ENHANCED GAS LIFT VALVE PERFORMANCE FOR SHARP EDGED SEAT USING LARGER BALL SIZES

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ABSTRACT

Theoretically, each Sharp Edged Seat has fully open stem travel based on the port and ball diameters. Gas lift valve 1.5” has 6 different port diameters (3/16”, ¼”, 5/16”, 3/8”, 7/16” and ½”). For each port the ball diameter is usually larger than the port diameter by 1/16”.

Laboratory testing for sharp edged seats showed that the actual flow area is less than theoretically calculated area resulting from the bellows stacking before the stem reaches the fully open. Consequently, the valve stem restricts the flow and the flow rate through the valve declines.

The purpose of this work is to examine the possibility of improving the efficiency of the gas lift valve by using larger ball size than conventionally used. For each port, different ball sizes were tested at different stem positions for the same condition (Injection pressure & Temperature).
Results obtained from benchmark test displayed increasing in the flow rate as the ball size increases at the same stem travel.

Flow Area

The theoretical minimum stem travel can be calculated using equation 1(Kulkarni, M. N. 2005). Table 1Shows the amount of travel required to get a flow passage equivelent to the port.

$$Y = R * tan\left[cos^{-1}\left(\frac{-R^2+\sqrt{R^4+4*r^2*R^2}}{2*r^2}\right)\right] - \sqrt{r^2 - R^2} \quad \text{...} (1)$$

Where, R : Port radius and r: Ball radius

The minimum stem travel for each port with different balls sizes was calculated using the same equation 1with different ball sizes. The results are compared with minimum stem travel when the ball is only 1/16” larger than the port. Table 2 illustrates that the stem travel required for each port with larger balls is less with the conventional one.

Experiment

Because the valve does not fully open immediately and the area increases gradually, the port was tested using benchmark valve. The benchmark valve has the same dimensions of the actual gas-lift valve. It has the same valve body, stem OD, ball/seat assembly, etc. However, there is no bellows or dome section, and we can adjust the stem position at different positions (Winkler, H. W., Camp, G. F. 1987).

These tests are simply discharging a certain volume of gas at a certain time till the upstream pressure reaches the final downstream pressure which is ambient pressure. Three different ports (¼”, 5/16” and 3/8”) were tested at 25%, 50%, 75%, 100%, 125% and 150% of fully open with different ball sizes for each port. At each ball position the gas was injected through the valve and the data was gathered digitally using data-acquisition system (DAQ).

RESULTS AND DISCUSSION

By using the new stem travel, the calculated area from tests at different stem position is larger than conventional one. Figures1, 2 and 3 show that as the ball size increases the flow area increases at the same stem travel. Calculating gas flow rate at new stem positions is another factor that demonstrates the effect of the ball size and can be seen in figures 4, 5 and 6. There are two main reasons for the effect of the ball size. The first reason is the contact point between the large ball and the top of the seat is higher. So less ball movement well generate the same flow area with smaller ball.

The second reason is the Coanda Effect. When the gas stream flows past the ball, some of the gas follows the contour of the ball and only leaves after it moves a significant distance along the surface of the ball, In effect, the ball pulling the gas around its surface, figure 7 shows schematic diagram for Coanda Effect. Because the ball was fixed to the valve body, it cannot move resulting in direction the gas stream toward the port which increases the flow rate. In all cases it was found that the larger the ball size, the greater was the efficiency.

CONCLUSION

- Large balls need less stem travel to create flow area equivalent to the port area.
- The experiment results showed that larger ball size provide higher flow rate at same stem travel for all ball positions.

REFERENCE

Kulkarni, M. N. 2005. Gas Lift Valve Modeling with Orifice Effects. MS Thesis, Texas Tech University, Lubbock, TX.

Winkler, H. W., Camp, G. F. 1987. Dynamic Performance Testing of Single-Element Unbalanced Gas-Lift Valves. *SPEPE* 183-190

Table 1- Minimum Stem Travel for Sharp Edged Seat

Ball size = Port size + 1/16”

Port	Ball	min. Stem Travel
1/4	5/16	0.1003
5/16	6/16	0.1302
3/8	7/16	0.1610

Table 2- Minimum Stem Travel for Sharp Edged Seat

Ball size = Ball Size + larger than 1/16”

Port, inch	Ball size,inch	Min. Stem Travel
1/4"	5/16"	0.1003
	6/16"	0.0884
	7/16"	0.0822
	8/16"	0.0783
	9/16"	0.0756
5/16"	6/16"	0.1302
	7/16"	0.1151
	8/16"	0.1069
	9/16"	0.1016
3/8"	7/16"	0.161
	8/16"	0.1428
	9/16"	0.1326

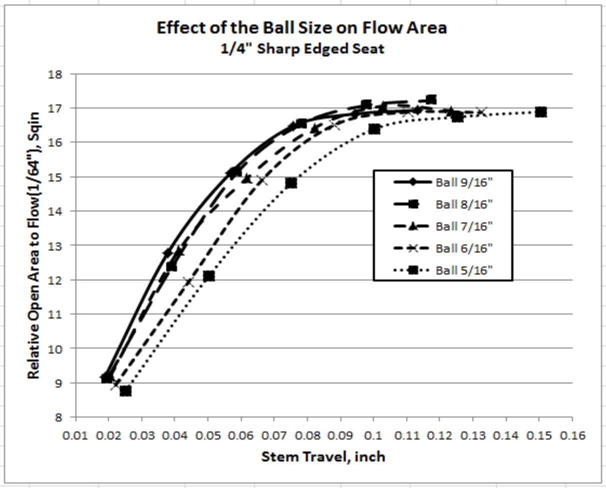

Figure 1- Effect of Ball Size on Flow Area (Port ¼")

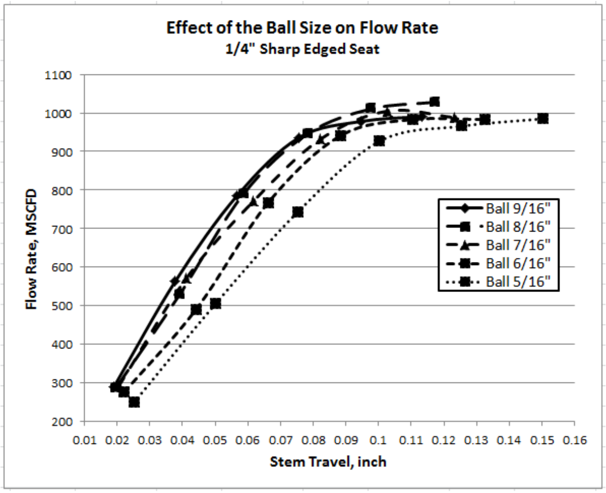

Figure 4- Effect of Ball Size on Flow Rate (Port ¼")

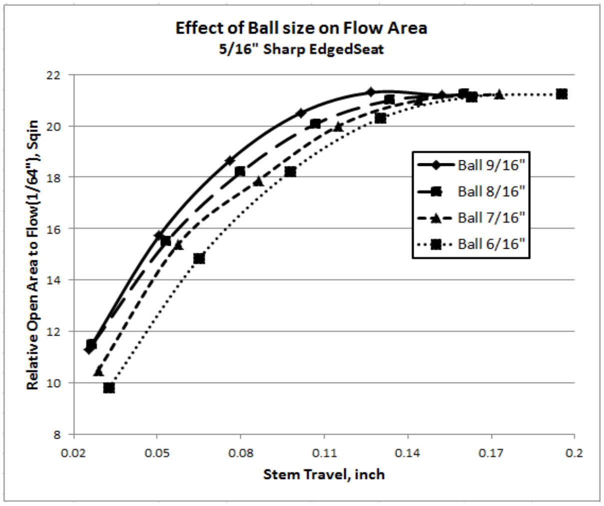

Figure 2- Effect of Ball Size on Flow Area (Port 5/16")

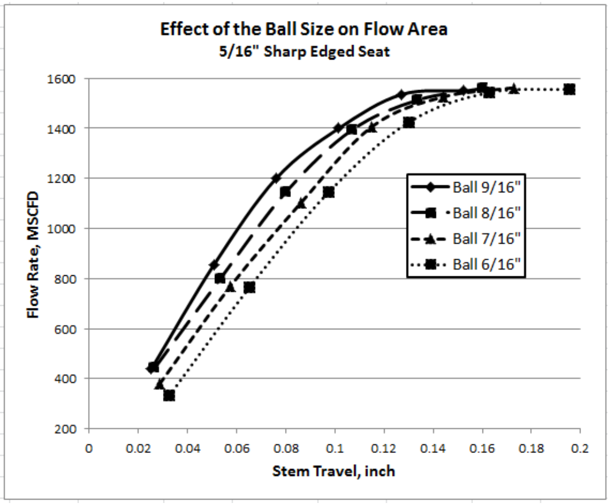

Figure 5- Effect of Ball Size on Flow Rate (Port 5/16")

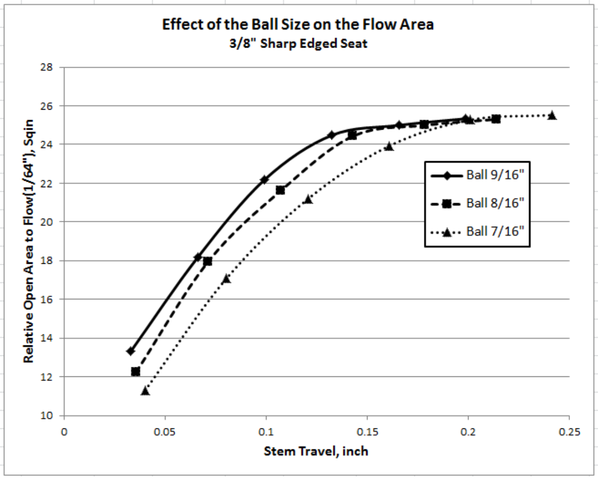

Figure 3- Effect of Ball Size on Flow Area (port3/8")

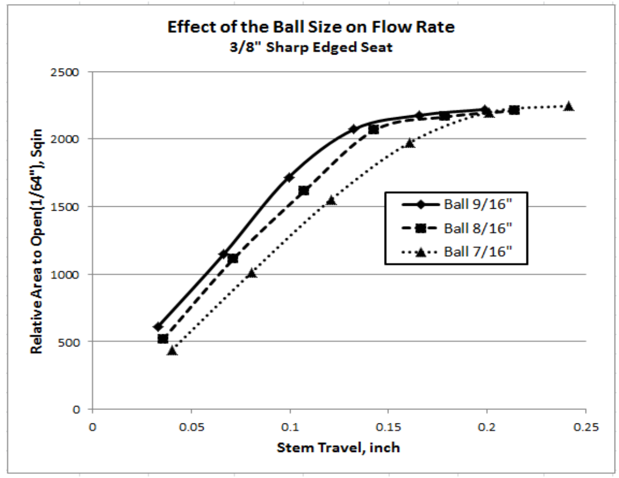

Figure 6- Effect of Ball Size on Flow Rate (Port 3/8")

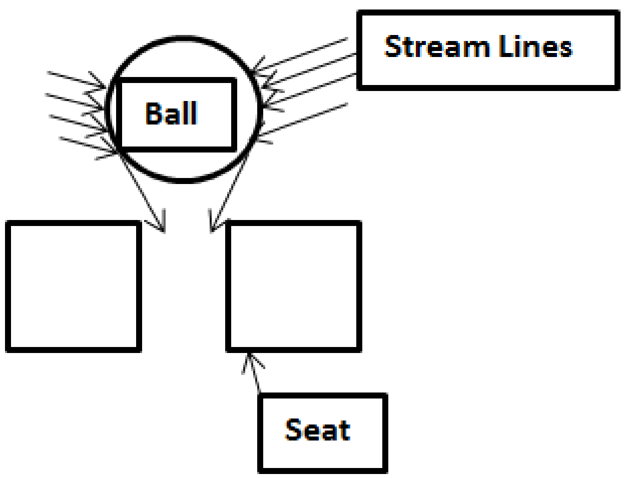

Figure 7 - Coanda Effect