Pressure-Driven Steady-State Simulation of Oilfield Infrastructure

Pascal Floquet[1], Xavier Joulia[1], Alain Vacher[2], Martin Gainville[3], Michel Pons[4]

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(2) ProSim, Labège, France
(3) IFP Direction Mécanique Appliquée, Rueil-Malmaison, France
(4) Michel Pons Technologie, Lyon, France

ESCAPE 17 - Bucharest - 27-30 May 2007

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- Part I : Introduction and Problem Statement
- Part II : Pressure-Driven Steady-State Simulation
- Part III : Case Studies
- Part IV : CAPE-OPEN Integration
- Part V : Conclusions and Future Work

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Part I

Introduction and Problem Statement

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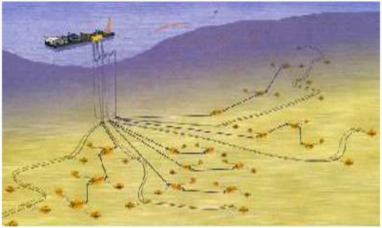
TINA Project

- Transient Integrated Network Analysis
- A TOTAL-IFP research collaborative project
- A platform for integrated multiphase flow simulations
  - From reservoir to process facilities
  - Based on an open software architecture
  - with INDISS as reference simulator
- TINA Application Domain



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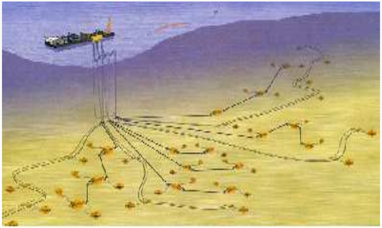

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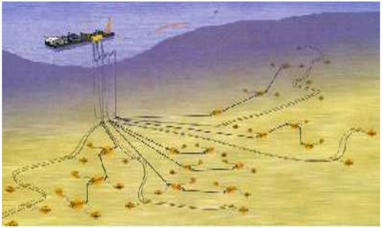

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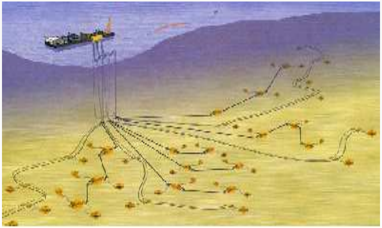

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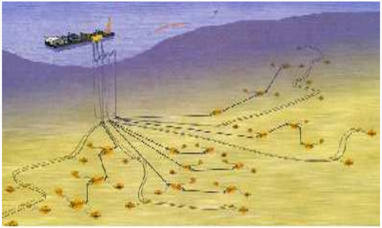

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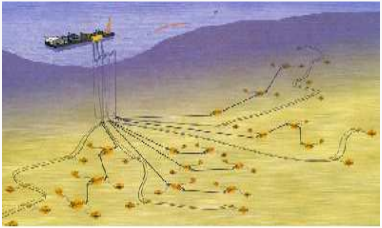

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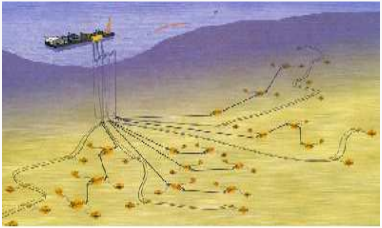

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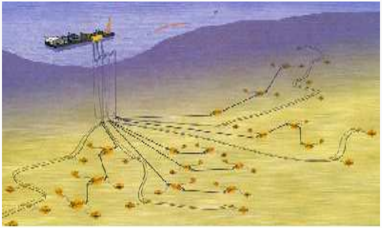

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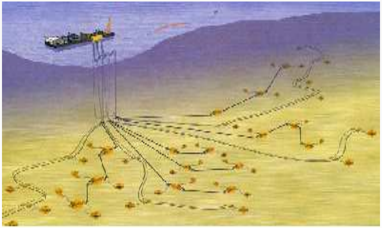

Purpose of the study

Pascal Floquet[1], Xavier Joulia[1], Alain Vacher[2], Martin Gainville[3], Michel Pons[4]

Extend simultaneous modular strategy

- for solving steady-state pressure-driven simulation and design problems
- in Oil and Gas production networks

Interoperate *via* CAPE-OPEN

- Extend INDISS simulator capabilities by integration of ProSim CO-SPEC module
- Extend INDISS simulator capabilities by integration of IFP TOTAL pipeline multiphase flow module

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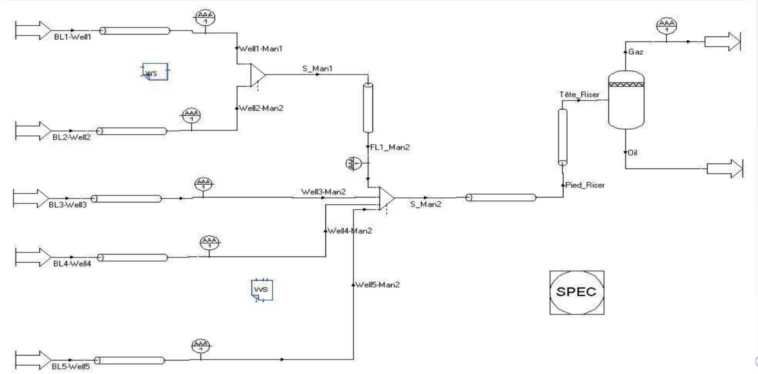
Base Case

Base case description

Two subsea production clusters,
Two and three subsea wells
controlled by choking wellhead valves,
Two flowlines connected to a riser and a basic surface process



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Part II

Pressure-Driven Steady-State Simulation

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Pressure-driven vs classical simulation

Sequential Modular Simulation

X^0 :Temperature T, Pressure P, Composition z and total flowrate Q
d : operating and design parameters of the modules
are the standard input of a pure simulation case

Pressure-driven Simulation

Characterize Oil and Gas upstream operations
For example, pipes connected to the same manifold must operate at the same pressure
n_w Pressure Equality Constraints

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Pressure-driven problem is a particular case of design problem

Variables associated to pressure constraints are

- the well flowrates
- other variables

Two types of problem are treated :

- **Flowrates/Pressure problems**
  - Well flowrates and riser top pressure are known
  - Action variables are chokes openings or well pressures
- **Pressures/Pressure problems**
  - Well pressures and riser top pressure are known
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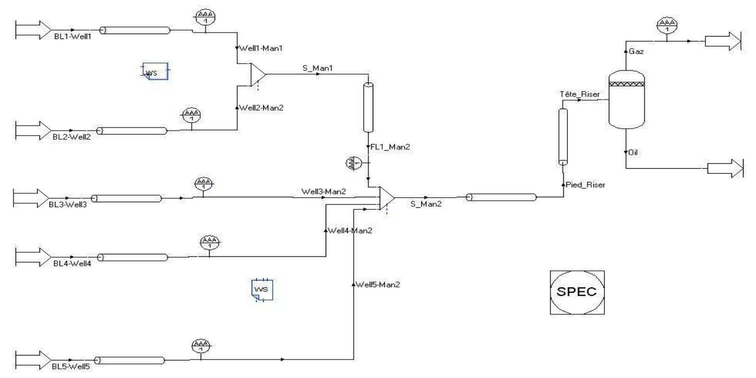
Part III

Case Studies

Flowsheet without recycle

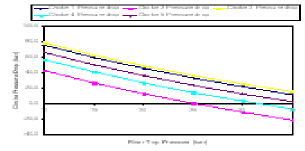


We are interested to examine the ability of convergence of Sequential Modular Simulator in Pressure Driven Problem

FP Problem :

- Specification on the pressure at riser top
- Well pressures, flowrates and temperature are fixed (base case)
- Action variables : 5 pressure drops of the 5 chokes
- *Quasi-Newton* Strategy used
- Results obtained in 4 iterations and 11 flowsheet simulations, for 15 bar

5 Pressure Drops *versus* Riser top pressure specification



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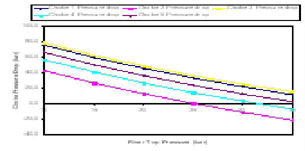

Pressures/Pressure problem

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PP Problem :

- Specification on the pressure at riser top
- Pressures drops of the 5 chokes, well pressures and temperature are fixed
- Action variables : 5 well flowrates
- Results obtained in 5 iterations and 12 flowsheet simulations, for 15 bar
- ...but it depends on initialization !

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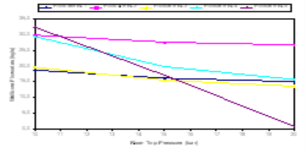

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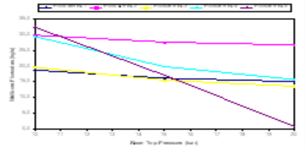
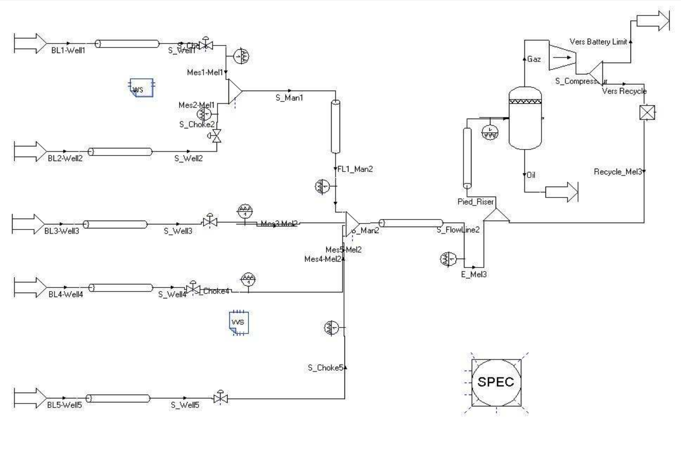


FP or PP Problem with recycle

Here gas-lift may be mandatory.



Flowrates/Pressure Problem

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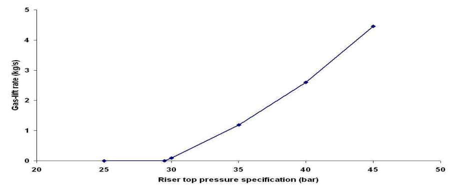
- Specification on the pressure at riser top
- Action variables : pressure drops of 4 chokes and flowrate of gas-lift
- Tear stream : compressor output (15 + 2 (T, P) iterative variables)
- Less eruptive choke completly open
- Results obtained in 5 iterations and 12 flowsheet simulations, for 30 bar

Recycle rate *versus* Riser top pressure specification



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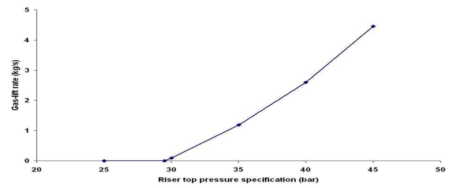

Part IV

CAPE-OPEN Integration

Interoperability

Pascal Floquet[1], Xavier Joulia[1], Alain Vacher[2], Martin Gainville[3], Michel Pons[4]

- ProSimPlus is reference simulator chosen to adjust the approach
- IFP TOTAL pipeline multiphase flow modules are specialized upstream Oil an Gas modules

- ProSim CO-SPEC (CAPE-OPEN Unit Operation 1.0)
- and IFP TOTAL pipeline multiphase flow modules

integrated in INDISS-TINA environment

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Part V

Conclusion and future work

To conclude...

CAPE tools such as ProSimPlus are able to solve pressure-driven simulation
CAPE-OPEN standards are the best way to plug-and-play CAPE software components

Future Works

Multi period optimization in an Oil and Gas context

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THANK YOU FOR YOUR ATTENTION !