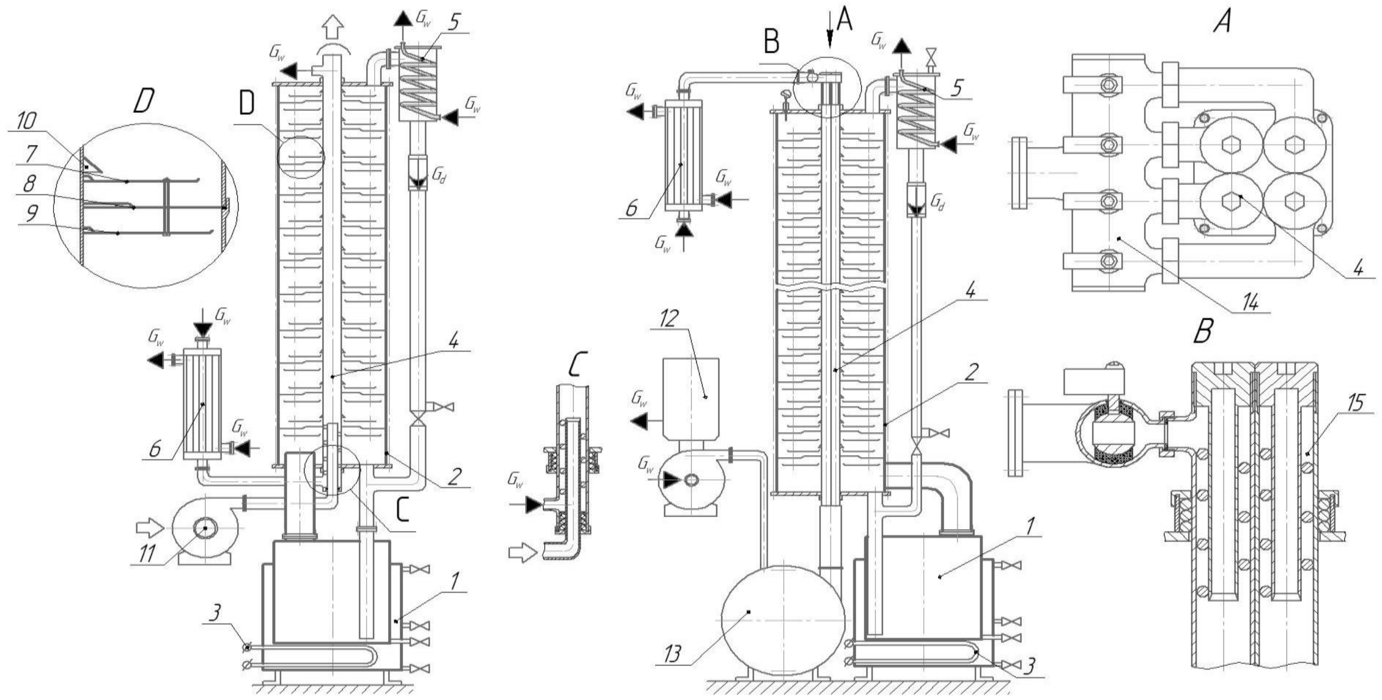
The purpose of the study is to intensify heat removal from diabatic columns by increasing heat transfer in the dephlegmator heat exchanger tubes.

The research objectives included:

- the study of approaches capable of providing heat removal in a wide range of column temperature and performance variations under diabatic conditions;
- the determination the most efficient approach of heat removal of the heat carrier in the diabatic column dephlegmator;
- the analysis of heat transfer intensification in a gravitationally flowing film.
- the estimation of the heat transfer factor.

Solution methods

An ethanol-water mixture was used as a test medium during rectification. The column was assembled from shells with a diameter of 200 mm and a height of 70 mm, between which the trays were placed. The trays consisted of bottom, middle and top horizontally installed plates. A dephlegmator was installed along the full-length axis of the column. The dephlegmator was made of a 1.8 m long 26×1 mm copper pipe into which the cooling water with an initial temperature of 7-60°C was supplied.



a) b)

Figure1. Diagram of thermal rectification units.

view A - liquid distribution sampler, view B - liquid distributor for creating a downward film flow, type C - liquid distributor for creating an upward film flow; view D - flow plate diagram.1 – reboiler; 2 – shell; 3 – heating element; 4 – heat-exchange tube; 5 – condensator; 6 – heat exchanger; 7, 8, 9, – upper, middle, lower plates; 10 – distributor; 11 – blower; 12 – vacuum pump; 13 – reservoir; 14 – sampler.

Conclusions

Results, implementation

- The application of artificial roughness on the tube surface increases the heat transfer factor value by 1.8 times. The maximum heat transfer intensity is achieved with a shoulder height of 0.13-0.25 mm.

- The maximum increase of the heat transfer factor in the film during boiling at a specific heat load q = 50000 - 30000 W/m^2, h = 1.5 mm, was by 1.7 times.

- Specific heat load from a heat transfer surface unit is 100-200 kW/m^{2}K.

- In the case of downward parallel flow, the increase in the gas consumption leads to a decrease in the heat transfer factor values.

- In the case of upward parallel flow, the heat transfer factor values vary insignificantly with gas consumption increase and are commensurate with the values obtained for the downward parallel flow.

- With the increase of air consumption, the experimental values of the heat transfer factor rise under the following empirical dependence

$$\mathrm{Nu} = 4 \cdot 10^{-7} \cdot \mathrm{Re}^{0,39} \cdot \mathrm{Re}_{\mathrm{go}}^{0,94} \cdot \mathrm{Pr}^{0,78}$$

where Re, Re_{go} – Reynolds number for film and gas; Pr - Prandtl number.

- With dispersed-annular flow the value of the heat transfer factor decreases.

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