Application of the DMX™ CO₂ Capture Process in Steel Industry

M. Dreillard¹*, P. Briot¹, T. Huard¹, K. Lettat¹, P. Broutin¹

¹IFP Energies nouvelles, BP 3, 69360 Solaize, France

Abstract
The objectives of the VALORCO project coordinated by ArcelorMittal and funded by ADEME are:
- to reduce CO₂ emissions from the steel industry,
- to reuse the CO₂ emitted as feedstock for valorisation processes.

The paper will present the main results of Task 1.1.A of the VALORCO project dedicated to CO₂ capture on blast furnace gas by amines scrubbing. For this application, it has been studied three IFPEN’s processes initially developed for CO₂ capture on coal power station flue gas:
- Hicapt™ process (MEA 30 wt.%),
- Hicapt+™ process (MEA 40 wt.%),
- DMX™ process using demixing solvent [1], [2].

Typical blast furnace gas composition after gas cleaning is given in Table 1.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (bara)</td>
<td>2.15</td>
</tr>
<tr>
<td>Molar composition (%)</td>
<td>dry</td>
</tr>
<tr>
<td>H₂</td>
<td>4.45</td>
</tr>
<tr>
<td>N₂ + Ar</td>
<td>46.7</td>
</tr>
<tr>
<td>CO</td>
<td>25.15</td>
</tr>
<tr>
<td>CO₂</td>
<td>23.7</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100</td>
</tr>
</tbody>
</table>

Blast furnace gas is characterized by a high CO₂ partial pressure, absence of oxygen but presence of CO. There are only few data in the literature on the effect of CO on CO₂ absorption and solvent degradation. Main reference is the PhD defended by A. Jamal in 2002 [3].

To get data of absorption in MEA and DMX solvent, an experimental work has been carried out:
- kinetic experimentation in a Lewis cell (see Figure 1a) to study CO absorption,
- kinetic experimentation in a wetted wall column (see Figure 1b) to study CO₂ absorption at high partial pressure,
- degradation experimentation in a rig equipped with 6 reactors in parallel (see Figure 2),
- experimentation in a mini-pilot (see Figure 3): parametric study and long test runs (1500 hours).

* Corresponding author. Tel.: +33 4 37 70 21 54
E-mail address: matthieu.dreillard@ifpen.fr
Main results of this experimental work can be summarized as follows:
- kinetic of CO absorption is very slow compared to CO₂ absorption;
- CO reacts also with amine solvents but CO absorption is mainly due to physical absorption, especially at high CO₂ loading;
- limited degradation of the solvents in the absence of oxygen;
- degradation is lower with DMX solvent than with MEA;
- on the mini-pilot, it was possible to reach high capture rate (above 99.5 %) and to confirm good operability even with DMX solvent. It was also confirmed high CO₂/CO selectivity (CO₂ produced contains less than 400 ppmv CO);
- with DMX solvent, CO₂ may be produced at 6 bara and Carbon Steel may be used (no corrosion observed on Carbon Steel coupons placed in the mini-pilot after 1500 hours of operation).
Based on this experimentation a process study and an evaluation of the CO₂ capture costs have been carried out for each of the three considered processes (MEA 30wt.%, MEA 40wt.% & DMX solvent) and for the three following cases:
- Power Station (PWS): CO₂ capture on the flue gas of the steel complex power station,
- Blast furnace (BF): CO₂ capture on the blast furnace gas,
- Oxy-BF (OXY): CO₂ capture on the Oxy blast furnace gas.

Figure 4 gives the impact of CO₂ partial pressure and solvent on the CO₂ production cost at 6 bara with a steam cost at 21 €/ton.

The DMX™ process is the most promising in terms of energy penalty and CO₂ production cost.

Figure 5 gives the impact of the steam cost on the CO₂ production for the DMX™ process.
The impact of the steam cost is very huge and it will be important to consider heat recovery on the steel complex in order to produce steam at low cost.

With steam at 15 €/t, it would possible by using the DMX™ process to produce CO₂ at 30 €/t as feedstock for valorization processes.

**Acknowledgements**
This work has been performed within the VALORCO project funded by ADEME (French Environment & Energy Management Agency).

We gratefully acknowledge ArcelorMittal for the data provided on blast furnace gas and on utilities available in the steel plant.

**References**

