Abstract
Continuous gas lift system is currently widely used as artificial lift in Kaji-Semoga Field, in fact at about 46% of total producing wells. The average depth of gas lift wells in Kaji-Semoga is 3,200 ft, utilizing 2 to 5 conventional gas lift valves in a single production string. Common problems experienced when optimizing gas lift wells in Kaji Semoga field are instability of flow due to fluctuation of gas lift injection rate and pressure, limited gas injection volumetric rate, and limited compressor discharge pressure that leads to limited casing head pressure at well head, especially for remote wells with high tubing pressure at injection point.

A new injection valve type, venturi orifice gas lift valve with breaking-out gas device, has been studied and proposed as a solution to the aforementioned problems. This type of valve has been installed as gas lift injection valve at some pilot wells by using slick-line unit. The aim of venturi orifice is to reduce pressure difference between casing (upstream) and tubing (downstream) at injection point and to deliver a greater amount of gas lift injection at the same casing head pressure (compared to traditional orifice valve). Meanwhile, the aim of the breaking-out gas device is to break the injected gas into very small bubbles and homogenize with the liquid so that flow stability can be achieved.

Selected candidates for pilot wells are the ones with high productivity index (PI), high flowing pressure gradient (above 0.18 psi/ft) and limited gas lift manifold pressure. Well modeling and simulation have been conducted for these selected wells using production optimization software to predict gas lift well performance after installation of new injection valve, whereupon the simulation result is matched with actual data.

Applying venturi orifice gas lift valve has produced successful results: the liquid rate of the pilot wells has increased by about 40%, with 30% gas injection rate increment under the same conditions. Computer simulation also provided similar results to the actual well performance and met expectations. The pay-out time (POT) of this project was less than 2 days.

Introduction
Kaji-Semoga field is located in Rimau Block (South Sumatra) and was discovered in 1996. The wells produce mostly from Baturaja Formation (carbonate reservoir). Overall, there are 384 wells in Kaji Semoga field, which consist of 200 oil producer wells, 92 shut-in wells and 92 water injection wells. Approximately 46% of these wells were produced using continuous gas lift system.

The production operation began in 1997, and oil production peaked at 89,784 BOPD in January 1999. Since then, production has declined due to an increase in water cut. Current oil production is about 14,000 BOPD and the current average water cut is 92%. At the moment the main objective and concern in Kaji Semoga field is to maintain oil production, i.e. to combat oil production decline. Optimization of continuous gas lift to increase liquid rate is one of the solutions, and is the focus of this paper.
All wells in Kaji-Semoga field use conventional gas lift valves (square edge type), which are limited in reaching gas volume injection with small pressure difference between casing and tubing at point of injection, and have caused difficulties during gas lift optimization at some wells with limited casing head pressure available at surface. Gas lift wells in the outlying areas, i.e. far from a gas lift compressor, tend to have insufficient gas injection rate due to limited casing-head pressure as a result of a large pressure drop in the gas lift line from the gas lift compressor. Therefore, the optimum gas injection rate cannot be achieved and liquid production cannot be optimized. Venturi orifice gas lift valve (a new type of valve) was proposed and implemented as a gas lift injection valve at some remote gas lift wells. The aim was to reduce differential pressure between casing and tubing in order to deliver a greater amount of gas injection rate at the same (even lower) casing head pressure.

This paper discusses the successful story of the implementation of venturi orifice gas lift valve to increase gas injection rate at limited casing head pressure in outlying areas. Preliminary candidate selection was conducted by considering well production performance, tubing pressure trending (based on flowing bottomhole pressure survey) and simulation results to obtain optimum oil gain.

**Theory and Methodology**

**Venturi Orifice Gas Lift Valve**

Venturi orifice gas lift valve is a new type of gas lift valve that utilizes venturi orifice in the port with breaking-out gas device modification in the bull nose. Venturi orifice can decrease the differential pressure drop required between casing pressure (upstream pressure) and tubing pressure (downstream pressure) to deliver same amount of gas flow compared to conventional square-edged orifice valves. Theoretically, it only takes about 10% to 15% pressure drop in a venturi orifice valve to reach gas critical flow rate (a region where gas flow rate through valve was constant, irrespective of downstream pressure), compared to 50% pressure drop required at conventional valve. In venturi orifice, the flow restriction inside the valve caused by the orifice vena contracta and choking effect can be reduced significantly or can be ignored. Port profile difference between conventional orifice gas valve (square edge) and venturi orifice gas lift valve (new valve) is illustrated in Figure 1, while gas flow - pressure performance chart difference between conventional and venturi orifice is described in Figure 2.

Breaking-out gas device is used to break the gas lift injection bubble into smaller bubbles in order to homogenize gas injection with liquid in the tubing, so that slugging can be prevented. Laminar flow can be achieved and the fluid flow inside the tubing is more stable. Figure 3 describes outer physical difference between conventional valve and venturi valve. In Kaji Semoga field implementation, the new venturi valve to be installed at the pilot wells was not brand new valve, but a modification from conventional valve with modified square edge port and bull nose.

**Well Candidate Selection Criteria**

Two (2) wells were selected as pilot wells before this new type of gas lift valve is implemented at all gas lift wells in Kaji-Semoga field. The wells were selected based on the following criteria:

- High Productivity Index (PI) Well
- High flowing gradient (> 0.18 psi/ft) based on flowing bottomhole pressure survey (traverse survey).
- Small pressure difference between casing head pressure and gas lift manifold pressure.
- Limited gas lift pressure, especially for wells in outlying areas.
- Gas injection rate lower than 400 MSCFD.

**Implementation, Evaluation & Considerations**

The well history of well candidates has been analysed before the installation of new valves, including history & trending flowing pressure survey, history of liquid rate, oil rate, and gas rate and gas oil ratio (GOR). For each well, inflow & outflow performance relationship (IPR & OPR) was built based on well test and flowing gradient survey data. Well simulation and modeling were then created by using Wellflo to predict the well performance after installation of a new venturi valve in order to obtain the correlation of gas injection rate to the well liquid production rate.

Methods of installation of venturi orifice gas lift valve are described in Figure 4. By installing venturi orifice gas lift valve, pressure difference between upstream & downstream pressure at gas lift point of injection decreases, resulting in a lower CHP at the surface to deliver the same gas injection rate. Lower CHP provides a greater pressure difference between CHP and gas lift manifold pressure, providing an optimization opportunity. Gas lift optimisation can then be conducted to increase CHP, which will increase gas injection rate and yield a lower flowing gradient pressure and lower flowing bottomhole pressure. An increase in liquid lifting rate (Q) will be obtained, which will bring higher oil production.
It was necessary to acquire the following data to determine the improvement of well and valve performance after installation of the new valve:

1. Liquid rate, oil rate, gas rate and water cut production data. These data were acquired by using a test separator.
2. Tubing head pressure (THP) and casing head pressure (CHP) monitoring by using 2-pen recorder combined with digital pressure recorder.
3. Gas injection rate measurement by using gas flow meter (Floboss).
4. Flowing pressure gradient / traverse survey to measure tubing pressure at valve by using electronic memory recorder (EMR) and slickline unit.
5. Well performance & behaviour simulation by using Welllfo (Production Simulator) before & after implementation.

Preliminary results from the simulation were used as a guideline / benchmark to determine the correct valve size to be installed in the wells at the depth of injection point by using wireline slickline unit. After the new valve had been installed, well monitoring was then conducted to acquire well performance data such as flowing pressure trending, liquid rate, oil rate, gas rate, gas injection rate and gas oil ratio. All of these actual data were then imported to the well simulator to be matched and analyzed, in order that the well performance before & after implementation of the venturi valve could be evaluated. A simple description of system pressure comparison between before and after installation of venture orifice gas lift valve is shown in Figure 5.

With the new venturi-type valve as gas lift injection valve, the gas lift injection rate is higher under the same well conditions (same casing head pressure and gas lift choke size). This can affect the gas lift distribution for overall field, so that the availability and limitations of gas supply must be taken into consideration when implementing venturi orifice gas lift valve on a larger scale.

**Result and Discussion**

Two (2) wells were selected for the installation of the new venturi valve. Figure 6 shows the individual well simulation results which show the potential oil production increment by gas injection rate adjustment. Table 1 shows well X-1’s production performance before and after installation of new venturi orifice gas lift valve. After installation of the new valve, the gas lift injection rate increased by about 29% compared to conventional valve (360 to 520 KSCFD at casing head pressure of 585 psig), while the liquid rate of well X-1 increased by 584 BLPD, from 1420 BLPD to 2004 BLPD, matched with the decrease in flowing bottom-hole pressure (FBHP / pwf) of about 12 psi (811 to 799 psi) between before and after installation, where the productivity index (PI) of well X-1 was about 50 STB/d/psi. With 94% water cut, an oil gain of about 35 BOPD is obtained.

Well X-2 also experienced the same result as X-1 well, Table 2 shows that the gas injection rate increased by about 120% at well X-2 (from 280 to 640 KSCFD, with even slightly lower casing head pressure) and that the liquid lifting rate also increased significantly, from 1402 BLPD to 2136 BLPD, with a water cut of 94% and an oil gain of 44 BOPD. This result also closely matches the decrease in flowing bottom-hole pressure (FBHP / pwf) of about 18 psi (750 to 732 psi) between before and after installation, where well X-2 had a productivity index (PI) of about 30 STB/d/psi.

Based on these results it can be concluded that the implementation of venturi orifice gas lift valve was succesful in increasing gas injection rate and liquid rate and yielded a gain in oil production. Actual production performance after installation of venturi orifice gas lift valve also matched the simulation result, where gas injection rate increment increases the liquid lifting rate. Production history after implementing venturi orifice GLV has shown that the liquid rate trend of these 2 wells tends to be more stable than before, as shown in Figure 7.

**Conclusions**

Implementation of venturi orifice gas lift valve at 2 pilot wells in Kaji-Semoga field has resulted in an increase in the oil production rate of about 40% on average, with an approximate 30% increase in gas injection rate under the same conditions (same casing head pressure). Also, computer simulation produced results similar to the actual well performance and matched expectations. The pay-out time (POT) of this project was less than 2 days.

The next project will implement this venturi orifice valve as gas lift injection valve for all of our gas lift wells in Kaji Semoga area to optimize overall field production.

**Acknowledment**

We would like to thank PT Medco E&P Indonesia, the RMU PRD Team, the PE Rimau Team, and everyone else who has been involved in the successful implementation of venturi orifice gas lift valve.
References
Figure 1. Port Profile of Conventional & Ventury Orifice Gas Lift Valve

Figure 2. Gas injection rate comparison between conventional GLV and venturi orifice GLV at constant upstream pressure and variable downstream pressure
Figure 3. (a) venturi orifice gas lift valve (b) conventional gas lift valve

Figure 4 Implementation method of venture orifice gas lift valve installation
Figure 5. Comparison of system pressure before and after venture orifice GLV installation
Figure 6. Well Simulation Result, KS X-1 (a), KS X-2 (b)
<table>
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<th>Parameters</th>
<th>Conventional Gas Lift Valve</th>
<th>Venturi Orifice Gas Lift Valve</th>
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<td>620 (Psig)</td>
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<td>Casing Head Pressure</td>
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<td>Gas Injection rate</td>
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<td>0.2 (Psi/ft)</td>
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<td>Pwf</td>
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<td>Q oil</td>
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<td>120 (Bopd)</td>
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Table 1. Performance of Well X-1, before and after venturi orifice gas lift valve installation

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional Gas Lift Valve</th>
<th>Venturi Orifice Gas Lift Valve</th>
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<td>Casing Head Pressure</td>
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<tr>
<td>Water cut</td>
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<td>94 (%)</td>
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<tr>
<td>Q oil</td>
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<td>128 (Bopd)</td>
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</table>

Table 2. Performance of Well X-2, before and after venturi orifice gas lift valve installation
Figure 7. Production History of X-1 (a), X-2 (b)