DESIGN OF CHEMICAL ABSORPTION PROCESS BASED ON SELF-HEAT RECUPERATION TECHNOLOGY

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Summary

We proposed a CO_2 absorption process of lower energy consumption. In this process, the regeneration energy of absorbent is provided from the exhausted heat of absorber by internal heat circulation based on self-heat recuperation technology. We evaluated an amount of energy consumption of the process as compared with the conventional absorption process for CO_2 separation by using a commercial process simulator. From the calculations, we can present a lower energy consumption process based on self-heat recuperation technology.

Keywords

CO_2 Separation system, Chemical absorption, Process simulation, Self-heat recuperation technology

Introduction

Recently, CO_2 separation technology from gas streams has received more attention than before to curb the green house effect. Methods of separation by absorption, adsorption, cryogenic separation and membrane separation are generally used to capture CO_2. These separation technologies are commercially available to capture not only CO_2 but also natural gas in refinery plants and waste gases in other industries.

Nowadays, many researchers have investigated amine-based chemical absorption processes to improve the effectiveness and efficiency of CO_2 capture[1)], because the chemical absorption processes consumes a massive of energy leading to some more CO_2 emission[2)]. As a result, the reduction of energy consumption in the CO2 separation process becomes the most important task to spread Carbon Capture and Storage (CCS) system into the society.

One of the most famous amine for CO_2 capture is a monoethanolamine (MEA). It is well known that MEA required a large amount of energy (4.0GJ/t-CO_2) for CO_2 stripping. Therefore, Goto *et al*. developed a new absorbent to improve the regeneration energy in the stripper[2)]. However, they have less paid attention to process configuration. On the other hand, Leites analyzed an energy saving system of the absorption[3)]. In the study, he analyzed and reported the individual streams/devices and the optimal condition of the flows, but he has not mentioned about the whole conditions of the integrated process.

Recently, self-heat recuperation technology, in which not only the latent heat but also the sensible heat of the process stream can be circulated without any heat addition, has been developed and applied to a thermal process in the gas stream and phase change stream between vapor and liquid [4-5)]. They analyzed the required heat input and output of the process and achieved the perfect internal heat circulation in the process for drastic energy saving.

In this paper, we propose an innovative design methodology for absorption processes of lower energy consumption based on the self-heat recuperation technology.

・ Simulation

In this paper process simulation with PRO/Ⅱ(Invensys plc) was conducted, and we used standard amine model in the software.

1) The conventional process

The conventional process is shown in Figure1. The inlet flue gas (S1 25℃, 1atm) is compressed, and supplied to absorber (S1→C1→S2). In the absorber, aqueous MEA absorbed CO_2 from the flue gas (COL1), and remain gasses are discharged from top of absorber (S3). The heat of rich amine sorbent from stripper bottom is exchanged with the heat of lean amine solvent, and the rich sorbent is heated by heat recuperation (S4→S5). S5 is fed into the stripper, and then CO_2 and steam is discharged from top of stripper (S6). The CO_2 gas is cooled, and steam is condensed by a condenser (CON1), then CO_2 and condensed steam are separated by separator (S7, SEP2). The condensed steam is returned to stripper as effluent

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flow (S8). CO_2 gas is recuperated through the separator and cooler (S7→SEP1→S9→S10). Aqueous MEA is boiled, and water is changed into steam with reboiler of bottom column, and vapor stream is returned to stripper (S11→S12→S13→R1→S14→COL2). Sensible heat of aqueous MEA of condenser bottom is cooled by heat exchanger (S12→S15→HEX1), and then aqueous MEA is pumped up to the same pressure as absorber(P1), and cooled for high absorption efficiency (CL2). The cooled steam is returned to absorber (S18).

We analyzed the heat input/output of the process. We found that the energy regeneration is consumed in three places where thermal processes occurred; the stripper for CO_2 striping in which the reaction heat is discarded, the lean solvent cooler between absorber and stripper, and the reflux condenser at the top of stripper in which the condensation heat to is consumed. It can be understood that we can achieve the drastically energy saving while these consuming energies are recirculated into the process.

2) The proposed process

We proposed an innovative process design for chemical absorption process based on self-heat recuperation technology, in which not only the latent heat but also the sensible heat of the process stream can be circulated without any heat addition. [4-7]

In the proposed process, the flue gas (25 ^{o}C, 1atm) is compressed and heated by compressor. CO_2 is captured from the flue gas with absorption column and then discharged from the bottom with absorbent. Remain gasses are discharged from top of the column. The heated flue gas is cooled by the top of gas after expansion. Absorbent of lean amine is fed into heat exchanger to heating, when waste heat from bottom of stripping column is used for heating of the lean amine. And then, the lean amine is fed into stripping column. In the stripping column, CO_2 and steam are discharged from top of stripping column.

By following self-heat recuperation technology[6-7], the heat of stripping column can be recovered from the process stream itself. In this process not only absorption heat but also the condensation heat of the stripping column are provided to the regeneration heat and to the vaporization heat of the stripping column. As a result, the process are not required any heat addition.

・ Conclusion

In this paper, we analyzed the heat input/output of the process, and develop a new design methodology based on self-heat recuperation technology. The required energy of the proposed process was drastically reduced as compared with conventional process.

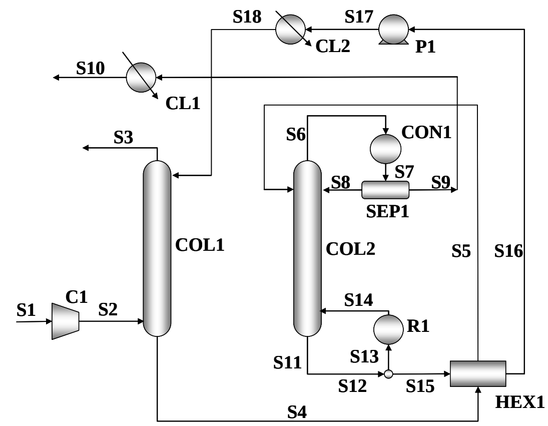

Fig. 1. The conventional process

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