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NEW CONTROL METHOD FOR FIXED SPEED COMPRESSORS WITH SIDE STREAM

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Authors



David is presently a Senior Control technologist within the Control Algorithms & Systems Development of the Turbo Machinery Solutions engineering department at GE Oil & Gas in Florence, Italy.

His responsibilities include the development and maintenance of compressor & process control system as well as support on specific project requirements fulfillment. He joined GE in 1995 as Field Control Engineer, working worldwide in plant commissioning and start-up activities for almost 10 years. He moved into the Field Technical support from 2006 and, in 2009 into the Control Development Engineering, working on the control system requisition, software development and New Products Introduction development; he currently holds 3 patents.



Laurence Casali is currently Principal Engineer for System Operability of Centrifugal Compressor & Turbo Expander Applications in GE Oil&Gas in Florence, Italy. Her responsibilities include the definition of process control philosophy and the analysis of transient scenarios through process dynamic simulation to ensure the correct operability of centrifugal compressors and turbo expanders in accordance with the process requirements. Laurence joined GE in 2003 as Design Engineer of Gas Turbines auxiliary systems and then, she worked for three years as System Engineer for auxiliary systems of centrifugal compressors driven by steam turbines or electric motors. In 2008 she moved to the System Operability department where she was appointed Senior Engineer and then, Principal Engineer. Laurence received a M.S. degree with honor in Chemical Engineering in 2002 from University of Pisa.



Marco is Engineering Manager for System Operability of Centrifugal Compressor & Turbo Expander Applications at GE Oil&Gas, in Florence, Italy. His responsibilities include the definition of process control philosophy, dynamic simulations and optimization as well as support to production and operation of centrifugal compressors and turbo expanders. He joined GE in 1999 as Centrifugal Compressors Design Engineer, becoming, in 2003, integrally geared and pipeline compressors design Team Leader, in 2006 he was Compressor Design Manager based in Le Creusot, France, and, in 2008 he went back in Florence, appointed axial and centrifugal compressors Design Manager for LNG and Down Stream applications covered for 5 years.

Mr Pelella graduated with honor in Mechanical Engineering at University of Naples, Italy in 1997, he has authored and coauthored 7 papers in compressor field and he presently holds 8 patents.

Contents

- Problem statement
- Process configuration
- Centrifugal compressor details
- Impact on compressor performance
- Issues at site – Start-up/Loading
- Feed gas and side stream throttling valves
- Parallel Trains Operation
- Advanced dynamic simulation
- Fouling and unbalanced parallel operation
- Conclusions/Lesson learned

Problem statement

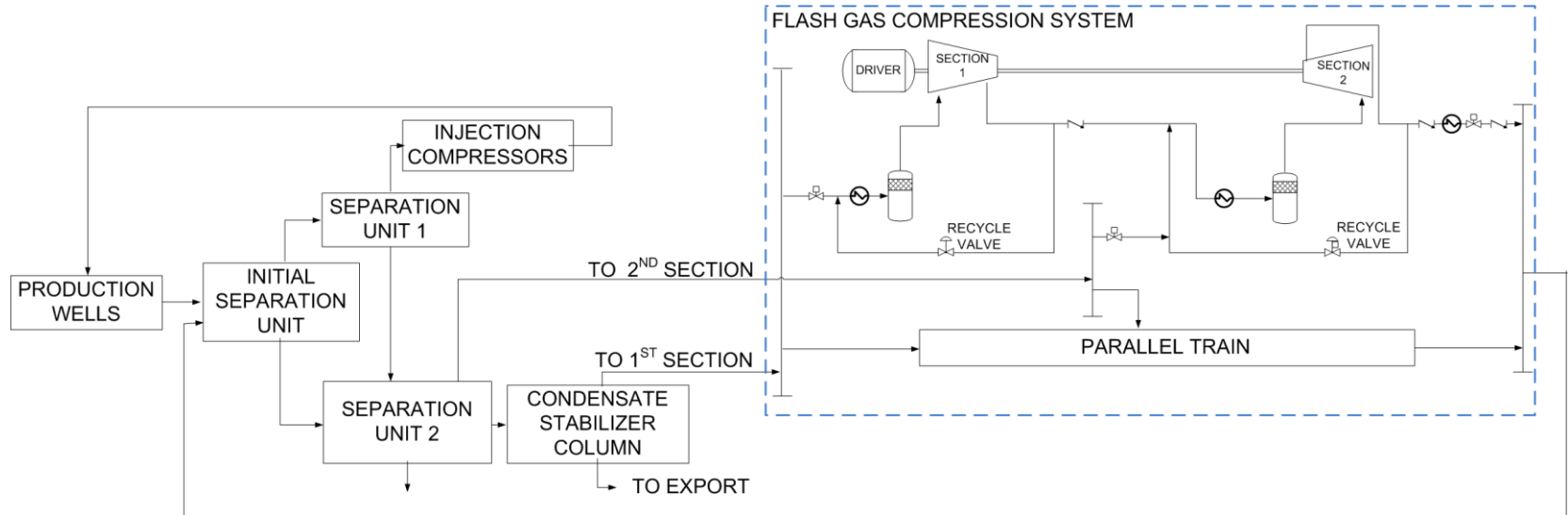
Operability issues were experienced on flash gas back-to-back compressors with lower molecular weight side stream, driven by fixed speed electric motor:

- Failed attempts of start-up/loading
 - During normal operation compressors went off-line due to process upset (e.g. inlet flow decrease)
 - Unable to operate parallel trains simultaneously
- Consequent loss of production



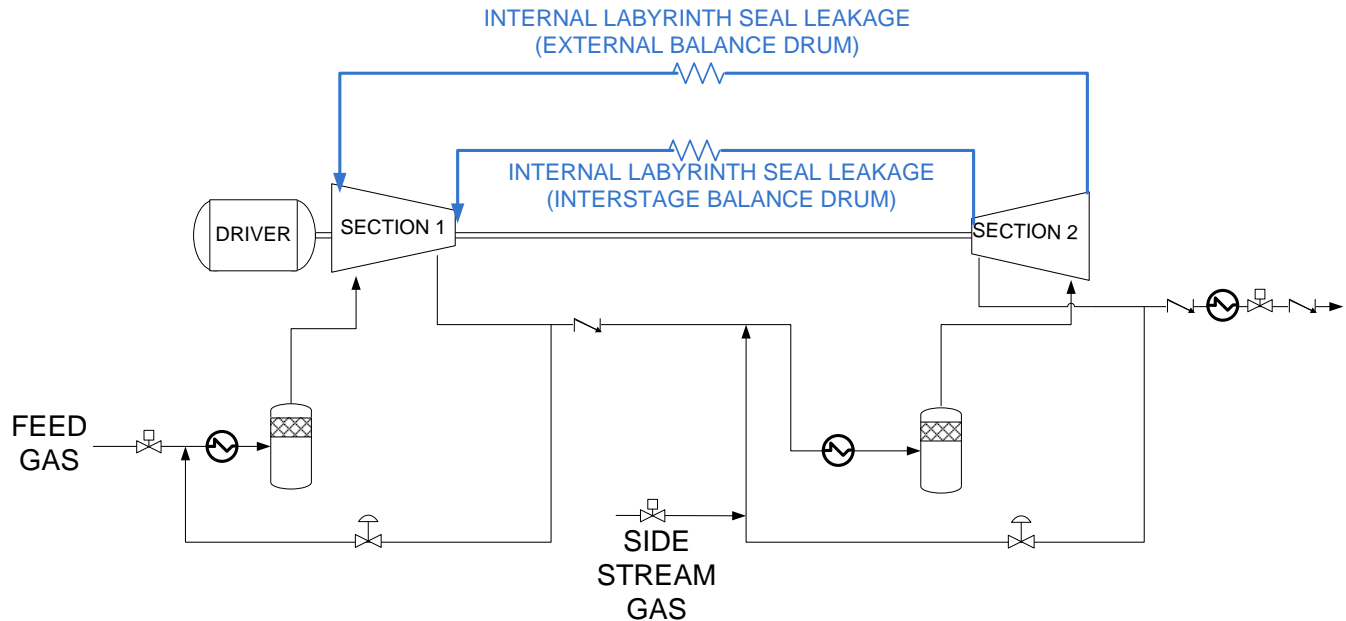
Process configuration

- Flash gas compression application
- 2x50% compression trains in parallel operation
- Back-to-back compressors
- Different molecular weight (MW) on each compressor section



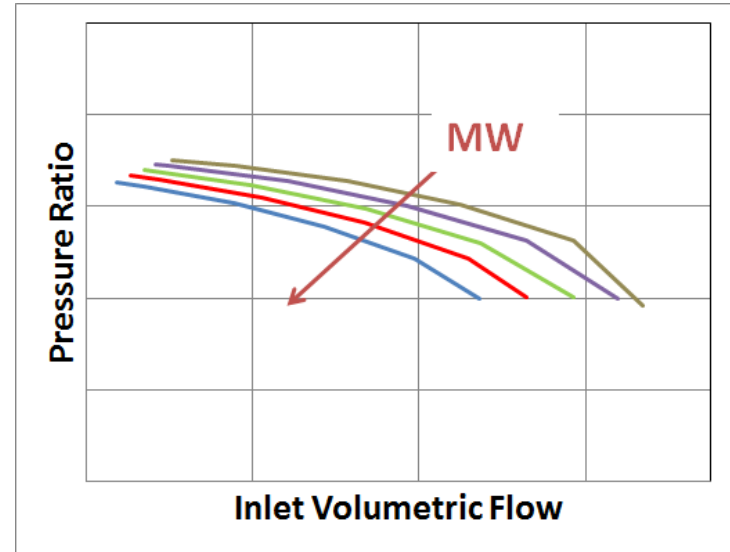
Centrifugal compressor details

- Back-to-back compressors work with higher MW on the 1st section and lower MW on 2nd section
- Two internal labyrinth seal leakages are present



Impact on compressors performance

- 1st section recycle includes the internal seal leakages from 2nd section
- 1st section recycle leads to gas MW decrease and performance reduction
- Since pressure at boundary conditions are fixed by the process the compressor may go off-line

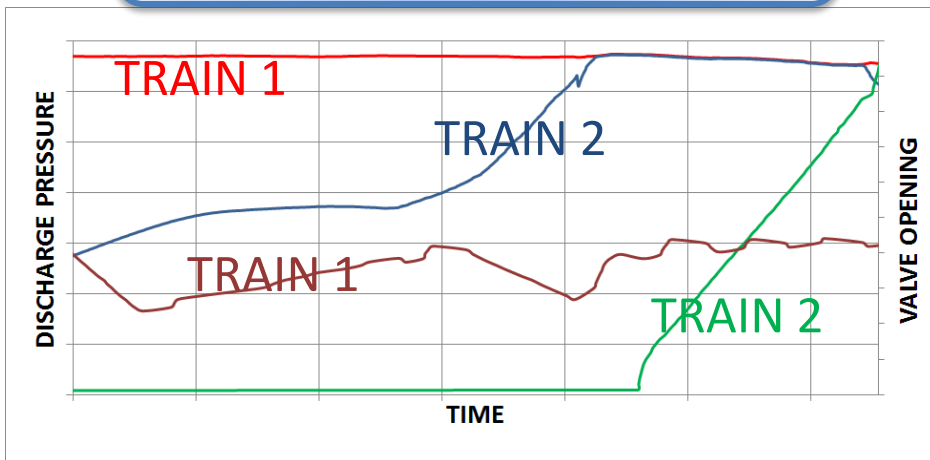


Compressor performance Vs
MW (fixed speed)

Issues at site – Start-up/Loading

Unable to bring the parallel train on line

Excessive side stream flow
(lower MW) decreases 1st
section MW



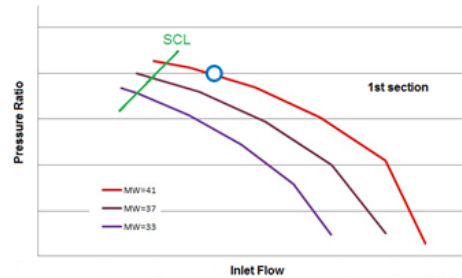
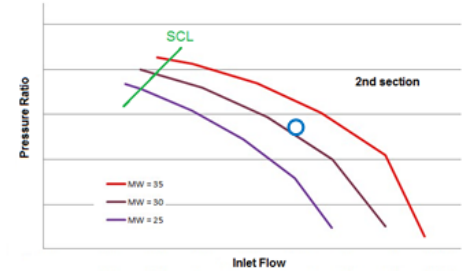
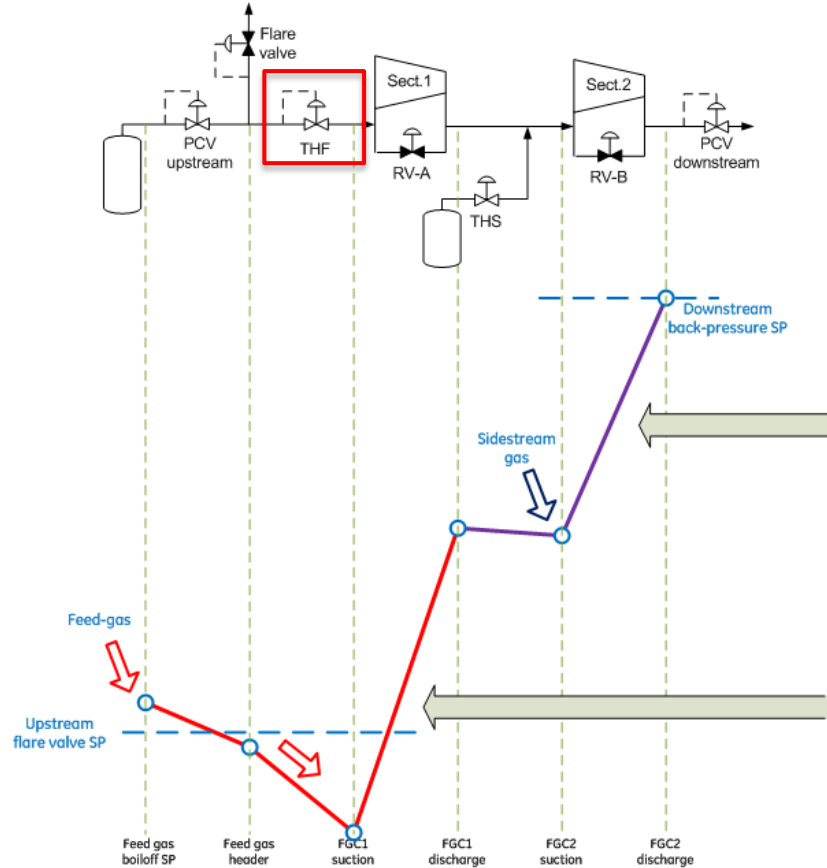
Not enough side stream flow
(lower MW) increases 2nd
section MW



High electric motor
current - TRIP

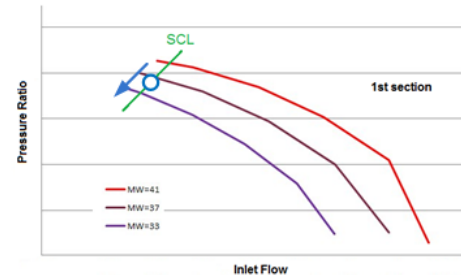
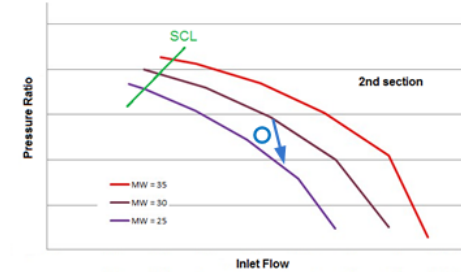
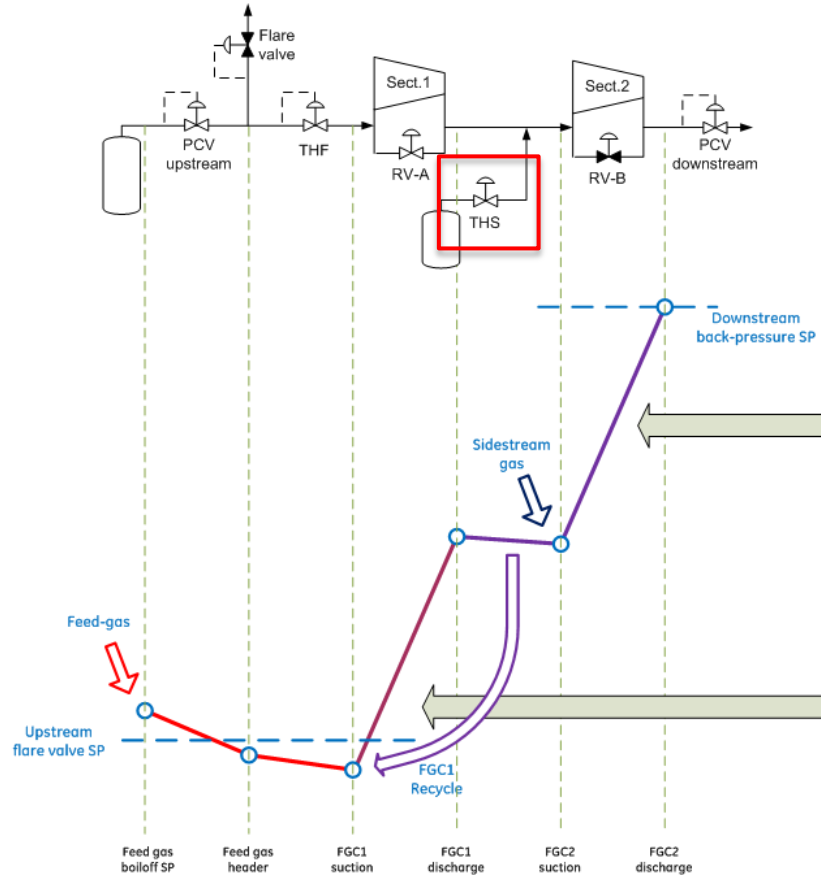
Feed gas Throttling valve

- Throttling valve introduced on feed-gas inlet line in order to allow feed gas header pressure regulation, minimizing recycled gas flow



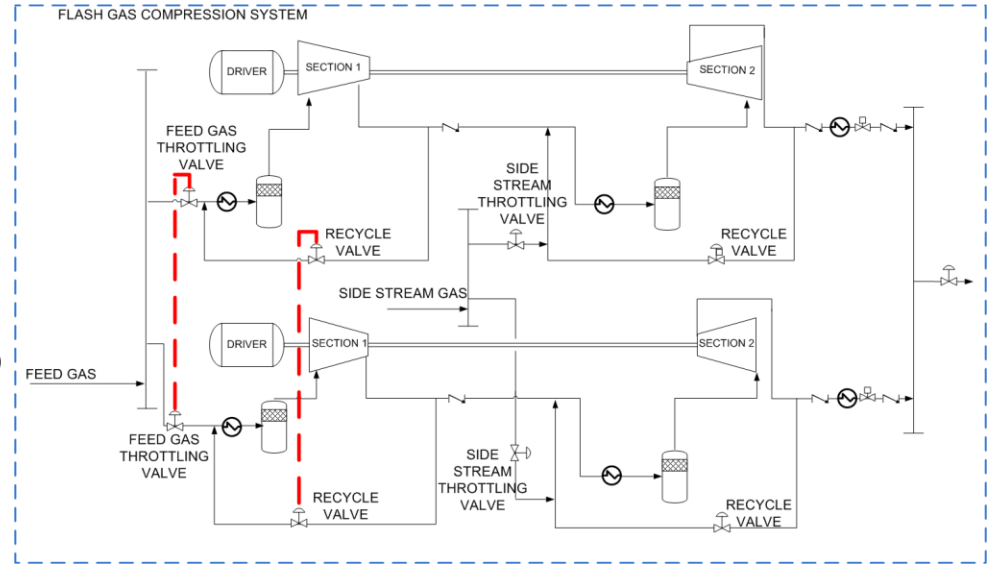
Side Stream Throttling valve

- Throttling valve introduced on side stream gas inlet line in order to keep the correct MW on the 1st and 2nd compressor sections, in order to maximize gas flow, avoiding the lean-out phenomenon



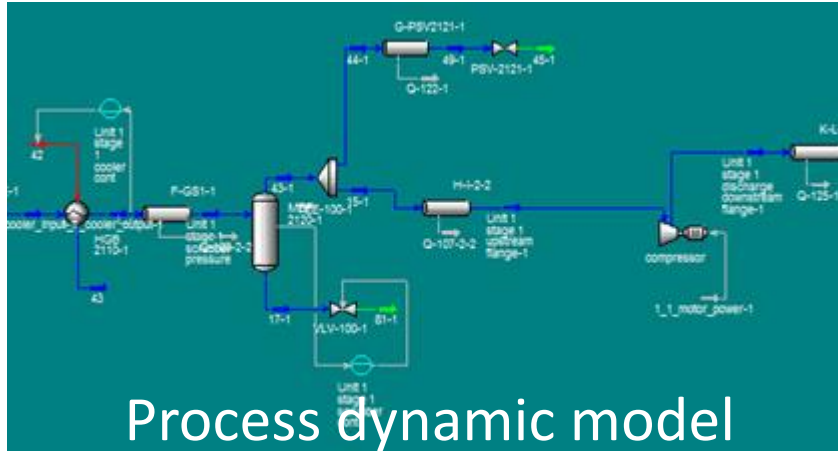
Parallel Trains Operation

- The 1st section lean-out get worse in case of parallel flash gas trains operation, due to unbalancing on the feed gas flow drawn by each compressor
- In order to properly split the available feed gas flow between the trains, it is necessary, not only to act on each throttling valve, but also to “link” the opening of both 1st section recycle valves of the parallel trains



Advanced dynamic simulation - Scope

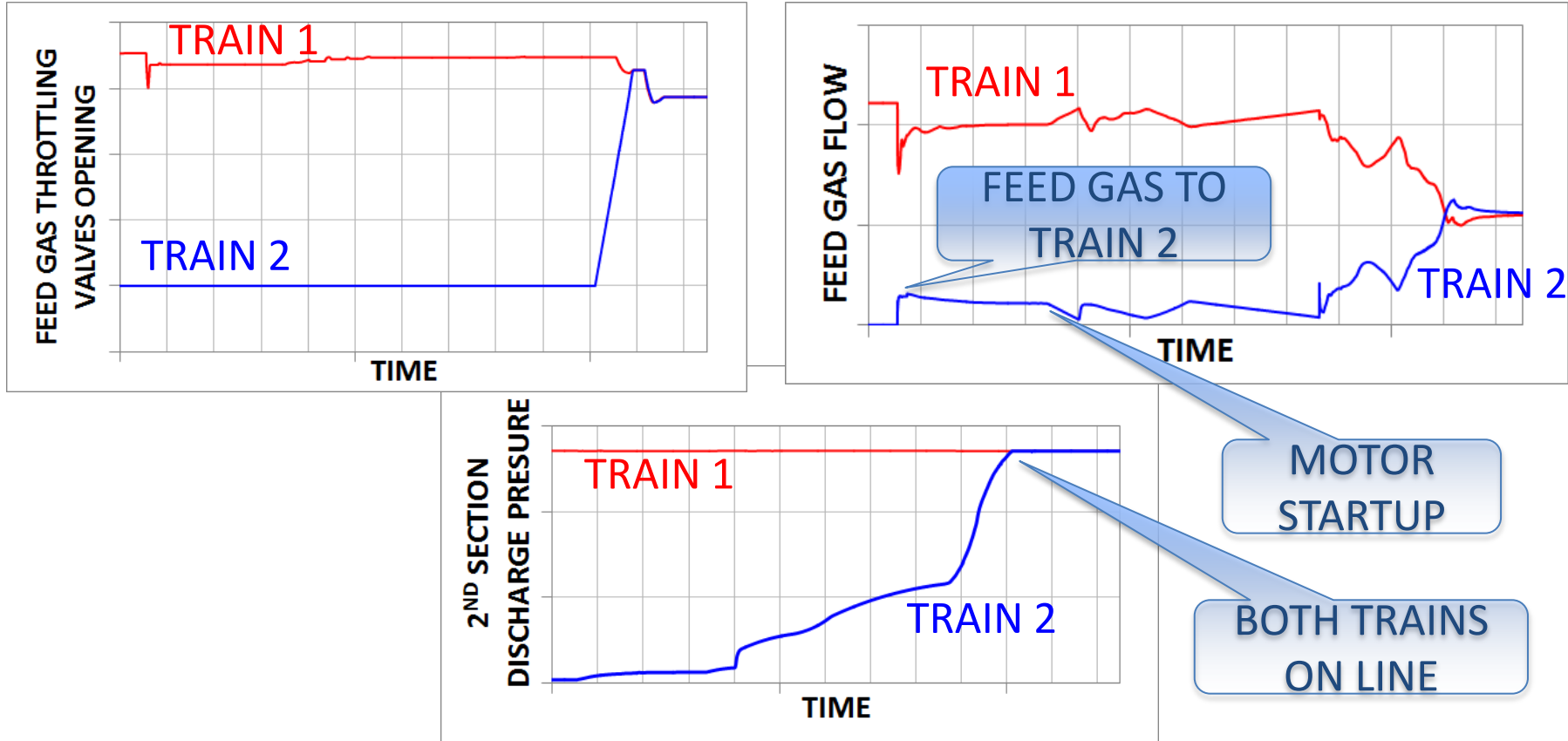
- Testing and validation of the new control algorithm
- Optimization of the process production parameters
- Pretuning of the software
- Minimize commissioning time at site



Control system CPU's
running job Software

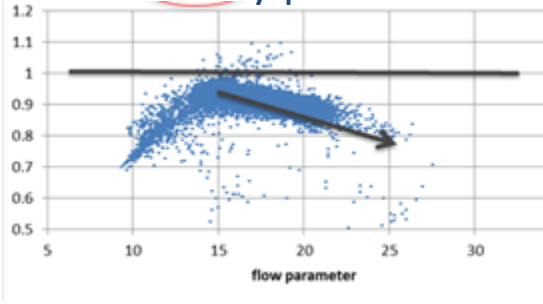
Advanced dynamic simulation - Example

Start-up of one train 1 while the parallel train 2 is running

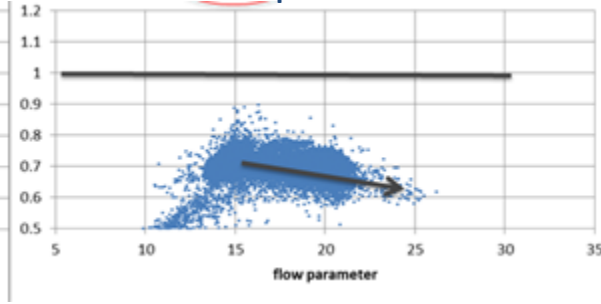


Fouling and unbalanced parallel operation

Efficiency parameter



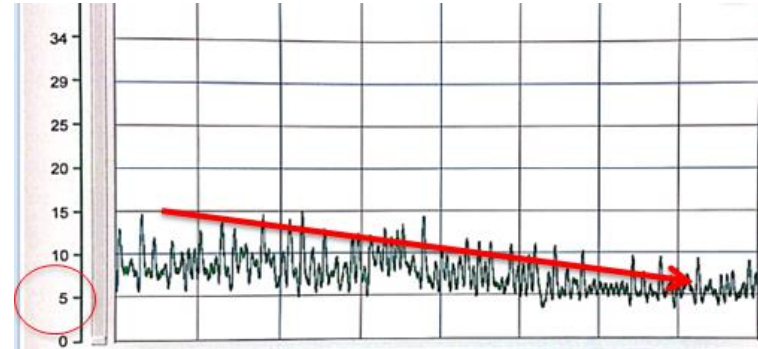
Head parameter



Severe compressor performance degradation, due to fouling phenomena, has been observed

Parallel train load balancing has been further improved in order to compensate for this additional issue, introducing adjustable factors on the throttling valves and recycle valves references

Flared side stream gas



Conclusions/Lesson learned

- On fixed speed back-to-back compressors the presence of the internal leakages can have a negative impact on the production if not properly managed
- A new control algorithm has been developed to mitigate this effect and improve the production
- Advanced dynamic simulation was used to:
 - ✓ validate a new solution before implementing at site
 - ✓ analyze the interaction between the machine and the process to ensure a correct operability and avoid issues during operation

Back-up

Patented Solution

The direct measurement of the current gas composition was not applicable; therefore, the side stream throttling valve controller has been developed based on the effects of the gas leaning on both sections to the available measured parameters. This is an example of so called inferential control in the Oil & Gas industry, applied in general to control product qualities without an on-stream analyzer and it is also a good example on how minimizing the number of measurement devices by leveraging the Physics Based Approach that connects different process/machine variables