

Analysis of the operating mode of the existing desorber and its modernization using additional contact devices

Analiza trybu pracy istniejącego desorbera i jego modernizacja z wykorzystaniem dodatkowych urządzeń stykowych

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ABSTRACT: Amine regeneration studies using two devices are presented in this work. In the first apparatus, a problem analysis was carried out in the operation of the desorber, which is used in petrochemical complexes, affecting various parameters of regeneration, such as temperature and pressure at the top and bottom of the column, pressure drop in the columns, rich amine feeding and flow rate, feed temperature, reboiler temperature and stripping pressure. The problems in the existing desorber and modernized the device was studied and an experiment that affects different parameters of regeneration was conducted. The desorber-1 (existing apparatus) and desorber-2 (modernized apparatus) mass-exchange apparatus was selected to serve as experimental regeneration plants. The dimensions of the experimental setup were determined based on the principles of geometric similarity with respect to the dimensions of an industrial regeneration column on a scale of 1:10 and physical similarity (with the same scaling) of gas and liquid flow rates and initial conditions. Thus, during the experiment, the pressure drop in the column increased in the desorber. To solve the problem and to improve the efficiency of the regeneration column, the desorber was upgraded using a Raschig packing. A laboratory stand was also developed for the purpose of conducting an experiment aimed at finding the optimal modes for the parameters of the regeneration column. As a result of the modernization of the desorber, the content of carbon dioxide in lean amine decreased, and there was a 4-fold reduction in column pressure drop. The modernization of the apparatus also led to an increase in the recovery factor.

Key words: regeneration column, modernized apparatus, desorber, rich amine, carbon dioxide, lean amine.

STRESZCZENIE: W artykule przedstawiono badania procesu regeneracji amin z wykorzystaniem dwóch urządzeń. W pierwszym aparacie przeprowadzono analizę tego problemu z wykorzystaniem desorbera stosowanego w kompleksach petrochemicznych, wpływając na różne parametry regeneracji, takie jak temperatura i ciśnienie w górnej i dolnej części kolumny, spadek ciśnienia w kolumnie, stężenie nasyconej aminy i szybkość przepływu, temperatura zasilania, temperatura reboilera i ciśnienie odparowania. Przeanalizowano zagadnienia związane z istniejącym desorberem, a następnie zmodernizowano urządzenie oraz przeprowadzono eksperyment wpływający na różne parametry regeneracji. Jako eksperymentalne urządzenia do regeneracji wybrano aparat wymiany masy desorber-1 (urządzenie istniejące) oraz desorber-2 (urządzenie zmodernizowane). Wymiary układu doświadczalnego wyznaczane są w oparciu o zasady podobieństwa geometrycznego w stosunku do wymiarów przemysłowej kolumny regeneracyjnej w skali 1:10 oraz podobieństwa fizycznego (przy tej samej skali) natężenia przepływu gazu i cieczy oraz warunków początkowych. Tak więc podczas eksperymentu w desorberze następował spadek ciśnienia w kolumnie. Aby rozwiązać problem i poprawić wydajność kolumny regeneracyjnej, zmodernizowano desorber za pomocą wypełnienia Raschiga. Przygotowano również stanowisko laboratoryjne do przeprowadzenia eksperymentu w celu znalezienia optymalnych trybów dla parametrów kolumny regeneracyjnej. W wyniku modernizacji desorbera zawartość dwutlenku węgla w regenerowanym roztworze aminowym zmniejszyła się, nastąpił również 4-krotny spadek ciśnienia w kolumnie. Modernizacja aparatury wpłynęła również na wzrost współczynnika odzysku.

Słowa kluczowe: kolumna regeneracyjna, zmodernizowana aparatura, desorber, nasycony roztwór aminowy, dwutlenek węgla, roztwór aminy regenerowanej.

Introduction

Amine scrubbing (Diao et al., 2004; Yu et al., 2009), membrane gas absorption (Yan et al., 2008), and mineral capture (Soong et al., 2004) are some of the understudied CO₂ abatement technologies. Among them, the most promising short-term strategy is amine purification. It has been decades since amines were first used to remove CO₂ or H₂S in gas processing plants or other gas treatment plants. Technologies for capturing carbon dioxide (CO₂) with amine-based reactive solvents have been known for many years (Idem et al., 2015; Liang et al., 2015).

H₂S and CO₂ removal processes are of great interest in modern industry, thus the aim of this work is to develop and improve the technical aspects of gas treatment for acid gas removal using amine processes.

Gas treatment requires different process units depending on the composition of the sour gas and the specifications of the treated gas. Unwanted components must be removed from gas streams to ensure safety and good operating conditions, since these compounds can cause various restrictions (Eimer, 2014).

A recently published review (Li and Keener, 2016) presented a comprehensive four-part study of amine regeneration. These are 1) traditional heating processes, 2) new methods, 3) optimization of operating parameters, and 4) regeneration costs. The last part is very important, as it has been the subject of research for many years. Several methods have been developed by researchers to partially or totally reduce the heat load (Idem et al., 2006; Aroonwilas and Veawab, 2007; Rochelle, 2009; Galindo et al., 2012; Zhang et al., 2012; Li et al., 2013; Gao et al., 2014; Shi et al., 2014; Zhang et al., 2014; Li and Keener, 2016; Xu et al., 2016). Two traditional methods are recommended: solvent improvement and process intensification (Liang et al., 2015). Since 2005, a number of approaches have been adopted to optimize the process configuration (Aroonwilas and Veawab, 2007; Gao et al., 2014; Liang et al., 2015), which focused on the maximum possible use of external energy.

Most of the currently operating installations were designed in the 1960s to 1980s. During this time, new high-performance contact devices appeared, which, instead of outdated ones, can improve the quality of mixture separation and reduce the hydraulic resistance of columns (Laptev and Krylova, 2012).

Increasing the competitiveness of manufactured products and reducing energy costs for carrying out processes leads to the need to develop new technologies and instrumentation or to modernize existing plants and industries. The second way is characterized by lower material and labor costs, however, the use of new technologies and apparatuses makes it possible to solve many production tasks in a more efficient and less energy-intensive manner (Farakhov and Laptev, 2008).

When studying the industrial mass transfer apparatus – desorber, which is used in the petrochemical complex of the Republic of Uzbekistan, it was found that the apparatus does not work effectively when regenerating a rich amine, which, in turn, affected the purification of gas. As a result of the examination of the amine gas purification unit, the main reasons for the unsatisfactory regeneration of the rich amine were identified. One of them is that the rich amine foams at the inlet to the desorber, forming a gas-liquid layer in the solution distribution zone. Foaming of the amine solution leads to excessive consumption of expensive absorbent, part of which is carried away with the gas (Ismagilov et al., 2000). This is because various impurities enter the solution together with the gas (mechanical impurities, liquid hydrocarbons, various surface-active substances (surfactants), corrosion inhibitors, equipment corrosion products (iron sulfide, iron oxide, etc.), amine degradation products) (Afanas'ev et al., 1993). Foaming leads to a disruption in the operation of installations and deterioration in the quality of the purified gas. This disadvantage is in many cases eliminated by adding antifoam additives to the solution or by extracting foaming agents from it. Formed gas-liquid layer forms an excess partial pressure in the lower part of the column after some time which, in turn, leads to an increase in the column pressure drop to a critical value. When the excess pressure of the gas mixture reaches a certain level of separation of the gas-liquid layer, a significant amount of the amine solution is carried away into the reflux tank. The entrained amine solution will have to be drained to a buffer tank and pumped back into the system again. At the same time, it is required to reduce the regeneration temperature, resulting in an increase in the CO₂ content in the regenerated amine solution. Therefore, it was decided to modernize the regeneration apparatus in the saturated solution distribution zone using a nozzle. The modernization of the device consisted of the following steps:

1. replacing the plate-shaped distribution zones of the amine solution with contact devices “Rashig ring nozzle”;
2. calculating and selecting optimal parameters.

In the work (Laptev et al., 2002), the modernization of mass transfer apparatuses is considered on the examples of hydrocarbon mixtures separation units of the Surgut CSP; alkaline purification of pyrogas in the production of ethylene and a distillation column in the production of isoprene, while in the work (Yasaveyev et al., 2004) specific examples of the modernization of process units at the Surgut CSP and the development of a mini-thermal power plants are considered. In this paper, the modernization of mass transfer apparatuses is considered on the example of the installation of amine purification of natural gas of the Ustyurt Gas Chemical Complex.

In this regard, the regeneration of the amine was studied on two devices in this work. The first apparatus was used to

analyze the problem in the operation of the desorber used in the petrochemical complex, affecting various regeneration parameters such as temperature and pressure at the top and bottom of the column, pressure drop in the columns, loading of saturated amine and flow rate, feed temperature, reboiler temperature and stripping pressure. The aim was to study the problems of the existing desorber, modernize the apparatus and conduct an experiment that affects different parameters of regeneration.

Methods and materials

Tertiary amine was used as raw material for regeneration. The tertiary amine N-methyldiethanolamine (MDEA) was supplied from the Ustyurt Gas Chemical Complex plant.

Laboratory desorber

Figure 1 shows a schematic diagram of an experimental setup for desorption of a rich amine. The pilot plant mainly consisted of a recovery column, a condenser, a spray tank, a reboiler, two constant flow pumps, two tanks with a rich and lean amine, a preheater, a gas flow meter, and temperature and pressure indicators.

The desorber-1 mass-exchange apparatus (the existing apparatus, which is shown in Figure 2a) and the desorber-2 (modernized apparatus, which is shown in Figure 2b), which are used to purify natural gas of petrochemical enterprises, were chosen to serve as an experimental regeneration plant. The dimensions of the experimental setup are determined based on the principles of geometric similarity with respect to the dimensions of the industrial regeneration column on a scale of 1:10 and physical similarity (with the same scaling) of gas and liquid flow rates and initial conditions. At the same time, data from the calculation of regeneration columns, as well as data from the technical passport of industrial regeneration columns were used.

The selected value of the inner diameter of the experimental regeneration plant, which was $\varnothing 0.11$ m, was considered as the initial one for determining all the main dimensions of the prototype regenerator in accordance with the data shown in Figure 1.

The calculations yielded the following geometric dimensions of the experimental setup: $l_2 = 0.03$ m, $l_3 = 0.16$ m, $l_4 = 0.12$ m, $l_5 = 0.075$ m, $l_6 = 0.29$ m, $l_7 = 0.34$ m, $l_8 = 0.07$ m, $l_9 = 0.062$ m, $l_{10} = 0.08$ m, $l_{11} = 0.21$ m, $l_{12} = 0.12$ m, $l_{13} = 0.61$ m, $l_{14} = 0.14$ m, $l_{15} = 0.61$ m, $l_{16} = 0.21$ m, $l_{17} = 0.2$ m, $l_{18} = 0.06$ m, $l_{19} = 0.14$ m, $l_{20} = 0.12$ m, $l_{21} = 0.66$ m, $l_{22} = 0.18$ m.

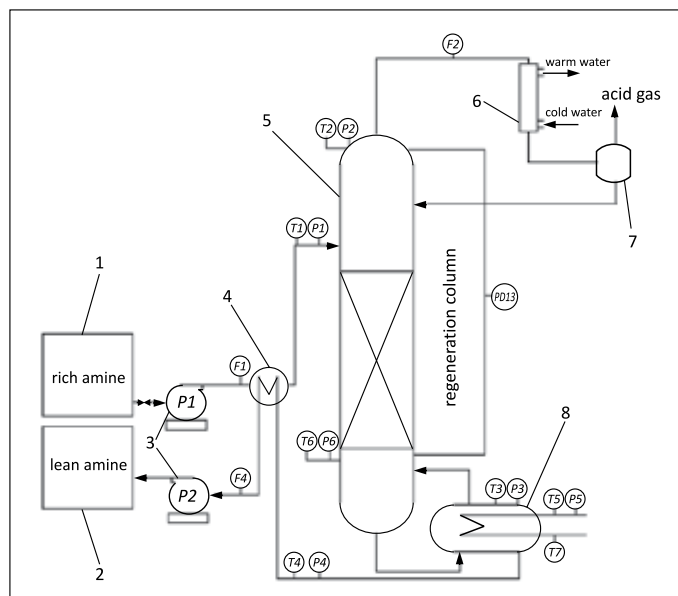


Figure 1. Schematic diagram of an experimental laboratory plant for amine regeneration; 1 – rich amine tank, 2 – lean amine tank, 3 – pumps, 4 – heat exchanger, 5 – regeneration column, 6 – condenser, 7 – reflux tank, 8 – reboiler

Rysunek 1. Schemat ideowy eksperymentalnej instalacji laboratoryjnej do regeneracji aminy; 1 – zbiornik aminy bogatej, 2 – zbiornik aminy zubożonej, 3 – pompy, 4 – wymiennik ciepła, 5 – kolumna regeneracyjna, 6 – kondensator, 7 – zbiornik odcieku, 8 – podgrzewacz

The regeneration column is made of metal packed with an annular random Raschig packing made of stainless steel 316L with a diameter of 50×50 mm. The Rashig nozzle is made of a metal mesh of uniform diameter and height and is mainly used for laboratory and low-volume separation processes for high purity products. The reboiler was a steam-heated metal heat exchanger. Two solvent pumps were used to circulate the amine solution. Sensors were installed at various locations to measure the temperature and pressure at the inlet and outlet of the amine solution. The recovery column was also equipped with an electronic sensor for measuring the differential pressure PDI3. The differential pressure sensor PDI3 was connected to a stainless steel tube. One end of the tube was connected to the top of the column above the eliminator and the other end was connected to the bottom of the column just below the second packing layer.

For a typical experimental solvent regeneration cycle, the CO_2 -saturated rich amine was first introduced into the reboiler and preheated to the reboiler temperature with steam. Once the reboiler temperature reached the set point, the required flow rate of 0.22 kg/s rich amine, which was heated to the set feed temperature, was continuously fed to the top of the recovery column. The mixture of CO_2 and water vapor released from the rich amine solution exited through the top condenser with a full reverse flow of water.

The already lean amine was heated to the boiling point in the reboiler and then collected in the rich amine tank for reuse. The regeneration experiment was run for a reasonable period of time (about 4 hours) to reach steady state as indicated by constant temperatures, lean/rich amine flow rate, and CO₂ content of the lean amine. During the experiment, all desorber parameters such as temperature, pressure, pressure drop, and liquid and acid gas flow rates were recorded. After that, 10 ml samples of the regenerated amine solution were taken to determine the concentration of the amine and the loading of CO₂, and the entire temperature value was recorded. After the completion of stationary data collection, the rich amine flow to the recovery column was stopped, while the cooling water feed to the overhead condenser and steam was maintained until stripped CO₂ ceased to exit the reboiler. The removed CO₂ determined from gas and liquid was used to calculate the mass balance error for all experiments to ensure the accuracy and reliability of the results. The system operated at approximately atmospheric pressure.

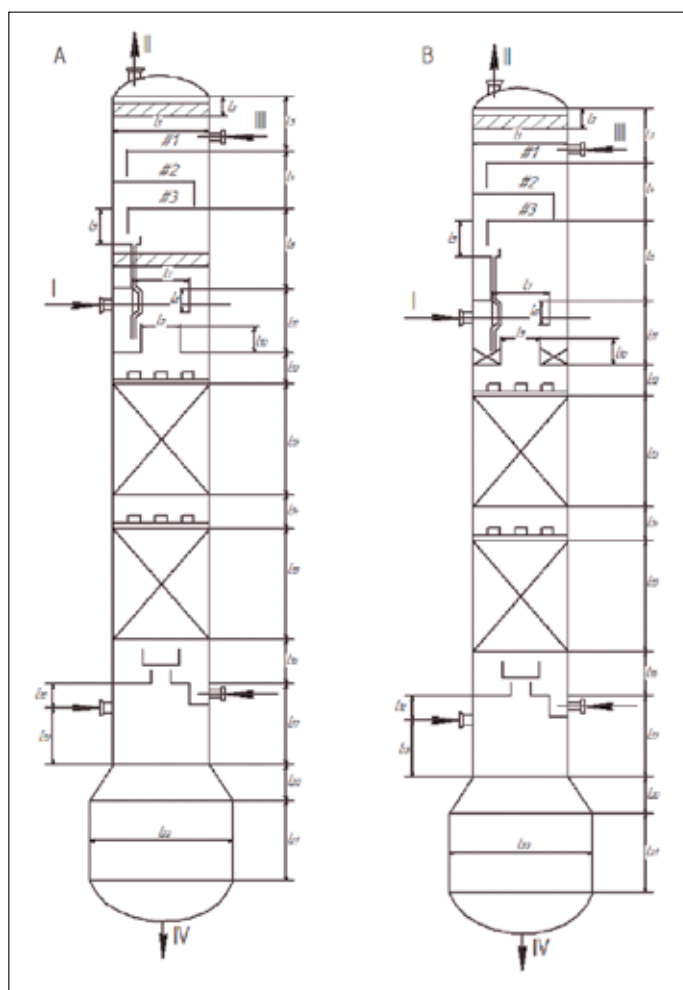


Figure 2. A – desorber-1 (existing apparatus); B – desorber-2 (modernized apparatus)

Rysunek 2. A – desorber-1 (urządzenie istniejące); B – desorber-2 (urządzenie zmodernizowane)

Equation 1 was used to determine the flow rate of the released CO₂:

$$G_{\text{CO}_2} = L \cdot (X_r - X_l) \quad (1)$$

where:

G_{CO_2} – consumption of released carbon dioxide [kg/s].

L – consumption of rich amine [kg/s],

X_r, X_l – mass fraction of carbon dioxide in the rich and lean amine.

For the solvent regeneration experiment, the required rich amine was taken from the plant of the Ustyurt Gas Chemical Complex. During the experiment, the concentrations of CO₂ in the rich and lean amine (MDEA) were determined using an Orsat gas analyzer (Auesbaev, 2023). A general view of the Orsat device with Fisher's improvement is shown in Figure 3.

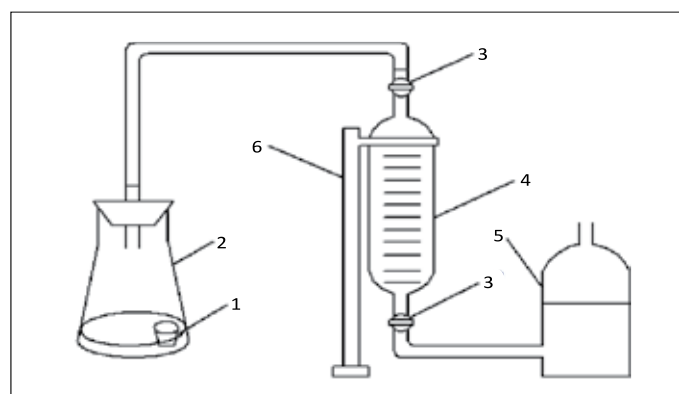


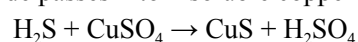
Figure 3. Orsat gas analyzer; 1 – glass for weighing amine, 2 – reaction flask, 3 – two-way valve, 4 – gas pipette, 5 – leveling vessel, 6 – tripod

Rysunek 3. Analizator gazu Orsat; 1 – kolba do ważenia aminy; 2 – kolba reakcyjna, 3 – zawór dwukierunkowy, 4 – pipeta gazowa, 5 – naczynie poziomujące, 6 – statyw

The Orsat gas analyzer is a piece of laboratory equipment used to analyze a sample of gas (usually fossil fuel flue gas) for oxygen, carbon monoxide, and carbon dioxide. Although Orsat has been largely replaced by instrumental methods, it remains a reliable and relatively easy to use measurement method.

The apparatus consists of a reaction vessel, a 250 cm³ conical flask with a well-fitting rubber stopper, connected by a rubber tube to a 100 cm³ graduated pipette with a 0.2 cm³ scale interval, and a balance vessel filled with saturated sodium chloride solution through a two-way stopcock. A glass with a capacity of (5–10) cm³ is placed inside the flask.

The measurement method is based on the interaction of an amine solution containing carbon dioxide and hydrogen sulfide with a solution of copper sulphate in an acidic environment. In this case, carbon dioxide is released into the gas phase, and hydrogen sulfide passes into insoluble copper sulfide:



5 cm³ of lean amine or 2.5 cm³ of rich amine are poured into the glass (1) and placed in the reaction flask (2), into which 10 cm³ of the solution of copper sulfate with a mass fraction of 10% and 20 cm³ of the solution of sulfuric acid with a mass fraction of 20% are added. The flask is tightly closed with the stopper and by turning the tap (3) the pipettes (4) equalize the pressure, bringing it to atmospheric pressure. The reaction flask is tilted (2) so that the beaker is tipped over and its contents are mixed with the acidic solution. By means of the leveling vessel (5), the pressure inside the pipette is brought to atmospheric pressure and the volume of released CO₂ is measured.

The measurement must be carried out at a constant temperature.

Processing of measurement results

The mass fraction of CO₂ in the amine solution *X*% is calculated by the formula:

$$X = \frac{V_{CO_2} \cdot M_{CO_2} \cdot 100}{22400 \cdot V_{PA} \cdot P_{PA}} \quad (2)$$

where:

*V*_{CO₂} – the volume of carbon dioxide released into the gas phase [cm³],

*M*_{CO₂} – the mass of one mole of carbon dioxide, equal to 44 g,

*V*_{PA} – volume of amine solution [cm³],

*P*_{PA} – amine solution density [g/cm³],

100 – coefficient for converting fractions of a unit into a percentage concentration by mass.

Using the formula below, we found the flow rate of the steam flow rate in the regeneration column:

$$G_{CO_2 + H_2O} = G_{CO_2} + G_{H_2O} \quad (3)$$

where:

*G*_{CO₂} – consumption of released carbon dioxide [kg/s],

*G*_{H₂O} – phlegm consumption for irrigation column [kg/s].

Gas capacity (CO₂ + steam), or *F*-factor of gas velocity (m/s) · (kg/m³)^{-0.5}, was determined by the equation:

$$F = w\rho^{-0.5} \quad (4)$$

where:

w – reduced gas velocity (CO₂ + steam), calculated for the free section of the column [m/s],

ρ – gas density (CO₂ + steam) [kg/m³].

The gas density (CO₂ + steam) in the column *ρ* under conditions *P* and *T* [kg/m³], was determined by the equation:

$$\rho = \rho_0 \cdot [T_0 / (T_0 + t)] \cdot P / P_0 \quad (5)$$

where:

*ρ*₀ – density under normal condition,

*T*₀ – temperature under normal condition,

*P*₀ – pressure under normal condition.

Superficial gas velocity (CO₂ + steam) in the column *w* [m/s], was determined by the equation

$$w = \frac{4G_{CO_2 + H_2O}}{\rho \pi d_{in}^2} \quad (6)$$

where: *d*_{in} – apparatus inner diameter [m].

Liquid load *q* [m³/(m² · s)], was calculated by the formula

$$q = \frac{4Q}{\pi d_{in}^2} \quad (7)$$

where: *Q* – volumetric flow rate of rich amine [m³/s].

The value of the hydraulic resistance of the column was determined by the difference in static pressure below and above it.

The efficiency of phase interaction was estimated by the recovery factor

$$\varphi = \frac{X_r - X_l}{X_r} \quad (8)$$

where: *X*_r, *X*_l – mass fraction of carbon dioxide in a rich and lean amine [%].

Results and discussions

Modernization of heat and mass transfer apparatuses with the use of highly efficient contact devices is an increasingly important direction in various industries. In column apparatuses with gas (steam) – liquid media, contact devices of both foreign and domestic companies are used (Sokol et al., 2009; Laptev et al., 2010).

At the beginning, the experiment was carried out on the existing desorber-1 to analyze the problems in the operation of the desorber, affecting different modes of regeneration parameters such as temperature and pressure at the top and bottom of the column, pressure drop in the columns, rich/lean amine feeding and flow rate, feed temperature, temperature reboiler and stripping pressure.

The flow rate of rich amine with carbon dioxide was set to 0.22 kg/s. This is the optimal flow rate for the experimental column. Liquid load *q* [m³/(m² · s)] was calculated by formula (7) and the obtained value was 0.024155. The liquid load of the laboratory column corresponds to the liquid load of the industrial column. The same was true for the mass content of carbon dioxide in the rich amine, with an average value of 6.5 wt.%, as in the industrial case.

It is widely known that the regeneration of rich amine is most dependent on the temperature of the regenerated amine solution. Thus, as the rich amine with acidic components is regenerated in the amine stripping column – desorber, the de-

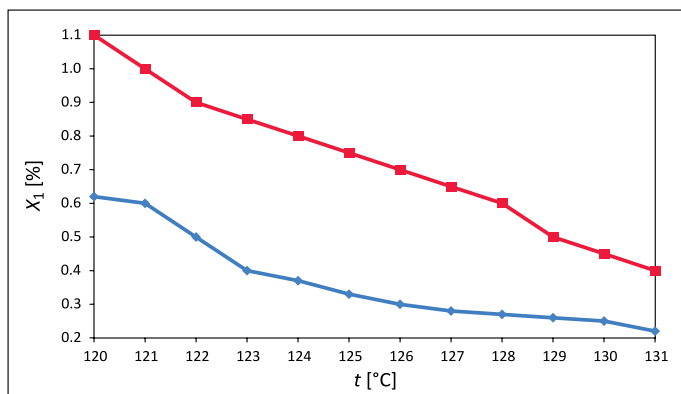


Figure 4. Influence of the temperature of the lean amine on the mass content of carbon dioxide in the lean amine; red line – existing desorber, blue line – modernized desorber

Rysunek 4. Wpływ temperatury roztworu zubożonej aminy na zawartość masową dwutlenku węgla w roztworze regenerowanej aminy; czerwona linia – istniejący desorber, niebieska linia – zmodernizowany desorber

composition of chemical compounds to amine and gases occurs upon absorption of heat (endothermic reaction). The desorption process proceeds by reducing the pressure and increasing the temperature. In order to ensure a stable operating mode, an antifoam agent is introduced into the system (Panzhiyev et al., 2020). Therefore, in this work we studied the effect of the temperature of the lean amine on other parameters of the regeneration column.

First, the influence of the temperature of the rich amine on the mass content of carbon dioxide in the lean amine was studied.

Figure 4 presents the dependence of the temperature of the rich amine on the mass content of carbon dioxide. From Figure 4, it can be seen that in the existing desorber, the mass content of carbon dioxide in the lean amine changes to 0.4–1.1 wt.%, while in the modernized desorber, the mass content of carbon dioxide in the lean amine solution changes to 0.22–0.62 wt.%. In the first desorber, as the temperature increases, the regeneration of the solution occurs to a much lesser extent than in the second (modernized) desorber. As we know, the deep regeneration of the amine solution gives us the opportunity for even deeper carbon dioxide saturation in the absorber in the process of natural gas purification from acidic components.

We also studied the influence of the temperature of the lean amine on the efficiency of phase interaction.

The efficiency of phase interaction was evaluated by the recovery factor, which was calculated by formula (8).

Figure 5 presents the results of the dependence of the temperature of the lean amine on the carbon dioxide recovery factor. From Figure 5, it can be seen that in desorber-1 the recovery factor reaches up to 93.6%, and in desorber-2 the recovery factor reaches up to 96.5%. The modernization of the appa-

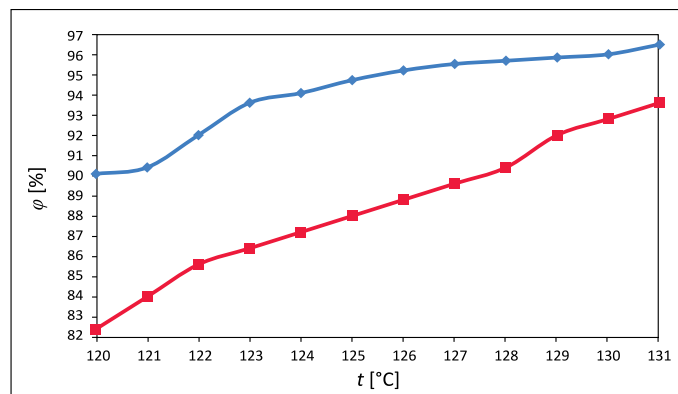


Figure 5. Influence of the temperature of the lean amine on the recovery factor of carbon dioxide in the lean amine; red line – existing desorber, blue line – modernized desorber

Rysunek 5. Wpływ temperatury roztworu zubożonej aminy na współczynnik odzysku dwutlenku węgla w roztworze regenerowanej aminy; czerwona linia – istniejący desorber, niebieska linia – zmodernizowany desorber

ratus has increased the recovery factor by almost 3%. As we know, a 1% change in recovery factor is of great importance in production. In our case, the column works very efficiently.

The value of the hydraulic resistance of the nozzle was determined by the difference in static pressure under and above it.

The results of the experimental values of the pressure drop of the column depending on the temperature are shown in Figure 6. Based on Figure 6 it can be said that increasing the pressure drop of the column affects the efficiency of the apparatus. As the temperature of the lean amine rises, greater amounts of CO₂ and solution vapor are released. Accordingly, the greater the release of gases, the greater the pressure drop of the column. From Figure 6, it can be seen that with an increase in the temperature of the lean amine, the pressure drop of the column increases. In the existing desorber, the pressure difference is 6.51–27.3 kPa, and in the modernized desorber it

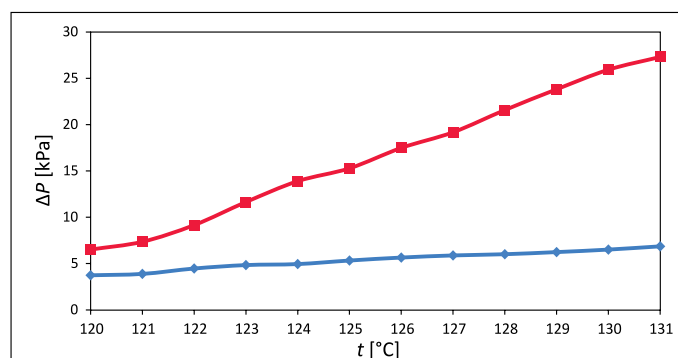


Figure 6. Influence of the temperature of the rich amine on the magnitude of the pressure drop of the column; red line – existing desorber, blue line – modernized desorber

Rysunek 6. Wpływ temperatury roztworu wzbogaconej aminy na wielkość spadku ciśnienia w kolumnie; czerwona linia – istniejący desorber, niebieska linia – zmodernizowany desorber

is 3.74–6.86. It is known that the pressure drop has a greater effect on the splashers in the heat and mass transfer apparatus. Reaching a pressure differential of up to 27.3 kPa at 131°C can affect the carryover of the amine solution to the irrigation tank. Accordingly, this will affect the normal operation of the apparatus, as well as the entire process of natural gas purification in the absorber. Therefore, the regeneration column was modernized in the area where the rich amine is distributed in the zone using a packing. The experiment resulted in the decrease in the pressure drop in the column to 6.86 kPa. After upgrading, the columns achieved up to a fourfold reduction in pressure drop at 131°C.

Obviously, the gas velocity in the column also affects other parameters. Therefore, the influence of the temperature of the lean amine on the reduced gas velocity in the column were studied.

The reduced gas velocity in the column is determined by equation (6). Figure 7 graphically presents the results of the dependence of the temperature of the lean amine on the reduced velocity of the gas in the column. It is known that during the regeneration of the amine solution in the desorber, the evolution of gas (CO_2 + steam) will increase with increasing temperature, and according to equation (6), an increase in the gas flow rate in the column corresponds to an increase in the reduced gas velocity in the column. The graph presented in Figure 7 shows that as the temperature of the lean amine increased in the range 120–131°C, the reduced gas velocity in the column varied between 2.175–2.46 m/s for the existing desorber, and 2.37–2.53 m/s for the modernized desorber. It can also be seen from the graph that in the modernized desorber, the limits of the reduced column gas velocity increased by a factor of 1.089–1.029 with an increase in the temperature.

The creation of modern equipment is impossible without an analysis of the factors affecting the efficiency of techno-

logical processes. Therefore, in the course of the experiments, the influence of the temperature of the lean amine on the gas velocity factor in the column was also investigated. A series of experiments were carried out in order to identify the optimal factor of gas velocity and temperature in the column.

Conclusion

During the experiment in the existing desorber, an increase in the pressure drop in the column was observed. The pressure drop was formed due to the gas-liquid layer located in the distribution zone of the rich amine.

To solve the problem and to improve the efficiency of the regeneration column, the distribution zone of the rich amine solution was modernized using the Raschig packing. We also developed the laboratory stand for conducting an experiment in order to find the optimal modes for the parameters of the regeneration column.

As a result of the modernization of the desorber, we were able to achieve up to 0.22 wt.% content of carbon dioxide in the lean amine at 131°C.

Due to the nozzle in the distribution zone of the rich amine, the formation of the gas-liquid layer decreased. As a result of the experiment, a decrease in the pressure drop in the column to 6.86 kPa was obtained. After upgrading, the columns achieved up to fourfold reduction in pressure drop at 131°C.

The modernization of the apparatus also affected the increase in the recovery factor by almost 3%.

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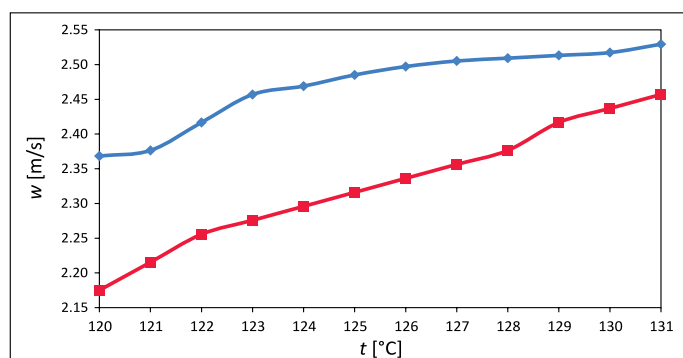


Figure 7. Influence of the temperature of the lean amine on the reduced gas velocity in the column; red line – existing desorber, blue line – modernized desorber

Rysunek 7. Wpływ temperatury roztworu zubożonej aminy na zmniejszoną prędkość gazu w kolumnie; czerwona linia – istniejący desorber, niebieska linia – zmodernizowany desorber

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