Characterizing CO₂ Compressors for Fossil-Fired Power Plant Carbon Capture Systems

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Purpose: To develop an internal predictive model for compressor performance

Motivation: Rising atmospheric carbon levels and pending Cap-and-Trade legislation threaten to severely disrupt the financial stability of generation organizations that depend heavily on fossil-based fuels. These issues are likely to severely affect coal power, a resource with tremendous domestic abundance. In order to ensure the future viability of this cheap, secure fuel source, technologies must be employed to curtail carbon output significantly. These technologies include chemical and mechanical methods of separating carbon dioxide from flue gases, as well as compression systems that reduce the volume of CO₂ so that it may be transported to geologic sequestration sites. This marks the first time industrial compressors have been used to handle such massive volumes of gas. As a result, the functionality of existing compressor designs in carbon capture applications is poorly understood, and conflicting methodologies for determining compressor performance exist within the industry. This project aggregated many different sources on carbon capture compressors to develop an internal model for compressor performance. In the future, this model will be utilized within software-based models of carbon capture systems, so that the energy penalty (and subsequent economic effect) of such a system may be minimized.

Methodology: Knowledge and data on compressor performance was gained from several major compressor manufacturers. This data was used, along with thermodynamic fundamentals and compressor industry tools like ASME’s PTC 10, to develop a complete, software-based model to calculate power requirements of various compression options in carbon capture systems.

Types of Compressors

Inline Centrifugal

Benefits/Drawbacks:
• Popular design
• Petroleum industry support
• Ease of maintenance
• Limited flexibility
• Large floor space requirement
• Input sensitivity

Integrally Geared Centrifugal

Benefits/Drawbacks:
• Variable-speed drivers
• Flexibility
• Easy interstage cooling
• Mechanically complex
• Less common

Ramgen “Rampressor” Concept

Benefits/Drawbacks:
• Compact design
• High pressure ratio
• Thermal integration possible
• Design still in testing phase
• Higher power requirements

Example: Integrally-Geared 8-Stage Design: Industry vs. Calculated Results

<table>
<thead>
<tr>
<th>Stage</th>
<th>Adiabatic η</th>
<th>Inlet T (°F)</th>
<th>Inlet P (psia)</th>
<th>Discharge P (psia)</th>
<th>Discharge T (°F)</th>
<th>% Difference</th>
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*Note: given discharge temperature for stage 4 is likely a typographical error.