

CARBON PARTICLE REDUCTION FROM THE FLUE GAS OF BRICK INDUSTRY

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Abstract- Brickfield is a manufacturing unit to manufacture bricks from mud soil or clay. Wood fuels and fossil fuels, which are burnt in brickfields, are mainly responsible for the emissions of the trace and non-trace greenhouse gasses, such as CO₂, CH₄, CO, N₂O, NO_x and NO. Therefore, brick industries are prime sources of greenhouse gases as they use wood fuel, coal and fuel oil for high temperature brick burning. In the regular brickfield, the ordinary chimney is used by which different toxic gases are emitted. Among these gases around 70% carbon substances is found which contribute to greenhouse effect. This paper will focus on reducing the carbon percentage by reducing the carbon particles dispersing them into the water by water spraying technique by which carbon particle will be submerged into water. The result of this process is considerably positive to reduce carbon particle from emitted gas. A total efficiency was calculated depending on the data found in different brick industries. From efficiency curve it was visualized that percent of carbon reduces afterwards and other harmful substances from flue-gas that causes anomaly to the nature also become less.

Keywords: CO₂ emission, Filter, Bricks industry, Membrane separation and MEA.

1.INTRODUCTION

Brick is an important material for different types of constructions. It is the backbone of any constructions. But in Bangladesh about 8,000 brick fields are set up without clear environmental guidelines (The Financial Express, 2013). In Bangladesh, two billion bricks are produced every year. Out of which, one billion and 375 million are burnt with wood, 400 million with coal and 225 million with natural gas [1]. For this reason, brickfields are also a source of environment pollution as well as rising the temperature of the environment and greenhouse effect. In the brickfields, woods are the main fuel of combustion. They also use coal, fuel oil for high temperature burning. Such toxic gases like CO₂, CO, NO_x, SO_x, CH₄, NO etc. are emitted with the flue gas because of using these fuels. About 40,57,110 t CO₂ 1,54,920 t CO 17,700 t CH₄ 4410 NO_x 2880 t NO 123 t N₂O etc. are emitted with the flue gases per year. These toxic gases are directly contributing to global warming. For this kind of pollutant, the ordinary characteristics of the brickfield is the main reason. In a brickfield, coal or wood is burnt until the color is turned to red. The exhaust gas is emitted through the chimney containing the toxic gases. There is no process to treat the emitted gas for the environment. The toxic gases such as CO₂, CO has to be separated from the flue gases. Membrane process is very useful to separate this kind of gases. CO₂, CO etc. the carbon particles are separated mixture of different gases through the membrane and is captured in a collector.

process includes filtering the flue gas coming out of the chimney. Generally, in clay bricks industry pure charcoal is used as a burning raw material so most of the element that comes out as flue gas contain carbon di oxide. To filter this Carbon-Di-Oxide membrane separation process is used.

2. METHOD

2.1 Present Method:

Generally, there is no filter process employed in most of the bricks industries in Bangladesh. Visiting Several bricks industries in Savar, Dhaka and Rajshahi it is found that after burning bricks, generated smoke is directly released to the environment.



Fig. 1: Brick industry Polluting Environment.[21]

2.2 Mono Ethanol Amine (MEA) Process:

An effective, economical, and traditional solvent that can be used for CO₂ absorption is Mono Ethanol Amine (MEA) [2]. The flue gas from a fossil fuel power plant is passed through a column in which MEA selectively absorbs CO₂ (Fig. 2). This CO₂-rich solution is then pumped to a tower in which thermodynamic conditions are manipulated to release the CO₂. High pressure and low temperature favor absorption, while low pressure and high temperature result in regeneration of the solvent. The pressure in absorption systems can be atmospheric or can be manipulated (as explained previously) to enhance absorption/desorption. Temperature manipulation (specifically, to release the CO₂ and regenerate the MEA) makes up 70–80% of operating cost. The main area of improvement for this process is finding a new solvent or refining the existing method to minimize regeneration conditions. [3] In Fig. 2, the flue gas is cooled prior to entering the absorption chamber. The temperature should not go below the condensation point of the gas; therefore, the minimum temperature should be above the condensation point of the gas and the solvent's freezing point. After absorption, the CO₂-rich solution is passed through a heat exchanger to recover some of the heat from a hot stream coming from the regenerator. It then goes into the regenerator and is heated to release the CO₂ in solution (if pressure is involved, the pressure is lowered). The CO₂-lean solution is then pumped back into the

Figure 2.

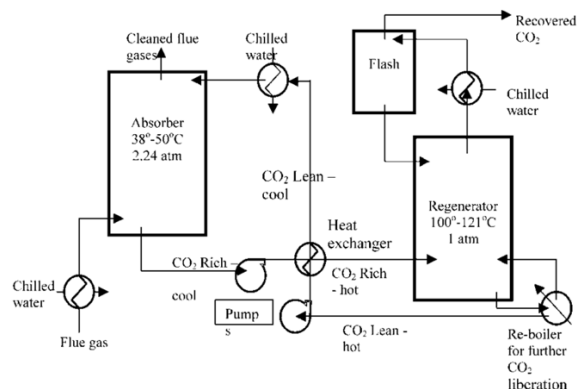


Fig.2: Typical chemical absorption system [6]

absorber for reuse (reusing solvent allows cost reduction; it has no bearing on performance of the solvent unless the solvent degrades with heating or is partially regenerated). The CO₂ liberated in the regenerator goes through a flash chamber where any water or other contaminants are removed, and the clean CO₂ gas stream is collected for storage or sequestration. [4] There are many points where a chilled water stream exchanges heat with a solvent stream; this heat exchanging is a cost-effective method to conserve heat (2). Some small amount of refrigeration is necessary to reduce the temperature of the cold-water streams. The absorption process has many design issues that it must overcome. The most important is regenerability of the solvent (regardless of the solvent,

the process is the same). Since it is desirable to carry out the process with as little energy penalty as possible, the solvent activity must have an optimum balance between absorption and desorption rates.[5] Absorption of CO₂ at low temperatures (35–50°C) and relatively low CO₂ partial pressure (proportional to concentration) can occur if the solvent is highly attracted to the solute, but this high attraction between the solvent and CO₂ causes regeneration energy to be high. If the solvent isn't very attracted to CO₂, regenerations simple, but little loading is possible. Another concern is oxygen content of the flue gas. [6] High oxygen concentration can corrode carbon steel facilities and cause excessive amine loss. Hindered amines (organic amine compounds with large attached groups that can hinder some interactions) offer some resistance against degradation of the solvent. Acidic gases, such as SO_x, are also a major concern. It is preferable to keep levels of these gases below 0.001% because they form stable salts with the amines used for absorption. A SO_x scrubber is generally more cost-effective than purchasing more solvent to account for the losses. However, since typical SO_x scrubbers only remove 90% of the SO_x in the flue gas, degradation of solvent will be a major issue if MEA is used. Fly ash and NO_x compounds create the same problems as SO_x compounds (any amount of any of these components will cause at least some degradation). Finally, the high temperature (at least 100°C, higher than the maximum ideal temperature for MEA at 45°C) associated with flue gases can degrade solvents and lower the solubility of CO₂. The temperature needs to be decreased to approximately 45°C in the SO_x scrubber upstream from the separation column (3). The greatest advantage of absorption is that there are solvents that can be easily regenerated. MEA has been used for over 60 years in the chemical industry, whereas new solvents operating on the same principles are currently being investigated (4). This is a well-established method of separating CO₂, and the mechanisms and involved thermodynamics are well known. The fact that CO₂ absorbers can be regenerated is possibly the most attractive feature that motivates renewed research efforts focused upon improvement of the absorption process.

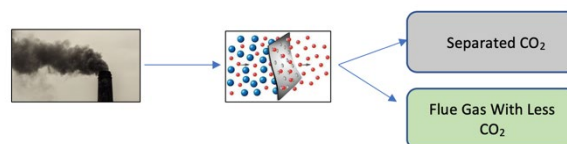


Fig. 3: Separation process of CO₂ from Flue Gas of Brick Field [20]

3. DATA AND DESIGN

In organic process by using methanol for absorbing CO₂ will result as a good removal of triggered component.[8] Table shows the CO₂ removal efficiency for using Methanol as diluent.

Table 1: CO₂ removal Efficiency Chart

test no.	MEA, wt %	methanol, wt %	water, wt %	density of overhead condensate, g/mL	CO ₂ removal efficiency, %
1	20	60	20	0.815	96.5
2	20	40	40	0.858	94.7
3	20	20	60	0.881	92.7
4	20	0	80	0.989	93.9

^a Absorber temperature: 37 °C; absorber height: 53 cm; mole MEA inlet/mole CO₂ inlet: 2.0.

3.1 Membrane material design (MMD). [9]

3.1.1 Non-facilitated membranes:

Non-facilitated membranes rely on the “solution-diffusion” transport process whereby the permeate first dissolves into the membrane and then diffuses through it. The solubility of the permeate follows the Henrys law. For a given temperature, the

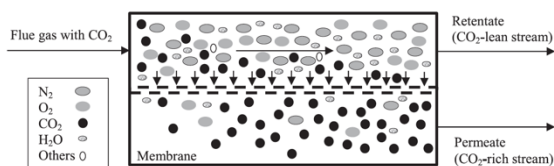


Fig 4: Schematic of membrane-based CO₂ separation process from flue gas streams.[19]

The major advantage of non-facilitated membranes is that there is a high tunable degree of controlling the membrane permeability and selectivity via the manipulation of polymer preparation and chemical composition.[10]Counteracting this is the characteristic swelling and plasticization of the materials as a result of CO₂ absorptions. Additionally, this material is generally only suitable for low temperature applications. The pioneering work on CO₂/N₂ separation using non-facilitated membranes may be traced back to the study by Kawakami et al.(1982) who blended a low permeable glassy polymer (cellulose nitrate) with a plasticizer membrane (polyethylene glycol (PEG)). They noticed that with the increase of PEG percentage and/or molecular weight, the permeability of CO₂ as well as CO₂/N₂ selectivity increased.[11]However, above a threshold concentration (30% PEG) plasticization was observed. The interesting point of this research was that the authors did not have a clear idea on industrial applications for this process and only projected that the separation of CO₂ from N₂ might be used “in order to recover carbon resources or to control CO₂ concentration in an artificial atmosphere.” Sidhoum et al. (1988) studied CO₂/N₂ separation using cellulose acetate (CA) hollow fibers with dense skin on the outside. They compared separation efficiency with the high-pressure feed on the outside and the inside of the fibers and reported permeances of about 20, 3, and 0.8 GPU₁ for CO₂, N₂, and O₂, respectively.[12]They also claimed that the inherent membrane separation capability

appeared the same whether the feed was inside or outside of the fibers. Sada et al. (1992) examined separation characteristics of CO₂/N₂/O₂ mixtures using hollow fiber modules of asymmetric cellulose triacetate membrane with a counter current plug flow model. They reported ideal selectivity of CO₂ relative to N₂ in the range of 21e24[13]. Polyethersulfones (PES) have a higher glass transition temperature than cellulose triacetate, thus making them more resistant to plasticization. Kumazawa et al. (1993) used

PES membranes and reported CO₂/N₂ ideal selectivity of 35 and 40 for asymmetric and homogenous membranes respectively[14]. Cellulose acetate membranes were later discarded due to their problems with plasticization (Bernardo et al., 2009; Scholes et al., 2008) though some studies showed that blending CA with other polymers such as PEG could improve the membrane performance (Li et al., 1995). Tokuda et al. (1997), with knowledge that Cardo polyimides have high CO₂/N₂ permselectivity, studied the impact of various functional groups on selectivity of Cardo polyimides. They noticed that Cardo polyimide (PI-BT-COOMe), having a CO₂ affinitive methyl carboxyl functional group, shows outstanding CO₂/N₂ selectivity behaviour. More specifically, Cardo polyimides which had 3,30,4,40 Benzophenone Tetracarboxylic dianhydride as a monomer (PI-BT) obtained the highest separation with CO₂/N₂ selectivity of

52 at 25 °C [15]. Later, it was reported that a bis(phenyl)fluorene-based Cardo polyimide could result in membranes with notably high permeance of 1000 GPU with good CO₂/N₂ selectivity of 40 (Kazama et al., 2004). Yoshino et al. (2000) studied the effects of hard-segment polymers (namely polyurethanes (PUs), polyamides (PAs), and polyimides (PIs)) on CO₂/N₂ separation properties of poly(ethylene oxide) (PEO). The study showed that compared with PEO-PIs, PEO-PUs and PEO-PA had much smaller CO₂ permeability values and somewhat lower or similar CO₂/N₂ selectivity. This was due to small diffusivity and solubility values for CO₂ as a result of the incomplete phase separation. They also noticed that in worst phase separation conditions, PEO-PIs still had CO₂/N₂ selectivity above 50.[16] They reported the best CO₂/N₂ selectivity value of 58 for a PEO-PI. In a similar study, Bondar et al. (2000) studied properties of poly(ether-b-amide) segmented block copolymers. They noticed that CO₂/N₂ selectivity's were greater in polymers with higher concentrations of polar groups. They obtained CO₂/N₂ selectivity as high as 56 with CO₂ permeability of approximately 220 Barrers₂ at 35 °C. Kim et al. (2001) used a membrane composed of two polymeric materials: a porous substrate and a filling polymer that fills the pore of the substrate[17]. By using this method, they obtained CO₂/N₂ selectivity of 32.4 which is higher than their non-filling membranes.[18] The results justified their proposal that the high selectivity of the pore-filling membrane is attributed to the high solubility selectivity due to the affinity of CO₂ to PEO segment. Nakagawa et al. (2002) synthesized three copolyimide membranes by the condensation polymerization of alicyclic 2,3,5-tricarboxy cyclopentyl acetic dianhydride (TCDA) with

diamino diphenyl ether (DADE) and bis(aminopropyl)polydimethylsiloxane (BAS). They observed CO₂/N₂ selectivity of 60 for TCDAeDADE. Lin and Freeman (2004) studied the impact of pressure and temperature on the solubility, diffusivity, and permeability of various gases including CO₂ and N₂ using PEO.

7. CONCLUSION

Brick industry produces huge amount of carbon particles each year. In this paper Membrane separation process is used for CO₂ separation from the flue gas of bricks burning. The maximum emission coming out of the chimney can be reduced by placing the MEA membrane through the path. It is found that most of the carbon content is filtered by that membrane process. This will reduce amount of carbon particle in the flue gas.

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