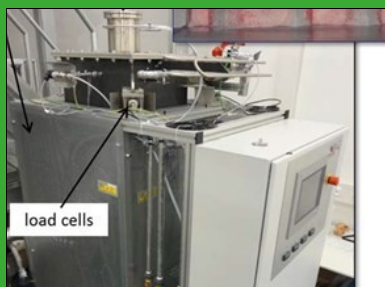
ANICA

Advanced Indirectly Heated Carbonate Looping Process

Integrating the indirectly heated carbonate lopping process in cement and lime industry for a sustainable CO_2-free production through CO_2 capture.

NEWSLETTER II - OCTOBER, 2020

What will you find here?



www.act-anica.eu

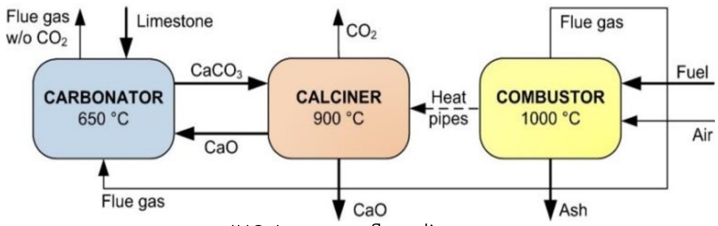
WHAT IS ANICA?

ANICA is an ACT project focused on developing novel integration concepts of the state-of-the-art indirectly heated carbonate lopping (IHCaL) process in cement and lime production. The project aims at lowering the energy penalty and CO_2 avoidance costs for CO_2 capture from lime and cement plants. Within 36 months, the project brings the IHCaL technology to a high level of technical maturity by carrying out long-term pilot tests in industry-relevant environments and deploying accurate 1D and 3D simulations.

WHY ANICA?

In order to decrease the global CO_2 emissions, sustainable and economical processes need to be applied in the energy and carbon-intense industry sectors. The production of lime and cement is one of the major sources of CO_2 emissions in the industry sector. During the production of lime and cement, natural Calcium Carbonate ($CaCO_3$) is calcined to Calcium Oxide (CaO). The necessary heat for calcination is generated by combustion of fossil fuels and waste. Process and combustion CO_2 from lime-based production accounts for around 8% of global fossil CO_2 emissions. These CO_2 emissions can be efficiently captured with the IHCaL process.

THE IHCAL PROCESS



IHCaL process flow diagram

Carbonate Looping (CaL), also known as calcium looping, is a CO_2-capture technology in which limestone is used as the sorbent that captures CO_2. The indirectly heated carbonate lopping (IHCaL) process is a variation of CaL in which the heat is provided externally, thus avoiding the necessity of an air separation unit (ASU) and therefore, achieving higher efficiencies and lower CO_2 avoidance costs. The main components involved in the process are the combustor that provides thermal energy for the separation; the carbonator, where the CO_2 is captured by reacting into CaCO3; and the calciner, where the CaO is regenerated and the CO_2 is released.

WHAT CAN BE EXPECTED FROM ANICA?

The main objective of the ANICA Project is the efficient integration of the IHCaL process into lime and cement plants. This can only be realized by synergic designs that contemplates both mass and energy integrations. In this way, processes will be developed that focus on the use of raw material for lime and cement production as sorbent, thus reducing operation costs and environmental impact. Furthermore, the utilization of cheap waste fuels of biogenic sources is being assessed, which would allow for net negative CO_2 emissions and costs reduction. Additionally, processes with high operation temperature will be selected, in order to produce power from the heat outputs.

To achieve this, not only 3D and 1D simulations are being carried out, but also experimental research, including testing at a 300 kW_{th} pilot plant under realistic conditions. Moreover, novel concepts of the IHCaL reactor system are being developed, including the design of a new solid-solid heat exchanger concept.

Besides the industrial scale investigations, a 20 MW_{th} demonstration plant will be developed towards the end of the project. In the last stages of the project, the developed solutions will be analyzed in terms of economic performance, environmental impact and associated risks.

WHAT HAS BEEN DONE SO FAR?

So far, concepts for the integration of the IHCaL process into real lime plants in Hönnetal (Lhoist Group) and Thessaloniki (CaO Hellas) have been developed. The corresponding one-dimensional simulations were successfully carried out. Parallel, the German Cement Works Association (VDZ) is assessing concepts for the high level integration of the IHCaL process into a BAT (Best available technic) -cement plant. The results will be published in the following months.

Regarding the experimental work, some experimental results are already available and fascinating tests are being prepared right now at TUDA (page 3) and at FAU (page 4).

WHAT IS HAPPENING AT THE PILOT PLANT?

ANICA 300 kW_{th} pilot plant at TUDA

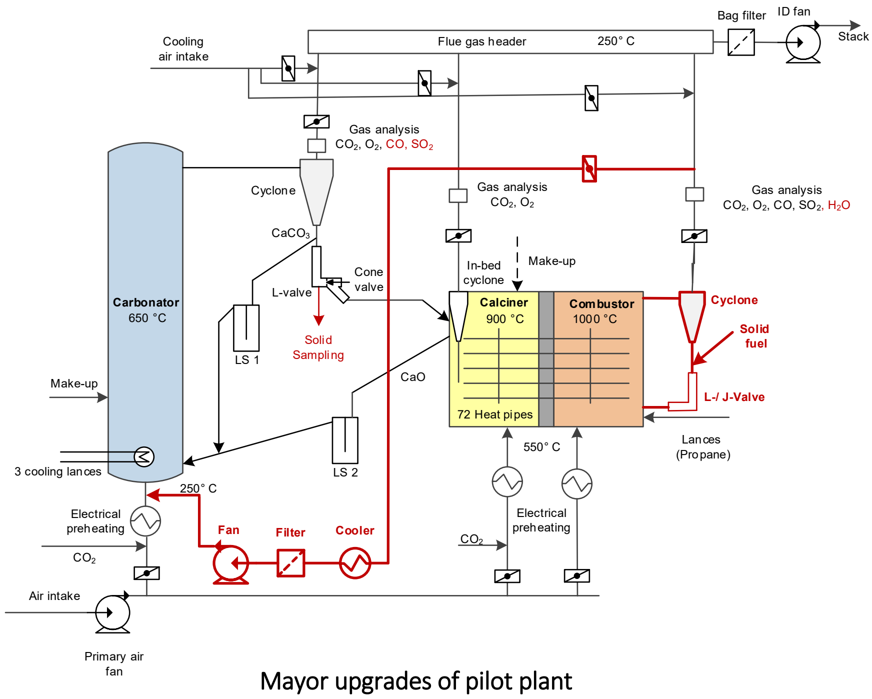
One major aim of the project is to prove the application of the IHCaL-process in the cement and lime industries. To achieve the experimental part of this objective, three test campaigns will be done at the 300 kW_{TH} pilot plant in Darmstadt, which was erected and commissioned in 2015. This plant has been used to successfully study the IHCaL concept for power generation plants over long time pilot tests. The heart of the process is a unique concept of two mechanically separate reactors, one for the calcination and the other delivering heat for this endothermic reaction. The reactors are thermally coupled via 76 heat pipes.

In order to enable realistic conditions for transferring the results of the future test to applications in cement and lime industries, some major upgrades need to be done. A solid fuel feeding system will be integrated in the combustor that allows for testing of fuels such as coal and waste-derived fuels, which are typically used in lime and cement plants. A real flue gas mixture is produced from these fuels to be tested in the carbonator, in order to separate the CO_2 from the flue gas stream. Therefore, a flue gas path from the combustor to the carbonator will be integrated into the pilot plant. This path consists of a tube bundle flue gas cooler, a bag filter and a flue gas fan. By adding CO_2 from an existing tank, the formation of a realistic flue gas composition that is typical for lime and cement plants will be enabled.

Heat pipes of the combustor

Furthermore, in order to improve the operability of the combustor, the installed in-bed cyclone will be exchanged with an external cyclone to increase the solid separation rate of this reactor. The solid fuel will be fed to the return leg of the combustor before entering the J-/L-Valve, which serves as pressure closure to the reactor. Hydrothermal test are currently carried out at a cold flow model, in order to prove the feasibility and operability of this concept. The sampling and feeding of the sorbent will be retrofitted to improve the evaluation of the tests, in terms of solid analysis and mass balances.

The major upgrades are marked in red in the graph below. The engineering of these upgrades are currently in process, the construction works of the new equipment will start in January 2021 and commissioning of the upgraded pilot plant is planned for April 2021. The following three test campaigns, in total three long-time pilot tests with 14 days (24h), are divided between two campaigns under lime plant conditions and one campaign under cement plant conditions.



Mayor upgrades of pilot plant

TECHNISCHE UNIVERSITÄT DARMSTADT

Tests on Calciners and Heat Pipes

Utilization of coal and biomass is one of the main focuses of the Chair of Energy Process Engineering of FAU. It is dealing with CCS-technologies, generation of SNG by gasification and methanation and combustion technologies for coal and biomass. The institute has many years of experience in the field of development and integration of especially high-temperature heat pipes in different processes.

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

Within the ANICA project, FAU will conduct experiments concerning an unheated second stage calciner and elaborate a more compact heat pipe heat exchanger. FAU develops advanced heat pipes and test them concerning long-term behaviour. FAU will manufacture heat pipes to be tested in the 300 kW_{th} pilot plant and provide thermodynamic evaluations of the IHCL process integrated into full-scale plants.

What is Happening At FAU's testing facilities?

The role of FAU in the ANICA project is the investigation of the calcination step within the carbonate looping process.

Since cement raw meal is too fine to be efficiently calcined in a fluidized bed, we at FAU make use of micro pellets and investigate the behaviour of these pellets in regards to their stability and reactivity.

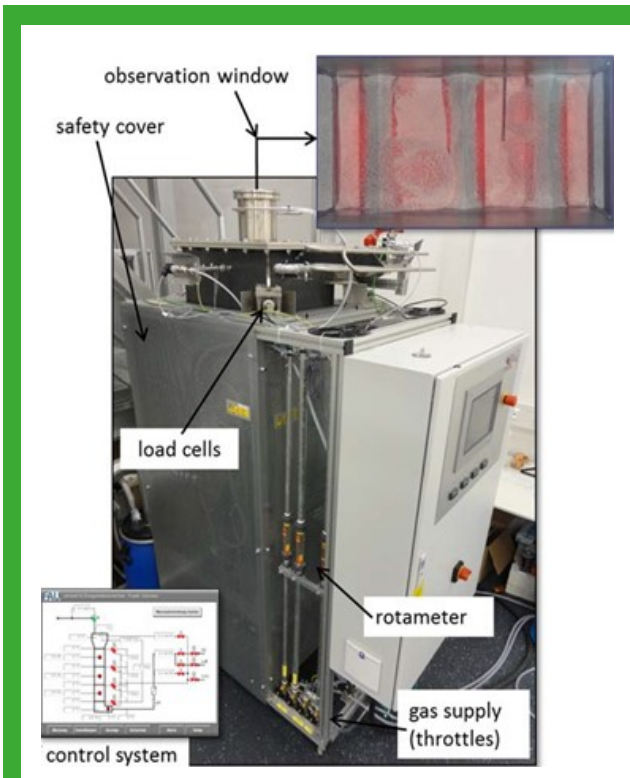
Another option for the fine cement raw meal to be calcined is to trickle the cement raw meal on the heat pipes. For this approach, FAU investigates the trickling behaviour in a cold model test, while being successful, tests in a hot test rig will follow.

Which tests are planned for the upcoming months at FAU?

FAU has a broad range of experience with heat pipes and will further optimize the heat pipes in the ANICA project. A heat pipe is a heat exchanger which can transport a high power density at a small temperature difference. The heat transport works over condensation and evaporation. With this principle, heat can be indirectly transported between two components. The performance of horizontal heat pipes is inhibited by their capillary limit. In order to improve the capillary limit of horizontal heat pipes, a test will be carried out with optimized heat pipes and evaluated in terms of their performance. If the use of these optimized heat pipes enhances the heat transfer, material costs can be reduced.

A further optimization of the calcination step is to use steam as a fluidized medium. This will be done after the primary calcination of $CaCO_3$. Steam reduces the partial pressure and works as a catalyst. With this step, the project anticipates a more efficient calcination step by increasing the calcination efficiency.

The batch calciner has a performance of 18 kW and works as a fluidized bed with electrical heat pipes simulating the previously described heat pipes. With this calciner, it is possible to investigate the calcination and carbonation reaction as well as to measure heat transfer coefficients.



18 kW Batch Calciner at FAU.

THE VIEW FROM THE INDUSTRY

LHOIST GROUP

Lhoist Germany Rheinkalk GmbH, with 11 locations and around 1,200 employees, is the German subsidiary of the Lhoist Group, a globally active family business in lime and limestone production with headquarters in Belgium. Lhoist stands for tradition and innovation. We combine decades of experience with modern mining, production and recultivation technologies. The mineral and lime-based products are used in steel & iron production, environmental protection, the chemical industry, construction, water & waste water treatment as well as agriculture & forestry. Our products are part of many areas of life and successfully contribute to the solution of challenges of our civilization.

LIME PLANT HÖNNETAL

The Hönnetal plant has been producing lime and limestone products for over 125 years. The site employs around 200 people and has a strong family atmosphere. Many of the employees are already working here in the 3rd generation. About 12 percent of the German lime demand comes from the Hönnetal plant. The high-purity limestone is extracted in the neighboring Asbeck quarry, then crushed, washed and classified. The fractions suitable for calcination are transformed into quicklime—calcium oxide— by heating over 1000°C. By further processing, *e.g.* gridding or hydration, the quicklime is tailored for its efficient utilization. The other part is used as pure mineral in different particles sizes—from aggregates to limestone powder.

Rotary Kiln at Lime Plant Hönnetal

THE INTERVIEW

In the LGE's philosophy statement, it reads: "We are pioneers. We look beyond boundaries, seize and generate opportunities to shape the future." Which role does the ANICA project play in the vision of the company?

As a family business, we think long-term and are committed to future generations. In doing so, we naturally go with the demands of the times". For example, the establishment of a flowering meadow for bees is just as much a piece of the puzzle as the introduction of electric vehicles and the reduction of CO_2 emissions in the factories or the development of new areas of application for lime products.

OUR INTERVIEWEE: DR. DIETHELM WALTER

Dr. Diethelm Walter is involved in the integration of the IHCaL into the lime plant Hönnetal. Besides providing valuable insight in the functioning of the lime plant, he also shares the data required for the exact process simulation. Moreover, through his expertise he makes valuable contributions on the design of the integrated processes and the validation of the simulation results.

We´re heading towards a carbon neutral lime production. Since the beginning of the calcium looping research initiatives we believe in the functionality of our products for carbon capture. Using lime-based-products to capture CO_2 means we´ll shape the future with our versatile products.

Why is it important that referents from the industry, such as LGE, are involved in the project?

The participation of industrial partners helps to guide the projects towards technically feasible solutions. With our long history and experience in research, production and behaviour we support the project with start of the art knowledge and realistic industrial background information.

Do you expect the results of the ANICA project to have a direct impact on the company? In which way?

The decarbonisation of our industry is a huge challenge. If we can demonstrate with the project that the envisaged solution, which is based on "our" mineral, helps to decarbonize industrial processes, would mean that we´re part of the solution to achieve the climate target.

What appealed to you personally in the ANICA project, sparking the interest to get involved in it?

Limestone and lime are known for thousands of years. It is a reagent with very interesting chemical properties. And again, a new application of this versatile material might open up. What appealed me most was that this could show again that lime is part of the solution.

What is your role in the project and what expertise do you bring to the consortium?

My role is representing LGE as a consortium partner, participating in steering committee meetings. Working since more than 30 years in research and application of calcium oxides, I hope to contribute to the consortium with many years of experience on the reagent behaviour.

Why do you think ANICA is an important project for society?

The technical solution to tackle climate change hasn´t been found yet. The high chemical affinity of calcium oxide to carbon dioxide is a very interesting path to follow. Together with many other initiatives it might help to enable to slow down global warming. We want to turn our challenges into opportunities!

Do you have any final words for our readers?

Our company extracts one of the most important raw materials in life. Securing raw materials and environmental protection are not contradictory. So, save the planet – use lime.

The Consortium

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More information on our website:
www.act-anica.eu

Do not miss any update!
Subscribe to the biannual newsletter and receive regular updates on the ANICA project.

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