CASE STUDY

UpwingEnergy

Subsurface Compressor System™

Increases Gas Production in Wells by as High as 58%

Concept Proven on Multiple Conventional Wells in Texas

Challenge

- Increase gas production from wells with drawdowns created by a downhole compressor, which has never been done before.

Solution

- Deploy the Upwing Subsurface Compressor System (SCS) experimental prototype in a total of four gas wells in Texas, USA to prove the application.

Results

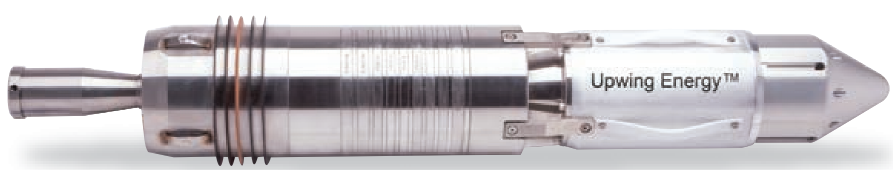
- The SCS proof-of-concept field trials demonstrated an increase of gas production ranging from 30 to 58%.

- The compressor system helped to lower the wells' bottom hole pressure and increased the direct drawdown on the reservoir completions, thus increasing the gas flow rate and significantly increasing the recovery rate.

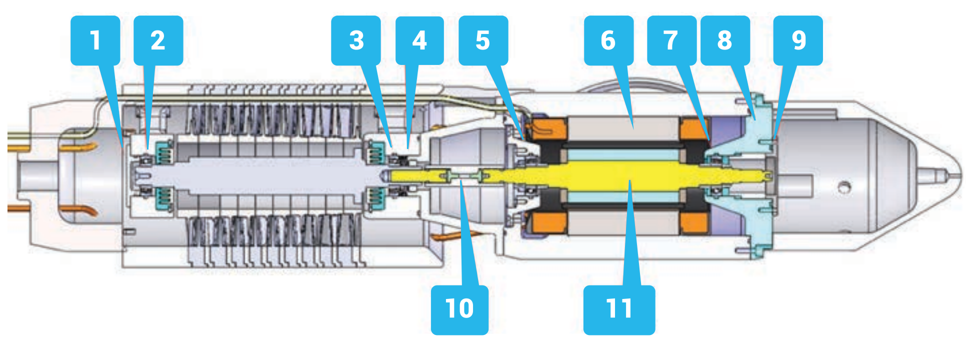
- Lessons learned from the proof-of-concept trials have served as the foundation for the design of the SCS commercial units.

Proof-of-Concept Experimental Prototype

The SCS proof-of-concept prototype is composed of two main sections: the compressor and motor sections. The compressor section is a multi-stage axial compressor. The motor section is a high-speed permanent magnet motor (PMM). The compressor rotor is connected via a mechanical coupling to and driven by the permanent magnet motor rotor. Both the motor rotor and compressor rotor are supported by traditional ball bearings. Ball bearings were used for fast prototyping, with the understanding that ball bearings might not last long in the downhole environment and might not be the final solution for either the motor or compressor section.



Proof-of-concept experimental prototype



1 Compressor Top Bearing End-Plate	**7** Motor Pre-Load Springs
2 Compressor Top Ball Bearing	**8** Motor Bottom End Bell
3 Compressor Bottom Ball Bearing	**9** Motor Bottom End Plate
4 Compressor Pre-Load Springs	**10** Coupling
5 Motor Top End Bell	**11** Motor Rotor
6 Motor Stator	

Cross-section view of the proof-of-concept experimental prototype with identified components

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Deployment of the Prototype

The experimental prototype was deployed into the 7-inch casings by sucker rods for fast prototyping with the understanding that sucker rod deployment may not be the best approach for deployment. The power cables were strapped to the sucker rods.

Lessons Learned

After conducting the field trials, Upwing engineers identified opportunities to modify the SCS design for future commercial units.

1 - The ingress of downhole fluids damages the motor -
A canned motor design and hermetically sealed, downhole rated electrical connections are required to withstand the harsh downhole environments.

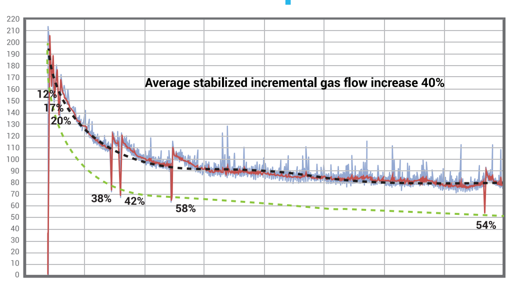
2 - Conventional bearings do not work -
This observation validates the need to use magnetic bearings to eliminate the physical contact between the rotors and stators that occurs with traditional contact bearings. Since there is no physical contact between the rotors and stators of magnetic bearings, there will be no failures caused by the introduction of foreign debris on the contact surfaces or efficiency loss due to friction.

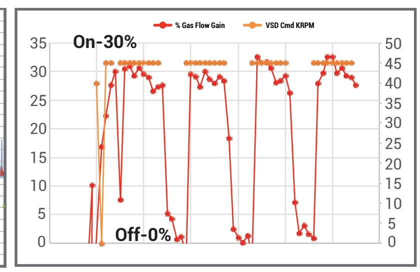
3 - Poor rotor axial positioning -
For the purposes of compressor reliability and performance, there is a need to use an active magnetic thrust bearing to ensure real-time closed loop controls of axial thrust loads and positions.

4 - Sucker rod deployment risky -
Sucker rod deployment was deemed unreliable in terms of rod connections and electrical cable attachments. The SCS will be deployed with more reliable tubing hung geometry and alternative deployment methods will be evaluated for future use.

SCS proof-of-concept trials sucker rod deployment

Proof-of-Concept Trial Results





The SCS proof-of-concept field trials demonstrated an increase of gas production ranging from 30 to 58%. The horizontal axis is time, and the vertical axis is thousand standard cubic feet per day (mscfd) for the first graph and gas flow rate percentage gain for the second graph.

At the intake of the SCS, downhole flowing pressure decreases, thus the gas production increases. Simulations demonstrate that the higher gas temperatures and higher kinetic energy of gas flow at the discharge side of the SCS could carry more liquid to surface to mitigate or remove completely the risk of liquid loading in gas wells.

Commercial Unit Design

Based on the lessons learned from the proof-of-concept field trials, Upwing engineers have applied proprietary and proven technologies developed and used by parent company Calnetix Technologies in other industrial applications to the design of the commercial unit, which is set to launch in 2019. The commercial SCS unit will be composed mainly of three technology parts – a hydraulic unit, a bearing unit, and a motor unit, from top (uphole) to bottom (downhole).

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