Economic analysis of CCU in the Korean cement industry:
CO₂ capture using KIERSOL & PCC conversion

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Abstract

After Paris Agreement being adapted, many countries are pursuing carbon dioxide reduction policy to keep the clean environment without climate disaster by global warming. Especially, many countries try to strengthen regulation of the carbon emissions by law. Major carbon emission sources are a power sector by pulverized coal power plant and an industrial sector by blast furnace in the integrated steelworks and kiln (a specialized oven or furnace used for industrial processes such as firing clay for pottery or manufacturing clinker of cement source) in the cement or limestone works.

South Korea, which is among the world’s top 10 CO₂ emitters, has finalized its 2030 target of reducing greenhouse gas emissions by 37% from BAU levels, higher than its earlier 2020 plan (30% below BAU levels). We must reduce CO₂ emission in the Korean cement industry to achieve the target, because a yearly CO₂ emission is about 4 million ton. CCS technology, the positive approach, will play an important role for global CO₂ reduction, 13 % by IEA energy technology perspective, 2015. Therefore, Korean cement industry feels keenly the necessity of superior CO₂ capture, conversion, usage and storage.

The economical CO₂ capture process, KIERSOL, which has the low reboiler heat duty (2.2 GJ/tCO₂), has been developed by Korea Institute of Energy Research using the promoted potassium carbonate aqueous absorbent. KIERSOL process has many advantages as follows: Very low reboiler heat duty because of using potassium carbonate as a main material and high efficient hybrid reboiler. Stable and simple operation like amine process, Cheaper than amine solution process, Non-volatile, Non-toxic and biodegradable, Resistance to degradation by oxygen, sulfur dioxide, heat and NOx, No need of cooling water for absorber.

This technology was transferred to Hyundai-Kia motor company to capture CO₂ from a LNG flue gas in the car manufacturing factory on September, 2012 and to Givan company to upgrade biomethane in the biogas (50~60% CH₄ and 40~50% CO₂) power plant on September, 2015. We used the transformed absorbent, KIERSOL-B and KIERSOL-N, for each industry, because the CO₂ concentration of feed in the LNG flue gas and biogas is different (8% in the LNG flue gas and 45% in the biogas).

In this study, we could apply to KIERSOL to capture CO₂ in the kiln gas, because the CO₂ concentration of kiln is about 25%. The heat duty of reboiler to regenerate an absorbent was supplied by heat recovery of rotary kiln, and we could reduce the operation cost, 0 GJ/tCO₂. An economical process draft from CO₂ capture to conversion using characteristics of a cement industry was made and a highly concentrated CO₂ from a stripper was used to manufacture a precipitated calcium carbonate (PCC) from CaO.

The operation cost of KIERSOL could be cut down from $25/t CO₂ to $20/tCO₂ by the heat recovery from a kiln. We could acquire a concentrated PCC (99.5%) by using a concentrated CO₂
and CaO, whereas a general PCC of a low degree of purity was made by CO₂ from flue gas without capturing.

Additionally, we suggested a liquefied CO₂ or a PCC transport by a railroad instead of using pipeline, which is a cheaper method than installing a new pipeline for a high pressure CO₂, if country is limited in area.

Optimum CCU operation for a cement industry was considered and economical potential, benefit to cost analysis was discussed.

Figure. 1 CCU process for cement industry