ADDRESSING INSTABILITIES IN SUBSEA DISTRIBUTED CHEMICAL INJECTION SYSTEMS FOR HYDRATE INHIBITORS

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ABSTRACT

This paper discusses how SkoFlo's pressure independent CIMVs address system instabilities in Subsea Distributed Chemical Injection for Hydrate Inhibitors. A recent study[1] indicates chemical operational expenditure to be the second highest with an increase in 2017 to $10.5B. A few contributing factors for this increased operational expenses are highlighted in this paper. A comparative analysis is established on pressure independent and pressure dependent CIMVs. Financial cost savings on using SkoFlo's pressure independent CIMVs are presented while addressing system instabilities.

Key words: *Pressure Independent CIMV, Distributed Chemical Injection Systems; Hydrate Inhibitors; System Stabilities; SkoFlo Industries Inc.*

INTRODUCTION

A study from FB industries[1] projected chemicals to be the second highest operational expense spending approximately $9.5 billion dollars in 2016. Chemical spend is projected to rise to $10.5B in 2017.

A few of the contributing factors are:

- Inadequate Hydrate Inhibition can cause hydrate plug formation resulting in well shutdowns. Some of these plugs take weeks and even months to disassociate. Not only do these plugs cause a loss in production, but they also create a safety and environmental hazard[2]. The financial loss from production interruption or asset damage due to flow assurance mishap can be astronomical[3].
- Excessive Hydrate Inhibition can cause higher operational expense as well. Logistics expense, overboard emissions, degradation of crude oil are all indirect expenses due to increased hydrate injection.

Injection of hydrate inhibitors into wells must be optimum and reliable to overcome substantial operational expenditures. Optimum and reliable hydrate injection can be only achieved when system instabilities are addressed.

PRIMARY CAUSES FOR INSTABILITIES IN A DISTRIBUTED CHEMICAL INJECTION SYSTEM

- Change in well pressure due to
  - Gas breakout in fluid column
  - Reservoir pressure
  - Gas lift conditions
  - Shut In
- Change in supply pressure due to
  - Pump delivery curve
  - Trunk line and branched line losses
  - Additional wells coming online / going offline
- Changes in differential pressure (DP) across the Chemical Injection Metering Valve (CIMV)
- CIMV/System imbalance due to CIMV interactions (see figure 1 for a distributed chemical injection system schematic)

Further instabilities are discussed in the next section.

OTHER CAUSES OF INSTABILITIES

Figure 2 shows DP vs flow comparisons at different % stem opening for a pressure dependent valve. Pressure dependent CIMVs vary in flow rate when upstream or downstream pressure changes. A stem motor is adjusted to compensate for pressure fluctuations[4].

- For a pressure dependent valve, a given change in DP causes a greater change in flow at a lower DP across the valve and/or branch. This can be mathematically explained as follows in equation 1:

$$Q = C_v \sqrt{\frac{DP}{SG}}; \qquad (1)$$

$$Q = Flow\ in\ Gallons\ per\ minute\ (GPM),$$
$$C_v = Valve\ flow\ coefficient,$$
$$DP = Differential\ pressure\ between\ inlet\ and\ outlet\ of\ valve (psi).$$
$$SG = Specific\ Gravity$$

$$Q_2 = Q_1 * \sqrt{\frac{DP_2}{DP_1}} \qquad (2)$$

From equation 2 and figure 2, flow changes 55% from 10 to 20 bar pressure differential at 60% stem opening compared to a flow change of only 10% from 60 to 70 bar pressure differential at 60% stem opening.

- Rangeability is the ratio of maximum controllable flow to minimum controllable flow. Greater the change in DP across the stem, less predictable the flow for a pressure dependent valve. Rangeability[5] is reduced due to actual operation by the varying valve pressure drop. At low system pressures this can adversely affect the chemical dosage rate for a pressure dependent valve which significantly increases operational expense.

Furthermore, when hydrate inhibition has multiple branched lines, pressure dependent CIMVs have a cause and effect relationship with each other. For every pressure imbalance, a pressure dependent CIMV reacts to changes in flow measurement by dithering the stem motor resulting in erratic delivery of chemicals. All the CIMVs on the branch will be hunting for their set flow rate resulting in overdosing and underdosing.

In order to overcome the limitations of pressure dependent CIMVs, operators typically set target flow rates higher than what is required to eliminate the risk of underdosing. Also, pressure dependent CIMVs undergo branched control loop tuning while commissioning which is onerous and can take up additional resources.

SkoFlo pressure independent CIMVs on the other hand can address system instabilities with very little oversight.

SKOFLO PRESSURE INDEPENDENT CIMVS

SkoFlo's pressure independent technology (figure 3) uses mechanically activated spring balance piston to respond to any system pressure fluctuation. No set point adjustments or tuning of the control loops are required to maintain constant flow. The mechanical spring balanced piston in each branched loop responds instantaneously to maintain system stability and accurate delivery.

Figure 4 illustrates DP vs Flow for a pressure independent SkoFlo CIMV. Once a minimum differential pressure across the CIMV is achieved, the delivered flow will remain within the narrow accuracy bandwidth regardless of system instabilities. A graph showing how pressure independent SkoFlo CIMVs respond to system pressure fluctuations compared to pressure dependent CIMVs is illustrated in figure 5.

With very little oversight over the life of the field, the operational cost savings can be enormous (see appendix 1 for operational cost savings using Pressure Independent CIMVs). Additionally, once the target flow rate is set, SkoFlo CIMVs use very little power for any system pressure fluctuation due to the robust mechanical nature of the CIMV.

CONCLUSION

Pressure dependent valves are more prone to erratic flow delivery. A small percent increase in hydrate inhibitor usage due to erratic delivery results in much larger operational cost. In today's environment where cost savings are of paramount importance, it is critical to evaluate operational costs when making capex decisions. Maintaining a stable system is critical for cost savings and operators are urged to evaluate and adopt the most reliable and accurate pressure independent CIMV in the market to address system instabilities.

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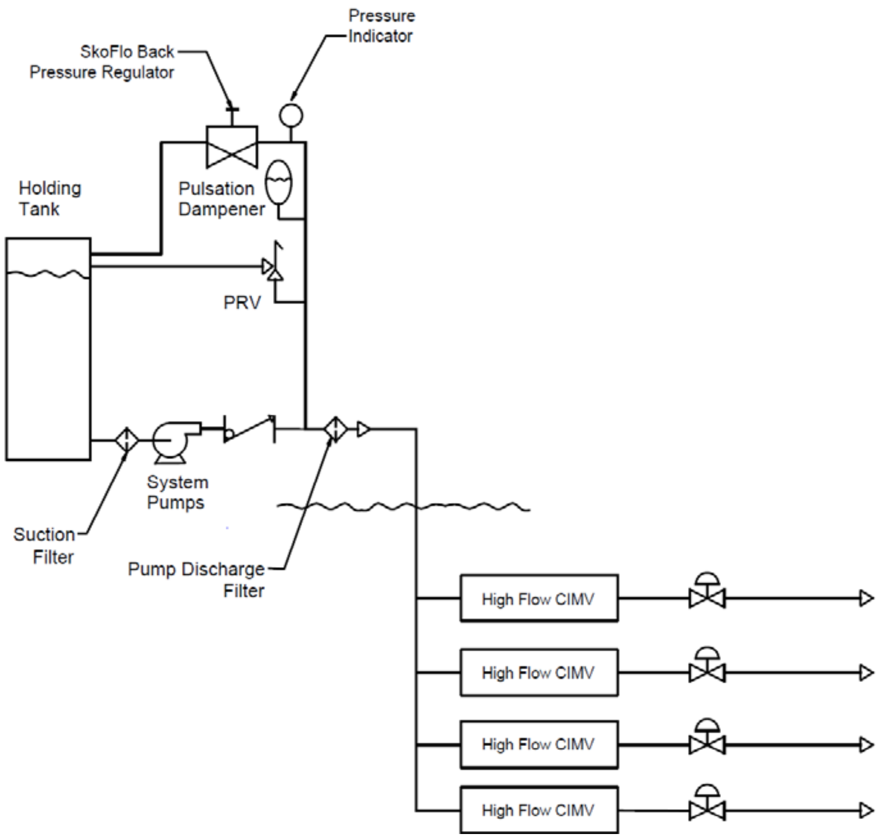

Figure 1. Distributed Chemical Injection System Schematic

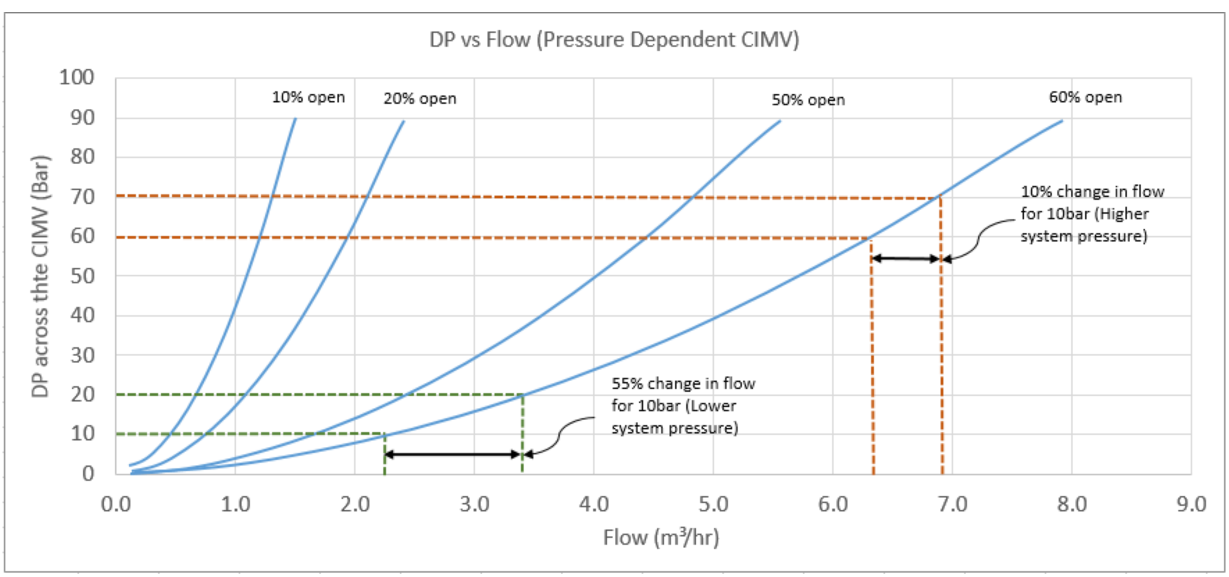

Figure 2. DP vs Flow (Pressure Dependent Valve)

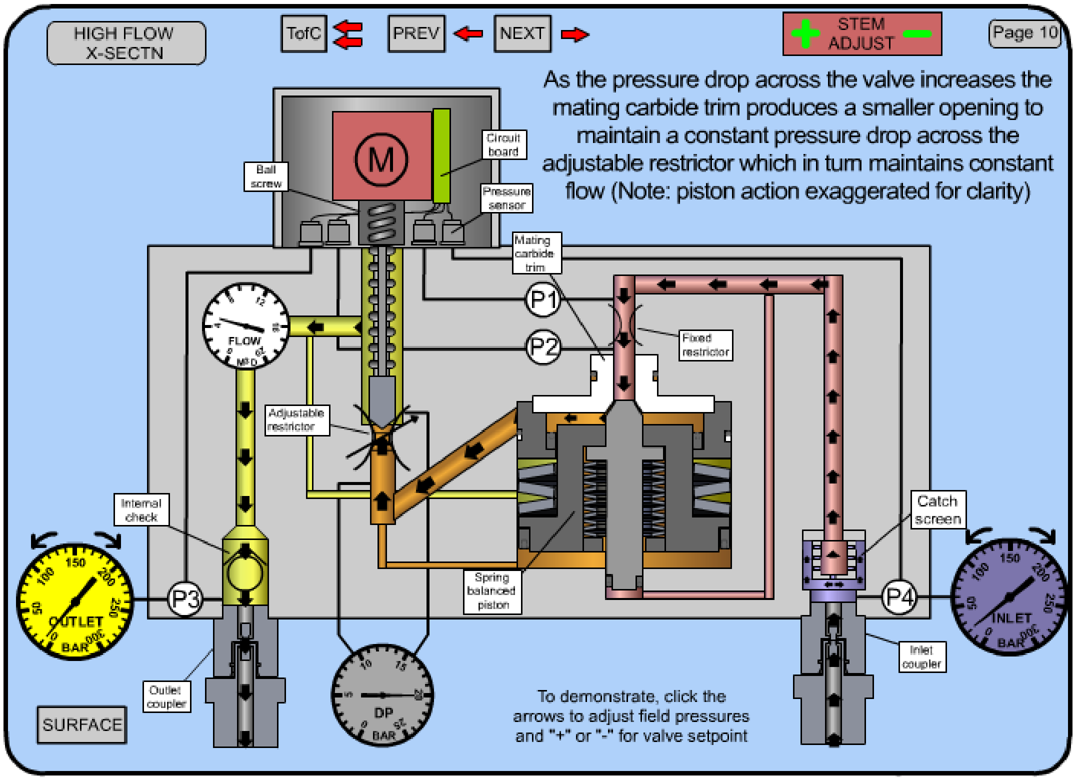

Figure 3. SkoFlo's Pressure Independent CIMV

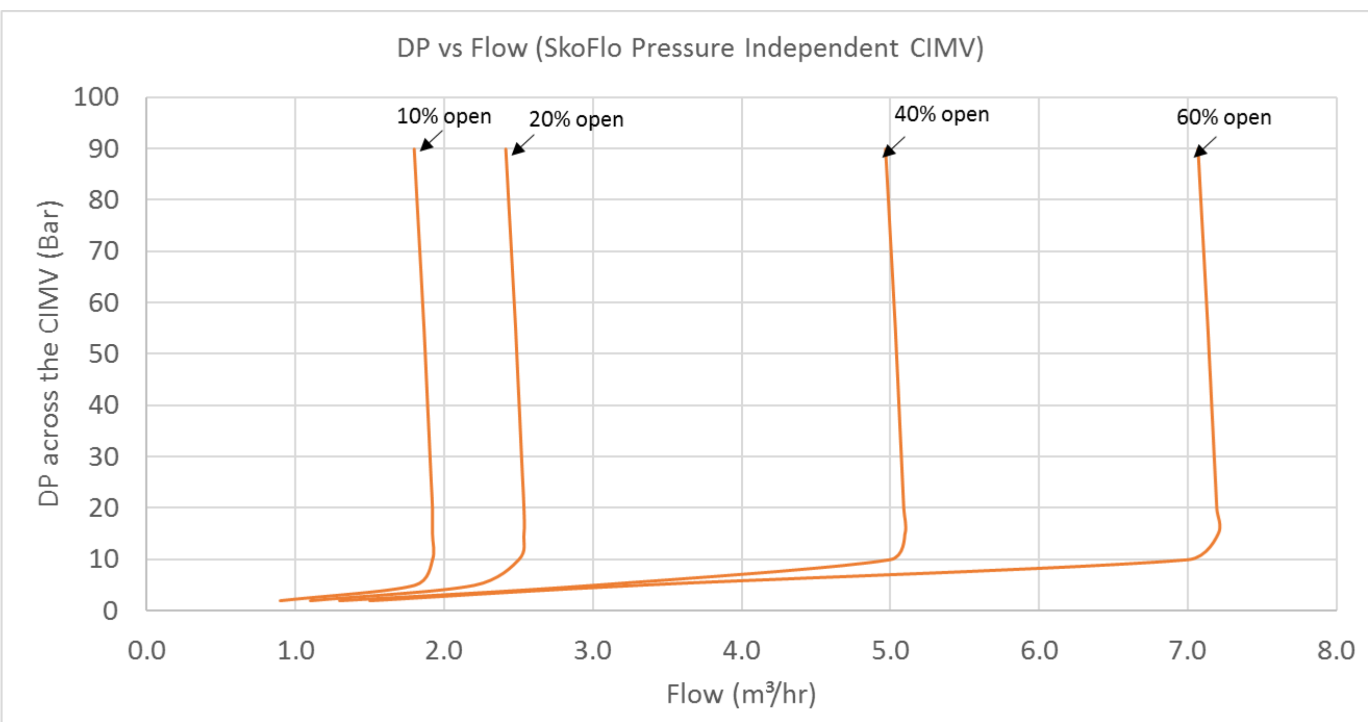

Figure 4. DP vs Flow for a SkoFlo Pressure Independent CIMV

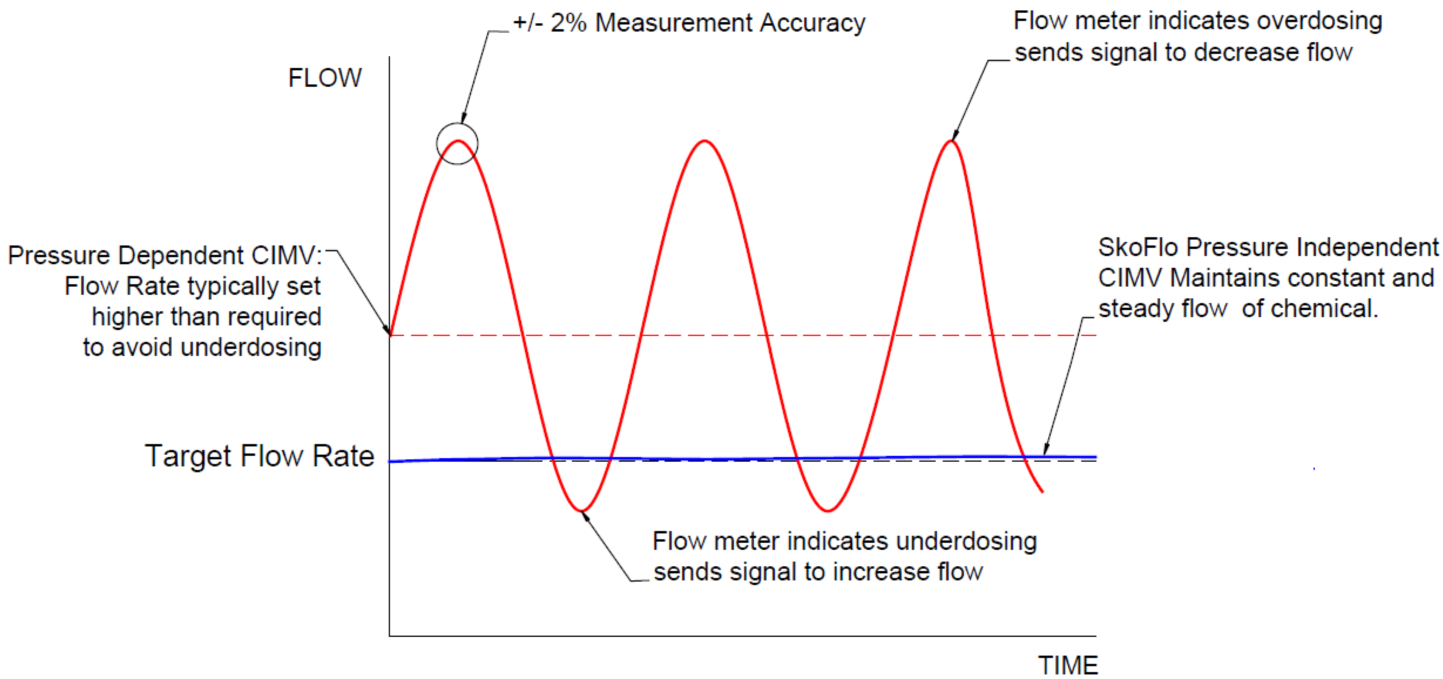

Figure 5. Response Time Curve (SkoFlo Pressure Independent CIMV vs Pressure Dependent CIMV)

APPENDIX 1: COST ANALYSIS

SkoFlo's pressure Independent Chemical Injection Metering Valves (CIMVs) deliver stable, reliable, continuous, and accurate flow of chemicals. This translates to significant savings in annual OPEX by minimizing chemical waste due to overdosing.

Pressure Dependent CIMV chemical wastage due to system instability

Qty CIMVs	Chemical	Flow Rate (GPM)	Total Gallons/Year	$/Gallon	Annual Chemical Cost*	5% Over dose	10% Over dose
6	Wax Inhibitor	0.051	161,481	$ 20.00	$ 3,229,624	$ 161,481	$ 322,962
12	Corrosion Inhibitor	0.004	24,521	$ 18.00	$ 441,373	$ 22,069	$ 44,137
12	80 % MEG**	22.015	41,655,902	$ 12.00	$ 499,870,829	$ 24,993,541	$ 49,987,083
3	Methanol	11.0075	17,356,626	$ 1.25	$ 21,695,783	$ 1,084,789	$ 2,169,578
				Totals	**$ 525,237,608**	**$ 26,261,880.39**	**$ 52,523,760.78**

*based on estimated market prices in 2016

**assume 70% MEG recovery with no cost for refining