

REACTION TECHNOLOGY

PROCESS DEVELOPMENT

Successful chemical process development is based on a foundation of trust:

Trust in the technology partner's competence and trust in his confidential handling of the client's IP. This foundation is a key factor for successful cooperation. Buss ChemTech's clients can rest assured that their gas/liquid reaction chemistry will remain their own and that it will run under optimized conditions. We have several approaches depending on our level of know-how with a particular process and the information the client brings to the project:

Proven process

Whether the plan is to replace an old reactor with the latest technology or to install an additional reactor to increase capacity, we will verify the suitability of the Buss Loop® Reactor for the process based on the client's process data and will provide an estimate of the expected performance increase that could be achieved.

"Tune up" your (lab) process

Using process parameters developed by the client's own efforts, most often using STR's, Buss ChemTech can adapt the process to a Buss Loop® Reactor. Usually, a preliminary process design can be developed from the lab-scale results. If necessary, additional testing in the pilot-scale will be performed to commercialize the process and define guaranteed performance parameters.

Development projects

Buss ChemTech can also put its full set of capabilities to work for clients with little or no development capacity starting with literature and patent searches, catalyst screening and lab tests. With the lab data in hand, we can design a preliminary process and proceed to testing in one of our pilot plants to confirm and optimize the necessary process parameters to design a commercial plant with process guarantees.



KEYS TO SUCCESS

The performance of an industrial plant depends on how well the process design is optimized. To aid in the development of optimized commercial processes, Buss ChemTech operates three pilot plants and a number of laboratory reactors.

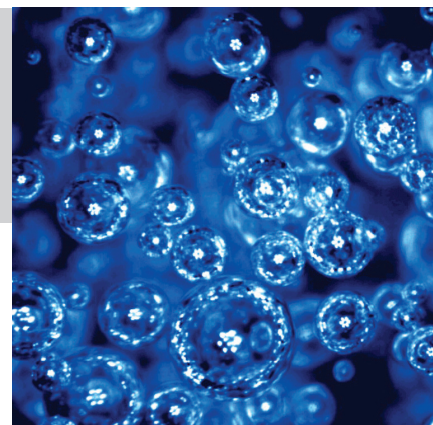
All warranties for process and performance offered by Buss ChemTech are based on actual data developed in our technology center (and backed up by industrial scale performance).

THE SHORTEST PATH FROM THE LAB TO FULL-SCALE PRODUCTION

For a **proven process**, a week or less is usually sufficient to optimize the process parameters in one of our pilot plants. Using the results from the pilot-scale, Buss ChemTech defines extensive process guarantees, such as yield, selectivity and catalyst consumption, depending on its scope of supply. This work forms the basis of our quotations and the design of the industrial plant.

Development programs to **"tune up" your (lab) process** usually needs two to three weeks to get useful result depending on the starting point of the cooperation.

Longer-term **development projects** usually start from a vision and can show early success as two completely different knowledge pools are collaborating. Early success is no guarantee, however, that an economically successful industrial plant will be the result. Buss ChemTech will propose a phased approach which will allow the client to minimize further



costs if it becomes apparent that the project will not be ultimately successful. And depending on the client's need and wishes, Buss ChemTech can enter the development process at whichever stage is appropriate.

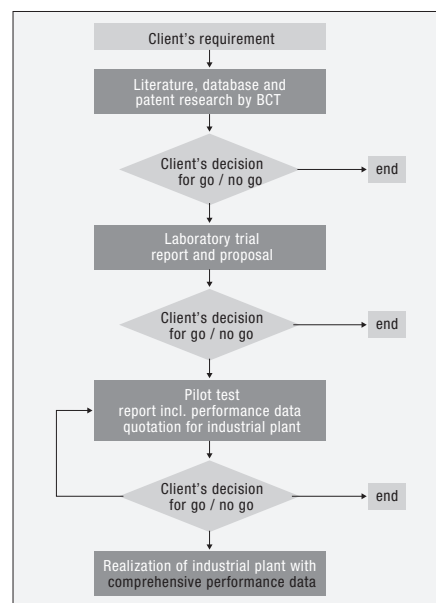
SCALE-UP

Regardless of scale, a Buss Loop® Reactor unit is characterized by:

- Uniform mixing (minimizing temperature, concentration and pH gradients)
- Smallest gas bubble size (average size in µm-range) and thorough distribution and hence highest mass transfer
- Independent and virtually unlimited heat transfer capacity

These characteristics allow scale-up without changes in mixing pattern and area-to-volume ratios.

A linear scaling of temperature and concentration gradients ensures optimum reaction kinetics for scale-up ratios of up to 1:4000.



DEVELOPMENT EQUIPMENT

- Batch and continuous laboratory reactors up to 200 barg
- 15 liter pilot plant in Hastelloy® (50 barg, 200°C)
- 15 liter pilot plant in glass for highly corrosive media (1 barg, from -20° up to 150°C)
- 50 liter pilot plant in SS316 (100 barg, 280°C)
- Batch and continuous filtration systems

CONTINUOUS SAMPLING AND ANALYTICS

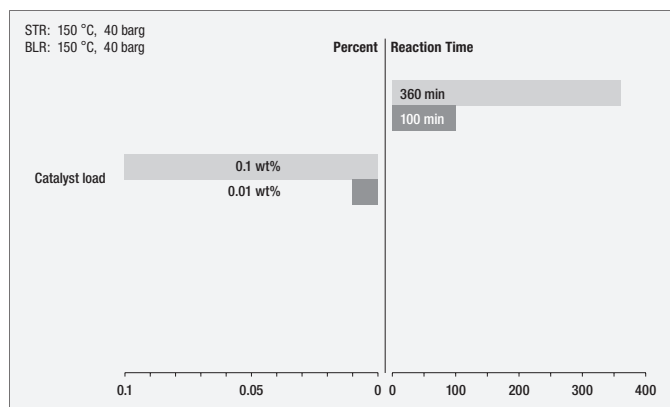
- Online monitoring by FTIR (Fourier Transform Infrared)
- Large numbers of analytical tools like GC, HPLC, IR, UV/Vis
- For specific needs such as rectification, crystallization and the like, we can offer extensive know-how in collaboration with our highly experienced partners
- Special analytics (NMR, MS,IC) provided by our network partners

BUSS CHEMTECH – FOR A SMART INVESTMENT

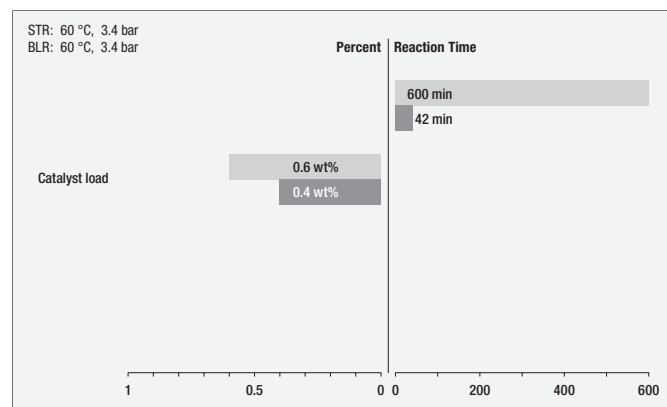
- Fast and efficient process development
- Excellently equipped laboratories, highly experienced and qualified staff
- Ability to demonstrate almost any multiphase reaction
- Full process and performance guarantees
- Scale-up factors of up to 4000 realized
- Reliable and reproducible process data and consumption figures guarantee the success of the investment decision

Some examples of successful applications

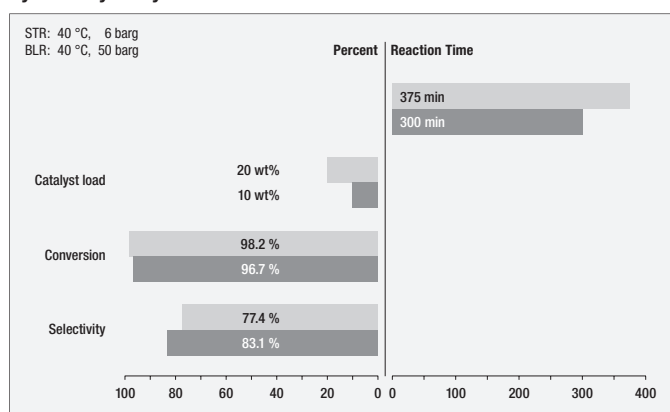
Hydrogenation of an aromatic nitro compound



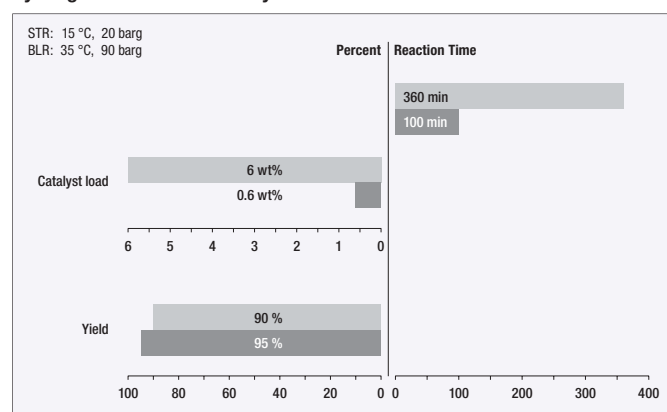
Oxidation



Hydrodehydroxylation



Hydrogenation of an aldehyde



■ STR: Stirred Tank Reactor ■ BLR: Buss Loop® Reactor

BUSS ChemTech

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