Transient Behavior of Pipelines Through Holistic Dynamic Models

BEYOND OPTIMIZE™ 21

Kirti Jain & Sameer Dankejar(CPE),
Silvia Galmes & Miguel Angel Alos (Inprocess)

中国石油集团工程设计有限责任公司
CHINA PETROLEUM ENGINEERING CO., LTD

Overview

China Petroleum Engineering Co., Ltd. (CPE) is a subsidiary of China National Petroleum Corp. (CNPC). CPE provides integrated solution for Oil and Gas field development. And CPE is the Technical Support Centre of CNPC Oil & Gas Field Surface Facilities.

90%	Development Plan, PreFEED & FEED For CNPC Overseas Oil & Gas Field Surface Facilities Projects
50%	PreFEED, FEED For CNPC Overseas Oil & Gas Pipeline and Storage Projects

60+
YEARS
IN OIL & GAS

1200+
TOTAL

28
COUNTRIES

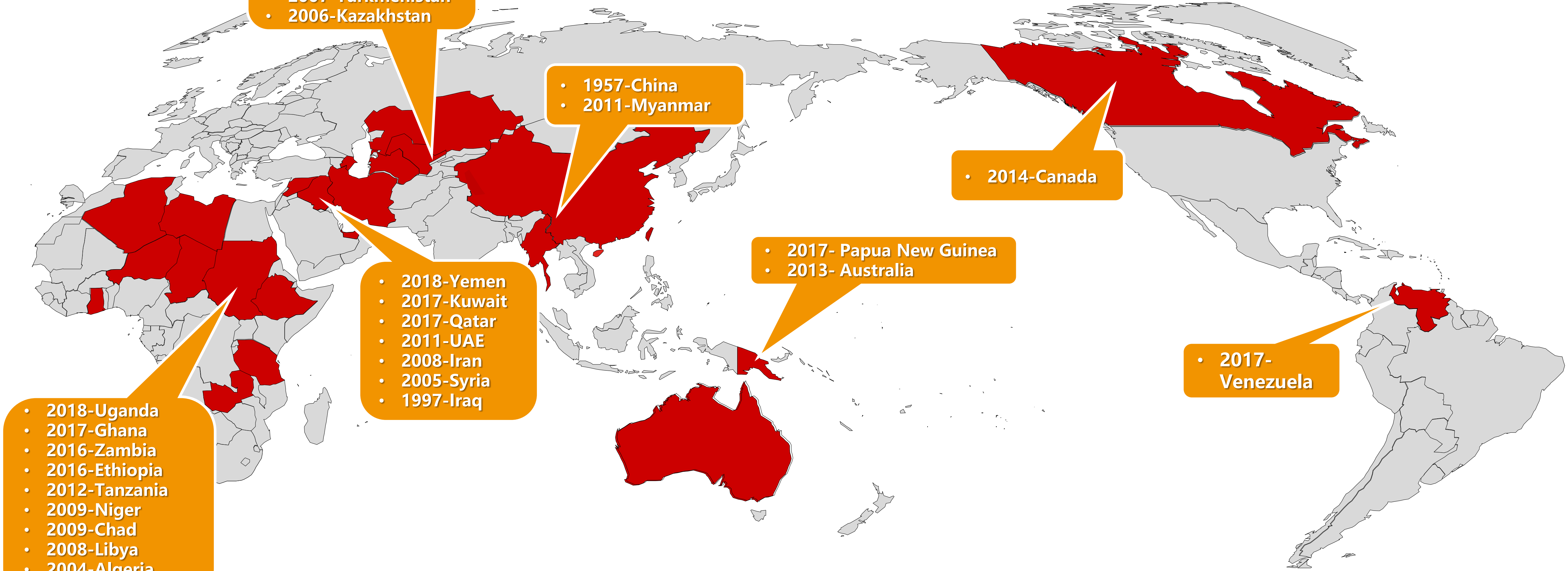
20+
YEARS OVERSEAS

300+
DUBAI OFFICE

100+
OIL & GAS FIELDS

Who We Are

Worldwide Footprint



- 2018-Russia
- 2013-Tajikistan
- 2012-Uzbekistan
- 2007-Azerbaijan
- 2007-Turkmenistan
- 2006-Kazakhstan

- 1957-China
- 2011-Myanmar

- 2014-Canada

- 2018-Yemen
- 2017-Kuwait
- 2017-Qatar
- 2011-UAE
- 2008-Iran
- 2005-Syria
- 1997-Iraq

- 2017- Papua New Guinea
- 2013- Australia

- 2017- Venezuela

- 2018-Uganda
- 2017-Ghana
- 2016-Zambia
- 2016-Ethiopia
- 2012-Tanzania
- 2009-Niger
- 2009-Chad
- 2008-Libya
- 2004-Algeria
- 2001-Sudan

inprocess

Company Introduction

independent from any provider (process simulator or ICSS)

our **core business** is Process Simulation

keen to **share its knowledge** with clients

2006
est. in Barcelona by domain experts

54 countries
worldwide presence

50+
simulation engineers

250+
years experience

350+
executed projects

330+
training courses

Mission

accompany our clients in their success in achieving **safer**, **greener**, more **reliable** and more **profitable** industrial operations

Inprocess Solutions & Services

Lifecycle Modelling and Operator Training Simulators

Process Simulation Studies

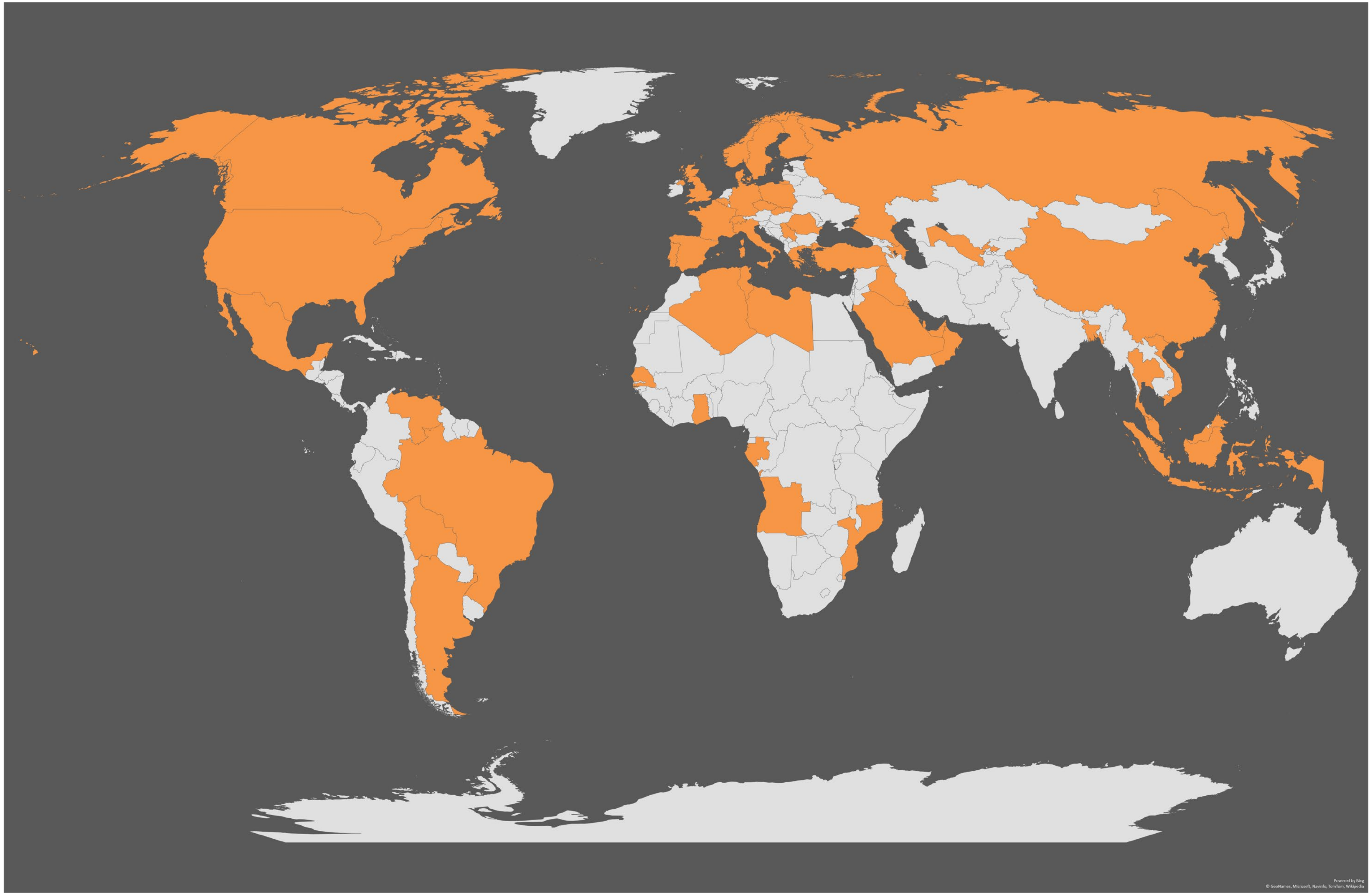
Professional Development & Training

Applications and Software Products

© by Inprocess

Worldwide footprint: Think globally, work locally

- Algeria
- Angola
- Argentina
- Austria
- Azerbaijan
- Bahrain
- Bangladesh
- Belgium
- Bolivia
- Brazil
- Canada
- China
- Czech Republic
- Denmark
- Dubai
- Finland
- France
- Gabon
- Germany
- Ghana
- Greece
- Indonesia
- Iraq
- Italy
- Kuwait
- Libya
- Malaysia
- Mexico
- Mozambique
- Norway
- Oman
- Poland
- Portugal
- Qatar
- Romania
- Russia
- Saudi Arabia
- Senegal
- Serbia
- Singapore
- Slovakia
- Spain
- Sweden
- Switzerland
- Thailand
- The Netherlands
- Trinidad & Tobago
- Tunisia
- Turkey
- UAE
- United Kingdom
- USA
- Uzbekistan
- Venezuela
- Vietnam



Powered by Bing
© GeoNames, Microsoft, Navinfo, TomTom, Wikipedia

© by Inprocess

Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

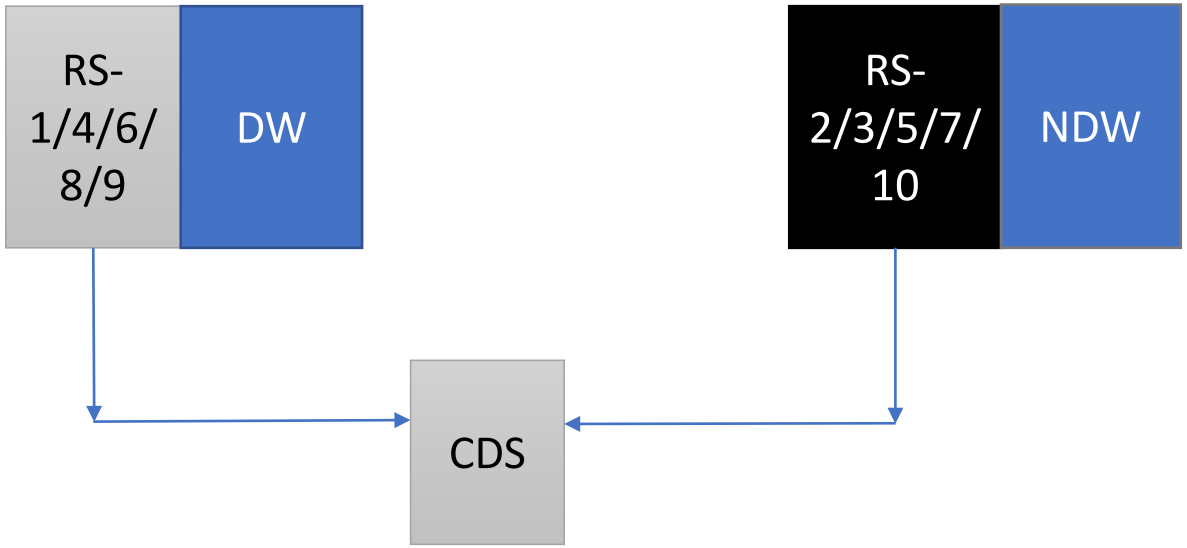
Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Project Description

- An Existing Oil Field presently producing for an Onshore production facility
- Project Intent is to increase crude oil production from the current production rate of 1.1 Million Barrels Oil per Day (MMBOPD) to 1.5 MMBOPD.
- This increase in production will be achieved by developing different fields.

BFD : Crude Gathering Facilities



- Project consist of total 10 remote stations with 5 of RS are having dewatering & remaining 5 without dewatering
- Well connected to RD by flow line & RS connected to CDS via various trunkline of sizes 16" to 20" length of trunkline 30-28 km
- CDS is main processing station consisting seven production trains

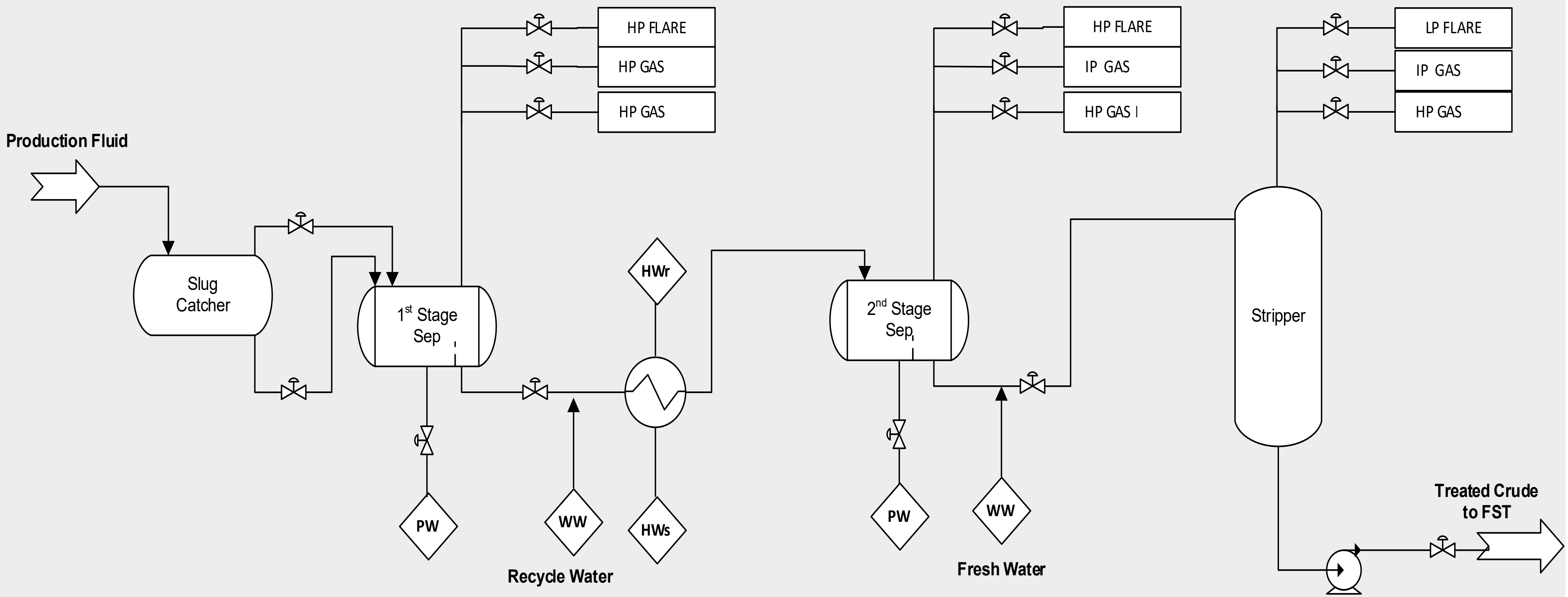
- RS- REMOTE STATIONS
- DW – DEWATERING, NDW – NON DEWATERING
- CDS – CENTRAL DEGASSING STATION

inprocess

BFD : Central Degassing Station (CDS)

中国石油集团工程设计有限责任公司
CHINA PETROLEUM ENGINEERING CO., LTD

Schematic [redacted] Train 8


Production Fluid
Slug Catcher
1st Stage Sep
HP FLARE
HP GAS
HP GAS
HWr
HWs
PW
WW
Recycle Water
2nd Stage Sep
HP FLARE
IP GAS
HP GAS
PW
WW
Fresh Water
LP FLARE
IP GAS
HP GAS
Stripper
Treated Crude to FST

Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Process Challenges & Solution

PROCESS CHALLENGE

Long start up time before the operation reaches normal operating conditions.

Avoid oversizing of equipment such as slug catchers.

SOLUTION

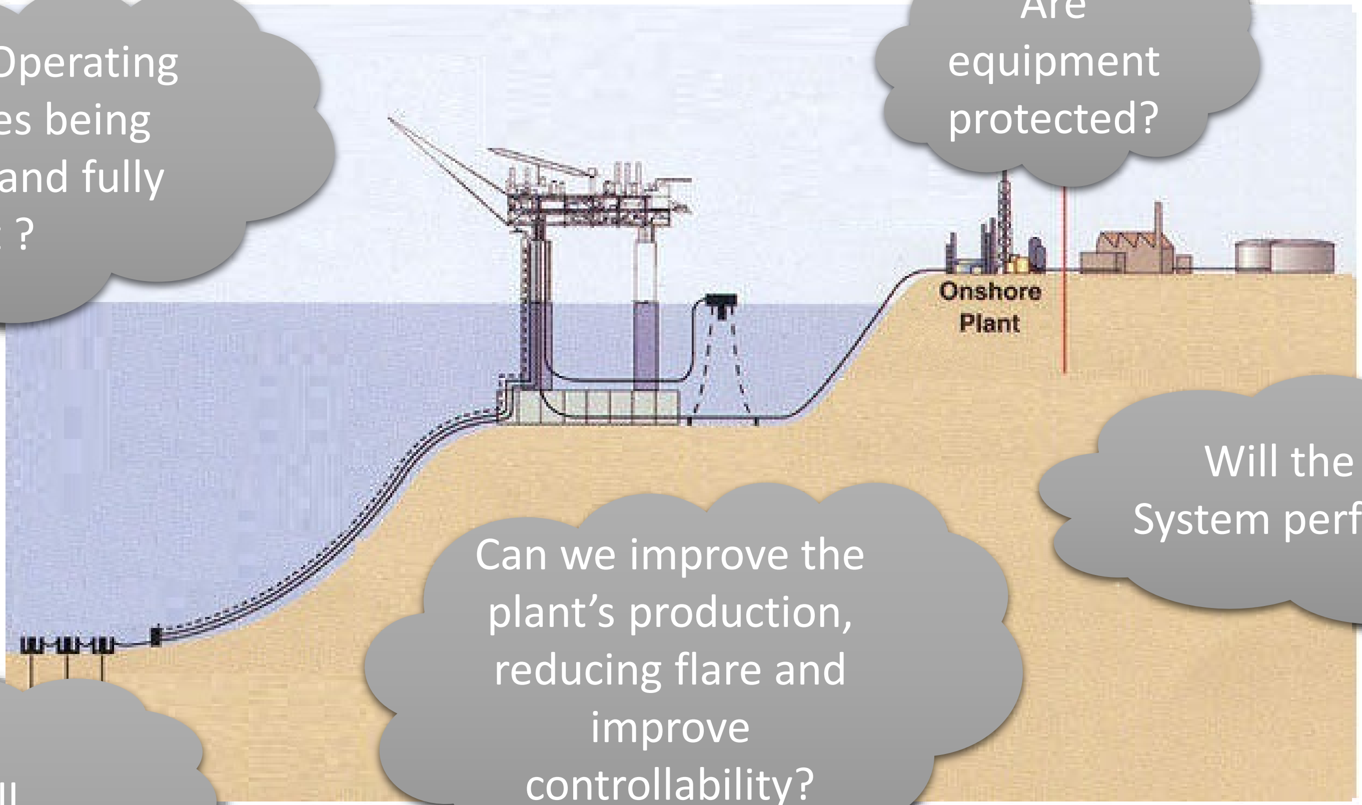
SLUGGING OF PIPELINE

- ➢ Study of Slugging (Hydrodynamic and pigging) behavior of multi-phase fluid in pipeline with production separators to optimize the hold up volume considering drain rate.
- ➢ Fix the trip set points of processing equipment to avoid frequent trips of plant

Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Holistic Dynamic Models



Could the Operating Procedures being improved and fully test ?

Are equipment protected?

Will the Safety System perform well?

Can we improve the plant's production, reducing flare and improve controllability?

Is the design suitable for all potential transients?

Introduction to Holistic Dynamic Models

➢Scenarios during Detailed Engineering Phase

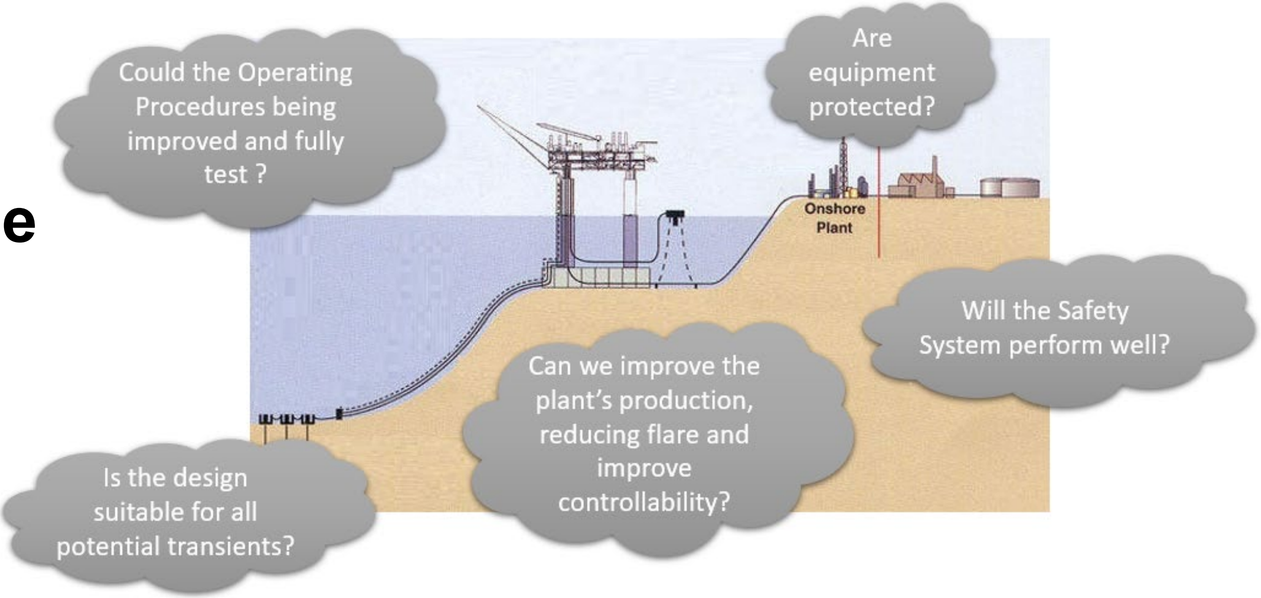
- Emergency Scenarios: Equipment and Instrumentation design check in front of trips, blocked lines, changes in production
- Control Philosophy: Control loops, alarms settings

➢Start-Up Operations

- Facilities Start-Up, wells management
- Early Production Simulation
- Transition to Normal Production

➢Daily Operations and Maintenance

- Analysis for future production rates


Could the Operating Procedures being improved and fully test ?
Are equipment protected?
Onshore Plant
Will the Safety System perform well?
Can we improve the plant's production, reducing flare and improve controllability?
Is the design suitable for all potential transients?

Introduction: Dynamic Simulation Benefits

Save in expensive equipment and materials

Leverage the modelling effort by training plant operators

Avoid lengthy and costly plant start-up

Skip unexpected trips and equipment damage during start-up

Reduce time-to-market and total project schedule

Test operating procedures candidates

Revalidate existing safety equipment

Check and select adequate alternatives in a risk-free environment

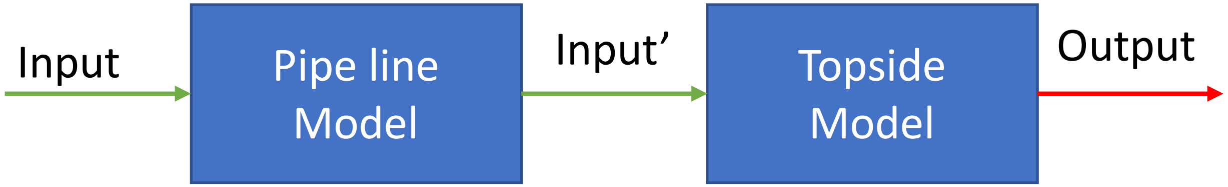
© by inprocess

Agenda

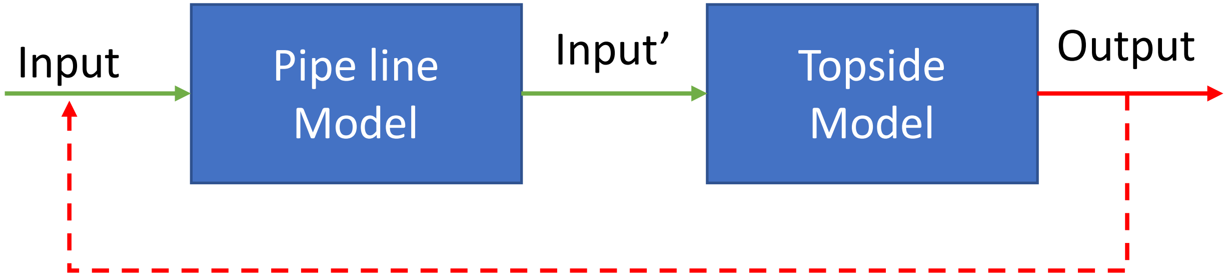
- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Scenarios WITH and WITHOUT link

Without link results

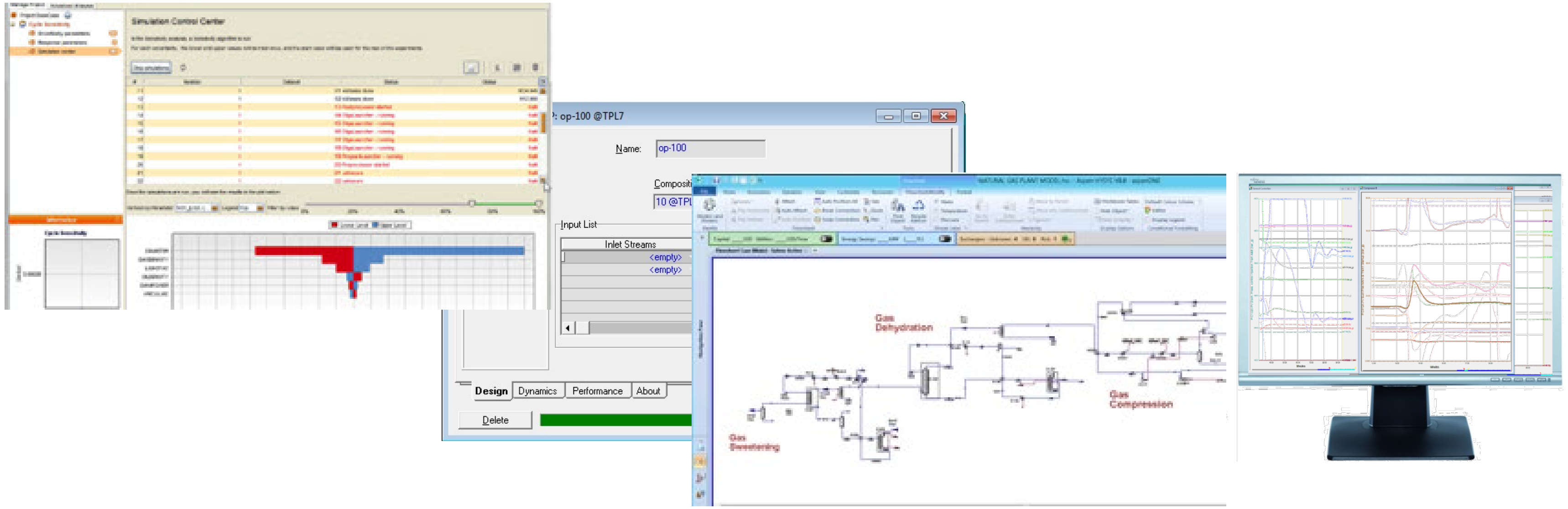

Input
Pipe line Model
Input’
Topside Model
Output

With link results


Input
Pipe line Model
Input’
Topside Model
Output

Why Use Aspen HYSYS-OLGA® Link

- Pipelines Transient Simulation Model (with OLGA®)
- Processing Plant Dynamic Model (with Aspen HYSYS Dynamics)
- Integrated Pipeline-Topside Model (through Aspen HYSYS-OLGA link)


Simulation Control Center
: op-100 @TPL7
Name: op-100
Input List
Inlet Streams
<empty>
<empty>
Design
Dynamics
Performance
About
Delete
Gas Dehydration
Gas Compression
Gas Sweetening

Aspen HYSYS

Advantages of Aspen HYSYS and OLGA® link tool

➢Aspen HYSYS Dynamic Process simulator

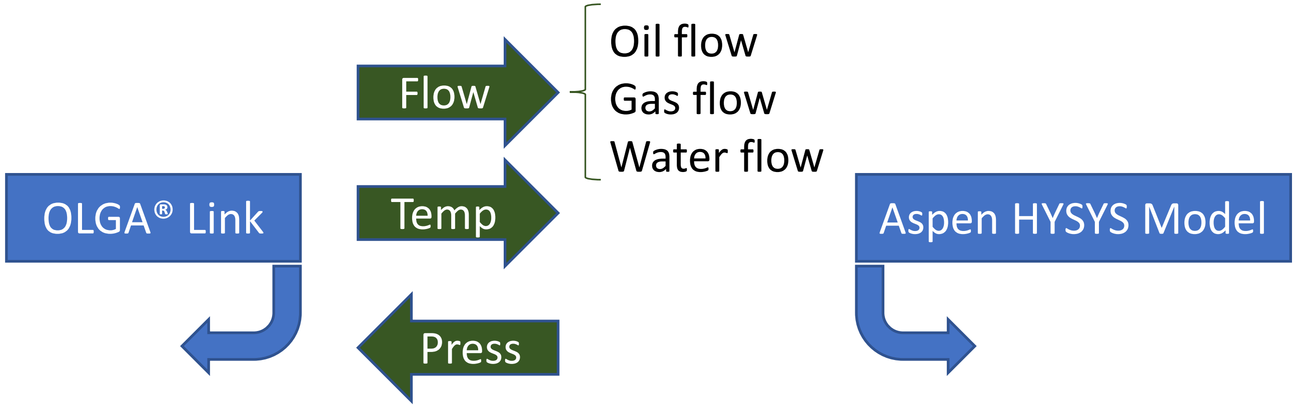
- ***Powerful thermodynamic engine*** for property calculation and three phase equilibrium
- **Very suitable for process equipment** such as rotatory machines, Distillation columns and heat exchangers
- **Pressure balance solver in dynamic Simulation**
- Flexibility to **implement complex control logic**
- **Industrial Standard tool** for Dynamic Process simulation

➢OLGA® Dynamic Multiphase Flow Simulator

- Helps predict multiphase transient behaviour in pipelines from wells to topside process facilities.
- Flexibility to implement long travel distances with complicated pipeline geometries
- It simulates key pipeline operational procedures like start-up, shut-down, and pigging
- Allows prediction of slug dynamics in liquid dominated systems

NOTE: Aspen HYSYS Upstream ™ also includes pipeline hydraulic sub-flowsheet for dynamic multiphase flow simulation.

How to Take Advantage of The OLGA® Link



Long pipelines

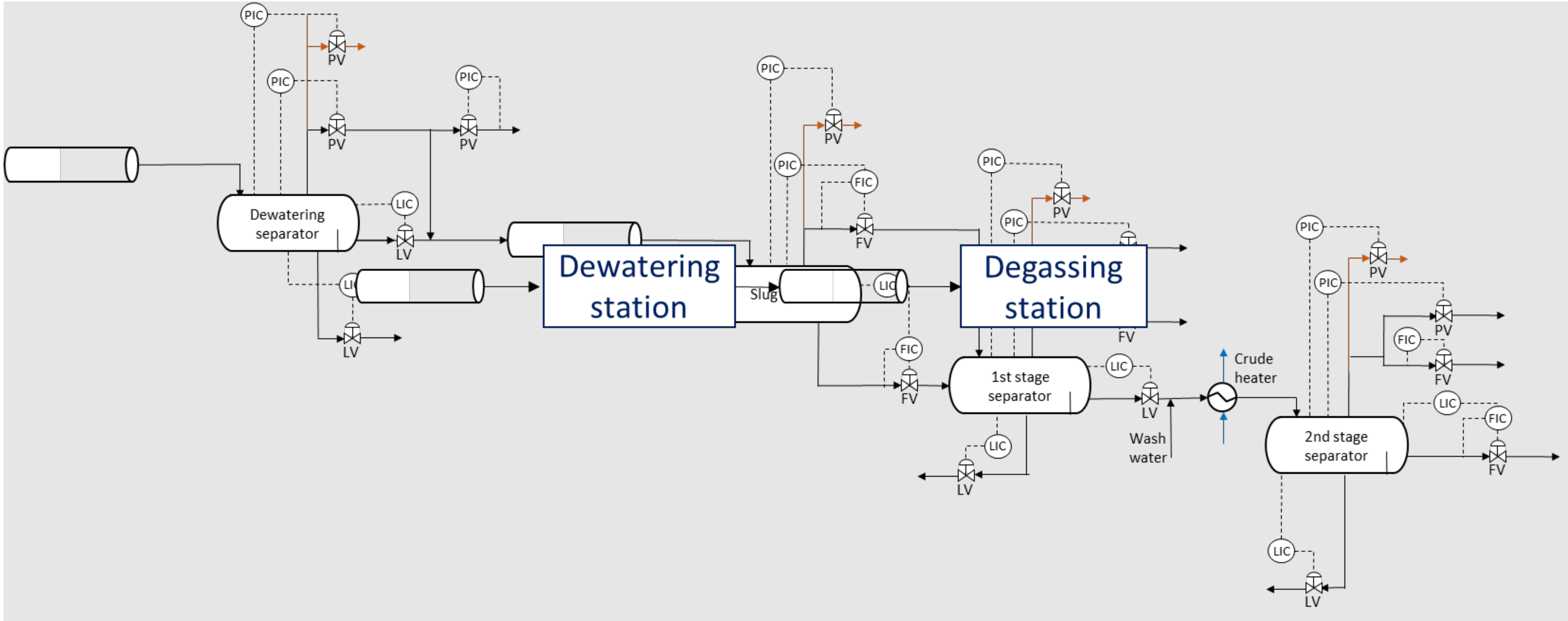
- Terrain profile properly modeled
- Temperature and pressure drop known more accurately
- Slugs profile obtained
- No compositional calculation is used to accelerate the calculations

Process site

- Compositional model is used
- Thermodynamic and flash at each main process equipment is considered
- Complex equipment is modeled
- Control strategy behavior is modelled and known

The integration between Aspen HYSYS and OLGA® Link provides the advantage of both of them to analyze the interactivity between multiphase pipeline and process for the key operational procedures of the Asset

Holistic Model Overview


Dewatering station
Degassing station
Dewatering separator
Slug
1st stage separator
2nd stage separator
Crude heater
Wash water
PIC
PV
LIC
LV
FIC
FV

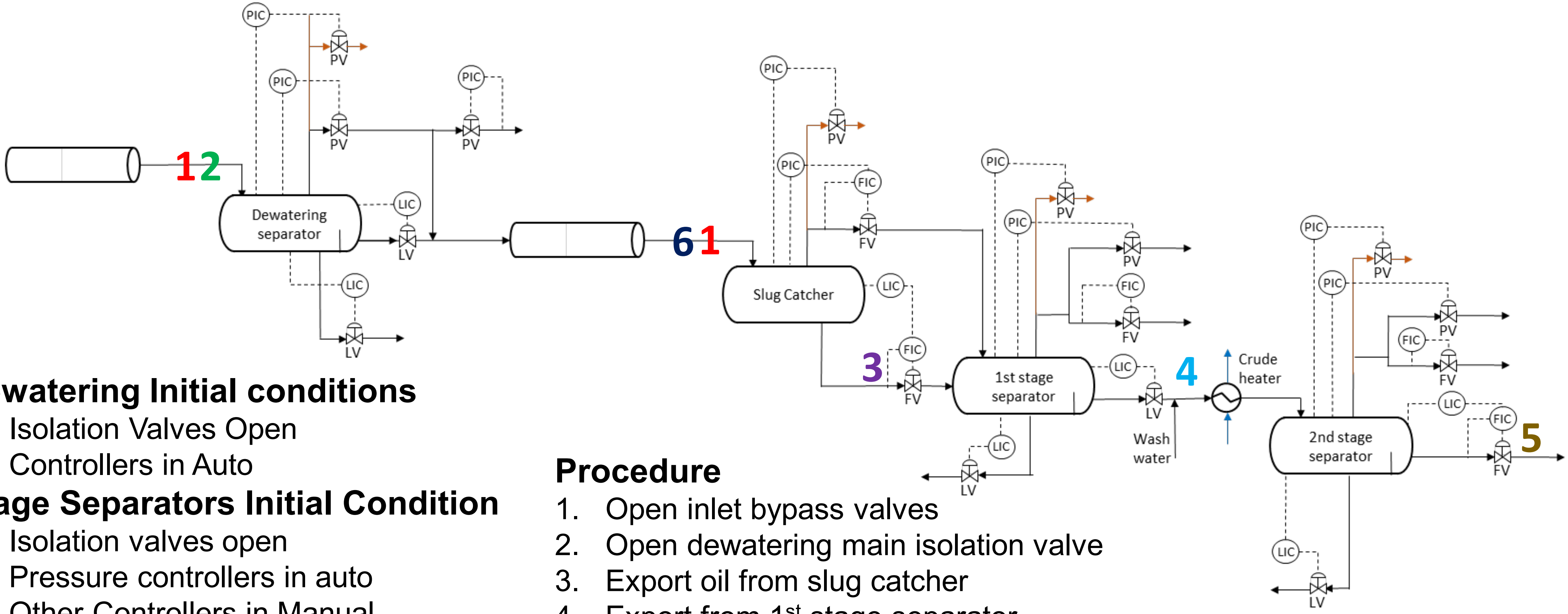
Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Start-up After ESD* - Procedure

Objectives

- Ensure trips are avoided during the start-up
- After ESD some liquid remains in the piping. During start-up this leads to a surge of liquid to downstream separators


PIC
PV
PIC
PV
PIC
PV
1 2
Dewatering separator
LIC
LV
LIC
LV
6 1
PIC
PV
PIC
FIC
FV
Slug Catcher
LIC
FIC
FV
3
PIC
PV
PIC
PV
FIC
FV
1st stage separator
LIC
LV
LIC
LV
4
Wash water
Crude heater
PIC
PV
PIC
PV
FIC
FV
LIC
FIC
FV
5
2nd stage separator
LIC
LV

Dewatering Initial conditions

- ✓ Isolation Valves Open
- ✓ Controllers in Auto

Stage Separators Initial Condition

- ✓ Isolation valves open
- ✓ Pressure controllers in auto
- ✓ Other Controllers in Manual

Procedure

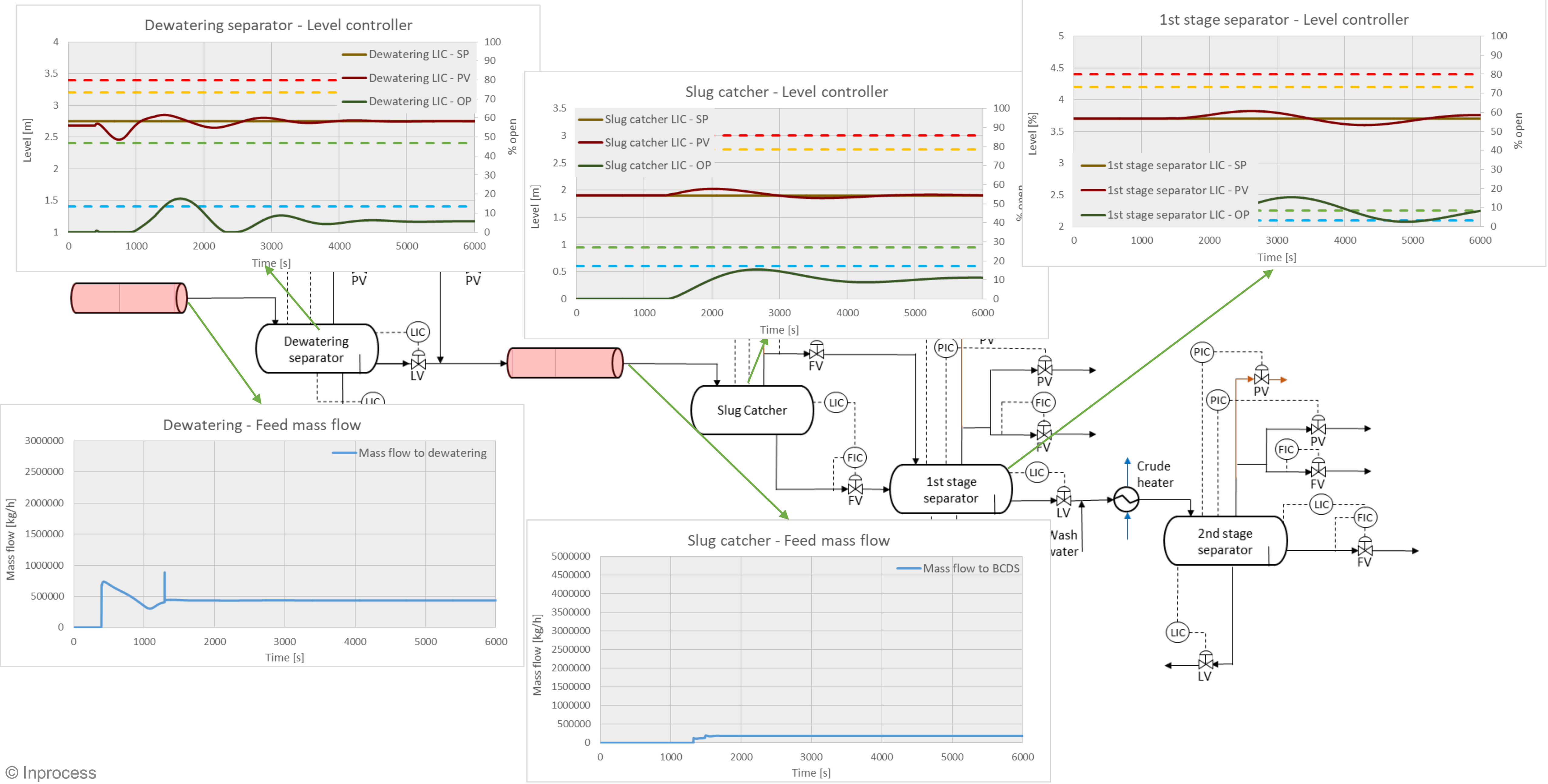
1. Open inlet bypass valves
2. Open dewatering main isolation valve
3. Export oil from slug catcher
4. Export from 1st stage separator
5. Export from 2nd stage separator
6. Open full feed

*ESD- Emergency shut down

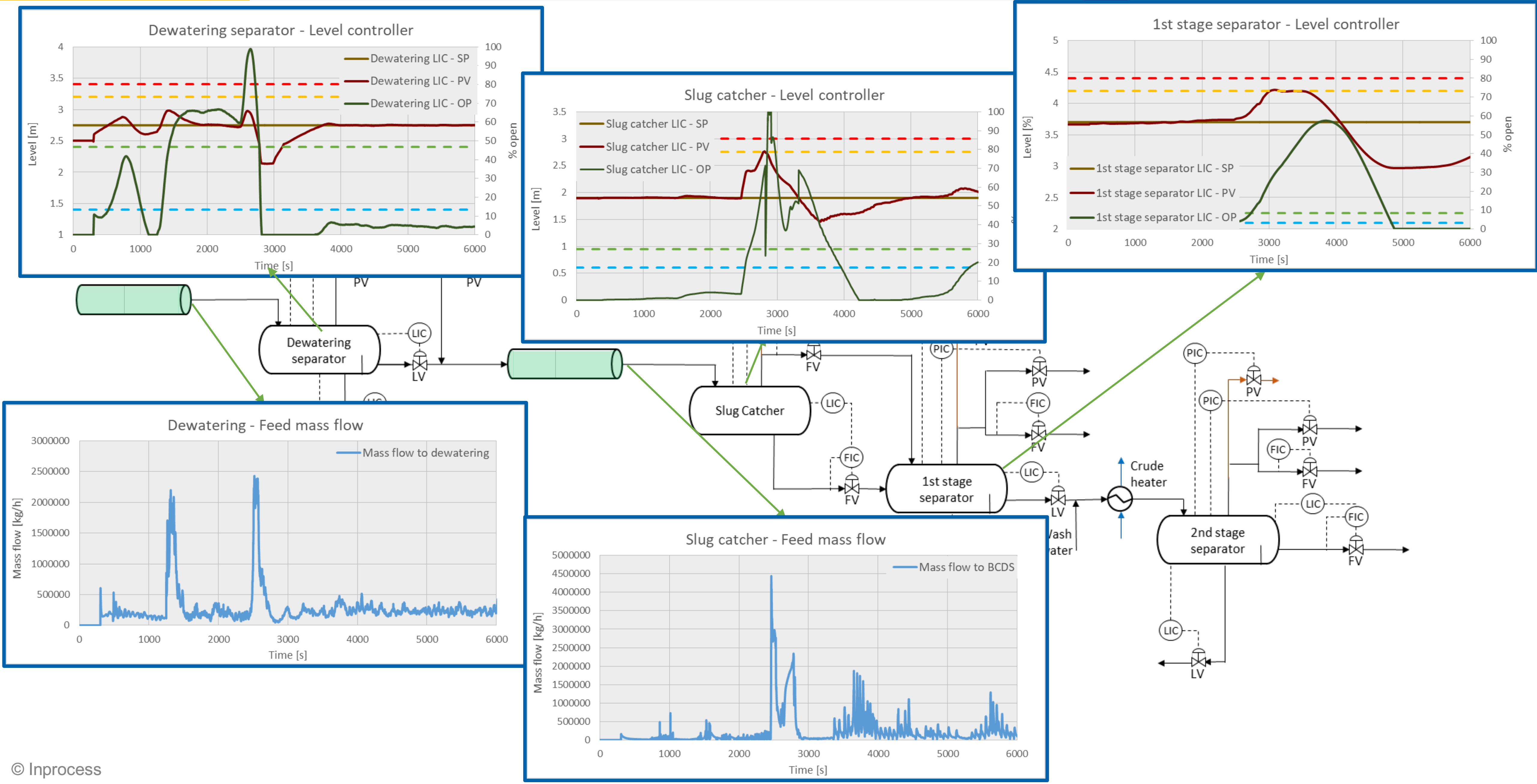
inprocess

Start-up After ESD – Results WITHOUT LINK

中国石油集团工程设计有限责任公司
CHINA PETROLEUM ENGINEERING CO., LTD



Start-up After ESD – Results WITH LINK



Start-up After ESD – Conclusions

General conclusions

✓ Avoided trips in the facilities during start-up

✓ Dewatering section is able to start-up in automatic mode

Aspen HYSYS-OLGA® LINK benefits for start-up

✓ Optimized the start-up procedure, reduces the start-up time by around 40%. For a typical black start-up

- A net saving of 4 days can be achieved for steady state operation
- Considering around 100,000 bbl/day of production & oil price of $50/bbl, results in savings of $20MM

✓ A surge to liquid reaches the facilities

- Stage separators surge of liquid is quite high.
- Controllers needed to be more aggressive than proved during startup without link. Slugging behavior at dewatering station is observed. It is proved that facilities are able to handle the fluctuations produced.

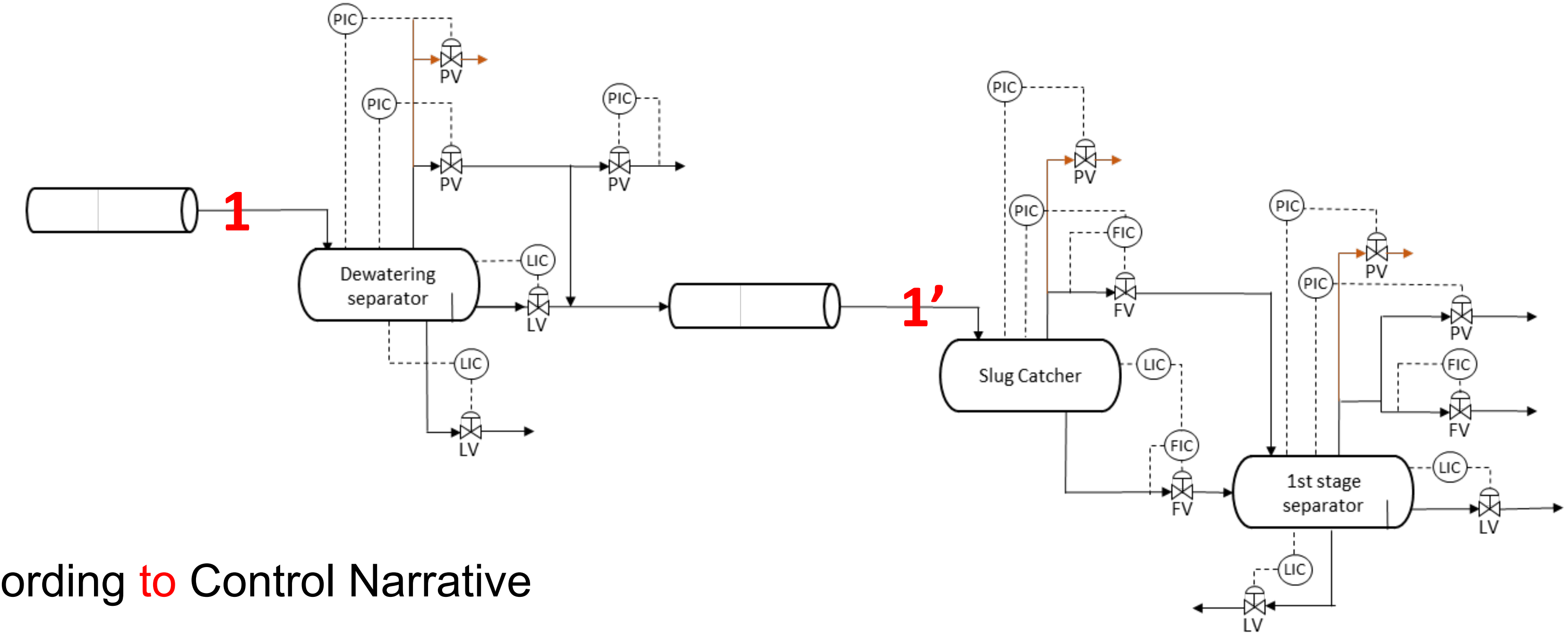
Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Ramp Down - Procedure

Objectives

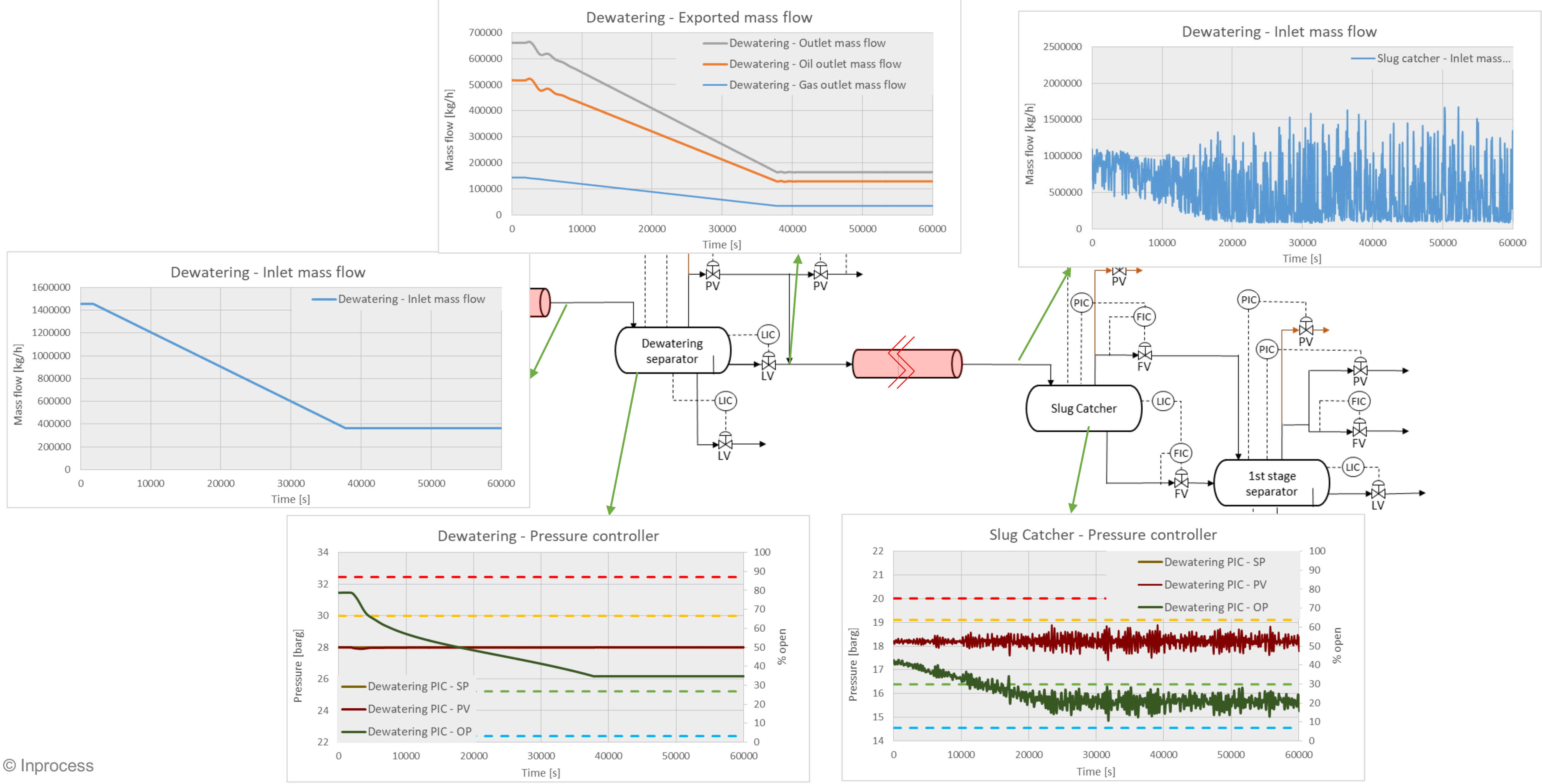
- **To ensure any trip is avoided in the facilities**


PIC
PV
PIC
PV
PIC
PV
1
Dewatering separator
LIC
LV
LIC
LV
1’
PIC
PV
PIC
FIC
FV
Slug Catcher
LIC
FIC
FV
PIC
PV
PIC
PV
FIC
FV
1st stage separator
LIC
LV
LIC
LV

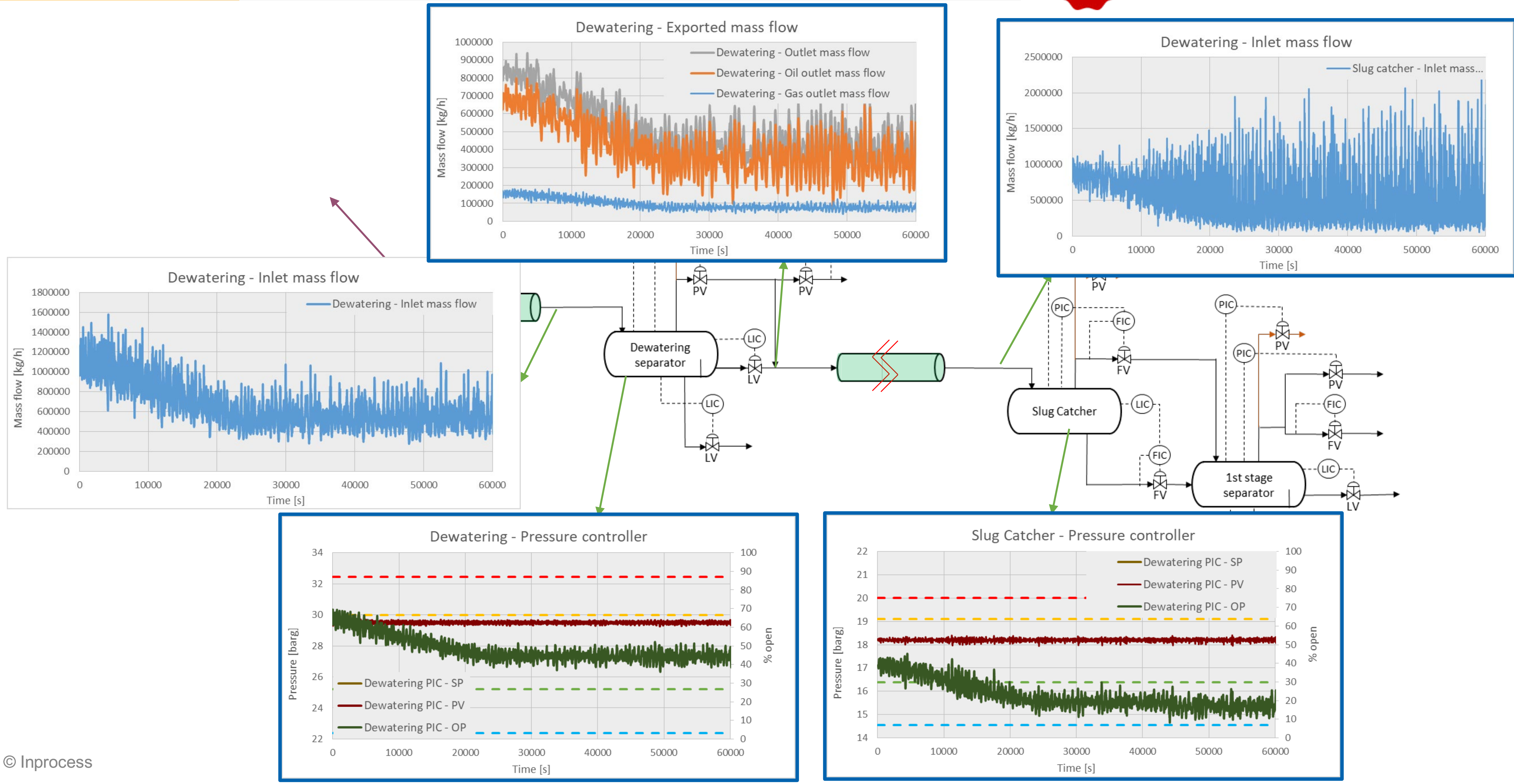
Procedure

1. Ramp down flow according to Control Narrative

Ramp Down – Results WITHOUT LINK



Ramp Down – Results WITH LINK



Ramp Down – Conclusions

General conclusions

✓ No trip is reached during the ramp down scenario

✓ Stage separators sections are able to handle the slug behavior

Aspen HYSYS-OLGA® LINK benefits for Ramp-down

✓ Scenario with the Linked model against data feed model is compared for stage separators

- Higher flowrate peaks than expected are found
- Lower pressure peaks are found

✓ Avoiding a trip could save 2 days of production loss, 50,000 bbl/day at $50/bbl would be around $ 5MM savings

✓ Dewatering separators are able to handle the fluctuations produced with the link

Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Project Conclusions & Comparison for Both Approaches

➢ WITHOUT LINK

➢ Aspen HYSYS Dynamics WITH OLGA® LINK

- No major issue was found during the performance of the scenarios mentioned above

Facilities are able to **handle the fluctuations** produced by the **slugging** behavior

- Startup after ESD was performed with a smooth transition and no significant impact

A surge of liquid reaches the facilities resulting in a peak of level **that needed some fast actions** by the level controllers

- Safety valves are properly sized

Some chattering is observed in the safety valves and measures to avoid them are taken

- Ramp down is performed with no major issue. Slugging in Stage Separator causes no trip alarm

No issue is found either. **Slugging flow is higher than predicted** without link while pressure spikes are lower.

NOTE: Aspen HYSYS Upstream ™ also includes pipeline hydraulic sub-flowsheet for dynamic multiphase flow simulation.

Agenda

- **Project Description**
- **Process Challenges**
- **Introduction to Holistic Dynamic Models**
- **Why use Aspen HYSYS-OLGA® link**
  - Advantages of Aspen HYSYS and OLGA® link
  - How to take advantage of the two of them
  - Holistic model overview
- **Scenarios 1: Start-Up**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Scenarios 2: Ramp Down**
  - Objectives and scenario overview
  - HYSYS results
  - Linked vs. non-linked model results
  - Scenario Conclusions
- **Overall Project Conclusions & Comparison for both Approaches**
- **Benefits and Future Improvements of using the Aspen HYSYS-OLGA® Link**

Benefits & Future Improvements

- **Benefits of Using Aspen HYSYS Dynamics -OLGA® Link**
  - Improve fidelity of dynamic process model boundaries
  - Optimise plant inlet arrangement to maximize production
  - It allows the analysis of the impact of piping scenarios over facilities such as pigging operations or wells start up
  - It provides the capability of understanding how the controllers impact over the pipelines facilities
  - It gives feedback on whether the facilities are able to handle the slugging behavior
  - Optimised the start-up procedure, reduces the start-up time by around 40%. For a typical black start-up
    - A net saving of 4 days can be achieved for steady state operation
    - Considering around 100,000 bbl/day of production & oil price of $50/bbl, results in savings of $20MM
  - Avoiding a trip could save 2 days of production loss, 50,000 bbl/day at $50/bbl would be around $ 5MM savings
  - Avoided overdesign of slug catcher
  - Additionally, other issues could be study like accurate estimation of the HIPPS plant safety time, resulting in a better visualization of operating parameters.
- **Future Improvements**
  - Less computational time to reduce the required man hours