HYDRAULIC STUDY OF GRE PIPING ADEQUACY USING PIPENET SIMULATION

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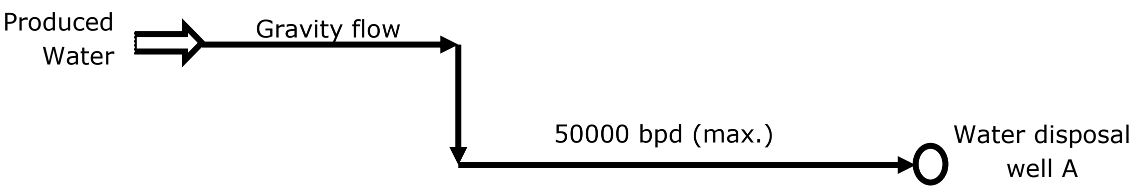
Abstract:

This article deals with hydraulic study of GRE piping carried out for our client in Qatar this year. In the offshore platform, produced water is dumped into the water disposal well by gravity, bypassing the IGF (induced gas floatation) vessel and also the produced water disposal pumps. In the proposed system, produced water shall be collected in the IGF vessel and pumped to two water disposal wells (1 existing and 1 new). This article provides a method to calculate the maximum water flow rate that shall ensure the system is hydraulically balanced using PIPENET – Standard module.

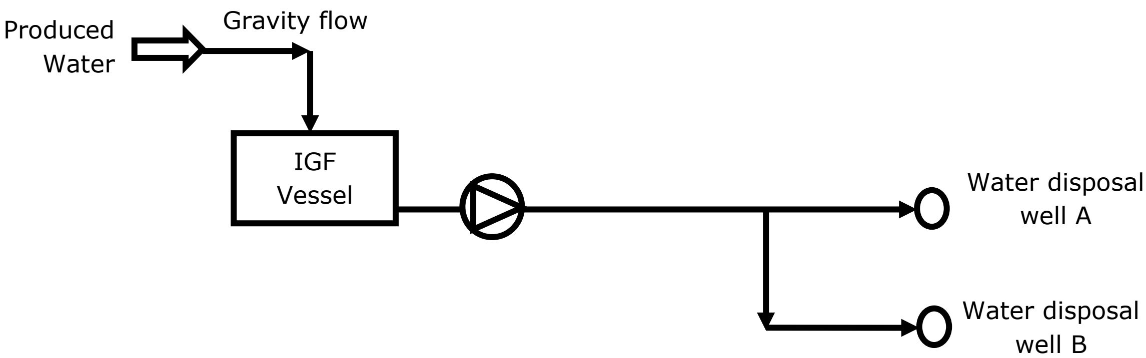
Introduction:

The existing system (refer figure 1) in discussion has the IGF vessel with pumps, but still the produced water was sent to disposal well A or caisson, bypassing the IGF vessels and its pumps. The maximum possible flow rate is about 50,000 bpd. However, client has one more disposal well B and existing system cannot handle the increased flow and back pressure. Therefore now the produced water must be routed to IGF vessel first and pumped to the disposal well A and B. The new system schematic is given in figure 2.

<u>Figure 1: Existing System</u>



<u>Figure 2: New System</u>



Constrains:

Following constrains are applicable for this system.

1. Flow v/s well back pressure data for water disposal well A is given in table 1. This prediction was a result of a separate in-house study by the operating company.

   Table 1: Well A flow and back pressure profile.

Flow, bpd	Back pressure, barg
25500	1.11
34000	2.68
42500	4.34
51000	6.07
59500	7.87
68000	9.75
76500	11.70
85000	13.73
102000	18.01
127500	24.98
170000	38.10

2. Flow v/s well back pressure data for water disposal well B is given in table 2. This prediction was a result of a separate in-house study by the operating company.

   Table 2: Well B flow and back pressure profile.

Flow, bpd	Back pressure, barg
56304	0.69
59879	1.38
63346	2.07
66811	2.76
70204	3.45
73559	4.14
76900	4.83
80151	5.52
83402	6.21
86581	6.89
106250	10.64
127500	14.95
170000	23.56

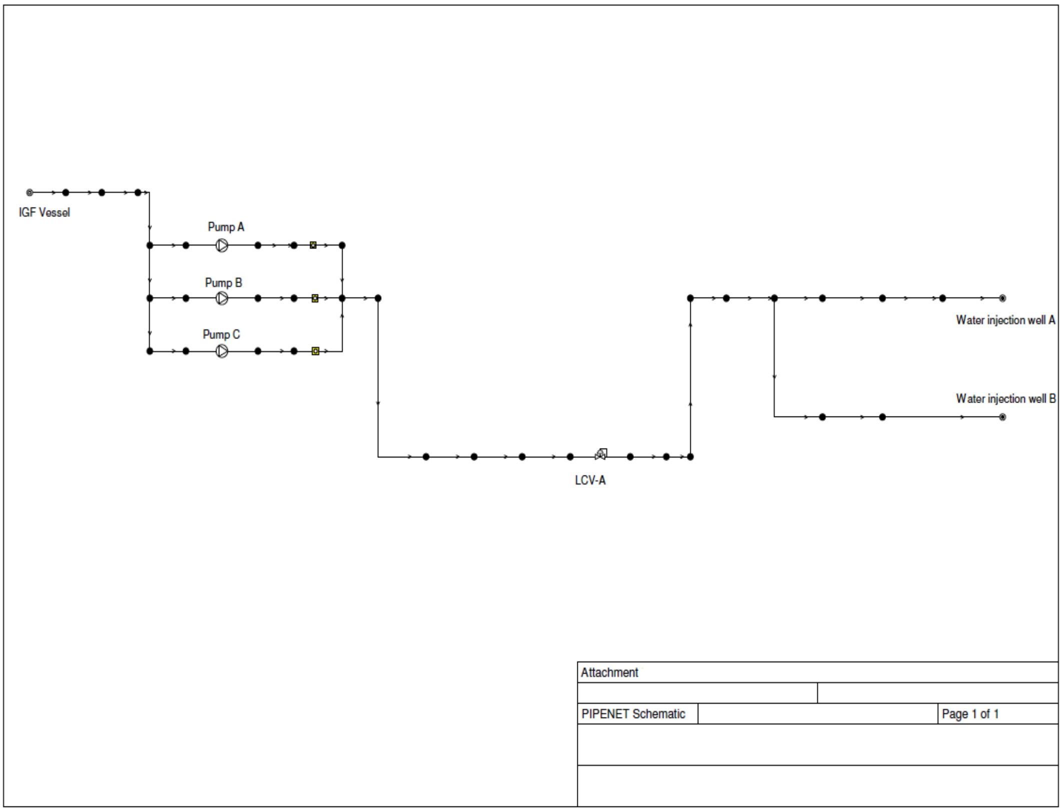
3. GRE pipe velocity should be less than 4.6 m/s as per pipe vendor.
4. There are total three pumps (Pump A, B and C) to transfer produced water from IGF vessel to two water disposal wells. There was a separate PIPENET – TRANSIENT study done earlier to study if the surge pressure was well below the design pressure of GRE piping. It was then recommended that the pump discharge pressure should always be less than 18.1 barg.
5. Level control valve (LCV-A) is available at downstream of pump. It is to be ensured that the valve opening is in between 10% to 80% for proper valve operation.

Note: All the parameters (flow rate, pressure, Cv value etc.) given in this article are changed from the actual values.

Methodology:

- A model in PIPENET – Standard was developed using the piping isometrics of the suction and discharge lines, pump characteristics data and control valve Cv values etc. Level control valve is available in the existing discharge header. The snapshot is shown in figure 3.

Figure 3: PIPENET – Simulation model snapshot



- Produced water flow rate v/s well back pressure data is available for both the wells. This is plotted in MS Excel and using trendline application, polynomial equation coefficients were extracted. The equation obtained is used to calculate well back pressure for given flow rate. This is particularly useful as this provides a faster means for doing the similar calculations repeatedly. The polynomial equation and the plot for the wells A and B are shown in Figure 4 and 5 respectively.

Figure 4: Well A - Polynomial equation and the plot

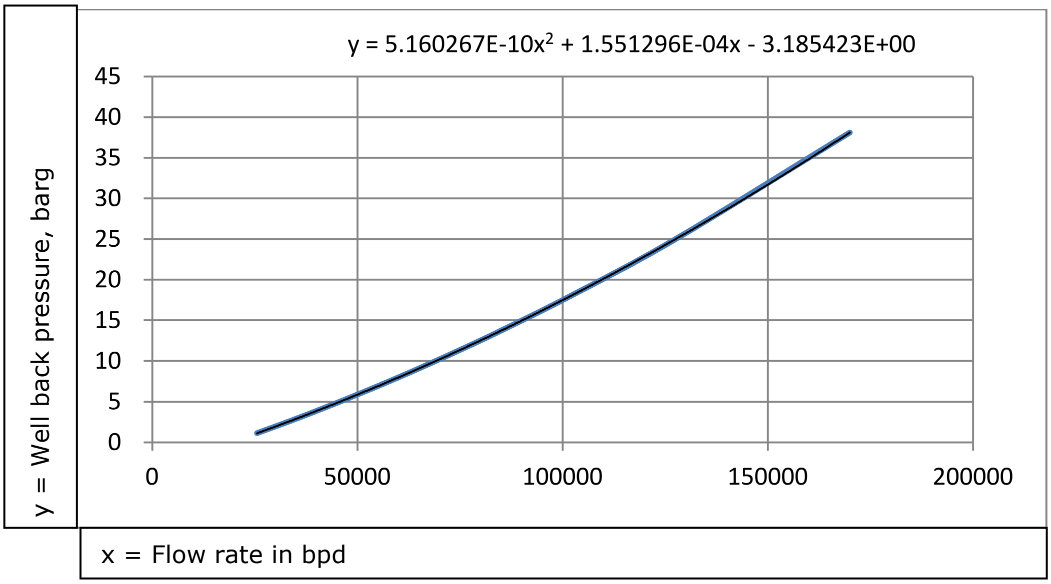
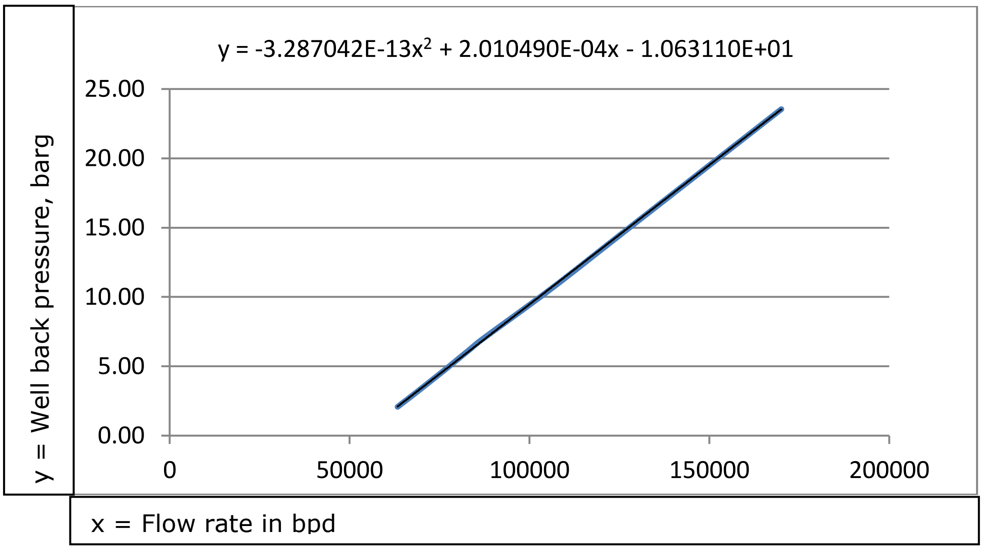


Figure 5: Well B - Polynomial equation and the plot



- Three different cases (minimum flow, normal flow and maximum flow) were studied for this project. However, here only maximum flow condition using all three pumps shall be discussed.
  - ✓ First a flow rate value is given in LCV-A, say 160000 bpd.
  - ✓ About 60% of the total flow is diverted to well B. It is to be noted that well B has lower back pressure than that of well A for the same flow rate.
  - ✓ The back pressure value for well B (calculated from polynomial equation as shown in figure 5 for assumed flow rate) and the flow rate is given in well B node (output node).
  - ✓ All other data is already provided in the model, e. g. Pump curve, pipe isometrics, elevations, pipe diameter, inlet node pressure etc. The model is run.
  - ✓ The output data of use are, if pipe velocities (if less than the recommended value), pump discharge pressure (if more than 18.1 barg), the valve opening of LCV-A is in between recommended range (the pressure drop value required for valve opening calculations shall be taken from simulation) and most importantly the back pressure at calculated flow rate at the well A output node should match with the polynomial equation as shown in figure 4.
  - ✓ This procedure is repeated until all above conditions are satisfied.

Case Study Results:

One sample example is provided for better understanding.

- ✓ Flow rate of 160000 bpd is given in LCV-A, 96000 bpd flow rate is given in well B. The calculated back pressure for well B at this flow rate is 8.67 barg. So same set of values are set in well B output node.
- ✓ PIPENET calculates the flow rate in Well A as 64000 bpd and pressure at outlet node as 9.15 bpd. Polynomial equation gives pressure as 8.86 barg at 64000 bpd, which means the flow rate to well A should be increased in order to match the calculated and the simulated pressures for the same flow rate. The pipe velocity (< 4.6 m/s) and pump discharge pressure (18.1 barg) was found to be adequate.
- ✓ New set of values are taken in the next run. Total flow rate is kept same as 160000 bpd, as this shall mainly influence the pump discharge pressure. As in first run itself the pump discharge pressure was found to be very close to the maximum allowable value. If the pressure had been, say 19 barg, then higher flow rate should have been considered. The flow rate to well B is considered as 94500 bpd, with calculated back pressure of 8.55 barg. These values are put in outlet node of well B. Model calculates well A flow rate as 64600 bpd and pressure as 9 barg, which is equal to the calculated from polynomial equation for well A.
- ✓ The pressures upstream and downstream of LCV-A is noted from the simulation results. Cv is calculated for the pressure drop and flow rate. It is observed from

the control valve sizing calculations that the valve opening is in the range 10% to 80%, which is as per requirement.

- ✓ This method normally requires 4-5 iterations and provides faster solution for such complex problems, if it were to be done without the aid of simulation software.

Conclusions:

The combination of spreadsheet tools and PIPENET simulations is employed in this study. The calculation method suggested is unique and can be utilized for similar problems where spreadsheet alone or simulation alone cannot solve the problem efficiently.