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Potential Application of Multiphase Pumps in Oil and Gas Exploration and Production

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Abstract. The global demand for energy is estimated to increase over the next few decades by 2-3% Per year. This increase will climb to a about 50% over the next 20 years. Unabated global demand for energy will translate into growing demand for traditional hydrocarbon resources. The producers, however, are looking at new technologies such multiphase pumping to extended reservoir life and improve production. Multiphase pumping technology have the potential to offer numerous advantages such as increasing production rate, improving recovery, operability, capital and operating cost, a lower risk of equipment failure and cleaner environment by reduction of flaring and ranting of greenhouse gases. This paper presents an overview of multiphase pumping technology and its potential application in improving the production on matured fields. Further, the potential application of this technology in the reduction complete elimination of flaring and venting of the associated gas production is also discusses.

Keywords: Multiphase pump, Energy, Oil production, Flaring and Venting, Environment

1. Introduction

Multiphase production system require the transportation of a mixture of oil, water and gas, often for many miles from the producing oil wells to a distant facility. This represent a significant departure from the conventional approach, in which to separate the phases, pump the liquid and compress the gas independently through separate pipelines (over short distance) by the reservoir energy. Beside the reservoir energy, a number of measures have been already been taken to gain as much as possible of the original hydrocarbon in place, especially for mature (or Brown) fields which have long passed their peak production. Such measures, for example, are the installation of down hole pumps, water and gas injection for maintaining reservoir pressure or gas lift. However, despite all the efforts numerous wells have shut in because of too low production, and, high water content. Also, surface flow line and facility pressure losses are a major bottleneck for the production as they have a considerable influence on the inflow performance from the reservoir to the production tubing.

With the convention production operation, in most cases, due to the high cost of transferring gas to the sale point by separation and compression, has occasioned the incessant flaring of associated gas. With regional legal framework call for stringent environmentally friendly handling of hydrocarbons, thus where gas flaring was state of the art in the past, it is no longer allowed today. Subsequently the past common production scenarios require adjustments to a considerable extent. This paper presents the challenges currently faced the mature and marginal field and the gas flaring and the potential solutions the multiphase pump technology may offer.

2. Multiphase Pumps- A Potential Approach

As mentioned above, with the conventional production operation the well fluid is first separated into gas and liquid before being pump and compressed through separated lines. With the multiphase pump (MPP), the

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idea is to transport unprocessed well fluids as mixture of water, oil and gas to a process facility. This is shown schematically in figure (1). The pump imports energy to the fluid stream to enable delivery to a distant processing facility from remote locations. At the same time the pump is capable of drawing down on the wellhead pressure acting as a surface lift method to increase production [1]. However different scenario have been applied [2-4] which their application depends on various parameters, and operators carefully select the potential technology.

Multiphase pump are classified according to two pumping concept, positive displacement and rotodynamic concept [3]. The characteristics of the most common types, based on these concept, namely, the rotory- screw pump and helico-axial pump are given in tables (1). Today, both concepts of working pump have been successfully used in multi phase applications onshore, offshore or sub-sea [5, 6]. In the following, a brief summary of possible solutions the multiphase pump technology can offer the above issues, are reviewed (summarized in Table 2).

2.1 Boosting Operational pressures

Surface flow line and facility pressure losses may considerably contribute to the summation of pressures acting as backpressure on the formation and subsequently the inflow performance. While there is little economic scope for a complete change of the surface flow line, or even plastic lining of the same to reduce pressure losses, the final separator pressure may be reduced. However, this will considerably influence compression facilities required to finally deliver the gas into dedicated gas export lines. It is needless to mention that gas flaring is not a viable option any longer.

Multiphase pumps may be used at any location with in the flow line system to increase the pressure of the untreated stream flowing directly from the wellhead. Whenever only boosting is required for certain applications, this will not only result in a higher delivery pressure, but may also be a proper way for removing deposits due to slug flow in the flow line. Furthermore production is assured even with low temperatures and a resulting increased viscosity. Upstream of the pump hydrate formation may be reduced due to lower pressure inside the flow line.

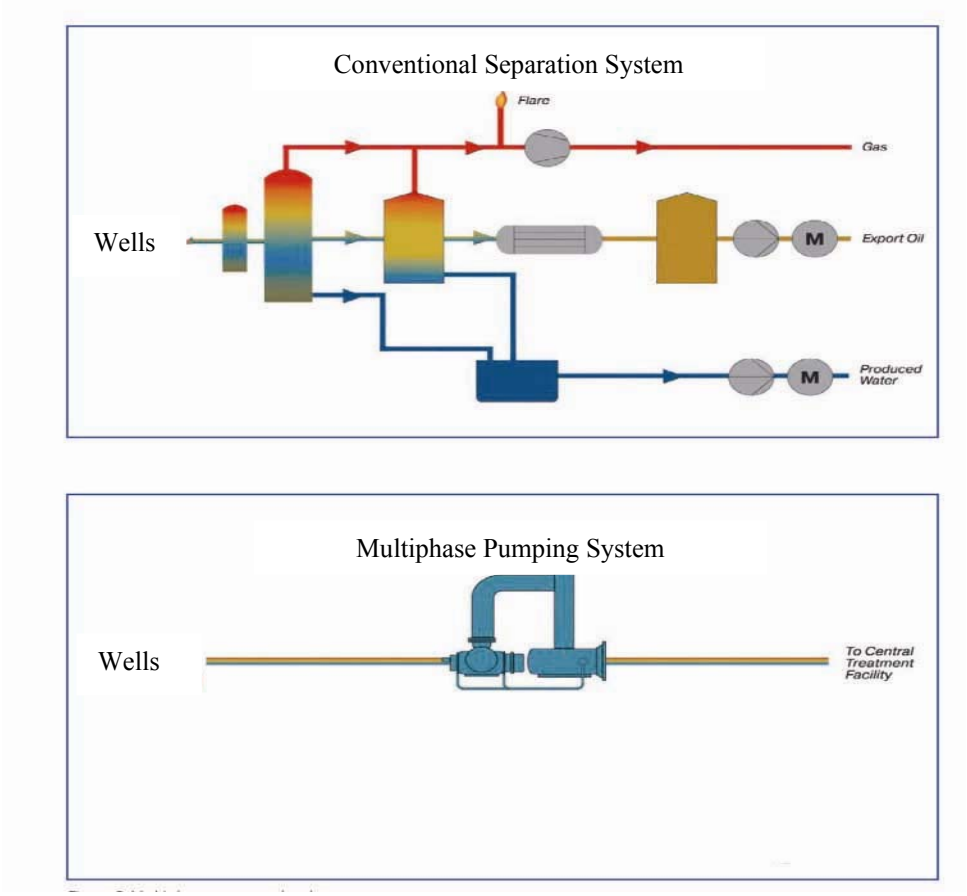

Figure 1. Conventional and Multiphase System

Table 1. General Characteristic of Multiphase Pumping

PUMP	ADVANTAGES	DISADVANTAGES
Helico-Axial Rotodynamic	Down-hole, surface, or submersible	If solids, potential for erosion?
		High sheer
	Flowrates up to 560,000 BPD	
	Differential Pressures up to 1125 psi	
	Can achieve up to 100% GVF	
Twin-Screws Positive Displacement	Surface, down-hole (in commercialization by one supplier), or submersible (in commercialization)	Surface pump with 4 mechanical seals
	Speed: Low to high speed Flow rates: up to 440,000 BPD (surface pumps)	
	Can achieve up to 100% GVF for designed time periods	
	Can run higher viscosities	
	Can run high temperatures	
	Low shear	
	Low NPSHr	
	Can run dry, non-contacting rotor and stator	
	1400 psig differentials	
	Particulates to 0.5 wt. %	

However probably the maximum benefit for the hydrocarbon production is a close location to the wellhead or a manifold gathering several ones. The closer a multi phase pump is installed to a well, the more of the downstream backpressure is cut off, and subsequently the flowing tubing head pressure is reduced which results in [4, 7]

- Lower pressure inside the tubing below the wellhead,
- Lower stresses on mechanical down hole pump drive equipment,
- Lower differential pressure over the down hole pump with decreased power requirement, and a
- Higher hydrodynamic level, when the casing annulus is tied into the flow line.

While the above certainly is valid for pumped wells, the advantage of a multiphase pump serving wells on natural flow is obvious. Even for gas lifted wells the amount and pressure of the lift gas required may be reduced. Additionally multiphase pumps may complement EOR activities.

2.2. Environmental Issues

Associated natural gas is a by product of the oil extraction process and is often considered more of a nuisance than an economic resource. In order to get rid of this waste gas, most oil-production countries flare and vent large volume of gas. Associated gas is the raw natural gas and is commonly a mixture of methane and other hydrocarbons, mainly, ethane, propane, butanes, and pentanes. Associated gas also contains water vapor, hydrogen sulfide (H2S), carbon dioxide (CO2), helium, nitrogen, and other minor compounds.

The burning of fossil fuel has significantly contributes to a climate change, also known as global warning carbon dioxide (CO2) emissions from flaring and methane (CH4) emissions from venting have a extremely high global warming. Even after 100 years 1.0 Kg of methane is still 23 times more powerful than 1.0 Kg of carbon dioxide [1]. Beside the carbon dioxide and methane emissions further pollutant are released into the atmosphere. Highly dependent on the proper combustion in the flare stack, hundred of toxic substances may be released in the atmosphere. Among these substances carcinogents, toxic metals as mercury or arsenic, as well sour gas with H2S or SO2 have been found. It is widely relized that better exploitation of gases released into atmosphere can be much more efficiently and environment friendly used to meet the world's increasing gas demand. Technologies as multiphase pumping can be used to eliminate or reducing the flaring and venting.

As already stated, in order to save the costs for an additional gas pipe line after gas oil seperators, the gas phase of the well production is already flared at the well site while the liquid phase is boosted to the processing or storage facilities. As shown in figure (1), the extensive upstream treatment equipment can be replaced by multiphase pump technology with reasonable savings in capital investments and short payback periods. Multiphase pumps boost the untreated well flow consisting of oil, water, gas and small amounts of solids through a single flow line to a control treatment facility where the gas fraction is separated and used for power generation or as basic material supply for successive industries. The gas volume fraction, (GVF) handled by a multiphase pump can be as high as 100%. Beside the elimination of flaring, there is also a considerable reduction of equipment at the well site. The lower visibility of the production equipment as tanks and seperators and a lower risk of equipment failures offered by the multiphase pump technology also contribute to the still growing consciousness for our environment.

In Iran, twin screw multiphase pumps were installed on an oilfield, which had been producing since 1959. The project has showed that 6 MCF gas flaring was eliminated and the flow was also improved [1].

2.3 Economical Issues

The cost of separation equipment installed at the well sites could exceed the revenues gained from production by far. Especially on aging fields the expenses for artificial lifting and field treatment can render a production site uneconomical. In old fields, the oil production drops and the water cut and gas-to-oil ratio (GOR) increases. While conventional production technology requires a constant modification of the field equipment to cope with the changing conditions, the large operating window of multiphase pumps allows a flexible reaction on changing well conditions. Already plugged and abandoned wells may return to production with multiphase pumping technology. The reduction of the well head pressure will allow the well to keep producing and the investment is paid off by the production very quickly.

The majority of all multiphase pumps supplied worldwide are of the twin-screw type, about 750 in total. They can handle considerably high flow rates and pressures at a high gas volume fraction (CAT) and tolerate GVF fluctuations. Usually, the GVB can be as high as 95 to 98 percent at inlet conditions. Additionally, longer gas slugs can be expected with marginal field applications. In order to maintain internal sealing for the compression of the gas phase, a small quantity of liquid must be provided during the entire operation.

Table 2. General Advantage of Multiphase pumping in oil and Gas Industry

Benefits	Industry Improvement
Production	• Extended life of mature wells; boosting the low pressure wells into manifold • Improving flow assurance by mitigating some potential problems; breaks up terrsion or riser-induced slugs and prevent separator flooding and liquid-carry over • Increasing production rate by tie in of new marginal field • Increasing the rate of production of gas field with high water rates; causing gas flow by eliminating the accumulation of water in the wellbore and resulting back pressure which may stop the gas to flow.
Environment	• Eliminating the need for flaring gas at the well • Eliminating local water storage and disposal and transport • Increasing more safer environment; Reducing of facilities complexity • Lowering noise emissions
Capital	• Eliminating the need of separation equipment at the well • Eliminating the need of vapor recovery system • Eliminating compressor and dual pipeline arrangement for transfer of separated gas • Reducing of topside/offshore equipment weight and space • Ability to move the multiphase pumping system from well site to well site; potentially reducing the number of required systems. • Capable of handling and controlling a broad range of application parameter associated with multiphase transfer • Removing deposits such as wax and paraffin due to slug flow in flowline • Eliminating gas flare system • Improving maintence of system • Increasing the life time of downhole equipments

This can be achieved by either an internal system which tolerates short gas slugs only or an external recirculation system which can be sized for gas slugs of 30 minutes or more. External recirculation systems are located upstream the pump discharge within the skid limits. Beside their ability to cope with long gas slugs, external recirculation systems usually operate without additional cooling requirements and can be cleaned from solids sediments without disassembling of the pump.

Twin screw multiphase pumps can handle a wide variety of well fluids such as emulsions, waxy crudes, bitumen and sand-laden extra heavy crude. This is an especially important feature when the qulity of the produced crude oil decreases. In areas with low temperatures in the winter months, multiphase pumps can be used for hydrate control and prevent a field shut-in during this period.

3. Conclusions

With the increasing demand for oil and gas and desired to keep marginal fields longer productive along with environmentally friendly handling of hydrocarbons, multiphase pumps are particularly suited to help overcoming the above concerns. Their ability to add energy to the untreated well stream, while reducing the wellhead pressure creates an entirely different pressure regime in the production system While down hole inflow is enhanced. Despite still being considered a new technology by many operators, multiphase pumps find a large field applications worldwide. In a changing world caring much more about the existing resources and the environment, multiphase pumps are a quite unique tool which gain increasing importance in future oil production and cleaner environment

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