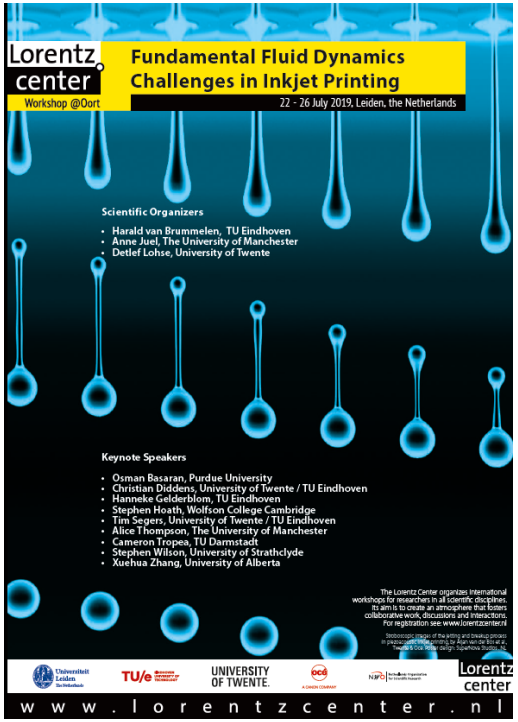
P2SAC SPRING 2023 CONFERENCE

Welcome, overview and what is P2SAC?



Safety
(npr.org)

→

Safety *and* assurance
(agdaily.com)

→

Flow assurance

Osman Basaran

Burton and Kathyrn Gedge Professor *and*
Academic and Founding Director of P2SAC
Davidson School of Chemical Engineering/Purdue University

OUTLINE AND GOALS

- Welcome to the **18th** biannual P2SAC conference!
- At the start of each day, Ray Mentzer and/or I will go over the agenda and provide corrections or updates to the program
- Also at the start of each day, Ray and/or I will provide an overview of P2SAC as well as a summary of our activities during the previous year
- I will also briefly touch upon the plans for the Fall 2023 conference (to take place in early December)

CENTER MANAGEMENT

- **Osman Basaran**, Burton and Kathryn Gedge Professor of Chemical Engineering:
  Academic and Founding Director (AD) of P2SAC
  [obasaran@purdue.edu]

- **Ray Mentzer**, Professor of Engineering Practice:
  Executive Director (ED) of P2SAC
  [rmentzer@purdue.edu]

- **Web site:** https://engineering.purdue.edu/P2SAC

EVOLUTION OF TWICE-A-YEAR P2SAC CONFERENCES

- The first conference (Fall 2014) and more than half a dozen subsequent conferences consisted of very full, one-day meetings

- We then introduced multi-day mini-conferences consisting of:
  - **Regular safety mini-conference** (*to be held twice a year*)
  - **Safety in the pharmaceutical industry mini-conference** (to be held once every 12 or 18 months)
  - **Flow assurance mini-conference** (to be held once every couple of years)

- A set of **tutorials** lasting half a day were then added to the program in Fall 2019 (to be held twice a year) but soon grew into a full-day program (with one exception) beginning in Fall 2021

P2SAC CONFERENCES: EVOLUTION AND OUTLOOK

- **Early years:** the first conference (Fall 2014) and about a half a dozen conferences after that consisted of very full, one-day meetings

- **Subsequent years:** multi-day mini-conferences consisting of
  - **General safety conference** (*twice a year*)
  - **Safety in the pharmaceutical industry conference** *(once a year*)
  - **Flow assurance conference** *(once every couple of years)*
  - **Tutorials** lasting one half to (hereafter) full day (*twice a year*)

- **Fall 2021:** company-led session on discussion of **management systems**
  Spring 2022: open discussion sessions and talks on professional development
  Spring 2023: additional types of open discussions (see agenda)

- After a two-year pause due to Covid 19 during which all meetings were virtual, future conferences will be FTF without a virtual option

AGENDA FOR SPRING 2023

Please, see other set of slides
for the conference
agenda/program

WHAT IS P2SAC?

- P2SAC is an academic research center that is based in the Davidson School of Chemical Engineering at Purdue University.
- P2SAC was conceived in 2013 and launched in 2014 by Professor Osman Basaran who is the Academic and Founding Director of the center (henceforward the AD).
- Dr. Ray Mentzer joined the center as Executive Director (ED) in 2016.
- P2SAC is focused on problems that fall in the large subject of safety and process and/or product assurance (hence the name the ***Purdue Process Safety and Assurance Center,*** **P2SAC**).
- Approach adopted at P2SAC, while **driven by problems in industry**, is **research-based**. P2SAC is not involved in critically important but more applied safety issues, e.g. training of first responders.
- P2SAC is almost entirely funded by membership fees paid by its industrial member companies or sponsors.

CURRENT INDUSTRIAL MEMBERS/SPONSORS* (I)

*The center's Advisory Board also includes **Air Products** and The National Institute for Occupational Safety & Health (**NIOSH**).

CURRENT INDUSTRIAL MEMBERS/SPONSORS* (II)

*The center's Advisory Board also includes **Air Products** and The National Institute for Occupational Safety & Health (**NIOSH**).

- We thank our sponsors for both their financial support but also their selfless participation in the center's many activities (as to be discussed).

- One out of seventeen engineers is a Purdue graduate. Therefore, our sponsors are making a huge impact with respect to the education, training, and development of future engineering and science talent. Moreover, they in turn reap many benefits by being members of P2SAC (as also to be discussed).

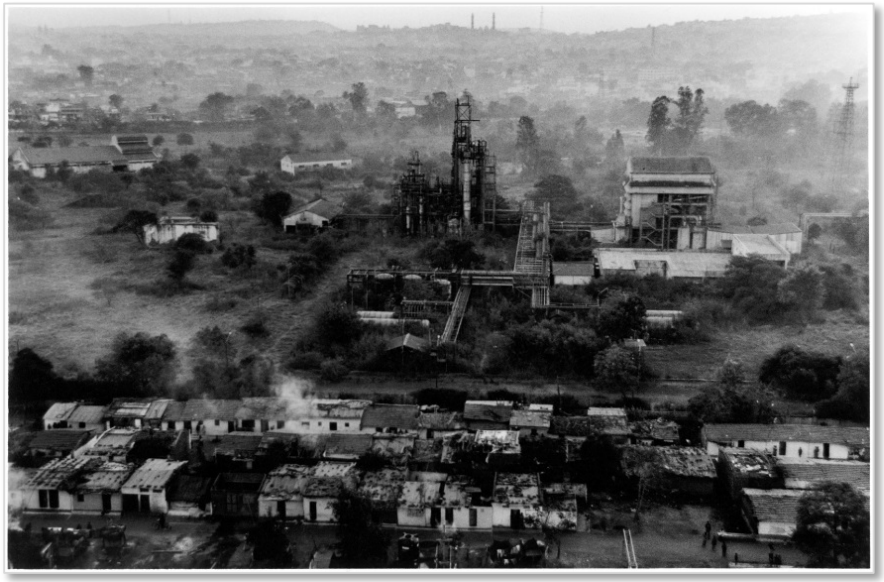
CURRENT INDUSTRIAL MEMBERS/SPONSORS* (III)

*The center's Advisory Board also includes **Air Products** and The National Institute for Occupational Safety & Health (**NIOSH**).

As we will discuss during the conference, some *benefits of membership* include:

- Direct as well as indirect involvement in research programs/efforts
- Early and/or first access to research results
- Preferential treatment with respect to licensing patentable technology
- Unique opportunity and advantage in identifying safety professionals as potential permanent hires
- Preferential treatment in identifying and hiring talent for internships which in some cases lead to permanent positions when the student finishes their studies

PURDUE PROCESS SAFETY & ASSURANCE CENTER (P2SAC)



Bhopal, India (1984): At least 3,787 and over 16,000 claimed fatalities

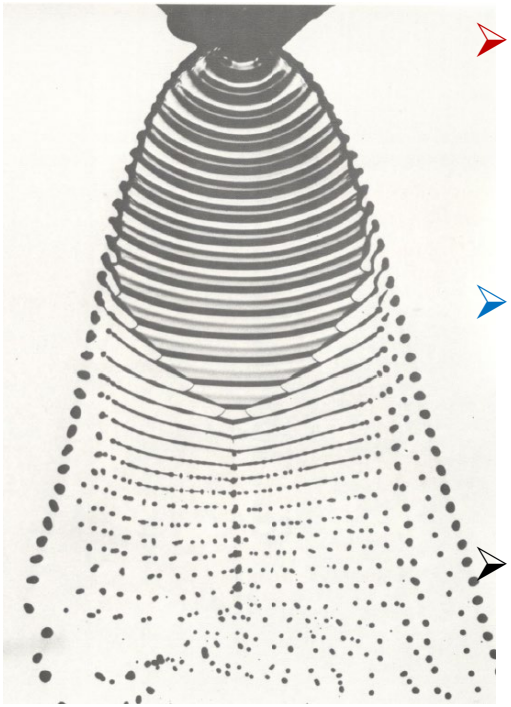
West Pharmaceuticals, NC (2003): 6 fatalities

BP Texas City (2005): 15 fatalities

Imperial Sugar, Georgia (2008): 14 fatalities

WHY ASSURANCE? SPRAY DRIFT EXAMPLE FROM CROP SPRAYING OR CROP PROTECTION

Liquid sheet from a fan spray nozzle (Crapper et al. JFM 1973; Villermaux ARFM 2007; Altieri and Cryer Biosys. Eng. 2018)



- **Small drops are undesirable because they lead to spray drift.**
- **Mystery: modern spray solutions do not disintegrate like pure fluids! Why?**
- **Image of rupturing sheet: Dombrowski (Van Dyke 1982).**

- **Spray drift is the most common cause of off-target movement of chemicals (e.g. pesticides) in crop spraying.**
- **It can injure or damage plants, animals, the environment or property, and even affect human health.**
- **"Drift" is the airborne movement of agricultural chemicals as droplets, particles or vapor.**

SAFETY

Texas Fertilizer Plant Explosion (West, TX)
(April 23, 2013, Washington Post)

Refinery explosion: How Philly dodged a catastrophe
(June 21, 2019, Philadelphia Inquirer)

ASSURANCE

FLOW ASSURANCE:

- **Coalescers, dehydrators, desalters, and oil-water-gas separators (in O&G industry)**
- **Hydrate formation in oil and gas pipelines**
- **Spray drift in agriculture**
- **"Drop size-modulation" and "satellite droplet or misting prevention" in ink jet printing and additive manufacturing operations**
- **Bottle filling (detergent bottles or drug vials)**
- **Rupture/integrity of coated films on substrates and free thin films/sheets (important in atomization and polymer processing)**

OTHER EXAMPLES:

- **Avoiding polymorphs in the pharma industry**
- **Personalized medicine: printing drugs on edible substrates**
- **Control of particle (or capsule) size as well as shape**
- **Safety, reliability, and durability of biomedical (e.g. implants) and surgical devices**

CENTER ACTIVITIES AND UNIQUE FEATURES (I)

- Involve **multiple faculty** (rather than a single person), **PhD students** (**2+ year projects**), **PMP students** (intense summer projects **mentored by member companies**), and exceptional **undergraduates** in safety-related research.

- Additionally, P2SAC aims in the long term to become a leader in certain aspects of safety education through development and teaching of primarily undergraduate and graduate courses. (*According to informal polling of first year graduate students in our program,* ***Purdue ChE is one of a handful of departments nationally and internationally*** *that requires all undergraduates to take a core course on safety in order to receive a BS degree*) *(The course is also offered to graduate students, which is even more unusual.)*

CENTER ACTIVITIES AND UNIQUE FEATURES (II)

- Our goal/mission is not to focus on a single or primarily one industry segment, e.g. we do not just want to have members that are oil and gas (O&G) producers

- Synergism: bring together people from different industries, e.g. pharma and O&G, who would normally not attend the same conferences and/or interact with one another on a regular basis

SUMMARY OF TYPES OF P2SAC RESEARCH PROJECTS

- PhD research projects: a listing of recent and/or ongoing current projects will be provided
- Professional Master's Program (PMP) capstone research projects: to be covered by Ray Mentzer
- Undergraduate (UG) research projects: also to be covered by Ray Mentzer

PROCESS FOR DETERMINING AND FUNDING PhD PROJECTS

(Program managed by Osman Basaran, AD)

- **There are two ways for coming up with new projects.** Either
  - Faculty or groups of faculty (within and outside ChE) come up with project ideas on their own or
  - Industrial members work with faculty to develop new projects
- **Timing for formulating projects:** *summer and early fall*
- **Timing and mechanism(s) for proposing projects:** either by
  - Making an oral presentation/pitch during the fall conference or
  - Submitting a 1.5-page written project proposal to Osman Basaran (AD) by the middle to the end of December of that year
- **How are projects to be funded determined?** Member companies rank order the projects and send their rankings to the AD in January
- **Final determination on funding:** AD selects projects to be funded based on input received and availability of funds

PhD PROJECTS APPROVED FOR FUNDING IN THE LAST ROUND

- Proposals for twelve (12) projects were submitted by the faculty for funding in 2021-2022
- Member companies were asked to rank-order the proposed projects
- Approximately 50% of the proposals were chosen to be funded
- An unexpected but desirable commonality among projects to be funded: all successful proposals involved participation and/or active involvement by one or more P2SAC member companies
- *Projects that will be funded in 2023-2024 will be announced in the near future*

PhD PROJECTS APPROVED FOR FUNDING (2021-2022)

Project title: Quantum chemical prediction of molecular thermodynamics to assess reaction safety and scale-up*

PI: Prof. Brett M. Savoie, Davidson School of Chemical Engineering, Purdue University

Project suggested/proposed or championed by: Brett M. Savoie (Purdue) and virtually all members of P2SAC from the pharmaceutical industry

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*This is a recent and rapidly growing area of research in P2SAC, and its impact on safety-related work at member companies will become quite clear on Monday.

PhD PROJECTS 2021-2022 CONT'D

Project title: Low-power, low-cost gas sensors with high specificity for hydrogen gas*

PI: Bryan W. Boudouris, Davidson School of Chemical Engineering, Purdue University

Project suggested/proposed or championed by: Bryan W. Boudouris (Purdue) and Hariprasad Janakiram Subramani (Chevron)

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*Research methodology can be applied to all sorts of sensors, i.e. hydrogen gas sensor is just one of many possibilities/targets.

PhD PROJECTS 2021-2022 CONT'D

Project title: Prevention through catalyst design for applications in the petrochemical industry*

PI: Prof. Rajamani Gounder, Davidson School of Chemical Engineering, Purdue University

Project suggested/proposed or championed by: Rajamani Gounder (Purdue)

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*The idea for the center to do research at the intersection of catalysis and PTD (prevention through design) was born after a presentation by a member of the center's advisory board at a P2SAC conference.

PhD PROJECTS 2021-2022 CONT'D

Project title: Real-time Li-ion battery monitoring using impedance spectroscopy and gas/pressure sensors for early thermal runaway detection*

PI: Prof. Vilas Pol, Davidson School of Chemical Engineering, Purdue University

Project suggested/proposed or championed by: Vilas Pol (Purdue); Edward Marszal, James Mcglone (Kenexis) and Erich Binder (Worley)

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*The proposal came together after weeks of back and forth between Prof. Pol and industry representatives.

PhD PROJECTS 2021-2022 (CONCLUDED)

Project title: Predicting spray dynamics for flow assurance, minimization of fines, and prevention of drift*

PI: Prof. Osman A. Basaran, Davidson School of Chemical Engineering, Purdue University

Project suggested/proposed or championed by: Pritish M. Kamat (Dow) and Osman A. Basaran (Purdue)

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*Although the general area of sprays is an active research area in the Basaran group, the project was initially suggested by Dow.

P2SAC FALL 2023 CONFERENCE

- The fall conference will take place in early December 2023

- The conference will most likely last two days
  Day 1: tutorials
  Day 2: safety conference

- Details will be communicated to the stakeholders this summer