# Process electrification by innovative electro-thermal fluidized bed reactor

Miha Grilc[1,2,*], Igor Shlyapnikov[1,2], Klaus Jacobs[3], Jeroen Lauwaert[4], Joris W. Thybaut[3], Blaž Likozar[2]

1) *Dept. of catal. & react. eng., National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia*
2) *Centre of Excellence for Low Carbon Technologies, Hajdrihova 19, 1000 Ljubljana, Slovenia*
3) *Laboratory for Chemical Technology (LCT), Ghent University, Technologiepark 125, 9052 Ghent, Belgium*
4) *Industrial Catalysis & Adsorp. Tech. (INCAT), Ghent University, Valentin Vaerwyckweg 1, Ghent, Belgium*

**Corresponding author: miha.grilc@ki.si*

***Highlights***

- Pilot scale electro-thermal fluidized bed reactor was designed and fabricated.
- Fluidized bed is el. conductive, between the electrodes, subjected to the electric current.
- System was tested for 1200 h in inert atmosphere, and 100 h for COS decomposition.

## 1. Introduction

For gas–solid systems, fluidized-bed reactors offer excellent heat and mass transfer, making them particularly attractive for electrified catalytic operation. Direct electro-thermal fluidized-bed reactors overcome the limitations of externally heated systems by exploiting conductive particle networks that form transiently between electrodes in the fluidized state. This enables efficient internal heat generation directly in the bed while preserving the advantages of fluidization. Such an approach is especially relevant for challenging endothermic and high-temperature transformations. No established technology currently enables the simultaneous reduction of $H_2S$ and $CO_2$ in an economically attractive way. The latter gasses can undergo condensation reaction forming COS intermediate, which requires 1000 C to decompose into S and CO in highly endothermic reaction.

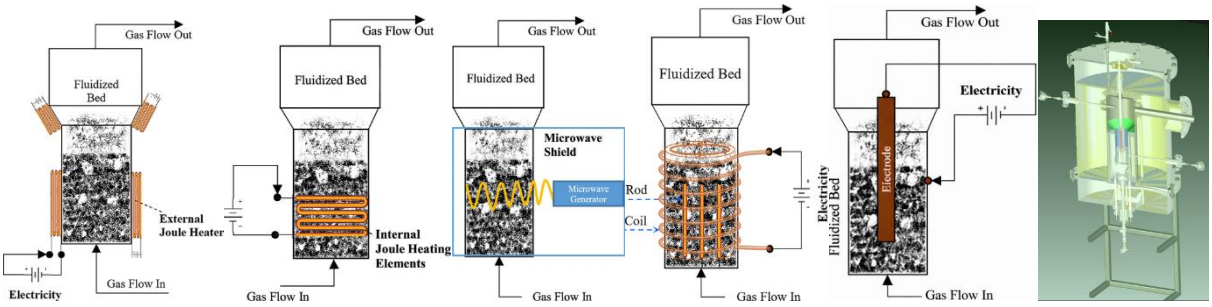


**Figure 1**: Electrification of fluidized bed reactors by: i) external and ii) internal Joule heater, iii) microwave heating, iv) AMF heating, v) direct electro-thermal heating (of conductive) fluidized bed (ETFB) [1], vi) 3D model of our ETFB reactor design.

## 2. Methods

A two-step catalytic concept is proposed for simultaneous acid-gas valorization. In the first step, $CO_2$ and $H_2S$ are converted to carbonyl sulfide (COS) over zeolite catalysts in a fixed-bed reactor. In the second step, COS is decomposed in an electro-thermal fluidized-bed reactor at elevated temperature to produce CO and sulfur species. The process was scaled from laboratory experiments to a pilot installation designed to demonstrate the second reaction step under relevant conditions. The fully automated pilot reactor was engineered for operation up to 1200 °C and enables long-duration testing, process control studies, and collection of experimental data for reactor and process validation.

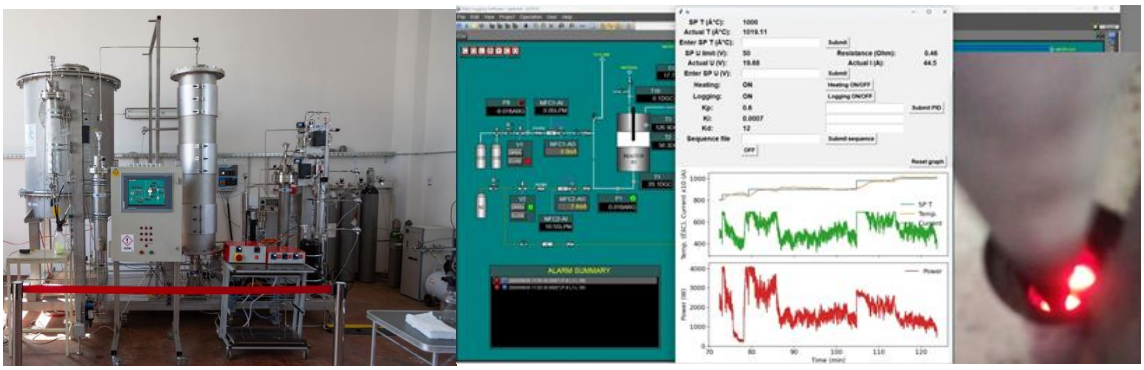

**Figure 2**: Pilot line (ETFBR on the very left), SCADA control system with temperature, current, voltage profiles, glowing graphite inside the reactor during inert tests.

## 3. Results and discussion

The proposed route generates CO as a platform molecule for downstream synthesis of chemicals and low-carbon fuels, while simultaneously producing marketable sulfur. Pilot-scale operation demonstrated the feasibility of stable electro-thermal fluidized-bed performance over extended time-on-stream. A 1000 h test campaign, extended to 1200 h, confirmed stable operation, smooth process control, and enabled identification of the main technical limitations and operational risks.

Several practical challenges emerged during long-term testing. Graphite attrition was observed, motivating reactor modification to allow graphite addition during operation. Electrode erosion and degradation became evident, highlighting the need to avoid suspended fluidization regimes and to impose high-voltage limits in the control system. A reaction between titanium thermocouples and nitrogen was detected, indicating that argon should be used in future campaigns. Although operation at low overpressure still allowed completion of the 1000 h test despite many heat-up and cool-down cycles, leakage became severe. This clearly identifies sealing as a top engineering priority.

The pilot data provide a basis for validation of microkinetic models [2] and for techno-economic and life-cycle assessments of the overall process. Beyond the specific reaction studied, the results underline the broader potential of electro-thermal fluidized-bed reactors as an unconventional catalysis platform for electrified high-temperature gas–solid transformations.

## 4. Conclusions

This work represents an important leap in process electrification by demonstrating that a fluidized-bed reactor can be heated directly through resistive (Ohmic) current passing across conductive fluidized particles between a central and a radial electrode, enabling efficient internal heat generation at high temperature. Beyond establishing this new electro-thermal reactor concept, we also successfully demonstrated the target chemical conversion under these operating conditions, confirming its promise as a practical platform for electrified catalytic processing.

## References


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***Keywords***

Electrified catalysis; fluidized-bed reactor; Joule heating; acid-gas valorization

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