If you’re not paying attention, it’s easy to overlook the revolution taking place around you. Walk behind gigantic milling machines and past workshop cubicles where welding light flickers through rubber curtains, pass through a flood of sensory impressions consisting of hammering and the smell of metal, and you’ll come to a glassed-in cubicle standing against a wall. You may enter it through the lock chamber only if you’re wearing mouth protection. Behind the big windows, a technician is producing components made of metal powder in a 3D printer that is as big as a cabinet. This method, which Evonik is using at the factory site in Hanau to develop and produce new reactors and components, is opening up entirely new opportunities for the chemical industry to shape its plants and processes. These opportunities include improving the plants’ performance, reducing costs, and decreasing their environmental impact.

At his computer in front of the glassed-in cubicle, Daniel Adam is preparing a structure for printing that looks more like an anatomical model than the model of a machine. It’s a construct made of pipes of various thicknesses that join together to form a larger structure which then again sprouts branches, similarly to the human venous system. Adam checks the construct layer by layer, planning in supportive networks at the spots where the slender pipes would otherwise buckle in the bath of metal powder. If you recognize models from the realm of biology in this machine component, you wouldn’t be wrong. “We do in fact observe how nature optimizes structures such as capillaries, muscles, and roots,” says Senada Schaack, who is responsible for 3D printing at the Process Technology and Engineering unit at Evonik.

Today Evonik is using 3D printing, along with other technologies, to construct its own production facilities. Metal powders are being used to build reactors and devices based on biological models. That’s good for the environment—and for cost-effectiveness.

Open to new things: Senada Schaack founded the SAM 3D innovation unit for 3D printing with metal at Evonik in 2018

OPTIMIZED FORM
Actually, Schaack was never especially interested in biology. In her home town of Sarajevo, she started to study mechanical engineering. Due to the war in Bosnia she ended up in Hanover, where she received a doctoral degree for her work on the simulation of multiphase flows. Later on she started to work at Evonik. Her enthusiasm about the opportunities opened up by simulations eventually motivated her to propose that the Group establish a competence center for 3D printing in the production of apparatus for chemical processes. “When I combine the opportunities offered by 3D printing with those of computer simulation, I can find an optimal shape for apparatus that could not be implemented by using traditional methods,” Schaack says. Since 2018 she has been doing research with a dozen colleagues in the facility she had visualized: the Simulation and Additive Manufacturing 3D competence center, or SAM 3D for short. They are finding out how to make reactors and components for the Evonik Group’s chemical production facilities even safer and more efficient with the help of 3D printing. Turning, drilling, milling, welding: Until now, these have been the technologies for making the reactors in which the chemical industry manufactures —
its products. Chemists, process engineers, and mechanical engineers have used many innovations to make them highly productive and efficient. “If I can use simulations in combination with 3D printing to customize the shape from the very start so that I have optimal conditions at every point in the reactor, I need much less energy and less solvent or none at all, and I get higher yields,” Schaack explains. “That way we can make a visible contribution to increasing sustainability.”

DEVELOPING A PROTOTYPE IN TWO MONTHS

Greater sustainability—that is Schaack’s motivation and her central idea behind the project. But this idea also offers tremendous economic potential, because the cost of development with the help of 3D printing is significantly lower than the cost of using conventional methods. “We printed a new construction in two days, and now we can test it, improve it, and test it again,” says Schaack. In the future she plans to submit optimized prototypes within two or three months. That’s the length of time that conventional methods sometimes require simply to create the first experimental structure.

Word of the possibilities that 3D printing offers for process development has spread quickly throughout Evonik. Inquiries and ideas are coming not only from Hanau and Marl, where the team operates, but from all over the Group. The SAM 3D team confers regularly with other Evonik locations, whether they are in Vancouver, Birmingham, or Singapore. At workshops conducted together with the Evonik business units, Schaack and her team explain their working methods and cooperate with their colleagues to find solutions for previously unsolved problems.

The group headed by Schaack is relatively young, but older colleagues also see the technology’s potential. Their reaction can be summed up in one word: “Finally!” Finally it’s possible to implement ideas that in some cases have existed for decades without being technically feasible. “In the workshops we start talking about topics such as microreactors—topics that emerged around 2000 but were then shelved,” says Johannes Ehrlich, the head of the special plant construction unit at Evonik. “Today these topics are sparking interest once again.”

The delicate structures that Schaack’s team can calculate and print make it possible to solve traditional challenges in chemistry, such as the tremendous amounts of waste heat that are generated by many reactions. “In exothermal processes of this kind, we sometimes see the formation of hotspots that are harmful for the product and also for the plant,” says Andreas Gumprecht. Together with his colleagues, he is clicking his way through a simulation model that was calculated via the SAM 3D process. “With the help of this method, we can develop apparatus for challenging reactions of this kind—apparatus with geometries that ensure an improved heat exchange process,” he concludes.

LESS EFFORT, MORE CONTROL

The new production technology is still in its initial phase. “It’s not a substitute for traditional plant construction—it’s a complement to it,” says Ehrlich. However, he adds that printed reactors already bring “smoother operation into the system” because they have fewer individual parts, require less maintenance, and enable more monitoring. “A reactor usually has one temperature measurement and one pressure measurement,” Ehrlich explains. “Now we are planning to incorporate 16 sensors, and we’ll be able to acquire much more data.” In the past, it was not possible to fit so many sensors into a narrow space by means of traditional production processes. Thanks to 3D printing, it’s now possible to print the access points for sensors directly along with the component.

3D printed reactors are already proving their worth in the first set of production facilities at Evonik. “It’s not a substitute for traditional plant construction—it’s a complement to it,” says Ehrlich. How-

Evonik is now one of the first companies that is permitted to produce metal pressure reactors by means of additive manufacturing methods. Schaack and her team are using the top quality of these processes and products to advertise their services. “In the next three years, they want to shorten the period of time from the initial idea to its implementa-

Plant operator David Fuchs wears a protective suit to fill a printer with metal powder.