Dipartimento
di Ingegneria Chimica,
dei Materiali e della
Produzione Industriale
Università degli Studi
di Napoli Federico II

Master's Thesis Opportunities in Dresden

The STEEL Group of DICMaPI offers a great opportunity for our chemical engineering students to prepare their Master's thesis in the laboratories of the Technische Universität Dresden - TU Dresden (Germany) on different topics of Chemical Engineering.

We have direct contact with Prof. Markus Schubert and his assistant Sara Marchini from the TU Dresden, who will supervise you during the thesis period.

The available projects are:

- Development of a New Reactor Concept for Hydrogen Production using immobilized metal powders;
- Development and Evaluation of a Recovery Process for Liquid Waste Streams of a Cellulose and Lignin Production Process;
- Development and Characterization of Innovative Ceramic Packings for Unit Operations;
- Enhancing Gas-Liquid Interaction in Bubble Columns using Innovative gas modulation;
- Effect of liquid conductivity on gas-liquid interactions in bubble columns;
- Modeling and simulation of methanol production plant;
- Experimental determination of kinetic and mass transfer parameters in hydrogen production from metallic hydrides;
- High temperature and pressure solvolysis for recycling of composite materials;
- Synthesis and kinetic evaluation of CO2 hydrogenation catalysts under anhydrous conditions;
- Development of a process for the digestion of microalgae;
- Optimizing Cavitation Dynamics for Enhanced Chemical Transformation in Hydrodynamic Cavitation Devices;
- Hydrodynamics and reaction engineering in an Archimedes reactor;
- Investigation and Optimization of CO2 Capture Processes in a Pilot-Scale Absorption Plant.

<u>These activities can also be carried out as part of the program: **Erasmus Traineeship**</u>

Interested students can contact Prof. Domenico Flagiello by e-mail or Teams to discuss about thesis projects and arrange a call-meeting with Sara Marchini, who is the direct contact with Italian student for these activities at TU Dresden, and also to ask about further information for the facilities and organization of your accommodation in Dresden.

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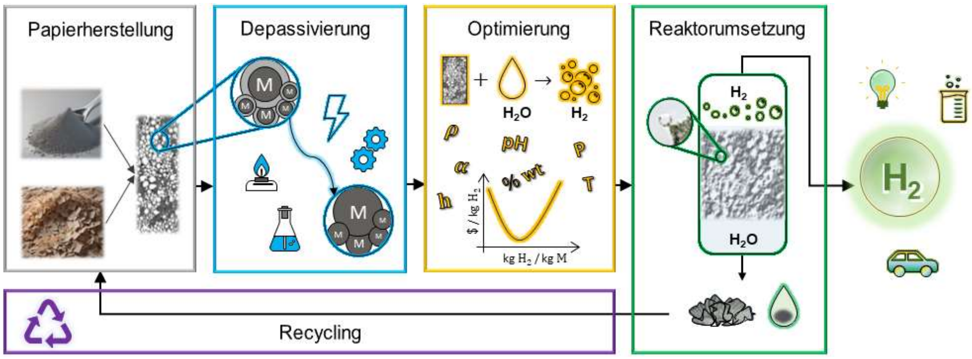
Development of a New Reactor Concept for Hydrogen Production using immobilized metal powders

Our current focus is on advancing hydrogen generation technologies through novel reactor designs that utilize reactive metal powders such as aluminum and magnesium. These metals, known for their exothermic reactions with water, offer a promising avenue for efficient hydrogen production. In collaboration with our research partner, the project's goal is to develop a new reactor concept that maximizes the hydrogen production rate from metal powders immobilized on special technical paper while overcoming the challenges posed by their surface passivation and the difficulties in handling of fine powders.



This involves starting from laboratory-scale experiments to design, optimize and scale up a reactor that can efficiently produce hydrogen in a safe, autonomous and decentralized manner, suitable for applications in various sectors, including mobility and energy storage.

Tasks and Objectives

- To experimentally investigate the hydrogen production efficiency of various metal powders, focusing on the effects of particle size, metal type and reaction conditions.
- To design and test a lab-scale reactor prototype that addresses the challenges of surface passivation and optimizes hydrogen generation rates.
- To systematically vary reactor parameters, such as temperature, pressure and metal surface treatment methods, to enhance the efficiency and scalability.
- To model the reactor performance to predict scalability and industrial applicability.

Requirements

- A solid understanding of reactor design, chemical kinetics and process engineering principles.
- Strong analytical and problem-solving skills.
- Passionate about sustainable energy technologies and innovation.

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Development and Evaluation of a Recovery Process for Liquid Waste Streams of an Cellulose and Lignin Production Process

In collaboration with partners, who have developed an innovative method for producing cellulose and lignin from agricultural or forest residuals, our research initiative aims to support the scale-up to a pilot plant. A crucial step for this scale-up is the effective treatment and recovery of the waste liquid streams , integrating principles of the circular economy. This project will focus on establishing a recovery process involving a catalytic bed reactor and a thermal separation unit, addressing the complex composition of the outlet stream. This work presents an opportunity to engage in cutting-edge research that addresses critical sustainability issues in the chemical production industry. The student will gain valuable experience in pilot plant development and process optimization, while working closely with both academic and industry experts.

Objectives and Tasks:

Process Design: Assist in the design and setup of the recovery system, focusing on optimizing the integration of catalytic and thermal separation steps.
Experimental Characterization: Perform detailed experimental studies to characterize the efficiency and effectiveness of the proposed recovery steps.
Feasibility Analysis: Evaluate the technical and economic feasibility of the recovery process, considering operational costs and environmental impacts.

Requirements:

Experience in reactor engineering and separation technologies is beneficial. Candidates should be motivated to support sustainable process development, have strong problem-solving skills, and be capable of working both independently and as part of a team.

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Development and Characterization of Innovative Ceramic Packings

Our research group is dedicated to advancing technologies in chemical process engineering, focusing on the development of sustainable and efficient material solutions. The use of ceramic packings is limited by their current design, which is often thick, heavy and costly, leading to decreased hydrodynamic efficiency in industrial applications. We have developed a new manufacturing process that produces thinner, lighter and more cost-effective ceramic packings. This thesis will explore the potential of these novel ceramic packings and quantify the improvement that they will bring to column operations.

Thesis Objectives:

- Assessment of the downsides of currently available ceramic packings in a comprehensive literature review.
- Conduct detailed experimental studies to assess the pressure drops and mass transfer coefficients of the newly developed ceramic packings. Comparisons will be made with traditional packings to highlight improvements.
- Evaluate packings of different geometries and porosity.
- Evaluate the structural integrity and durability of the lighter, thinner ceramic materials.

Requirements:

- Currently enrolled in a Master's program in Chemical Engineering, Materials Science or a related field.
- Familiarity with fluid dynamics and chemical process equipment.
- Detail-oriented with analytical thinking, proactive in problem-solving, and motivated by innovation in engineering solutions.

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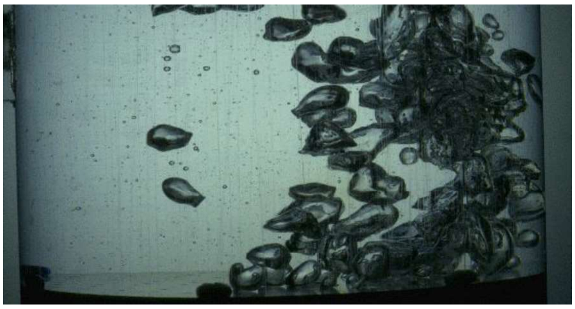
Enhancing Gas-Liquid Interaction in Bubble Columns using Innovative gas modulation

The project focuses on improving the performance of bubble columns, particularly in addressing the gas maldistribution issue associated with conventional perforated plate gas spargers at low flow rates. The positive effects of vibrations applied to bubble columns is already reported in the literature in terms of improved mass-transfer rates (up to 30%) and reduced bubble size. However, these findings have only rarely been applied in column design due to excessive energy input required. Our lab has developed a novel technical solution to obtain comparable effects with a minimum energy input. Preliminary results are available to interested candidates and their supervisors. These results show the potential of our innovative solution to significantly improve gas-liquid interactions within bubble columns. We have observed a notable increase in gas holdup, reduced bubble size, and enhanced mass transfer rates, all achieved with minimal energy consumption.



The student will verify the applicability of the proposed technical solution to columns of several diameters equipped with perforated plates of different characteristics. Gas holdup, bubble rise velocity, bubble size distribution, regime transition velocity and mass-transfer rates will be measured with and without modulation. Results will be compared to assess the effectiveness of the proposed modulation. In addition, the required energy input will be measured for each tested configuration.

Requirements:

- Enrolled in a Master's program in Chemical Engineering, Industrial Chemistry or a related field.
- Strong background in fluid dynamics.
- Enthusiasm for research and scientific inquiry.
- Ability to work collaboratively within a research team.
- Good communication skills in English or German

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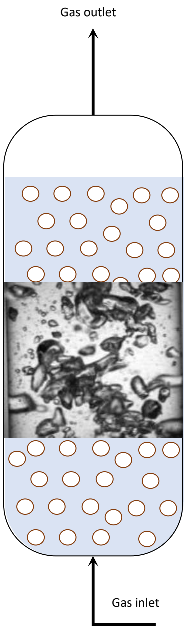
Effect of liquid conductivity on gas-liquid interactions in bubble columns

The project aims to investigate the influence of water conductivity on gas-liquid interactions within bubble columns. Preliminary studies have already been conducted, and the results are available for interested candidates and their supervisors. These preliminary findings have revealed significant differences in gas holdup, particularly at low conductivity range. Interestingly, existing literature often discusses gas-liquid interactions in deionized water without providing further details. This lack of specificity has led to inconsistencies in reported results, which we aim to solve with this study.



The student will conduct experimental studies to measure gas holdup, bubble rise velocity, and bubble size distribution in bubble columns under varying conditions, including water conductivities, dissolved species and gas sparger types. Measurements will be performed at different column heights. Due to the multiplicity of variables involved, the experiments will be planned applying the principles of design of experiments.

Requirements:

- Enrolled in a Master's program in Chemical Engineering, Industrial Chemistry or a related field.
- Strong background in fluid dynamics.
- Enthusiasm for research and scientific inquiry.
- Ability to work collaboratively within a research team.
- Good communication skills in English or German

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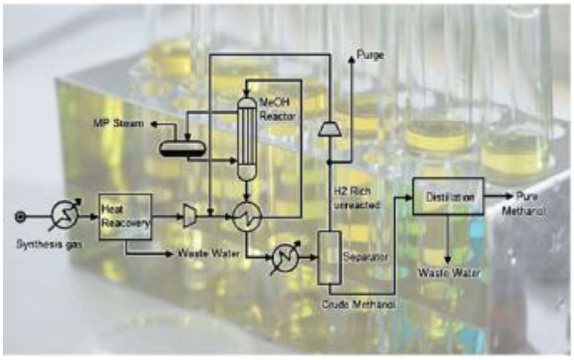
Modeling and simulation of methanol production plant



The synthesis of electrolysis hydrogen and CO2 into methanol is a crucial process step and an important intermediate stage in the production of synthetic chemicals.
The basic process concepts of methanol synthesis are known and have already been technically realised in many ways. For the design of a pilot-scale demonstration plant, basic estimates must first be made. To prepare the design planning, in particular for the holistic (energetic) evaluation of the process concept and as a basis for the pre-selection of components, stationary mass and energy balances should therefore be drawn up.

Thesis Objectives: The aim of the work is the implementation of a process model for methanol synthesis consisting of conditioned feed, tubular reactor, product separator and gas cycle in an object-oriented modelling environment for flowsheet simulations (e.g., ASPEN). For various specified feed volume flows (CO2 and H2), simulation calculations will allow estimating apparatus specifications (pump, reactor dimensions, heating and cooling capacity). In addition, concepts for saving energy through heat integration should be evaluated.

Requirements:

- Currently enrolled in a Master's program in Chemical Engineering, Materials Science or a related field.
- Familiarity with chemical process equipment and unit operations
- Experience in operating with ASPEN Plus or similar software is helpful

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Experimental determination of kinetic and mass transfer parameters in hydrogen production from metallic hydrides.

This activity finds it context into a larger research project, which focuses on advancing hydrogen production technology through the hydrolysis of metallic hydrides for decentralized applications. The overarching project aims to develop dynamic reactor models and optimize reactor operations, accounting for complex variables such as side reactions, diffusion, passivation effects and the precipitation of metal salts.

Thesis Objectives: The primary goal of this thesis is to design and carry out part of the experimental campaign to derive basic kinetic and mass transfer parameters essential for the development of effective reactor concepts within the project. The thesis will focus on identifying optimal operating conditions to maximize hydrogen formation rates while minimizing by-product spectrum and ensuring efficient heat removal. Specific tasks will include:

- Developing and carrying out experiments to measure kinetic and mass transfer parameters under various operating conditions (temperature, pressure, reactant concentration…).
- Analyze experimental data to extract reliable kinetic models and mass transfer coefficients.
- Use statistical and computational tools to interpret the data and validate the experimental methods.

Requirements:

- Currently enrolled in a Master's program in Chemical Engineering, Materials Science or a related field.
- Familiarity with kinetic models and reaction engineering.
- Problem-solving skills and willingness to work independently.

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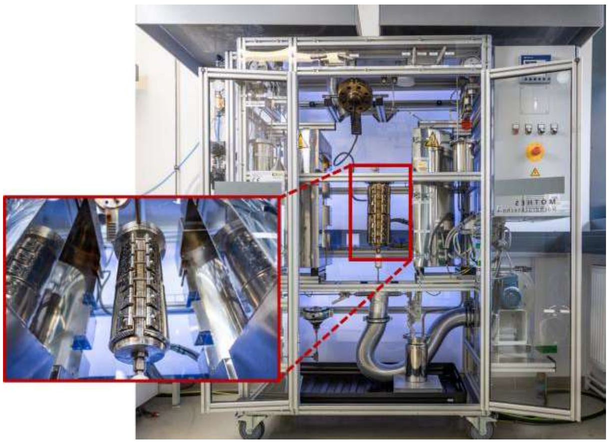
High temperature and pressure solvolysis for recycling of composite materials



A part of our research focuses on exploring innovative solutions for material recycling and sustainable manufacturing processes. Our current project involves the study of high temperature and pressure solvolysis, a cutting-edge method for the recycling of composite materials using subcritical (SubCW) and supercritical water (SCW). This technique offers a promising route for the solvolysis of polymers, including carbon fiber reinforced composites (CFRC) and polyurethane (PU), potentially revolutionizing the approach to recycling these challenging materials. The goal of this thesis is to contribute to our ongoing research by supporting the analysis and experimentation of CFRC or PU decomposition in SubCW and SCW environments. Working within our state-of-the-art high-pressure and high-temperature reactor facilities, the candidate will carry out reactions, followed by the collection and detailed analysis of the resulting products. The specific focus of the thesis (CFRC vs. PU decomposition) can be tailored to align with the student's interests and the project's needs.

Thesis Objectives

- Conduct a comprehensive literature review to understand current technologies and identify research gaps in high temperature and pressure solvolysis for material decomposition.
- Design and perform experiments involving the decomposition of CFRC or PU in SubCW and SCW within a high-pressure and high-temperature reactor setup.
- Analyze the reaction products to assess the efficiency and effectiveness of the solvolysis process.
- Document findings in a well-structured thesis and contribute to research publications or presentations as appropriate.

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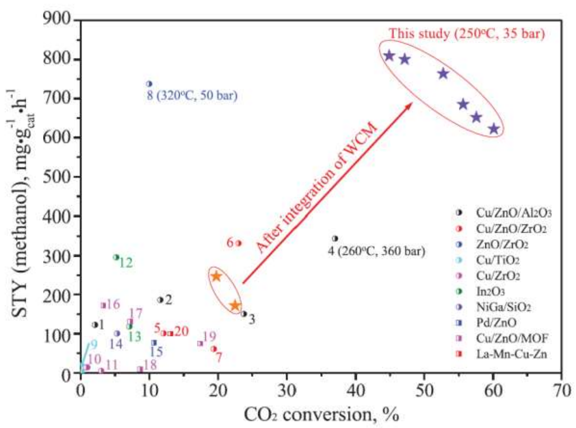
Start: any time

Sustainable production of chemical building blocks

Synthesis and kinetic evaluation of CO2 hydrogenation catalysts under anhydrous conditions.

Methanol synthesis is a process that is operated on an industrial scale. The traditionally CO-based process is realized in plants with production capacities of up to 10,000 tons of methanol per day. However, the use of CO is unattractive due to its production from fossil raw materials and will increasingly be replaced by CO2 in the future.



The use of CO2 poses challenges that need to be overcome.

In addition to the challenge of activating the less active CO2, the co-product water poses a particular problem. On the one hand, the water ensures that an unfavorable equilibrium (CO2 + 3 H2 <-> CH3OH + H2O) is always established and, on the other hand, that the catalyst is deactivated. The use of a water-selective membrane (WCM) remedies this by removing the water from the process. This also changes the conditions for the catalyst, as it is less deactivated due to the reduced amount of water.

The aim of the work is the synthesis and kinetic evaluation of known catalysts for methanol synthesis under anhydrous conditions. This also includes the validation of suitable desiccants at process conditions of up to 50 bar and up to 250 °C.

Requisits:

- Safe handling of chemicals
- Fun working in the lab
- Basic understanding of inorganic, physical and technical Chemistry
  Interest in experimental work

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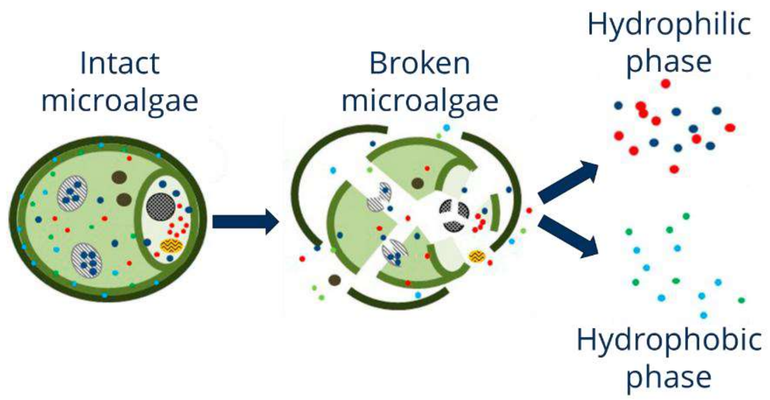
Development of a process for the digestion of microalgae



Due to the limited resources of arable land, the bioeconomy is also striving to utilize aquatic resources.

The cultivation of microalgae, which can be used to produce dyes or omega-3 fatty acids, among other things, appears particularly promising. In addition to the cultivation of microalgae, the efficient extraction and purification of valuable substances (downstream processing) is of particular importance. Typical cell disruption processes use mechanical-physical or chemical active principles. The hydrodynamic hydrodynamic cavitation is characterized by low energy consumption low energy requirements and the simultaneous absence of chemicals.

Aim of the work: Within the scope of the work, the modern procedure of method of hydrodynamic cavitation for cell disruption will be further developed. A test rig is available for this purpose. The work is carried out in close cooperation with an industrial partner (PUEVIT GmbH).

Requirements:

- Interest in apparatus and flows
- Creativity and skills in modifying experimental equipment
- Currently enrolled in a Master's program in Chemical Engineering, Materials Science or a related field.
- Problem-solving skills and willingness to work independently.

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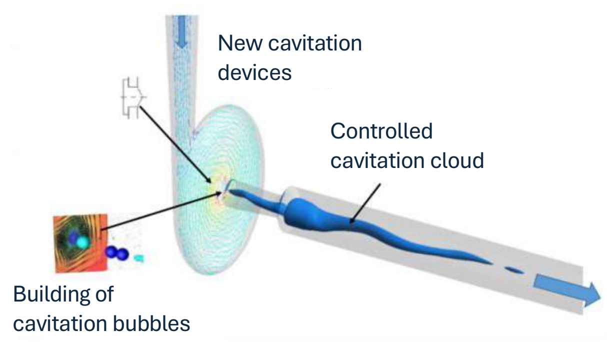
Optimizing Cavitation Dynamics for Enhanced Chemical Transformation in Hydrodynamic Cavitation Devices



As partner in the European Project CaviPRO, our research group is deeply involved in exploring the potential of using controlled hydrodynamic cavitation for intensifying chemical processes. In particular, our activities focus on the innovative control and optimization of cavitation dynamics using novel hydrodynamic cavitation devices. The project seeks to enhance the yield and performance of physico-chemical transformations by precisely controlling the location and intensity of cavitation, thereby improving energy efficiency and mitigating equipment stress.

Aim of the work: This proposed activity will specifically support the planning and execution of the experimental aspects of the project by focusing on the performance evaluation of 3D-printed devices, with and without internal modifications. The work aims to directly contribute to the development of next-generation cavitation systems optimized for wastewater treatment and other applications.

Requirements:

- Interest in apparatus and flows
- Creativity and skills in modifying experimental equipment
- Currently enrolled in a Master's program in Chemical Engineering, Materials Science or a related field.
- Problem-solving skills and willingness to work independently.

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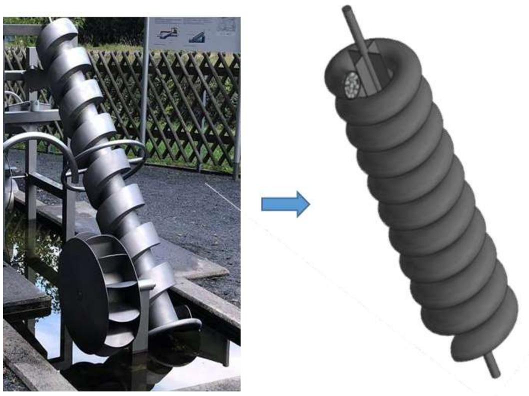
From the playground to plant engineering

Hydrodynamics and reaction engineering in an Archimedes reactor

The principle of the Archimedean screw is to transport fluids in a rotating tortuous tube.



Archimedean screws are mainly used as hydrodynamic screws to drive electrical generators or as screw pumps to convey fluids (as in playground installations).

The same principle is followed in the Archimedes reactor for mass-transfer limited reactions. Here, the coiled tube is filled with a catalyst packing. The liquid is conveyed in portions so that the catalyst packing is alternatingly in contact with gas and liquid.

The concept has promising potential for process intensification due to local binary wetting, portioned fluid transport with low backmixing, and high geometric flexibility for adaption to reaction processes.

The aim of the work is the development of geometry models for Archimedean screw in the form of single or multiple helical tubular reactor internals (screw) and tubular helixes (helix), taking into account continuity and Bernoulli equations and operational boundary conditions such as liquid throughput, residence time, bulk porosity, and desired dynamics of binary catalyst wetting. Finally, selected geometry models will be printed and investigated experimentally.

Requirements:

- Affinity for mathematics and geometry
- Creativity and spatial imagination
- CAD knowledge is helpful
- Interest in reactor design and fluid flow

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Investigation and Optimization of CO_2 Capture Processes in a Pilot-Scale Absorption Plant

As the global community confronts the escalating consequences of climate change, the imperative to reduce atmospheric carbon dioxide levels has become more pressing. Carbon capture processes have consequently gained significant attention as a vital technology against global warming. These processes not only address the immediate challenge of mitigating greenhouse gas emissions but also play a crucial role in achieving long-term climate goals. The proposed activity requires operating an available pilot-scale plant designed for studying gas scrubbing processes, with a focus on carbon dioxide capture from flue gas, biogas, and syngas using aqueous amine solutions for absorption and subsequent regeneration of the absorbent. The facility comprises three energetically coupled glass columns (DN100) with an effective packing height of three meters each, equipped with cooling and heating systems to control the temperature during the absorption and desorption processes.

Aim of the work: The activity will explore general aspects of the CO_2 capture process using the pilot plant. The goal is to investigate the efficiency and effectiveness of the absorption and regeneration steps and to propose optimization strategies for improving the overall performance of the plant. Activities will include monitoring and recording of various parameters (such as temperatures, pressures and mass flow rates), analyzing the collected data to identify bottlenecks and inefficiencies in the system, proposing and test modifications to the process or equipment to enhance the CO_2 capture efficiency and reduce energy consumption.

Requirements:

- Interest in chemical plants and unit operations
- Basic understanding of kinetics and mass-transfer processes
- Creativity, problem-solving skills and willingness to work independently.

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