



Multiphase Pumps in Synergy with Artificial Lift

Author: Neil E. Gibeau

***Weatherford International, Ltd.
Houston, Texas USA***

Today's Oil and Gas industry is faced with a multitude of challenges. Among geographical and political forces are depleting reservoir resources and a world wide increase in petroleum usage. These challenges force us to create new and innovative concepts to help optimize, recover, and more affectively deplete existing reserves.

Artificial lift systems have been around for decades and continue to help oil and gas production when natural reservoir pressures are no longer sufficient. Innovations, however, are needed to provide a more economical solution in handling many of the complex well streams and declining well performances we see today. Surface multiphase pumps individually and in use with other artificial lift equipment are just one of the innovative concepts recently used to help producers recover more of their reserves.

Though a relatively new technology, surface multiphase pumps have been designed effectively filling a niche between conventional gas compression and liquid pumps. When applied correctly, they can enhance well recovery as well as improve efficiencies on artificial lift requirements.

Two separate applications and their results relating to the well and artificial lift performance are discussed and convey the considerations and benefits of utilizing multiphase pumps in a variety of applications. In addition, a portion of the paper is used to describe how the new positive displacement, vertical duplex plunger, surface multiphase pump works.

Those interested in field optimization and surface pressure management will benefit greatly by this discussion as will those interested in the application of surface multiphase pumps.

“Multiphase Pumps in Synergy with Artificial Lift”

Introduction

Today's Oil and Gas industry is faced with a multitude of challenges. Among geographical and political forces are depleting reservoir resources and a world wide increase in petroleum usage. These challenges force us to create new and innovative concepts to help optimize, recover, and more affectively deplete existing reserves.

Artificial lift systems have been around for decades and continue to help oil and gas production when natural reservoir pressures are no longer sufficient. Innovations, however, are needed to provide a more economical solution in handling many of the complex well streams and declining well performances we see today. Surface multiphase pumps individually and in use with other artificial lift equipment are just one of the innovative concepts recently used to help producers recover more of their reserves.

Since 2001 multiple vertically disposed surface multiphase pumps have been installed in a number of applications and these installations have exposed this type of pump to a wide variety of well streams. This range includes heavy oil / gassy emulsions in Venezuela to gassy wells flowing condensate and

salt water in the Gulf of Mexico, to vapor recovery, tar sands (Bitumen) and gas injection in under balanced drilling all in Canada. Inlet pressures have varied from 0 psig up to 1000 psig while inlet temperatures have ranged from 20 deg F up to 365 deg F. Discharge pressures have varied from 100 psig to 2000 psig. Liquid viscosities have ranged from 0.5 up to as high as 20,000 cp. Most installations have had concentrations of sand and paraffin while some flows have included percentages of H₂S and CO₂.

How the vertically disposed surface multiphase pump works

Weatherford's multiphase RamPump™ system (Type L) is a duplex, vertical, long stroke, positive displacement pump. **(Fig. 1)** The plungers draw in well fluids (liquids and gas) on the upstroke through check valves (near the bottom) into a fluid chamber and then discharge the fluids during the downstroke at flowline pressures effectively boosting the well stream.

Each plunger (ram) is connected to a yoke and two hydraulic cylinders. These cylinders are called the drive (or power) cylinders. The hydraulic cylinders are used to pull the rams downward.

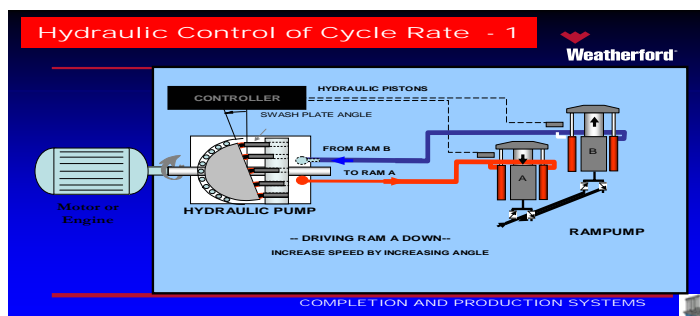


(Fig 1)

A RamPump™ system consists of four parts: the pumping unit (RPU), Hydraulic unit (HU), Prime mover unit (PU), and a Unit Control Panel (UCP). These units are normally supplied in either two or three separate skids. The RPU skid connects to the HU skid through flexible hydraulic hoses.

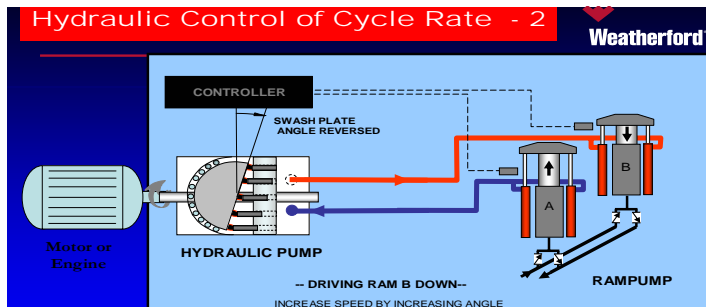
The RPU's pumping rate is hydraulically controlled by electronically varying the angle of the swashplate between neutral and its maximum of the hydraulic pump, resulting in an infinite selection of pumping speeds between zero and the maximum rate. Of particular interest is that no variable frequency input is required.

This hydraulic pump is capable of directing its flow in two directions. When pumping into the drive cylinders on ram A (the "front" ram), the hydraulic pressure will force the ram to descend, pushing out the gas and liquids that are in the plunger chamber through a check valve into the discharge line. **(Fig. 2)** At the same time ram B is rising. Well pressure flows into the chamber, through a check valve, due to differential pressure, filling the plunger chamber. ⁽¹⁾



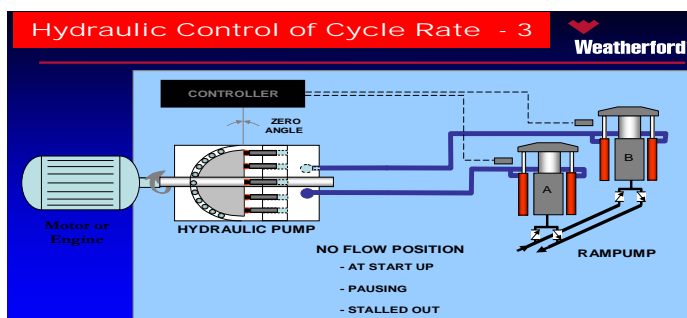
(Fig 2)

When ram A descends, near the bottom of its stroke, a proximity switch senses the presence of the metal yoke, and a signal is sent through the UCP to the hydraulic pump control to reverse its pumping direction. Within a short period of time the hydraulic pump shifts to pump in the opposite direction, and ram A starts to rise and ram B is now forced downward. **(Fig. 3)** The process of reversal repeats once the yoke of the descending ram arrives near its proximity switch at the bottom. One complete cycle is made when both Ram A and B Ram have tripped their respective proximity switches. ⁽¹⁾



(Fig 3)

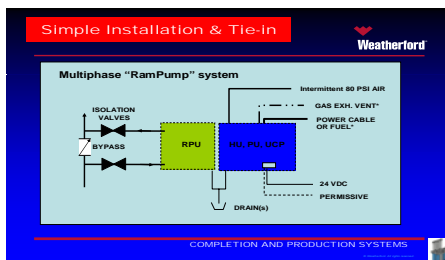
The hydraulic pump moves through a neutral position each time it reverses flow direction. In this neutral position no flow occurs. (Fig. 4) The hydraulic pump neutral has several functions. During start up the prime mover shaft will rotate and turn the hydraulic pump shaft, however, due to the internal design of the hydraulic pump, neutral position results in zero flow out of the hydraulic pump and therefore zero speed of the RPU. By gradually increasing the control signal to the hydraulic pump the displacement increases and the plunger speed increases. (1)



(Fig 4)

During normal operation, should a blockage in the process discharge line occur, the hydraulic pumps internal pressure limiting valves will sense this pressure, which in turn will cause these valves to internally drive the displacement of the hydraulic pump to its neutral position irregardless of the UCP signal to the pump. The hydraulic pump will automatically resume once the cause of the blockage has been eliminated. (1)

Because of this feature as well as others, this system has a simple installation and tie-in procedure. (Fig. 5) RamPump™ systems do not need outside recirculation lines and controls. In addition, the ability to infinitely vary the hydraulic pump rate means that speed changes to the prime mover are not required to control pumping.



(Fig 5)

Weatherford's multiphase RamPump™ system (Type S) is a duplex, vertical, long stroke, positive displacement pump similar to the type L system. (Fig. 6) Each plunger (ram) however, is connected to four hydraulic cylinders. These extra set of cylinders are called the trim or sync cylinders.

The rod ends of each of the four sync cylinders are connected to each other. The hydraulic fluid in this area intensifies between the ascending ram and descending ram sync cylinders due to the suction pressure on the bottom of the ascending plunger. This intensification helps to push down the descending ram reducing the overall pressure required within the power cylinders. The type S system is very effective when elevated suction pressures are present.



(Fig 6)

Application Examples

Example 1: A recent application request for a customer in Malaysia. This particular well is a water drive reservoir with very good potential recovery. The offshore platform's separation and pipeline system induced a surface back pressure of 650 psig on to the well and the downhole pressure had declined far enough that it was no longer flowing due to this back pressure.

A decision needed to be made as to the next step in the well's designs. A number of artificial lift solutions were considered including Gas lift and Jet pump; however, these solutions by themselves were both uneconomical and inefficient.

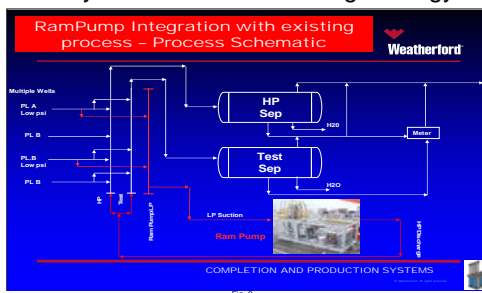
Production methods considered included

- Install Gas Lift – Well currently not producing enough volumes for re-injection. Installation of conventional compression & associated process equipment required considerable space not currently available, anticipated injection pressure quite high.
- Install Jet Pump – Relatively simple wireline installation, however, pressures required to overcome this surface back pressure increases purchase and service costs dramatically and the efficiency of hp / BPD is very poor.
- Install Jet Pump with a multiphase system – Relatively simple installation, surface space requirements will fit space available. Detailed study needed.

Comparison of the Jet Pump only to Jet Pump with multiphase system requirements:

The estimated equipment costs difference between the use of the Jet pump without multiphase system and Jet pump with the multiphase system was around **15%**. The Jet pump only installation would require extensive platform piping modifications to handle the high surface pressures both entering the well and exiting into the power fluid cleaning system while the Jet pump with multiphase system had minimal piping integration with the existing platform. In addition, the multiphase system was sized to handle additional well head pressure reduction and thus provides further well depletion and increased reserves.

Example 2: An application applied in the GoM for a company by the name of Newfield Exploration. A total of four satellite wells were flowing into a high pressure (1100 psig) separation system and of these four only two of them had enough energy on their own to flow through this system. **(Fig. 7)**



(Fig. 7)

A host of problems associated with these wells forced a decision regarding a novel approach made in the next step in the well(s) process.

One well, EI 202A-1, was a series of commingled reservoirs through two zones. The lower was an oil and water zone with a high water drive and the upper a gas zone with slightly less pressure. Attempts to use a water shut-off down hole failed and they were unsuccessful in unloading the well after shut-ins. The potential of the well was still high however, with 3 MMSCFD, 200 BOPD, and 800 BWPD volumes. ⁽²⁾

A second well, EI198A-15, was a gas well producing in a depletion drive reservoir. It was unable to produce into the high pressure processing system but still had potential volumes of 1.5 – 2 MMSCFD, 30 BOPD, 5 BWPD. ⁽²⁾

Solution Considerations consisted of:

- Abandon current zones for next recompletion. (Unacceptable loss of reserves)
- Install conventional compression & associated process equipment. (High install costs, considerable space requirements, modest lease costs)
- Install multiphase system. (Modest install costs, reduced foot print, higher lease costs)

In the case of these two wells, both had production intervals higher up in the well bores that had not yet been opened and the customer considered abandoning the current producing zones and recompleting the wells, but that option would mean an unacceptable loss in reserves. Restoring production from the wells would translate directly into increased reserve recovery. ⁽²⁾

Newfield chose to go with the multiphase pump solution due to better economics over conventional type systems, better availability, and smaller foot print. After installation of the multiphase system the following were the production results. ⁽²⁾

Production Results

- | | |
|--------------------|--|
| EI 202 A-1 | <ul style="list-style-type: none">- Lowered flowline pressure and unloaded well to multiphase system.- Placed well back into HP system after 4 days of unloading.- Stabilized flowrate to: 3.3 MMSCFD, 160 BOPD, 830 BWPD @ 2600 FTP. (Average of 96.8% GVF)- Unloaded well average of once per month due to misc. overnight shut-ins. |
| EI 198 A-15 | <ul style="list-style-type: none">- Lowered FTP below HP sys psig and unloaded well to multiphase system.- Stabilized flowrate to: 1.0 MMSCFD, 6 BOPD, 96 BWPD @ 400 FTP. (Average of 99.2% GVF) |
| Summary: | <ul style="list-style-type: none">- Multiphase solution proved to be a viable wet gas compression solution that handled both liquid and gas slugging common to Gulf of Mexico.- Density variations in the flow were not an issue.- The multiphase system tolerated sand and paraffin including periods of slugging during well cleanup without any problems.- The unit was relatively simple to install and tie-in. |

In Summary

Use of a multiphase pump can be an effective innovation used with or without other artificial lift equipment. The overall reduction in surface back pressure imposed on the well(s) can result in reduced artificial lift horse power, reduced maintenance intervals and costs, as well as accelerated and improved recovery and reserves.

Weatherford's multiphase RamPump™ system in particular has found multiple applications where its characteristics have successfully managed a wide variety of multiphase flow streams. Specifically those flow streams where sand may be, periodically or constantly, a maintenance issue, or in those cases where a high delta P is needed, and / or those situations where the flow mixture may vary substantially.

References

- (1) Butler, Bryan., Manager Multiphase Systems with Weatherford., "Multiphase Flow Boosting – Differences in Using vertical Positive Displacement Piston Pumps", MPUR – Bahrain, UAE – Nov, 2005.
- (2) McCauley, Michael E., Production Engineer with Newfield Exploration Co., "Unloading Gas Wells In The Gulf Of Mexico Using The RamPumpTM", MPUR – Houston, TX – May 6, 2004.