Reduction of Greenhouse Gases Emission and Production of Potable Water and Valuable Salts through Power Plants' Stacks

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Abstract

The goal of this research is simulating an optimum reactor to eliminate greenhouse gases, mainly CO_2, through combined cycle in stacks of power plant, using a strong base (sodium hydroxide) thinned by water. During this process sodium bicarbonate salt is generated together with water and the produced salty water is desalinated and its useful salts are also extracted. Four scenarios have been considered which are simulated by ASPEN PLUS and HYSYS softwares. By using scenario A as an optimum scenario simulated by ASPEN PLUS, the amount of existing water and existing CO_2 in the exhaust of the Rudeshour power plant's stack have decreased from 102.780 to 36.642 tons/hr and from 116.430 to 5.3×10^{-10} tons/hr in the reactor's output to be released into the atmosphere, respectively. The amount of water in exiting salty water flow from the bottom of the reactor equals to 1115.280 tons/hr. The amount of produced salt which is a mixture of carbonate, bicarbonate and sodium hydroxide salts also equals to 406.365 tons/hr.

Introduction

Combustion of fossil fuels in power plants is one of the most important sources of air pollution and greenhouse gases such as carbon dioxide. The goal of this research is simulating an optimum reactor to eliminate greenhouse gases, mainly CO_2, through Rudeshour combined cycle power plant's stacks, using a strong base (sodium hydroxide) thinned by water. During this process sodium bicarbonate salt is generated together with water and the produced salty water is desalinated and its useful salts are also extracted.

Material and Methods

Four scenarios have been considered which are simulated by ASPEN PLUS and HYSYS software in order to eliminate and minimize the greenhouse gases in Rudeshour power plant. Using ASPEN PLUS software, on the whole, three scenarios were considered to compare and choose an optimum reactor in all purifying dimensions for the exhaust from the stack and recycling salt and water. One more simulation of the absorption tower was also created by HYSYS software in order to reduce greenhouse gases. Scenarios A, B and C were simulated by ASPEN PLUS software. Choosing a proper thermodynamic equation is the main step in simulation. The amount of the electrolytes can be controlled by equilibrium constants and estimating the amount of produced salts. Furthermore, kinetic data of reactants should be added, too.

In scenario A, reactants start the reaction in flash drum containers. The reactor exhausts contain clean gas that is ready to be released to the atmosphere and thick salty water as a result of a reaction between the acid gases and injected bases. Then, the produced water flow enters the cycle and the existing salty water is desalinated via membranous or thermal method. A make-up water flow is considered to compensate the probable base flow in the cycle. A schematic plan of simulated reactor with recycling salt and water from the cycle in Rudeshour power plant is shown in fig. 1.
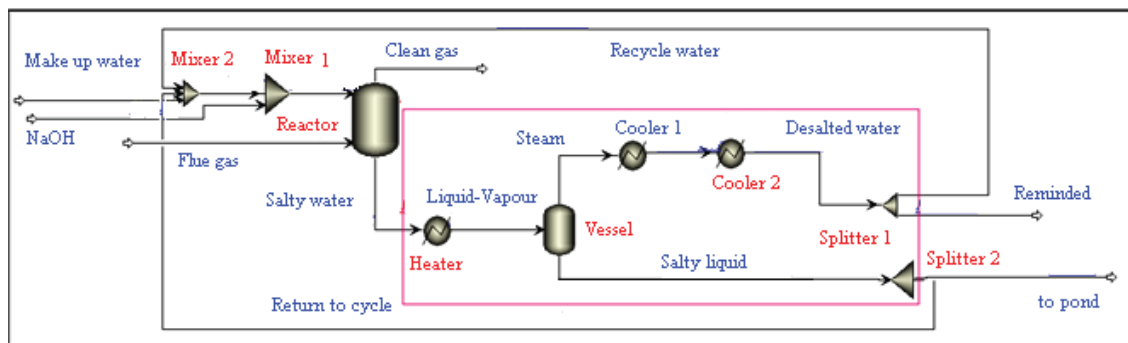
Fig. 1. A schematic plan of simulated reactor with recycling salt and water from the cycle in Rudeshour power plant (scenario A)

In scenario B (Fig. 2), instead of continual circulation of water in the cycle, water is segmented in the reactor and then it enters the evaporating pond and drinking water enters the system instead. All features of gas flow, considered base flow and also the used equipment in the cycle, are the same as those of scenario A, except for the mass of extra water flow.
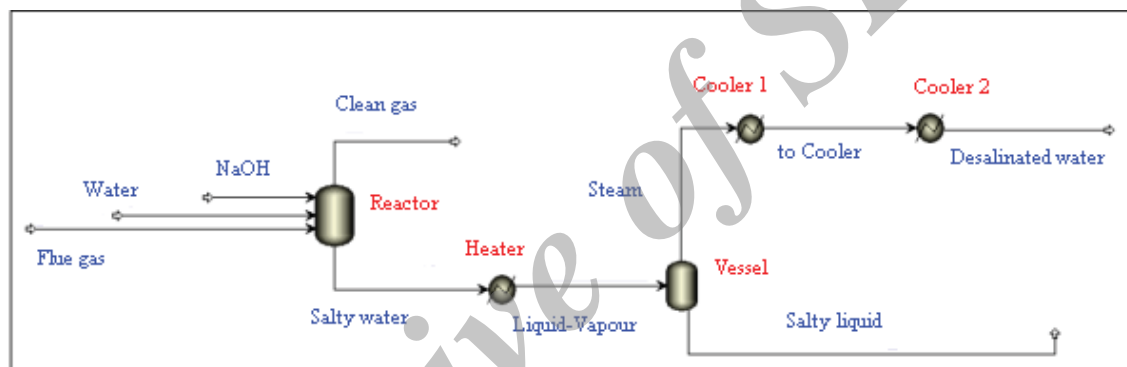

Fig. 2. A schematic plan of simulated reactor with injecting the water to the cycle and recycling salt and water in Rudeshour power plant (scenario B)

In scenario C, the flow of flue gas exiting from the power plant stack enters a thermal converter. Then, the exhaust flow of liquid – gas enters the first reactor. The steam flow and the base flow enter the second reactor. After an acid – base reaction, two flows exit the reactor; one is the clean gas flow exiting from the upper part and the other is the salty water from the bottom. A schematic plan of using two reactors with recycling salt and water in the simulated cycle of Rudeshour power plant is shown in figure 3.
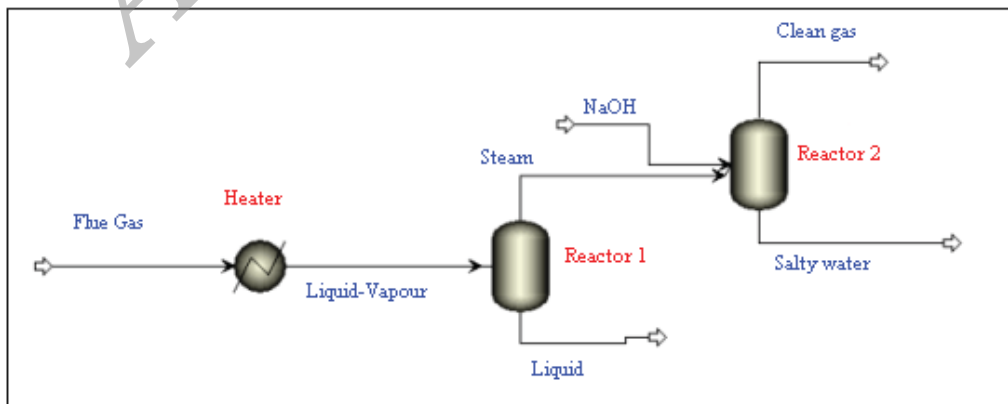

Fig. 3. A schematic plan of using two reactors with recycling salt and water in the simulated cycle of Rudeshour power plant (scenario C)

Scenario D simulated by HYSYS software, is the simulation of the absorption tower in order to reduce the greenhouse gases. Almost all input data in HYSYS is similar to that of ASPEN PLUS, except for some little

differences in equipment and equations. However, the output is designed in completely different flow sheets. The flue gas flow and the absorbent substance of Diglycolamine enter the absorption tower and start reacting on the stages. The produced two exhausts can be referred to as a clean gas flow in the upper part and Rich flow in the bottom of the tower.

Result and Discussion

In scenario A the amount of existing water in the exhaust of the Rudeshour power plant's stack has decreased from 102.780 to 36.642 tons/hr in the reactor's output to be released to the atmosphere. The amount of water in exiting salty water flow from the bottom of the reactor equals to 1115.280 tons/hr. The amount of produced salt which is a mixture of carbonate, bicarbonates and sodium hydroxide salts also equals to 406.365 tons/hr. The amount of existing CO_2 in the exhaust of the Rudeshour power plant stack has decreased from 116.430 to 5.3×10^{-10} tons/hr in the reactor's output to be released into the atmosphere.

In scenario B, the amount of existing water in the exhaust of Rudeshour power plant stack has increased from 102.780 to 136.970 tons/hr in the reactor's output to be released to the atmosphere. The amount of water in the exiting salty water flow from the bottom of the reactor equals to 2033.467 tons/hr. The amount of produced salts also equals to 408.8 tons/hr. The amount of existing CO_2 in the exhaust of Rudeshour power plant stack has decreased from 116.430 to 2.840×10^{-8} tons/hr in the reactor's output to be released into the atmosphere.

In scenario C the results shows that the amount of the existing water in the exhaust of Rudeshour power plant stack has decreased from 102.780 to 65.049 tons/hr in the reactor's output to be released to the atmosphere. The amount of water in the exiting salty water flow from the bottom of the reactor equals to 1085.829 tons/hr. The amount of produced salts also equals to 398.345 tons/hr. The amount of existing CO_2 in the exhaust of Rudeshour power plant stack has decreased from 116.430 to 1.655×10^{-9} tons/h in the reactor's output to be released into the atmosphere.

Results in scenario D shows that the amount of existing water in the exhaust of Rudeshour power plant stack has decreased from 102.780 to 91.544 tons/h in the reactor's output to be released to the atmosphere. The amount of the existing CO_2 in the exhaust of Rudeshour power plant stack has decreased from 116.430 to 9.821 tons/hr in the reactor's output to be released into the atmosphere. No salt has been produced in this scenario and the Amine flow should be refined at the end of the route and returned to the cycle.

Conclusion

In scenario A, as an optimum scenario, the amount of water in the exhaust gas of the reactor to be released in the atmosphere would be reduced to 10^{-8} tons/hr. The reactor also is capable of minimizing the amount of CO_2 to 10^{-13} times in comparison to the existing carbon dioxide in the exhaust of Rudeshour power plant's stack. The amount of produced salt, which is a mixture of carbonate, bicarbonates and sodium hydroxide salts, is equal to 406.365 tons/hr. The desalinated water in this process can be used in agricultural or potable cases or it can be reused in the cycle. The sodium bicarbonate salt can also be offered to various industries after being refined and purified.