Closing the Gap between Process Engineering and Safety with a Safety–Focused Master‘s Degree

Prof. Krause

Dr. Hecht

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Survey Results (from Presentation)

Safety: In Education vs. in Practice

What percent of your studies was dedicated to safety?
- None (0%): 13.8%
- All (%): 25.2%

What percent of your working time is dedicated to safety?
- None (0%): 36.5%
- All (%): 25.2%
"safety" is always on the mind. You can't even walk into your office without thinking about ...entry/exit procedure.

“prevent relearning those tragic lessons“

“Safety is part of the fabric“

“LELs“

“COSHH, learning events, audits, worst credible event analysis, LOPA, HAZOP“

“I learned "on the job.““

“playing with data“

“thermodynamics“

“Risk Assessment“

“calculations“

“quality“

“optimization“

“benchmarks“
Job Postings

Senior Process Engineer
Krefeld 21.08.2019 115932

Tasks
• Super absorber process optimization and improvement
• Project management
• Quality
• Work with production

Requirements
• Result-oriented
• Master or higher in process, chemical, or mechanical engineering
• Project management experience
• Black belt
• Data mining

Process Safety Engineer
Marl 07.09.2019 90961

Tasks
• Moderate safety discussions
• Calculations related to safety
• Develop safety concepts
• PHA

Requirements
• Master or Ph.D. in chemical or process engineering
• Experience in production/planning
• Experience in safety
• International mobility
• Communication, team player
Job Postings

Senior Process Engineer
Winona MN USA 04.09.2019 9753

Tasks
• Resolve issues
• Manage projects
• Quality (Six Sigma, DOE)
• Adhesive material production

Requirements
• 5-7 years engineering experience with adhesive materials
• BS mech. or chem. eng.
• Black belt
• Management experience
• Flexibility to travel
• Results-oriented

HSE Engineer
Kalamazoo MI USA 11.09.2019 9706

Tasks
• Safety, loss prevention
• Training, oversight
• Documentation
• Compliance

Requirements
• Engineering degree
• 6-8 y safety experience
• Quality experience desired
Podium discussion:

- “Process and plant safety competence requires specific knowledge and skills beyond what can be expected of graduates having successfully passed a standard curriculum in chemistry of chemical engineering. However—a sound basic knowledge in process and plant safety has to come with every relevant bachelor or master degree. Obviously this is only rarely the case.”

- “Both universities and the individual professors need to be encouraged—or even urged—and enable to ensure the necessary basic knowledge.”
### Process Safety Education Initiatives (Selection)

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Description</th>
</tr>
</thead>
</table>
| **ProcessNet Model Curricula “Process and Plant Safety”** | - Deals with basic knowledge of process and plant safety  
- One module for bachelor and master programs (process & chem. eng.)  
- Offers a concept for the integration into existing study programs. |
- 2 semester study program and a master’s thesis  
- Focus on petroleum industry but also suitable for chemical industry |
| **SACHe Certificate Program** | - 3 levels completed over the course of bachelor studies:  
  Level 1 (8 hours), Level 2 (35 hours), Level 3  
- Online courses through AIChE Academy, free for students and profs  
- Some universities (USA) offer their students certification through this program (Texas Tech, Ohio University, Northeastern University) |
| **Resources for Educators** | - Workshops have been offered usually in conjunction with AIChE and CCPS and sponsored by firms such as Covestro, BASF  
- Chemical Safety Board Videos  
- Possibilities to integrate safety aspects of processes into most engineering classes, case studies |
The Safety Gap

• Many students of chemical and process engineering finish their studies without hearing much about process and plant safety.

• Consequently, graduates must handle safety topics by:
  • Learning by doing
  • External consultants
Concept of the Master Program „Process Safety and Environmental Engineering“

• Admission Criteria: Bachelor degree (210 CP, EQF 6) in chemical engineering, process engineering, or closely related discipline.
• 3 semester study program (90 CP) offered completely in English.
• Specialization in process, plant, and environmental safety.
• Job profile „Safety Engineer“

• Started in winter semester 2016/17
• 51 students enrolled (Summer 2018)
Concept of the Master Program PSEE

Mandatory Study Topics
Total: 50 % mandatory + 50 % electives

- Technical
- Safety
- Environment
<table>
<thead>
<tr>
<th>Module Title</th>
<th>1. Semester</th>
<th>2. Semester</th>
<th>3. Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1 – Thermal Process Engineering</td>
<td>5 CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 2 – Advanced Heat and Mass Transfer</td>
<td></td>
<td>5 CP</td>
<td></td>
</tr>
<tr>
<td>Module 3 – Chemical Reaction Engineering</td>
<td></td>
<td>5 CP</td>
<td></td>
</tr>
<tr>
<td>Module 4 - Hazardous Properties of Materials</td>
<td></td>
<td>3 CP</td>
<td></td>
</tr>
<tr>
<td>Hazardous Materials and Safety Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispersion of Hazardous Materials</td>
<td></td>
<td>4 CP</td>
<td></td>
</tr>
<tr>
<td>Industrial Explosion Protection</td>
<td></td>
<td>3 CP</td>
<td></td>
</tr>
<tr>
<td>Module 5 - Technical Risks and Risk Assessment</td>
<td></td>
<td>4 CP</td>
<td></td>
</tr>
<tr>
<td>Methods of Risk Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Safety in Industrial Facilities</td>
<td></td>
<td>4 CP</td>
<td></td>
</tr>
<tr>
<td>Simulation Lab</td>
<td>2 CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 6 - Environmental Engineering</td>
<td></td>
<td>4 CP</td>
<td></td>
</tr>
<tr>
<td>Air Pollution Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Water and Sludge Treatment</td>
<td></td>
<td>4 CP</td>
<td></td>
</tr>
<tr>
<td>Environmental Science Research Project</td>
<td></td>
<td>2 CP</td>
<td></td>
</tr>
<tr>
<td>Module 7 – Process Safety</td>
<td></td>
<td>3 CP</td>
<td></td>
</tr>
<tr>
<td>Legal Issues in Plant Operation and Process Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excursion</td>
<td>2 CP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 8 - Elective Courses</td>
<td>7 CP</td>
<td>3 CP</td>
<td></td>
</tr>
<tr>
<td>Module 9 - Master Thesis</td>
<td></td>
<td></td>
<td>30 CP</td>
</tr>
</tbody>
</table>
Simulation Lab

- Process Simulation + Safety

Ethylene Oxide Production
Simulation Lab
• Process Simulation + Safety

![Safety Analysis](image)

**Pressure Relief Valve**

<table>
<thead>
<tr>
<th>General</th>
<th>Control Valve Related</th>
<th>Heaters and Coolers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>Blocked Outlet</td>
<td>Exch. Tube Rupture</td>
</tr>
<tr>
<td>Thermal Expansion</td>
<td><strong>Control Valve Failure</strong></td>
<td>Cold Side of Exchanger Blocked-In</td>
</tr>
<tr>
<td>Overfilling</td>
<td>Abnormal Flow through Valve</td>
<td>Blocked-In Fired Heater</td>
</tr>
<tr>
<td>User Defined</td>
<td>Failure of Automatic Controls</td>
<td>Fan Failure</td>
</tr>
<tr>
<td>Flare</td>
<td>Reaction/Mixing</td>
<td>Distillation Column/Tower</td>
</tr>
<tr>
<td>General Power Failure</td>
<td>Chemical Reaction</td>
<td>Reflux Failure</td>
</tr>
<tr>
<td>Local Power Failure</td>
<td>Accident Mixing</td>
<td>Reflux Failure (Side Stream)</td>
</tr>
<tr>
<td>Cooling Water Failure</td>
<td>Inadvertent Loss of Segregation</td>
<td>Abnormal Heat or Vapor Input</td>
</tr>
<tr>
<td>Coolant Failure (Other than CW)</td>
<td>Pressure Surge or Internal Explosion</td>
<td>Accumulation of Non-Condensables</td>
</tr>
<tr>
<td>Loss of Heat</td>
<td></td>
<td>Loss of Absorbent</td>
</tr>
</tbody>
</table>
Excursions

BAM
Bundesanstalt für Materialforschung und -prüfung

PTB
Messen ▪ Forschen ▪ Wissen
Master Thesis

Bachelor Mechanical Engineering
University of Nigeria

Work Experience – Maintenance Engineer
FFINE Investment Limited, Nigeria

Master Process Safety and Environmental Engineering
Otto-von-Guericke University, Germany
Thesis: Upscaling of a thermochemical process for an adiabatic fixed bed reactor for the treatment of contaminated substances

− Combustible dust explosion tests using 20 liter sphere at the laboratory.
− Investigation of explosive behavior of combustible dust and gases.
− Ensured safety and cleanliness in the laboratory after experiment.
− Steady state simulation and process modelling using Aspen Plus.
− Projects completed include simulation of Haber–Bosch process for Ammonia production, Chlorination of ethylene...

Field Technician
The Safety Team Inc., Seattle, USA
Gasification in a Fixed Bed

**Updraft Gasifier**

- $C_nH_m + 0.5nO_2 \rightarrow nCO + \frac{m}{2}H_2 \rightarrow$ Partial Oxidation
- $CO + 3H_2 \rightarrow CH_4 + H_2O \rightarrow$ Methanation
- $C + H_2O \rightarrow CO + H_2 \rightarrow$ Water gas
- $CO + H_2O \leftrightarrow CO_2 + H_2 \rightarrow$ Water Gas Shift Reaction
- $C + 0.5O_2 \rightarrow CO \rightarrow$ Char partial oxidation
- $C + CO_2 \rightarrow 2CO \rightarrow$ Boudouard reaction
Steady-State Simulation of Biomass Gasification
Dynamic Simulation of Biomass Gasification
Master Thesis

Bachelor Chemical Engineering
Technological Institute of Toluca, Mexico

Work Experience – Safety & Health Engineer
VPR, Mexico

Master Process Safety and Environmental Engineering
Otto-von-Guericke University, Germany
Thesis (at BAM): Investigation on Ignition Temperatures and Flame Propagation of Metallic Nanopowders

Monica Reyes

Project Coordinator, Technical Risk Area
ERM, Mexico City
Motivation

Metallic nanopowders

High specific surface area

Higher reactivity

Experimental determination

Determination of Safety Characteristics:
- LEL
- MIE
- MIT
- Pmax
- (dP/dt)max
- Kst
- SL

Potential Hazard of dust explosions
Determination of Flame Velocity

<table>
<thead>
<tr>
<th>Time (ms)</th>
<th>0-20</th>
<th>20-40</th>
<th>40-60</th>
<th>60-80</th>
<th>80-100</th>
<th>100-110</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{fl \ max}$ (m/s)</td>
<td>4.57</td>
<td>6.10</td>
<td>4.57</td>
<td>3.05</td>
<td>6.10</td>
<td>12.2</td>
</tr>
</tbody>
</table>
Comparison of results with similar studies

Experimental results

Escot Bocanegra, et al. (2010)

Limitations

- Agglomerate and sintering.
- Oxidation take place on particles surface (passivation).
- Wide particle size distribution.
Master Thesis

Bachelor Mechanical Engineering
Sri Prakash College of Technology, India

Work Experience – Mechanical Engineer
Megha Engineering & Infrastructures Ltd., India

Master Process Safety and Environmental Engineering
Otto-von-Guericke University, Germany
Thesis: Probability Assessment for Quantitative Risk Analysis (QRA) of a Power-to-X Methanol Plant

Naresh Virothi

Project Position
Otto-von-Guericke University
Identification and process simulation of critical areas of a power-to-x methanol plant
Hazard and initiating event identification – Master Logic Diagram

Loss of containment

Structural failures

Corrosion
Erosion
Vibration
Design failure
Ageing/wear and tear
Overpressure
Underpressure
High temperature
External Load
Spontaneous events
Nearby explosion/fire
Natural Phenomena
Support fails
Low level
Low temperature
Floods
Earthquakes
Storms
Thunderbolts

Overfilling
Excess heat
Direct pressure increase from gas
Rollover
Boiloff
Filter clogging
Pressure control system failure

External heat source
Internal heat source
Cooling malfunction

Combustion
Runaway reaction
Chemically Incompatible material

Unintentional release during operation
Valves malfunction
Operational failures
Structural defects

Open when operation starts
Open during operation

Support fails

Otto von Guericke Universität Magdeburg
FAKULTÄT FÜR VERFAHRENS- UND SYSTEMTECHNIK
VST

26.09.2019
Accreditation

• Program was reviewed and received accreditation from ASIIN (German Accreditation Agency for Engineering, Computer Sciences, Natural Sciences, and Mathematics) in October 2018, just before the first graduate finished.

• Applicants: 256 → 74 → 40
Outlook

• The Safety Gap:
• Process engineers spend a lot of time on safety.
• Basic safety knowledge is being incorporated into engineering curricula at the bachelor and master levels.

• The chemical industry hires and has a need for full–time safety specialists with a working knowledge of both process engineering and safety technology.

• The Process Safety and Environmental Engineering program at the Otto–von–Guericke University Magdeburg was initiated in 2016 and produced its first graduates in 2018. These graduates are trained in scientific and engineering principles as well as in safety and environmentally related issues. They are able to analyze and evaluate safety problems related to processes and plants to reduce and control accidents and environmental damage.