ONEJOON

L2P PROGRAM

SCALING FROM BATCH TO CONTINUOUS PRODUCTION

CHALLENGES, RISKS, SOLUTIONS & POTENTIALS

Simon Schurr, Vice President Advanced Materials and Processes, reports about four current SOFC/SOE projects and the challenges of the upscaling process.

PART 2
INTERVIEW WITH SIMON SCHURR

SOFC/SOE CELLS – FROM LABORATORY TO LARGE-SCALE PRODUCTION

For solid oxide fuel cells (SOFC) and electrolytic cells (SOE) the upscaling process from laboratory to large-scale production is complex and challenging. As the current market growth is often driven by startups and university spin-offs, the know-how for large scale series production is often not available.

Simon Schurr, Vice President Advanced Materials and Processes, reports about four current SOFC/SOE projects and the challenges they face in the upscaling process.

INTERVIEW WITH SIMON SCHURR, VICE PRESIDENT ADVANCED MATERIALS AND PROCESSES

▶ ***What are the biggest challenges in upscaling from a small-scale production in the laboratory to a large-scale production in the factory?***

"The expectation of our customers from the R&D environment is to be able to linearly scale up their process from small batches of, say, 50 cells to several thousand cells per day, or even hour. However, this is bound to fail, because the manufacturing processes from the laboratory are not suitable for mass production for both technological and economic reasons as their process and plant equipment is completely uneconomical for large scale production."

One of the key problems is the extremely long cycle times in the laboratory furnaces. These arise from the very high demands on process control and temperature uniformity of small-scale batch productions. Increasing the throughput requires considerably shorter cycle times or significantly larger furnaces. With linear scaling, scrap rates increase, times for correction work and workarounds lengthen, and material usage rises disproportionately.

▶ ***What are the resulting requirements for a large-scale production?***

"Manufacturers from the R&D environment need a turnkey solution with both a technical and an organizational plan. Early in the L2P process we can also provide initial budgets for potential investment planning. Among other things, we calculate the requirements for continuous production furnaces, circulating conveyors, kiln furniture, automation and product handling, exhaust gas treatment, and even integration into a factory process control system. In addition to the actual plant technology, the turnkey solution involves the planning and optimization of the processes and the transfer of plant operation know-how."

▶ ***Can the realization of such projects succeed in just two years? What are the steps of implementation?***

"The time frame is very tight, nevertheless realistic. We have developed the "Lab to Production (L2P)" program with four development stages particularly catered towards the upscaling from the laboratory to large-scale production.

In the current projects, the first task was to create an awareness of the challanges associated with the requirements of mass production, because three out of four project companies lacked the know-how of how to operate a large-scale production. We call this "Closing the Gap Mentally." The clients mainly lacked a suitable roadmap, optimization and scale-up know-how and the required simulation models. Here, together with our partner network, we have analyzed the actual state of the kiln customer's kiln processes in their own facilities and in our own test equipment by means of numerous measurements and chemical analyses. With a strong focus on the gas exchange behavior of the cells during the debinding process and their heat-up characteristics throughput the thermal profile setting clear boundary conditions for future production equipment."

▶ ***How high is the optimization potential of laboratory processes with regards to large-scale production?***

"Through thermomechanical analyses (STA/TMA) of the cell material, experiments, calculations, simulations and tests in our test center in Bovenden, we have determined maximum heat-up gradients for the debinding and sintering processes for the products as well as the kiln furniture.

This analysis and insight phase of the projects have confirmed that the optimization potential is very high. We have achieved firing time savings of up to 50 percent and weight savings of up to 40 percent in the thermal process by selecting the right furnace and kiln furniture for our clients. Less weight means less energy consumption thereby lower operating expenses.

It was also a matter of selecting and qualifying the right kiln furniture for an automated handling system. In this phase, our customer's had to commit to a manufacturing concept with concrete processes in order to achieve the specifications as quickly as possible."

▶ ***How was the practical suitability of the manufacturing concept demonstrated?***

"Validation of the manufacturing concept is a separate stage of development in the L2P program. We now have a lot of experience in using digital models of the furnace and kiln furniture to simulate the thermal processes and gas flow in a very practical way. In doing so, we map the debinding and sintering processes on a full production scale.

Automation and cycle time challenges in the projects included very complex product assemblies of carrier plates, product and active layers. Depending on the design of the SOFC / SOE, we can still adjust the process parameters in detail at this stage.

The validation of the concept also included the total costs of ownership analysis including all capital expenditures (CAPEX) and ongoing operating costs (OPEX)."

▶ ***What follows after the proof of concept? What challenges do SOFC / SOE customers have to tackle next??***

"The final step is about implementation and ramp-up. The realization of very large furnace projects is part ONEJOONS daily business as an experienced furnace manufacturer. After the delivery of the equipment, the design is optimized as required and the equipment is put into operations. Finally, the processes are gradually ramped up and optimized.

The biggest challenge at this stage is the customer's lack of expertise in operating such a large-scale production facility. Therefore, the last important step is the extensive training of the customer's employees in the daily plant operation, monitoring and maintenance. We also provide support to production teams during the first few months of plant operation by dispatching our own engineers and technicians to the customer's plant." ■

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