Challenges in industrial dynamics: coupling process simulation with accident simulation

Sara Brambilla and Davide Manca
Dipartimento di Chimica Materiali e Ingegneria Chimica
Politecnico di Milano – ITALY
Presentation outline

- **Dynamic Process Simulator** features
- **Accident Simulator** features
- A step forward: **coupling two worlds**
- **Example** of accidental scenario
- Simulation **results**
- Discussion
- Conclusions
Dynamic Process Simulator features

Dynamic process simulators allow:

• **checking control system configurations** before implementing them on the real plant so as to uncover possible control system errors;

• **training the operators** to increase their awareness and skill;

• planning and testing the **start-up** and **shutdown** procedures;

• increasing **process safety** by testing and validating the operative procedures in a non-destructive environment.
Accident Simulator attributes

The Accident Simulator allows simulating the:

- emission of liquid/gas substances;
- pool spreading and shrinking over soil and water;
- pool boiling (cryogens) and liquid evaporation;
- pool fire;
- view factors of surrounding process units;
- radiative heat flux to process units and field operators;
- gas dispersion in complex environments;
- …
**Accident Simulator features**

The **Accident Simulator** allows:

- improving the **training of operators** to increase their awareness and skills;
- performing an **accident investigation** to learn from accident;
- **assessing** and **managing** the **safety**, to reduce the probability of accidents and the magnitude of their consequences;
- evaluating the **effectiveness of mitigation systems**.
Coupling two worlds...

- The previous remarks are consolidated knowledge.
- However, at present, dynamic process simulators and accident simulators are two different, independent worlds.
- **We coupled them to produce a software tool that is more than sum the of their strong points.**
The coupling

**Dynamic Process Simulator**

\[ n\dot{x}_z(t_n), n\dot{x}_v(t_n), T(t_n) \]

\[ Q_{irr}(t_n), C(t_n) \]

**Accident Simulator**

**DYNAMIC SIMULATION**

The Accident Simulator is either a standalone program or a user-added module of the process dynamic simulator.
Accidental scenario

**Storage tank**

- Diameter: 6 m
- Height: 5 m
- Liq. level: 3 m
- Holdup: 84.8 m³

**Intermediate process tank**

- Diameter: 1 m
- Height: 2 m
- Liq. level: 0-5 m
- Holdup: 0.4 m³
Intermediate process drum

Temperature increase: 8 K
Max radiative flux: 60 kW

Ignition

Valve closure
Storage tank

Temperature increase: 0.4 K
Max radiative flux: 310 kW

Ignition
Valve closure
Discussion

• **Different response dynamics** to the same accidental event in terms of both **offset** and **characteristic time**

• When the flame extinguishes, the temperature of the process drum goes back quicker to the steady-state value because of the lower material inertia and of the continuous operation
Conclusions

• This presentation showed:
  ▪ the **link** of an accident simulator and a dynamic process simulator;
  ▪ the **quantification** of the **interactions**;
  ▪ the **effectiveness** of the approach in:
    • checking the **control system configurations** in case of unexpected events;
    • improving the **operator’s training** and **awareness**.