*Exclusive Interview with Werner Faulhaber of Arburg and Paul Filz of Simcon*

# "We Tear down Walls"

The injection molding machine manufacturer Arburg and the simulation software supplier Simcon presented the first filling simulation directly on the injection molding machine three years ago. Now, the two cooperation partners have enhanced the simulation of an operating point to an operating space. With the new FillAssist generation, the user has the advantage of seeing the effect of a parameter change in advance in real time during the setup of the process.

Three years after holding talks with Simcon managing director Dr. Paul Filz and Dr. Eberhard Duffner [1], Filz and Werner Faulhaber, Duffner's successor as head of development at Arburg, met up during Arburg Technology Days at the end of June 2022 for an exclusive interview with ***Kunststoffe*** to talk about the latest joint developments. The glass pane of the first floor conference room opens onto a view of the hustle and bustle in the Customer Center. But none of it can be heard. An opportunity, therefore, for a concentrated exchange on a special topic.

***Kunststoffe:*** *Dr. Filz, three years ago we were sitting here in a somewhat different constellation to talk about filling simulations on the injection molding machine. As an introduction, can you briefly sum up the state of affairs at K 2019?*
**Paul Filz:** At the last K, we were at the stage of transferring an operating point that had previously been optimized by simulation to the injection molding machine. The control system then adapted this input to the conditions of the actuators in the individual injection molding machine and used it to generate an optimum machine setting data set so that the application can run. The operator could observe the mold filling on the Gestica machine control system as a function of the screw position, simply by moving a slider on the display. He could see how the part was filling and figure out when the ejectors were overflowed, so that the part could be ejected. So that it doesn't have to be pried out by force. (*laughs*)

***Kunststoffe:*** *Mr. Faulhaber, can we say that Arburg is responsible for this? You had to convert all the data from the simulation into machine parameters?*
**Werner Faulhaber:** In the control system, we combine the knowledge about the three domains of mold, simulation and machine. We can integrate the simulation results into the control system and generate a data set that contains the injection profile and temperature profiles, which the operator would otherwise have to create manually. In this way, we have integrated the ideal operating point in the first step.

***Kunststoffe:*** *What does that mean specifically in terms of the machine?*
**Faulhaber:** Our task is to work backwards again, so to speak, starting from the screw tip, or more precisely the gate: what is taking place in the machine? We have very good knowledge about the performance at the injection axis: what filling rate and pressures can we achieve? What is happening in front of the screw and along the screw? We calculate this information in advance, combine it with the simulation results from Simcon's Cadmould, and introduce it into the control system with our FillAssist assistance system. This gives the machine operator a feeling of what degree of filling has been achieved at what screw position, even before the first shot. With this visualization, he can decide, for example, to fill the part by 90 percent at first, to avoid a miss-shot. The melt thus overflows the ejector pins and the first shot can be safely demolded. This caused a certain excitement in the industry at K 2019.

> *"Even before the first shot, you can vary parameters and investigate the influence of individual parameters."*
>
> Werner Faulhaber

***Kunststoffe:*** *This joins two worlds that have been incompatible until now. What does this step mean?*
**Filz:** It means that we are really tearing down walls. Until now, the simulation world lived in one bubble and the machinery and production world in another. The two worlds didn't even speak the same language. And now, that barrier is being broken down; we have an automatic translator, so to speak. That means we have provided the data and explained their origin, and Arburg has adapted them so that they apply to the specific individual injection molding machine that is being used. The entire translation work is Arburg's work completely. Of course, this is a sophisticated art and it requires intimate knowledge of the machine's characteristics.

***Kunststoffe:*** *We would like to know more about this sophisticated art …*
**Faulhaber:** In principle, we have greatly simplified the process. If we translate the results from the simulation, we also have to take into account how the machine is equipped, what components are installed in it and how they respond. With all this information, we are capable of translating the physical parameters that come from the machine-independent simulation into machine-specific settings that the operator understands. In many cases, simulations happen before and during mold installation. But the results and insights don't travel from engineering to the shop floor. The operator at the machine is often not aware of these insights. That is a pity, since the data are, in principle, available. That is precisely where we start out. To be able to transmit the data without loss or errors, we have linked our computation tool with the simulation. You can simply import an STL file of the part, and thereby perform the simulation on the machine – all at the touch of a button. You do not need to be a material and simulation specialist. This can be done by any operator of an Allrounder injection molding machine with a Gestica control system.

***Kunststoffe:*** *So the user determines the ideal operating point before start-up. What then?*
**Faulhaber:** Then he has the opportunity to say: machine, please use these parameters. The simulation settings are transferred losslessly to the machine control. What you see is what you get.

***Kunststoffe:*** *And if he doesn't do that?*
**Faulhaber:** Previously, if the machine operator changed parameters, i.e. deviated from this simulated ideal operating point, we weren't able to provide a clear-cut solution to the user. Simply because we had only calculated simulation results for this one operating point. It is precisely here that we have now deepened the level of insights that the user gets.

***Kunststoffe:*** *How must we imagine that?*
**Filz:** As you know, we not only have our simulation tool, but also a tool called Varimos. It does what we call rapid variant analysis and what-if-analysis. So we thought, how can we make this kind of what-if analysis (**see Info box**, *editor's note*) available directly on the injection molding machine? We've solved this by transferring simulation results from an entire operating space to the injection molding machine, instead of only a single optimized operating point. That is an AI based function. The machine operator can then virtually try alternative settings on the machine control, and see a real-time prediction of how that will impact e.g. the filling pattern. Arburg adjusts the operating space that we have explored in simulation to the actual possibilities of the specific injection molding machine. What remains is what really works on the injection molding machine, and you can see what's going to happen directly on the display.

***Kunststoffe:*** *What does Arburg's role look like, precisely?*
**Faulhaber:** If, for example, we cannot model the injection speed calculated in the simulation with the machine, the procedure is as follows: We use the calculated speed, which triggers a data error. The operator sees the problem and then responds according to his own process knowledge: He can either decide to adjust the speed but then knows that he is deviating from the simulated, that is to say the optimized, process. Or he decides to perform the simulation again with reduced speed – as in the past – or to choose an operating point within the process space that the machine is capable of; that is the new situation. Then, before you make the first shot, it is possible to vary parameters and investigate the influence of individual parameters.


The new tool works on any Arburg injection molding machine with Gestica control. © Arburg

## What Is Varimos?

Varimos is a rapid variant analysis and optimization solution for injection molding. It is used to perform interactive what-if analyses and generate suggestions for better solutions. Usually, after you've done your baseline design of part, mold and process parameters, you will want to explore some alternatives, to get even better results. Instead of using trial-and-error to set up and simulate design alternatives one by one and evaluate them manually, Varimos automates the repetitive steps. You simply give it a list of variables and a range for each variable. This tells Varimos what your options are. It will then create, run and evaluate a large number of simulations for you, to explore these options. Varimos is CPU-efficient. For most parts and computers, it will provide same-day or next-day results, for the full plan of simulations. It uses artificial intelligence to understand cause and effect from the simulations.

### References & Digital Version

You can find the list of references and a PDF file of the article at ***www.kunststoffe-international.com/archive***

### German Version

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***Kunststoffe:*** *Does the final decision – of which parameter set is now the best – still lie with the user?*
**Filz:** The decision lies with the user. We don't take away his »

responsibility. He remains the master of the process. But we give recommendations.

***Kunststoffe:*** *What level does the variation take place on, and with what parameters?*
**Faulhaber:** There are two program levels in the Gestica control system. The active level controls the currently producing machine, in the preparation level a next process can be superimposed. The simulation results can be examined and varied in the active level. Of course, we concentrate on the injection profile parameters, which have a large influence. In order to see what parameters are most impactful, the operator is also allowed to make corrections later if the process is running in a direction that would not be optimal for the part.

***Kunststoffe:*** *You're talking about troubleshooting? The problem solution is approached playfully, by simulating possible variants?*
**Faulhaber:** The simulation of variants is actually performed beforehand. This creates a modeled operating space that has been virtually explored. In the Gestica machine control, the model is used to predict the effects of arbitrary parameter combinations in real time.


## About the Interviewees

**Dipl.-Ing. Werner Faulhaber** (56, left) has been head of development at Arburg since 2021. He started his training in the field of electrics in the automotive industry, followed by studies at the technical university of Trier, Germany, as Diplom-Ingenieur in electrical engineering specializing in information technology. He wrote his diploma thesis with the automotive supplier ITT Teves on the topic of "Sensors in the Field of Automotive." After joining Arburg, he held various posts in electronics development with a focus on control technology, sensors and actuators, until being appointed head of the electrical engineering development department.
**Dr.-Ing. Paul Filz** (65, right) studied mechanical engineering at the RWTH Aachen University. In 1988, he completed his doctoral thesis with the title "new developments for the simulation of injection molding processes with thermoplastics." In the same year, Filz founded Simcon kunststofftechnische Software GmbH, Wurselen, Germany, and has been managing director ever since. Since 2017, his daughter Ines Oud has been co-managing director.

***Kunststoffe:*** *And then the decisive moment comes: accept or cancel?*
**Faulhaber:** FillAssist can be used on the preparation level to take over the calculated data in the data record of this plane, but the data then also have to be taken over into the production level. Alternatively, the variants can also be tested and viewed directly in the production level. As long as the calculated data are not taken over, no harm is done to the running process.

***Kunststoffe:*** *What are the advantages of this for the customer?*
**Faulhaber:** It gets a lot easier to commission the mold. Irrelevant tests are avoided, which saves material, energy, machine time and money. Sampling becomes more targeted; it is no longer necessary to explore all physical limits up to their boundaries. The simulation also predicts which parameters have a meaningful impact, and up to which limits. The main difference from the former situation is that if you explored alternative settings in the past, you did it physically on the machine. You did not have any advance information about how changed settings would impact the part. Now, on the Gestica, you can see a simulated preview of what will take place in the injection molding process. In addition, if persistent problems are identified during sampling, the machine operator can assess more quickly and systematically how they can change the settings in order to resolve them.

***Kunststoffe:*** *Saving time and money always sounds good. If you wanted to put a figure on it – how far can you stick your neck out?*
**Faulhaber:** It is certainly a great simplification, but it's difficult to give an accurate figure. As I said, in troubleshooting, it's an ideal helper if the process is running away. In that case, even experienced setters can benefit from assistance when they try to get back into the process window: which parameter change is helpful and which is useless? We see a lot of promise in providing this support. The people at the machine usually have a lot of experience, and now we can augment this with real-time predictions from the simulation.
**Filz:** There will always be a significant return on investment. The customer actually benefits in more than one way: commissioning time is significantly accelerated, and at the same time, part quality will improve. We know from our own optimizations and first applications that we can always improve cycle time. It could be three percent, but it could also be 15 percent – how much you can achieve varies from case to case, of course.

***Kunststoffe:*** *You talked about an AI-based function for the operating space before. But that seems to be a one-way street. Or can you restore the data?*
**Filz:** For the machine parameters used by the operator, it will certainly be possible in the near future. Where the part data are concerned, we are already pleased if we get feedback on how well the simulation corresponds to real-world results. We have to do more work on automatically incorporating the feedback and

receive such data in large amounts. Regarding the type of AI we deploy: what we use to optimize the process is an algorithmic AI. Because we know the relationships, we need only a relatively small number of observations to train it.

***Kunststoffe:*** *What is the situation regarding provision of data by the processor?*
**Filz:** It is not a problem technically speaking. It is more a matter of barriers in people's minds or legal concerns than a technological limitation.

*"The customer profits in various ways: through shorter commissioning and better part quality."*

Paul Filz

**Faulhaber:** Today, we are capable of supporting the customers with parameters that are relevant to the quality of his part. We can monitor these parameters and see when something changes. We can perform trend analyses and display aberrations before a bad part is produced. At this point, we can give the operator information: this is where you have to intervene and make corrections now.

***Kunststoffe:*** *That will become a component of your assistance systems?*
**Faulhaber:** Monitoring parameters and preparing trend analyses is presently being integrated, yes. Today we have an IIoT gateway in every machine that we deliver. That means that we are able to record data quality parameters via OPC UA and transmit them to a higher-level system such as an ERP system or our ALS. The idea would be to use these data in the future in order to retrieve information again, and refine the AI so that we are continually improving.

***Kunststoffe:*** *How complex can the part or the mold be, for what type of applications are there still restrictions?*
**Filz:** We are not restricted on the simulation side.
**Faulhaber:** We still have restrictions. Multicavity molds are not a problem, though we can't simulate multicomponent parts yet. But that is only a question of time. We are making progress one step at a time.

***Kunststoffe:*** *Extreme example: what if you are working with a 96-cavity closure mold? Do you need to walk while running in development?*
**Faulhaber:** It is definitely an ambitious task, I have to admit. In that case we would work closely with the customer to get going together.

***Kunststoffe:*** *In that context, have you worked together with pilot customers?*
**Faulhaber:** We started working with pilot customers already in step 1 – it is a big help if you have customers who have a certain mindset as well as experience with simulation and can give you feedback. There also has to be a high level of trust, a willingness to handle challenges together if not everything works perfectly from the beginning. We work with such pilot customers to test, refine and improve our products.

***Kunststoffe:*** *What is the pilot customers' preliminary conclusion? Is the product ready for the market?*
**Faulhaber:** Yes, we will have stage 2 ready for the market by K 2022.

***Kunststoffe:*** *Then you will surely also be demonstrating the new evolutionary stage in Düsseldorf. On what object?*
**Faulhaber:** We will show them on our biggest machine, the Allrounder 1120 H, which will be producing a toolbox designed by Arburg. »

***Kunststoffe:*** *Assuming that you have already persuaded the visitor at the trade show booth. Which product does he have to purchase?*
**Filz:** For starters, when a customer wants to use the new functions, he needs the Cadmould/Varimos results from the simulation. It doesn't matter whether he computes the simulations himself or gets them as a service from a provider like us. Once the results are there, he can continue on the injection molding machine.
**Faulhaber:** We will offer this as an option after the K show, recognizably close to FillAssist. We are also considering offering Varimos analysis as a service in our customer portal arburgX-world.

***Kunststoffe:*** *Is Arburg's role proprietary know-how?*
**Faulhaber:** You can protect certain things.

***Kunststoffe:*** *And have you?*
**Faulhaber:** We have tried to secure some things, yes.

***Kunststoffe:*** *Are we already talking about intelligence on the machine – is that part of the vision?*
**Faulhaber:** That is certainly a declared aim. We must be aware that our industry has a problem with training. Whether plastics engineers at the institutes or plastic molders at the technical colleges – there's a lack of new blood. That means that, in the medium term, we will have to face the fact that we are likely to have operators at the machine who do not have the same level of qualification and experience that we see today. At the same time, the processes are becoming ever more complex. And there is another issue: the increasing use of recyclates. We will have to build a circular economy in plastics. That is inevitable, but it also means that the material quality will vary. It is becoming more complex to respond to this in the process – intelligence will be needed on the machine, which then provides support.

***Kunststoffe:*** *What steps have you planned for the coming years?*
**Faulhaber:** We actually have precise ideas for the next steps. But we prefer to keep them under wraps for the time being.

***Kunststoffe:*** *As regards recyclates – will we have standards for reliable quality in the foreseeable future? What are your thoughts?*
**Faulhaber:** For the simulation, you always need the three domains, i.e. machine, mold and material. For recyclates, the material data are often not available. In addition, these materials have very high variance in their properties. If we have a variance of these parameters in production, there will inevitably also be a variance in the product. That is something we have got to handle. The machine must identify why the process is currently drifting outside its process window. In future we will handle this with an AI controller, which will then try to return the process back to the optimum working range. That is an absolute necessity, which we will approach strategically. We do not know how the situation with recyclates will develop. We only know that we must be prepared.
**Filz:** One thing you can do in simulation is to change the material artificially. For example, a viscosity curve or a pvT diagram could be changed within certain bounds. Other data, too, such as thermal material data, can be varied. Then you can see what happens if you are leaving the process otherwise the same. What we do not always know is the magnitude by how much these properties vary in the real world, for a specific material. If it varies by more than what we have simulated, we are not giving useful information. We must certainly work on this question, also together with the recyclate manufacturers. The aim is to provide a simulation that is just as reliable as that for virgin materials, despite their high variance in properties.

***Kunststoffe:*** *That could be an interesting business model if such data were collected in arburgXworld. Are thought experiments being conducted in this direction?*
**Faulhaber:** At least we are already deeply involved in R-Cycle, and try to give the material a unique identifier as it is produced. That means we have a clear association with a database entry throughout the entire life cycle. This would be such a scenario: if we manage to identify relevant process parameters for a specific batch and store in the database what variance the material has from the known standard. This is not trivial since it depends on whether homogeneous recyclate or a mixture is being processed. The technical possibilities are here, we just have to make it happen. But this is not a "one-week project," there is just a lot to do.

***Kunststoffe:*** *While you are talking about projects, how big is the team that has been involved in translating simulation language into machine language?*
**Faulhaber:** At Arburg, we have data scientists and mathematicians and people in the field of application process development who work closely together with the specialists at Simcon during the definition phase. In addition, there are software colleagues who translate everything into the machine domain and control technicians who assess the influences. Only then is there the test phase, in which we really go into plastic, verify everything and feed back the results.

***Kunststoffe:*** *Oh gosh, whatever has happened to mechanical engineering?* (laughter) *But now, away from the sober, objective level and to the emotional. You are breaking new ground, here, so are you proud of what you have achieved?*
**Filz:** (*with a solemn voice*) We are very, very proud of it.
**Faulhaber:** And very confident!

***Interview: Dr. Clemens Doriat, editor***