Use of Eductor for Lifting Water

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Overview

• Eductor theory
• Case studies
• Equipment configuration
Eductor Theory

- From the family of thermocompressors that includes Air Ejectors, Evacuators, Sand Blasters, Jet Pumps, and Eductors
- High pressure gas entrains and compresses suction gas and the combined stream is left at an intermediate pressure
- Compression ratios 1.3-2.0 are possible, limited by:
  - Power gas pressure
  - Suction pressure
  - Discharge pressure

Eductor Example

- $P_{atm} = 12$ psia
- Gas is Methane
- $m_{\text{power}} = 600$ lb/hr
- $m_{\text{suct}} = 300$ lb/hr
- $P_{\text{pwr}} = 100$ psig
- $T_{\text{pwr}} = 80^\circ$F
- $P_{\text{disc}} = 21$ psig
- $R = 1.5$
- Find
  - $P_{\text{suct}}$, $q_{\text{power}}$, $q_{\text{suct}}$

\[
\begin{align*}
q_{\text{power}} &= \frac{MW \times P}{10.73 \times T \times Z} = \frac{(16) \times 112 \text{ psia}}{10.73 \times (460 + 80) \times 0.97} = 0.319 \text{ lbm/ft}^3 \\
q_{\text{suct}} &= \frac{m_{\text{suct}}}{\rho_{\text{air}}} = \frac{600 \text{ lb/hr}}{0.319 \text{ lbm/ft}^3} = 1970 \text{ ft}^3/\text{hr} \left( \frac{112 \times 520 \times 0.98}{14.73 \times 540 \times 0.97} \right) = 24 \times 333 \text{ MCF/d} \\
P_{\text{suct}} &= \frac{P_{\text{disc}}}{R} = \frac{21 \text{ psig} + 12 \text{ psig}}{1.5} = 22 \text{ psia} \\
\rho_{\text{air}} &= \frac{16 \times 22}{10.73 \times (460 + 60) \times 0.98} = 0.064 \text{ lbm/ft}^3 \\
q_{\text{suct}} &= \frac{300 \text{ lb/hr}}{0.064 \text{ lbm/ft}^3} \left( \frac{22 \times 520 \times 0.98 \times 24}{14.73 \times 520 \times 0.98 \times 1000} \right) = 168 \text{ MCF/day} \\
\end{align*}
\]

At 10 psig, 60°F, and 168 MCF/d you can
Move 0.75 bbl/day up 3,000 ft of 2-3/8 tubing
Eductor Theory

- Small amount of hp
  - 16 hp for power gas
  - 7.4 hp used in eductor
  - $\varepsilon=46\%$
- Slow to react (can take 2-3 weeks or longer to stabilize water level)
- Pretty effective in maintenance mode

Eductor Rules of Thumb

- For an eductor with gas as the power fluid:
  - Exhaust pressure should be less than $\frac{1}{2}$ power-gas pressure (in absolute terms)
  - Exhaust pressure should be less than twice suction pressure
  - Mass flow rate of power gas will be about twice suction mass flow rate.
- With liquid as the power fluid:
  - You don’t get to critical flow so the exhaust pressure can be higher
  - More “compression ratios” are possible (i.e., the ratio of the exhaust over the suction can be more than 2)
- If the power gas is a mixture of gas and liquid, calculate the density and the mass flow rate carefully
Case Studies

Hendrickson /B/ 1

Installed Compressor

31% decline

75% decline

Compressor

Base rate

Actual

So Ute Tribal /B/ 2

Raised casing pressure from 10 psig to 24 psig.
Ratios went from 0.9 to 1.3

22% decline

33% decline

Base rate

Actual
Equipment Configuration

- Must have
  - At least two lines from wellhead to separator
  - Check valve on tubing line between eductor and separator
  - Compressor with at least 50 psig discharge and 20 Hp extra
  - Patience (it can take 2-3 weeks before you see results)
- Good to have
  - Block valve between eductor and check with blow down on check side of block
  - Two inlet nozzles on separator (without this, you must be very careful how you bring the two lines together)
Screening Criteria for Other Applications

- Need a source of gas pressure at least twice (in psia) the exhaust pressure.
- Need an application where 1.5-2.0 ratios does some good.
- Example:
  - You have a well with 500 psig upstream of a choke, line pressure is 150 psig
    \[
    \frac{500+12}{2} - 12 = 244 \text{ psig} > 150 \text{ psig} \quad \text{--OK}
    \]
  - A nearby well would flow better at 75 psig line pressure
    \[
    \frac{150+12}{75+12} = 1.86 \text{ ratios} \quad \text{--OK}
    \]
  - Can you use the energy you’re losing across the choke to drive an eductor to pull on the nearby well? Possibly, need to check rates

Other Possibilities

[Diagram showing pressure drops and flows]