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Surface Jet Pumps Enhance Production and Processing

Surface jet pumps (SJPs) are simple, low-cost, passive devices that use a high-pressure (HP) fluid as the motive force to boost the pressure of produced-gas and -liquid phases. In recent years, the oil and gas industry has become more aware of their applications and benefits. These systems enable the flowing wellhead pressure (FWHP) to be reduced in order to increase production while meeting downstream production-pressure requirements.

SJP Operation and Applications

In an SJP, the HP fluid passes through the nozzle, where part of the potential energy (pressure) is converted to kinetic energy (high velocity). As a result, the pressure of the HP fluid drops in front of the nozzle. It is at this point that the low-pressure (LP) flow is introduced. The mixture then passes through the mixing tube, where transfer of energy and momentum takes place between the HP and LP fluids. The mixture finally passes through the diffuser, where the velocity of fluids is gradually reduced and further recovery of pressure takes place. The pressure at the outlet of the jet pump will be at a value between that of the HP fluid and that of the LP fluid. **Fig. 1** illustrates the general configuration of the SJP.

In the case of gas production, both HP and LP fluids are primarily gas. The presence of liquids (condensate, oil, or water) in the LP flow can be tolerated as long as the volumetric flow rate of liquids is less than 1 to 2% of the volumetric flow rate of the LP gas at the operating pressure and temperature. Beyond these values, the effect on the achieved pressure difference (ΔP)—discharge pressure minus LP pressure value—could be significant, requiring the LP liquids to be separated upstream of the SJP and to be boosted separately.

Alternatively, the LP liquids can be sent to a part of the process system that operates at a lower pressure, if such a source is available. The presence of liquids in the HP gas also has a similar limitation, beyond which the liquids need to be separated upstream of the SJP. The main reason in this case is that the performance and sizing of the nozzle are affected on the basis of whether the HP flow is liquid or gas phase. A further point is that if the HP flow is multiphase, the fluctuating flow regime associated with multiphase flow reduces the efficiency of the SJP significantly further, because the mixture is not usually homogeneous. The exceptions in these cases are transient conditions such as startup, when the system may be subjected to a high flow rate of liquids passing through the SJP. The SJP recovers quickly in such cases as soon as the liquids pass through. If no HP gas is available in gas-production applications, the HP source can be an HP liquid (oil or water). In this case, the solution is viable and economical mainly when the LP-gas-flow rate is small and is limited to a few MMscf/D. The reason for this limitation is the relatively high volumetric flow rate of liquids needed for each MMscf/D of the LP gas.

This article, written by JPT *Technology Editor Chris Carpenter, contains highlights of paper SPE 164256, "Novel Examples of the Use of Surface Jet Pumps To Enhance Production and Processing: Case Studies and Lessons Learned," by* ***Syed M. Peeran, Najam Beg,*** *and* ***Sacha Sarshar,*** *Caltec UK, prepared for the 2013 SPE Middle East Oil and Gas Show and Exhibition, Manama, Bahrain, 10–13 March. The paper has not been peer reviewed.*

SJP Applications

SJPs have a wide range of applications in both oil- and gas-production contexts, including the following:

- Increase production from LP oil and gas wells
- Revive liquid-loaded wells; deliquification of loaded wells
- Prevent oil or gas wells from being liquid loaded
- Boost the pressure of LP gas from the process system
- Prevent flaring of very-LP gas
- Debottleneck compressors
- Remove intermediate compressors
- Prevent HP wells from imposing backpressure on LP wells
- Lower the operating pressure of the main separator to increase production
- Improve the performance of compressors
- Improve the effectiveness of gas lift systems

These applications are discussed in detail, with field examples, in the complete paper.

In oil-production applications, both HP and LP flow may be from oil wells that produce a mixture of oil, gas, and water. In this case, gas from the HP fluids should be separated so that the HP liquids alone serve as the motive flow. The SJP may in this case be able to handle both produced LP gas and liquids. The separated HP gas bypasses the SJP and is combined with the fluids from the outlet of the SJP. This is a patented system (described in detail in the complete paper). The main factors affecting the performance of the SJP in this case are the HP/LP ratio, the mass-flow ratio, and the flow rate of the LP gas produced with LP liquids.

Boosting the pressure of the LP liquids requires a source of HP liquid phase, because the HP gas has insufficient mass

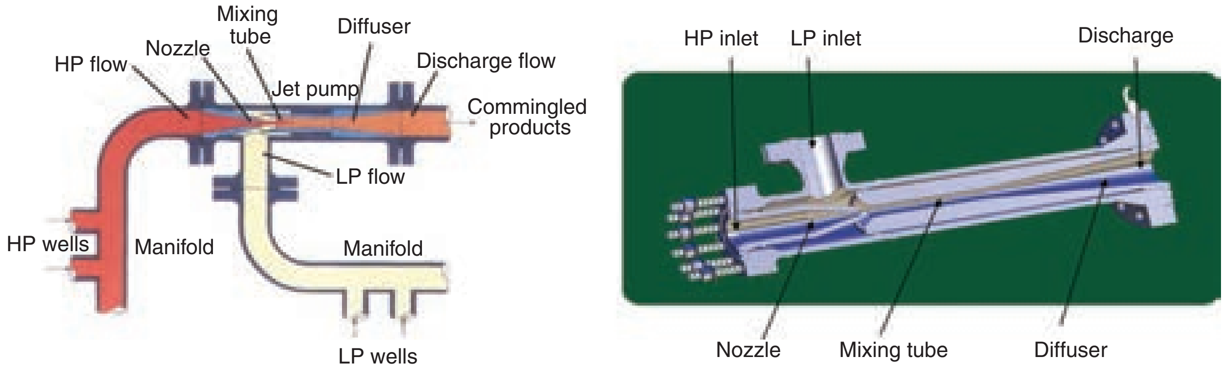

Fig. 1—General configuration and key components of the SJP.

to boost the pressure of the liquid phase effectively. In cases where there is no HP oil well or an HP liquid phase such as injection water or export oil, the LP liquid phase can be boosted by use of a single-phase pump. In this case, the LP gas and liquids can be separated by use of a compact separator.

Use of a Compact Separator With SJPs

When either HP or LP flow is multiphase, separation of gas and liquids is required. Gravity separators can be used to achieve the desired separation of gas and liquids. However, gravity separators are bulky and have limitations in their design pressure. Ideally, a compact unit is required so that the total system occupies minimum space and the system is easy to operate. A patented compact separator can be used to perform the desired separation tasks. In the complete paper, the separator is a cyclonic passive device that requires no active level or pressure control.

Ideal SJP Location

The optimal location for the SJP is dictated by the details of the production system and by the location of the sources of HP and LP fluids. In most cases, the aim is to minimize the interconnecting pipework. This rule applies to both onshore and offshore applications.

In the case of onshore wells, because the wells are usually scattered over a vast area and thus a source of HP fluids may not exist near the LP wells, a suitable location for the SJP may be at the gathering or production station where flow from all wells arrives and enters a manifold. In the case of offshore applications, the location of the SJP depends primarily upon where the source of the motive (HP) fluids is located. This is a particular issue for satellite platforms, where there may or may not be a source of HP flow on the platform.

Temperature and Noise

In gas-production applications, generally speaking, two issues are checked and are considered in the design of the system. At large HP/LP ratios (greater than 2:1), noise generated by the SJP could exceed 85 dBA, which is generally the acceptable level onshore and offshore. Noise is measured at 1 m away from the axis of the SJP. Noise also travels through the LP and the discharge lines of the SJP. Silencers are therefore needed to prevent noise travelling beyond the SJP along these lines.

Silencers are flanged spool pieces that are installed at the LP inlet and at the discharge line of the SJP. In some cases, the noise emitted through the body of the SJP may be beyond the permitted limit. In this case, the body of the SJP can be acoustically lagged. Silencers can be designed to limit the noise to lower than the quoted 85 dBA in cases in which the SJP is close to populated onshore areas.

Temperature Effect. A significant drop in the HP-gas pressure at the outlet of the nozzle of the SJP could cause a drop in the temperature of gas at the outlet of the SJP. This is a complex phenomenon beyond that expected under the pure Joule-Thomson cooling principle because, immediately after the nozzle, LP gas is combined with HP gas and further recovery of the pressure takes place. There is also the generation of shock waves within the SJP in most cases, which affects the resultant temperature.

Analytical tools are available to predict the temperature at the outlet of the SJP at each stage of operation, including the startup. In general, the temperature of the gas at the outlet of the SJP is well above that calculated by considering only the Joule-Thomson cooling effect as a result of the HP value dropping to the LP value in front of the nozzle.

In oil-production applications, in cases in which HP liquid is the motive flow, neither noise nor temperature pose problems. Silencers are therefore not required in such cases.

For a discussion of instrumentation, fabrication, and safety-related aspects of SJPs, please see the complete paper.

SJP-Performance Assessment

The performance of the SJP is assessed simply by noting the ΔP. The discharge pressure is not controlled by the SJP and is mainly dictated by the downstream pipeline and production system. The SJP, however, responds to changes in the parameters that affect its performance by adjusting the LP value, which it generates.

In applications where the LP flow is directly from LP wells, the LP value is automatically adjusted by the SJP so that it matches the performance of both the LP wells and the SJP.

Operators are often anxious to know by how much the production is increased as a result of reducing the FWHP of the LP wells by a known amount. In this case, if the performance characteristics of the wells [productivity index (PI) values] are known and are reliable and up to date, the increase in production can be simply estimated by multiplying the PI value and the achieved drop in the FWHP of the LP wells.

In the absence of a reliable PI value or a metering system, each LP well can be diverted to the test separator and its production rate can be measured. In this case, the test separator should be able to operate at the pressure generated by the SJP.

Economics

The simplest way to assess the economics of using an SJP system is to compute the payback period needed to recover the capital costs, bearing in mind that, in practically all cases, there is little to no operation cost. The capital cost includes the cost of the SJP and the cost of the silencers, if needed.

In addition, the costs of the additional interconnection piping, the valves, the instrumentation, and the installation of the system should be considered. In many cases, these costs are greater than the cost of the SJP.

The costs of the total system may increase significantly if, for any reason, high-grade materials and an HP rating are required. The many field applications so far have proved that the economics is very attractive, and, in practically all cases, the payback period has been a few weeks to a few months. **JPT**