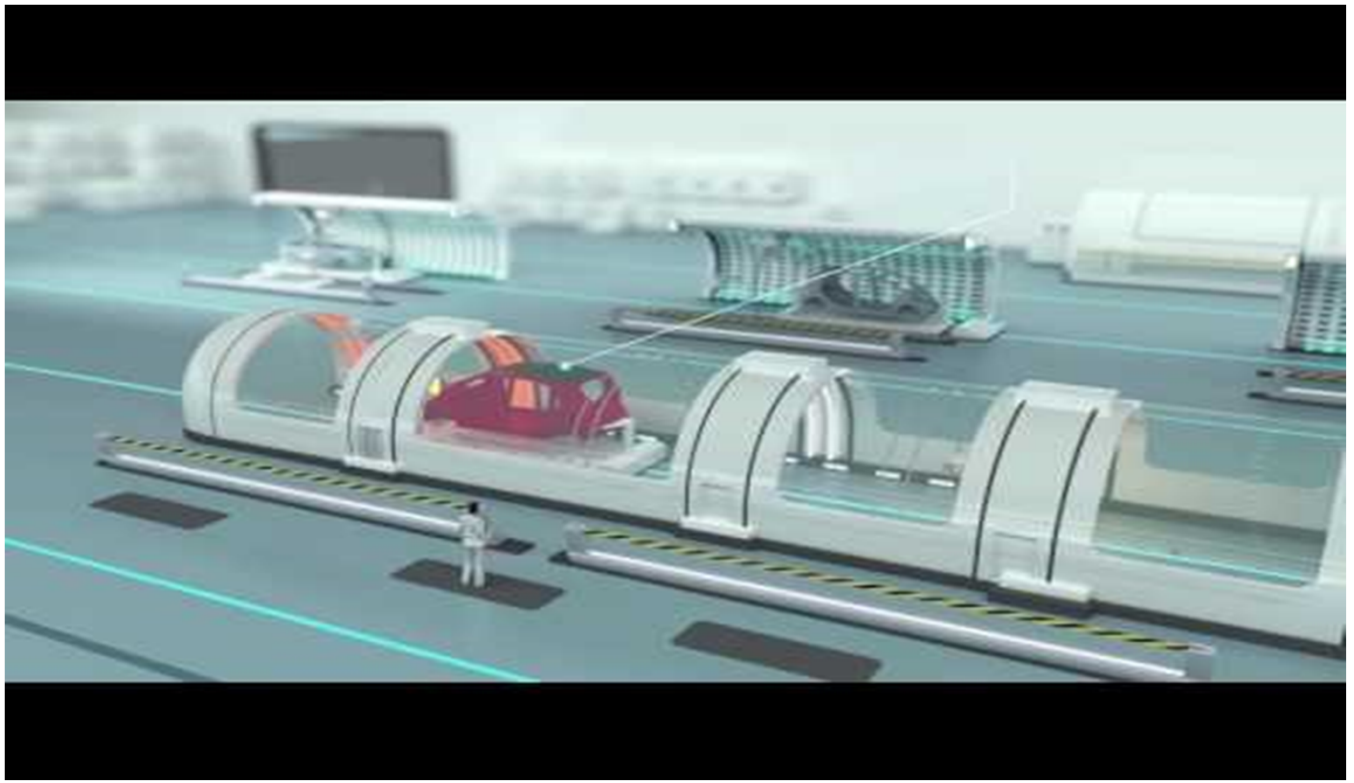
Smart factories for chemical sector; threats or opportunities for the risk control?

Franck Prats

INERIS
maîtriser le risque
pour un développement durable

Smart factory : the concept

Example: From the order to the delivery of a new car



https://www.youtube.com/watch?v=igW-MyX7PkI

Smart factory : the concept

Ideally, this new way of manufacturing may:

- Decrease the delay of development of a new product through the use of numeric tools :
  - Design of the product: the use of Virtual Reality becomes intensive in the automotive industry (more generally assembly industries)
  - Use of simulators to perform a large spectrum of tests
- Give the opportunity of direct integration into the manufacturing process:
  - Change during the conception
  - Feedback process will operate during the manufacturing and the use of the product

⇨ at the end of the development the result is a **digital twin of the final product**

Smart factory : the concept

Ideally this new way of manufacturing may:

- **Decrease the delay of industrialization by the massive use of robots and virtual reality** :
  - Flexible robots (no fixation on the ground, use in cooperation with human operator, self control functions, …); robots are supposed to increase human capabilities/expertise
  - Manufacturing devices connected to each other and final product compared to the digital twin at each step of manufacturing (internet of things)
  - Virtual/Augmented Reality applications use to support operators during manufacturing, training
  - Artificial intelligence applications use to give deep learning capabilities to robot or supervision centre
  - Real time connections with end-users, RD Department and suppliers

    – More flexible factories
    – Less quality defaults

Is it possible for chemical industry?

Challenges to face :

- Acceleration of the speed of product innovation : in 70's the time to market (half time of product innovation) for a new substance was around 10 years and nowadays around 1 year : speeding up the product/process development is necessary to preserve high margin business
- Rapid growth in consumer demand for targeted end-use (complex) properties (therapeutic activity, sensory property…) or functions (cleaning, adhesion,…) meaning constant adjustment to the market demand

Possible evolutions for chemical industries :

- **High-volume bulk chemicals** (40% of the market and worldwide - capacity assumed increase by a 6 fold by 2050)-**Need of process optimization:**
  - Process intensification (increase of temperature, pressure, decrease of the size of equipment),
  - Use of new catalyst, solvent, …
- **Batch industries** (active material industry, pharmaceutical, cosmetics,…)-**Need of flexibility :**
  - Generic equipment and/or multipurpose equipment
  - Flexible organization of the production: no dedicated equipment but rather in whatever equipment available at the specific time

Is it possible for chemical industry?

Decrease the delay of development of a new product by the use of numeric tools/simulations :

- **High-volume bulk chemicals:**
  - Use of Computer Fluid Dynamics (CFD) approaches in order to:
    - optimize the process (T, P, …),
    - determinate the location of sensors for process control (real time control)
  - Development of a digital twin and use of artificial intelligence approaches in order to have predictive maintenance (see video) and/or manufacturing advise
- Use hybrid multifunctional process/equipment (catalytic distillation, reactive extraction or absorption, …)

https://www.youtube.com/watch?v=2dCz3oL2rTw&feature=youtu.be

Is it possible for chemical industry?

Decrease the delay of development of a new product by the use of numeric tools/simulations :

- **Batch industries**:
  - Use of Computer Aided Molecular Design and/or Virtual laboratory (coupled with real laboratory tests) in order to have a fast development of substances able to match the end user requirements
  - Use of Computer Aided Process Engineering (and/or Process System Engineering) in order to optimize the supply chain and the time taken by each individual process stages :
    - Identification of the possible bottle-neck production
    - Identification of the quantity of the targeted material in each individual process stages
  - Use of coupled CAMD/CAPE approaches in order to increase the speed of process scale-up

Is it possible for chemical industry?

Decrease the delay of industrialization by the massive use of robots and virtual reality :

- Virtual/Augmented Reality for supporting operators during manufacturing, training ; already done for maintenance (Air Liquide Connect project : https://www.airliquide.com/connected-innovation/connect-digital-technology-heart-our-plants)
- Artificial intelligence for giving learning capabilities to robot or supervision center (see GE video)
- ?Flexible reactor/equipment (no fixation on the ground, automatically linked equipments, use in cooperation with human operator, self control functions,…);?
- ?Manufacturing devices connected to each other and final product compared to the digital twin at each step of manufacturing (internet of things)?
- ?Real time connections with end-users, RD Department and suppliers?

What are the potential challenges for safety control?

New products/substances

- Will it be necessary to assess the different numeric approaches which are supposed to speed-up the development of new substances? How is it possible?

Digital twin

- Will it be necessary to assess the different thresholds used to do predictions? Will it be necessary to assess the numeric approaches used as artificial intelligence? How is it possible? How will be possible to perform an audit/inspection of the maintenance policies?

Implementation of robots and virtual reality

- How is it possible to assess the impact of these new technologies on:
  - Human behavior?
  - Organizational behavior?

What are the potential challenges for safety control?

Risk identification and assessment

- Is HAZOP Method adapted to drift identification of hybrid multifunctional process/equipment?
- Because of the possible acceleration of the industrialization :
  - Will a change in the process conditions (use of new reactor/equipment even of lower capacity, use of new conditions of temperature, pressure,…) be automatically assessed?
  - Will it be possible to computerize HAZOP studies?
- In case of leak on an intensified process, will the “traditional” simulation methodologies adapted to these conditions of scenario? (multiphasis leaks, supercritical solvents, …)
- Will it be possible to develop digital safety study or emergency plan?

What are the potential challenges for safety control?

Intensification of “traditional” process

- With intensification of process will it be possible to reduce the volume/amount of chemicals involved in the process and to have smaller plants. Is the Seveso classification system still relevant (based on the quantity of product)?

Some reference

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- Integrated Chemical Product-Process Design: CAPE Perspectives – Rafiqul Gani – ISBN: 3-527-30804-0 (2006)

- Air liquide digital policy/approach (Benoit Potier of Air Liquide Keynote at Financial Time Manufacturing: https://www.youtube.com/watch?v=LC6Egjyuyug)

- The future of employment: how many jobs are susceptible to computerisation?-Carl Benedict Frey and Mickael A. Osborne- September 17, 2013

QUESTIONS

Thank you for your attention