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Real-time demand for a gas pipeline design: dealing with modern challenges – Part 2

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Following-on the previous article on this subject published in the December 2015 issue of *Pipelines International*, this article presents new functionalities of the GasPipelineDesign and GasPipelineExpansion mobile applications as part of the innovative mobile technology that has been developed to support gas pipeline design through the web.

The availability to study the compression system and the optimum capacity ramp-up of a transmission system are the new functionalities of the application, and are of key importance in the process of designing a feasible gas pipeline project.

INNOVATIVE TECHNOLOGY

Following the approach presented in the previous article, At Work Rio has implemented new features in the GasPipelineExpansion application, which are described here through a case study that highlights the application's capabilities.

The application has been designed to:

- Perform cost estimates for new gas pipeline projects or capacity expansions of existing projects;
- Allows the addition of compressor stations to an existing project, undertake capacity ramp-up and availability studies; and,
- Work with GIS information (latitude, longitude, and elevation profile) for the pipeline route.

NEW PROJECT OR CAPACITY EXPANSION

Where transmission or distribution companies see an opportunity to increase the system's capacity, GasPipelineDesign and GasPipelineExpansion can be used together to provide the best feasible solution for the expansion project, be it construction of a loop pipeline, compressor station(s), or a pipeline interconnection.

CAPACITY RAMP-UP

New gas pipeline projects generally do not start operation with full capacity and it is necessary to determine the best configuration for compressor stations and compressor units to cope with the capacity ramp-up through the first years of operation, along with the schedule for installation of compressor stations and compressor units. The GasPipelineExpansion approach optimises CAPEX cash flow and makes the project more competitive.

AVAILABILITY STUDY

GasPipelineExpansion incorporates a powerful and flexible module for an availability study that performs Monte Carlo simulations. Compressor unit failures, their frequency and scenarios, are identified and each scenario is thermos-hydraulically simulated and its capacity under failure is quantified. The frequency of failures versus capacity under failure will allow the evaluation of the compressor-system availability, and also support decisions on the provision of an

	Reliability (%)	Availability (%)
Electric motor + centrifugal	99.4	98.9
Gas turbine + centrifugal	98.2	97.1
Gas motor + reciprocating	97.1	94.3

TABLE 1: The reliability and availability values of different compressor station arrangements as surveyed by the Electric Power Research Institute.

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adequate level of redundancy (stand-by units) for gas pipelines. The simulation process can be as follows:

1. Simulate the compression system without any stand-by units and obtain the availability.
2. Select target compressor stations to have stand-by units, and re-run the simulation to obtain an improved availability for the system.
3. Continue testing other arrangements of stand-by units until the availability satisfies the project's needs.
4. Alternatively, simulate using a stand-by unit for all the compressor stations and compare the outcomes.

Electric Power Research Institute (EPRI) [1] has surveyed many compressor stations with different arrangements of compressor (centrifugal or reciprocating) and driver (electric motor, gas turbine, or gas motor) and identified reliability and availability values in Table 1.

The simulation runs 100,000 iterations and compiles groups of failure results with their respective gas-transmission capacity and frequency. The application can handle different sizes and types of compressor units at any compressor station, with each unit having its own availability figures. An availability study using a Monte Carlo simulation is of key importance for a feasible gas pipeline project. Transmission companies must mitigate their operational risk to comply with their transportation agreements with local distribution companies or end users with regard to firm-capacity clauses and related penalties for non-compliance. In the event of a compressor unit's failure impacting the pipeline capacity, the transmission company would face penalties and loss of revenue, dramatically impacting its economic result [2-5]. »

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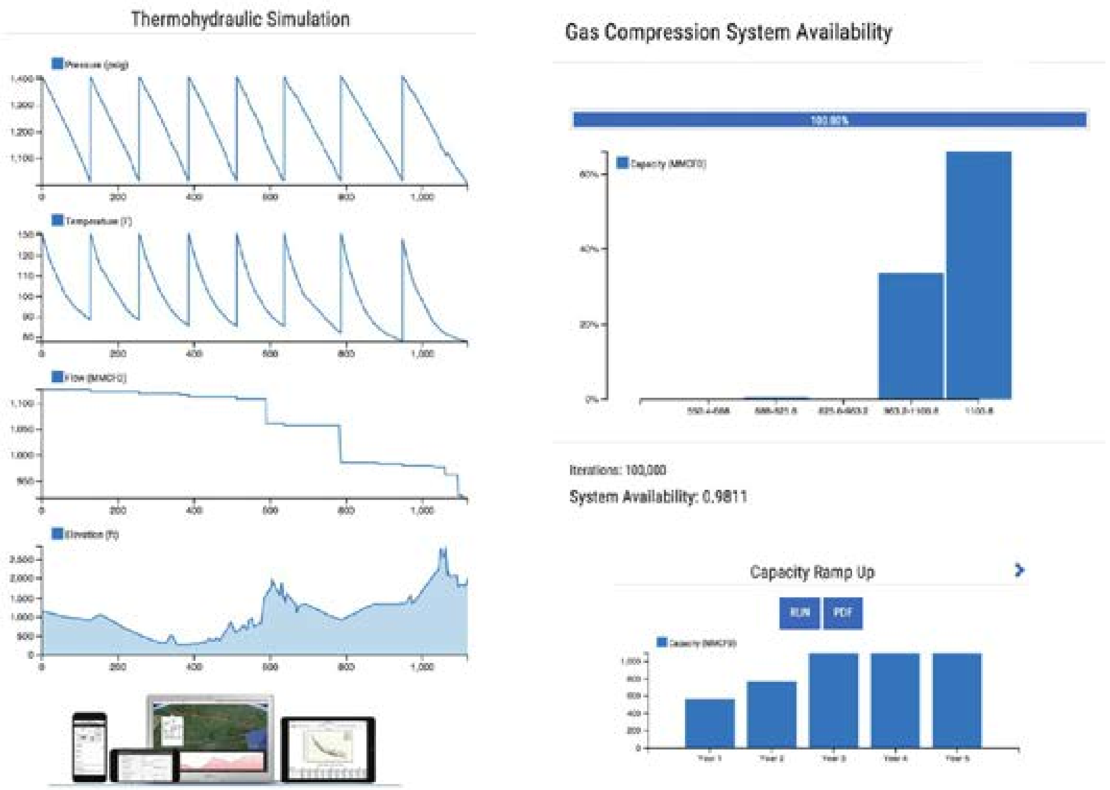

ABOVE: The graphical result of a GasPipelineExpansion thermohydraulic simulation (left) showing a availability analysis without a stand-by compressor units, and the results of a capacity ramp-up study (right) with one compressor station (year 1), three compressor stations (year 2), and seven compressor stations (years 3 to 30).

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CASE STUDY: GASBOL PIPELINE

The case study used to illustrate this article is based on the GASBOL pipeline project if it was being designed now. Based on the prevailing market condition and technical and economic assumptions at the time it was designed – around 1995 – the main section of the project has a nominal diameter of 32 inches and 14 compressor stations. The transmission capacity is 1,059 MMcf/d.

With the same technical requirements and today's economic assumptions, and by using At Work Rio's innovative technology, the best alternative for the project is as follows:

(a) **Technical assumptions:**

Capacity: 1,059 MMcf/d
Length: 1,068 miles (straight route)
Length: 1,118 miles (geographic route)
MAOP: 1,420 psi
Pipe material: API 5L X-80
Gas specific gravity: 0.6000
Inlet pressure: 1,410 psig
Delivery pressure: 1,000 psig
Compression ratio: 1.4000
Gas deliveries, MMcf/d:

D1, at milepost 363.4 miles: 1.7657
D2, at milepost 589.3 miles: 47.6748
D3, at milepost 781.6 miles: 68.8636
D4, at milepost 877.1 miles: 2.8252
D5, at milepost 1025.1 miles: 14.1259
D6, at milepost 1092.5 miles: 40.2587
D7, at milepost 1104.3 miles: 5.6503

(b) **Economic assumptions:**

Pipe material cost: US$2,500/ton
Fuel gas cost: US$5/MMBTU
Pipeline operation and maintenance cost: 1.5 per cent of pipeline CAPEX per year
Compressor station operation and maintenance cost: 5 per cent of compressor station CAPEX per year
Project economic life: 30 years
Discount rate: 12% per year
Construction time: 4 years
Pipeline CAPEX schedule: 15% year 1, 30% year 2, 30% year 3, 25% year 4
Compressor station CAPEX schedule: 0 % year 1, 10% year 2, 40% year 3, 50% year 4

Results for the selected gas pipeline configuration:

(a) **Technical:**

Nominal diameter: 36 inches
Total length: 1,118 miles
Transmission capacity: 1,100.76 MMcf/d
Number of compressor stations: 7
Number of operating units per compressor station: 2
Number of stand-by units per compressor station: 1
Total required power: 125,144 hp
Total installed power: 298,812 hp
Total required fuel gas per year: 9,517.08 MMcf
Compressor system availability:
without stand-by units: 0.9811
with one stand-by unit at CS# 4: 0.9836
with stand-by units at CS# 2, 4, and 6: 0.9925
with stand-by units at all CS: 0.9997

Capacity ramp-up:
with one compressor station (CS# 4): 565.21 MMcf/d
with three compressor stations (CS# 2,4,6): 775.83 MMcf/d
with seven compressor stations (CS# 1,2,3,4,5,6,7): 1,100.76 MMcf/d

(b) **Economic (in MM US$):**

Pipeline total cost: 3,528.48
Pipeline total cost present value: 2,630.48
Compressor station total cost: 800.55
Compressor station total cost present value: 546.13
Pipeline operation and maintenance present value: 270.95
Compressor station operation and maintenance present value: 204.91
Total fuel gas present value: 237.26
Inventory (line pack) gas present value: 11.01
Total CAPEX: 3,176.61
Total OPEX: 724.13
Total Project PV: 3,900.73

CONCLUSION

At Work Rio's innovative technology covers all the important aspects related to the design process for a gas pipeline, including thermos-hydraulics, failure analysis with Monte Carlo simulation, capacity ramp-up, cost assessment, and economics. This state-of-the-art, innovative mobile technology improves productivity for gas pipeline conceptual design with simple, practical, accurate, reliable, and speedy solutions. **P**

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About the developer

These mobile technology applications have been developed by the author Sidney Santos, who retired from Petrobras in 2012 after working for more than 25 years as a Senior Consultant and a gas-pipeline design engineer. Using his knowledge of pipeline design technology, as well as programming using spreadsheets Visual Basic and C#, Mr Santos has recently worked with qualified software developers to perfect his applications. His most recent projects at Petrobras, prior to retiring, were the design of the Bolivia – Brazil Gas Pipeline (GASBOL), and the expansion project for the gas pipeline network in Brazil. He had a role in many prospective projects such as the Venezuela – Brazil Gas Pipeline (GASVEN) and the Integration Gas Pipeline (GASIN); he also provided consulting assistance to KazTransGas and Intergas Central Asia for the Kazakhstan section of the Trans Asia Gas Pipeline.