BAUMÜLLER

Drive simulation as a silver bullet

Five application cases – five problems – one tool: ProSimulation

be in motion

Drive simulation as a silver bullet

Image: Cyclone Project

Five application cases – five problems – one tool: ProSimulation

Modern simulation methods open up new opportunities and do so in numerous applications. Modeling and simulation are used in drive technology to reproduce complex machine parts. Machine behavior can be tested virtually by creating a simulation model. This digital twin enables shortened development times, cost-efficient machine designs and reduced standstill times.

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1. Introduction

Developing machines is one thing. Designing them efficiently and controlling them precisely is another. Experienced engineers are faced with major challenges: How is the machine made more compact? Which drive solution is the most efficient? How can the machine be made particularly precise? Can an optimum design save costs? How can the commissioning be undertaken faster? How is the machine made to be more profitable? Can the machine still function despite the use of lower quality materials?

These are only a few of the issues faced by engineers when developing and commissioning a machine. In particular, the design of the drive and optimum controller setting are the hurdles to be overcome. If the drive is too small, for example, the required cycle time cannot be achieved or the required product cannot be produced. If the drive is overdimensioned, it results in unnecessary costs and a large machine footprint.

For several years, numerous software solutions have been available on the market for the simulation of precisely such application cases. In this way, different options can be determined and tested until the optimum result is found. With the help of the drive simulation, the mechanical engineer ensures optimum functionality and operating reliability of the machine, without the risk of overdimensioning. The simulation opens up new possibilities for developing and optimizing machines. Engineers can make use of this potential with the help of simulation tools.

2. A comparison of simulation types

From an application standpoint, there is a wide range of simulation types. A look at the technical simulation shows everything that is possible: The finite element method (FEM) is a numerical method that is used to conduct stress and deformation calculations. These can be used, for example, to calculate how a car is deformed in a frontal collision.
Thermal simulations are also quite common today. They are an important part of evaluating temperature behavior in different components. With efficient heat management, the power density of components can be increased. In addition, for complex fluids like polymer-based fluids, particle and fiber suspensions, foams, concrete, etc., simulation can be used to get a picture of reality so that robust and efficient solutions can be found based on the requirements of the application.
The flow simulation is a cost-effective alternative to testing in the wind and water tunnel and allows for calculation of resistance values. Flow simulation is primarily used on airplanes, which constantly have to contend with turbulence. Hardware-in-the-loop (HiL) simulation is used in plant and machinery construction when a programmable logic controller is connected to a model of a machine through a fieldbus. The objective of the hardware in the loop simulation, or HiL simulation for short, is to uncover errors early and to shorten the commissioning phase. Process simulation is used, for example, for the simulation of production facilities to test out alternative production processes and areas of potential optimization of the production lines.

The white paper focuses on drive simulation. The focus is therefore on virtual commissioning, drive designs, optimization of the controller parameters and topics such as energy management, which are explained using specific application cases.

3. Five hurdles when choosing the right software provider

The decision to go with simulation software is anything but simple. The market offers innumerable simulation tools. But which software is the right one? Choosing can be difficult! There are five points that need to be considered in choosing the right provider:

1. **Many software solutions are complex and take time to get up to speed with before they can be used.** That is why it is advisable to choose a user-friendly and easy-to-operate tool that can quickly be used and without prior skills.

2. **The visualization and analysis capabilities vary widely.** For that reason, particular priority should be given to the display format and easy-to-understand analysis options.

3. **Licensing for a simulation software product can become expensive quickly.** In many situations high-end solutions are not needed at all. This is why it is important to determine in great detail which features are needed before making a purchase. This can save a considerable amount of money.

4. **The software should be flexible to use.** That means that compatibility with open interfaces like FMI/FMU (Functional Mockup Interface) is an important requirement. This means you can import simulation models from other software tools.

5. **The software should also be updated regularly and offer support** so that you can get answers to questions from experts quickly and easily.

4. The ProSimulation simulation software

Speed is of the essence: With Baumüller's new ProSimulation simulation tool, customers shorten their development and commissioning times for machines and plants significantly.

ProSimulation contains an extensive library of ready-made modules for different drive mechanisms with Baumüller drive components. Another advantage of ProSimulation is that it is very easy to operate. The software is integrated directly in the ProDrive commissioning software.

The graphic user interfaces for setting the b maXX controller apply to the simulation in the same way as they do to the real drive. This allows novices in simulation to get started quickly and electrical designers, commissioning or service technicians can also benefit from the advantages of simulation.

The tool can be used for a wide variety of industries and machine types, both for standard and special machines. Manufacturers of servo presses, rolling systems, filling systems or robots, for example, can save time and costs now with the simulation software. This is because the use of ProSimulation results in optimization through to complete replacement of a prototype. The time and financial cost of the overall engineering process is therefore reduced significantly.

The advantages of ProSimulation

Time and cost savings during development and commissioning

- Virtual commissioning
- The creation of a real prototype can be optimized or completely replaced
- Open standard for importing customized models
- Simple user interface and operation (ProDrive add-on)
- No need for license for additional modeling software
- The feasibility of the application can be ensured during the mechanical design
- Cost-efficient drive design
- Energy-efficient design of components and the movement profile

Optimization and service support for existing machines and plants

- Virtual troubleshooting and optimization are possible
- Testing of customized requirements

Accumulation of simulation know-how in your company

- Easy introduction to "digital twin" technology
- Faster setting up of your own simulations
- Development of system understanding through user training on the digital twin (risk-free testing of your own settings)

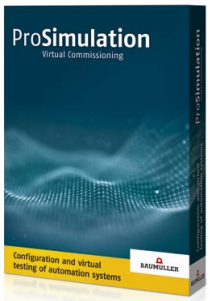
Simulation platform in ProDrive

- Baumüller drive technology as verified controller models
- Extensive library of common mechanics

» Linking of various existing simulation models for the simulation of machine movements

Display of simulation results in oscilloscope with reference measurement

» Direct evaluation and comparison with reality



Parameter settings via virtual controllers

» Virtual commissioning
» Controller optimization and parameter set issuing for real drive

CAD import with 3D animation and machine movements

» Import of existing models from other simulation tools, e.g. Matlab® Simulink®, Modelica®, etc.

Drive optimization with simulation made easy

Use the basic library or import your own models

ProSimulation contains models for the Baumüller drives, motors and a selection of different drive mechanics as a standard feature. Thanks to this basic library, ProSimulation enables newcomers to simulation without their own models to easily set up and test their own simulations. It therefore saves resources and simultaneously enables companies to build up their own simulation expertise. Thanks to open standards such as FMI/FMU (functional mockup interface), customers who already have their own, well-engineered simulation models can import their models into ProSimulation quickly and easily. Baumüller offers the complete creation of new customized models, support for the modeling, the virtual commissioning through to the digital twin as an optional service.

Simple user interface and fast parameterization

ProSimulation enables drive settings to be tested realistically without risk and for the results to be displayed conveniently. After the machine model has been set up, customers can test different drive components and settings and they can use the integrated oscilloscope to show the simulation results. The graphical representation of the results supports the user in controller optimization. Thanks to the new simulation tool, users can start parameterization at an early stage and change it quickly and easily.

Troubleshooting and optimization

ProSimulation is not only a tool for product development. Once a machine has been commissioned or for existing machines and systems, the simulation software also offers the option of troubleshooting and optimization. Users can make parameter settings quickly and directly on the digital twin in ProSimulation without having to operate the system directly on site.

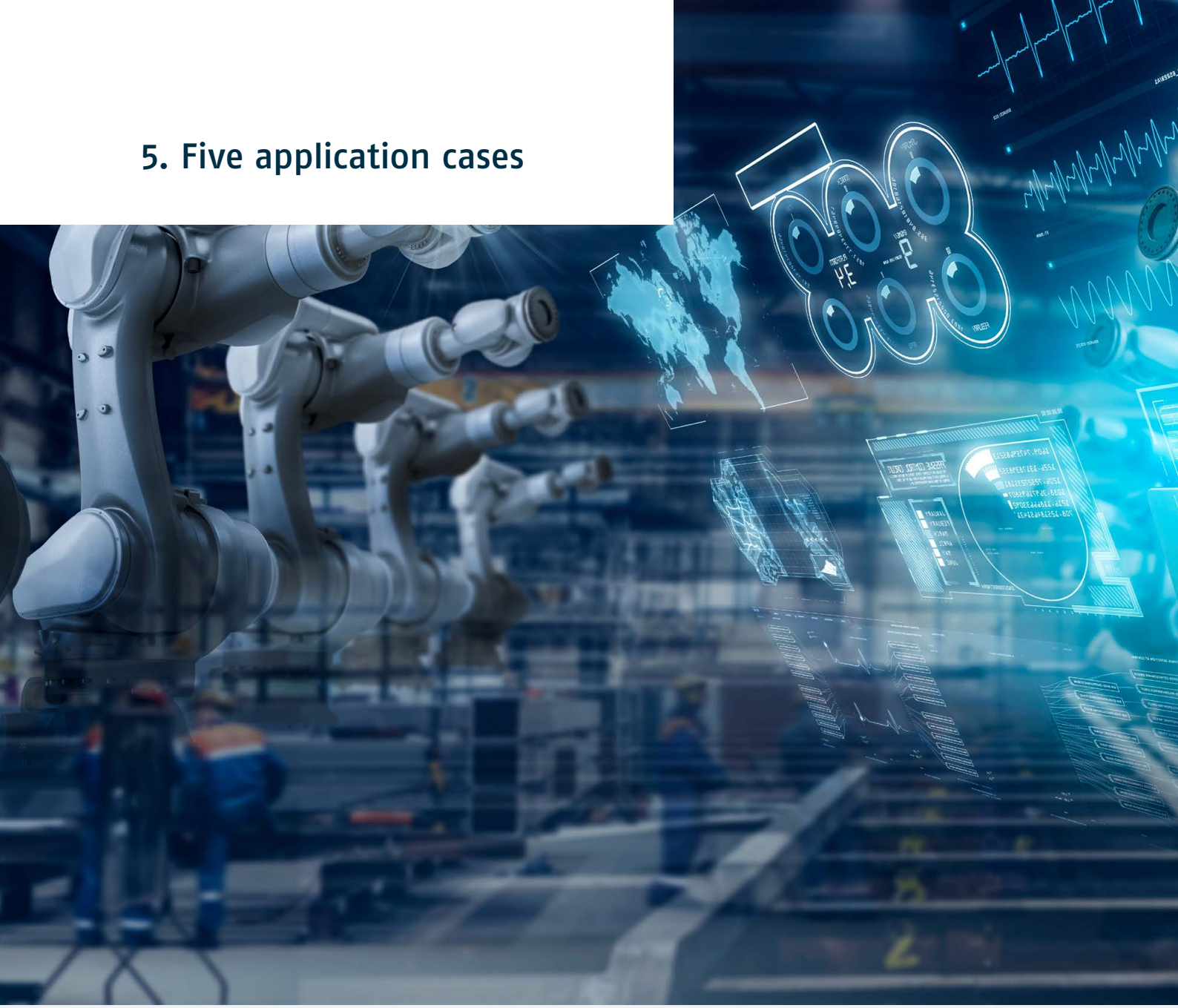
The software uses the identical data interface to the one used by bmaXX servo drives. This means that a real data set can be loaded into the simulation quickly and easily. A data set optimized in the simulation can naturally also be loaded directly onto the real servo drive.

The software also provides the possibility of reading in real oscilloscope measurements and comparing reality and simulation directly in a diagram. In this way the real measurement can be set quickly in relation to the simulation results.

ProSimulation: How does the software work?

https://www.youtube.com/watch?v=WKuuMgwxTFM

5. Five application cases



5.1 Roller drive

A customer reported to the Baumüller engineer on the phone that their glue-roll system was causing problems. A small motor drives a large rolling mill, in order to apply adhesive for the production of corrugated board and to convey it to the next processing step. The crunchpoint here is the high load to inertia ratio of 1:218, which makes it difficult to parameterize the controller.

The plant swung up and affected the coupling and gearing. A simulation model is therefore to be created to test the parameter settings reliably from the desk.

Simulation specialist Michael Stiegler designed a virtual simulation model with the help of the data sets and measured values provided by the customer that provide information about, for example, the change in speed and current. "After I had read the data into the simulation, in the first step, I was able to compare the simulation model with reality. In the second step, I determined the optimum controller settings, safely in the simulation model, to enable reliable operation and to optimize the control behavior of the glue roll", summarized Michael Stiegler.

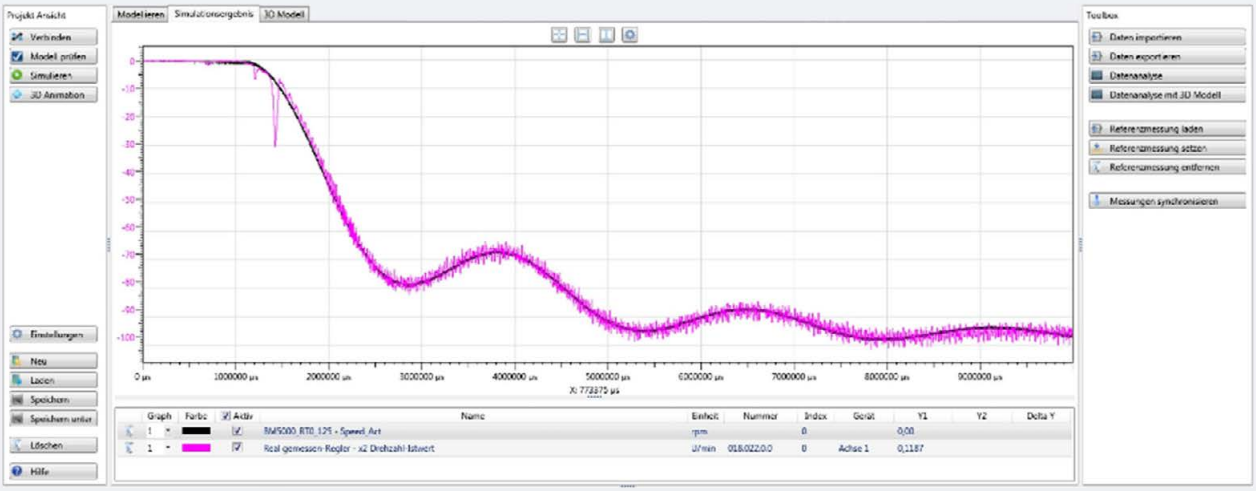


Fig.: Real drive data set and real measurement were read directly into ProSimulation. The speed behavior of the real machine (pink) is represented in detail by the simulation model (black). The vibration can be identified in both measurements.

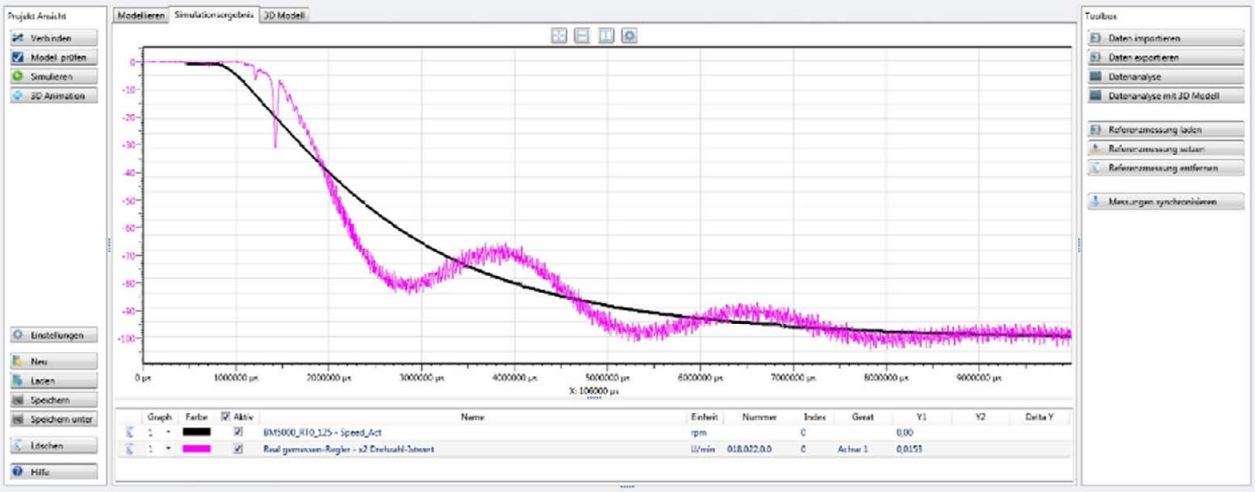


Fig.: With the controller settings found in ProSimulation, the actual speed value (black) is without vibrations and enables optimum operating behavior of the machine. This data set can be exported and loaded directly onto the drive. In this way, the optimum parameter setting was found with ProSimulation.

5.2 Sampling hammer

Africa is rich in numerous mineral resources. The continent also has a large amount of bauxite. Bauxite is an aluminum ore and is quarried in surface mining. Samples of the mined bauxite are taken regularly to examine the ore. This is done with the help of a sampling hammer, which in less than two seconds, removes up to 300 kilograms of bauxite from a conveyor belt with a speed of 5 m/s.

A high-torque motor of the DST2 series was used to implement this technically. This meets the high speed and torque requirements. It was also possible to do without a transmission, i.e. the hammer shaft is connected directly to the motor. A b maXX 5662 converter is used for precise control. This enables a peak torque of up to 18,000 Nm.

Continuous commissioning

The commissioning and optimization of the hammer was a very challenging task, since this took place while the production process was running. In the event of incorrect parameterisation, the hammer could get stuck on the conveyor belt, block the conveyed material and stop the entire production. This would cause high loss of production costs. There were also only very short time slots available for testing the hammer. "By using ProSimulation, we were able to optimize the movement profile and control of the hammer in the simulation. In this way, the drive behavior could be tested and evaluated extensively in the simulation. The risk of belt stoppage in the real machine was thus minimized or rather eliminated", explained Franscoir Potgieter of Motion Tronic.

The simulation team in Nuremberg created a model of the machine, which contains the drive components used. It was mostly possible to take the simulation parameters directly from the real machine data. The model was set up using standard library components.

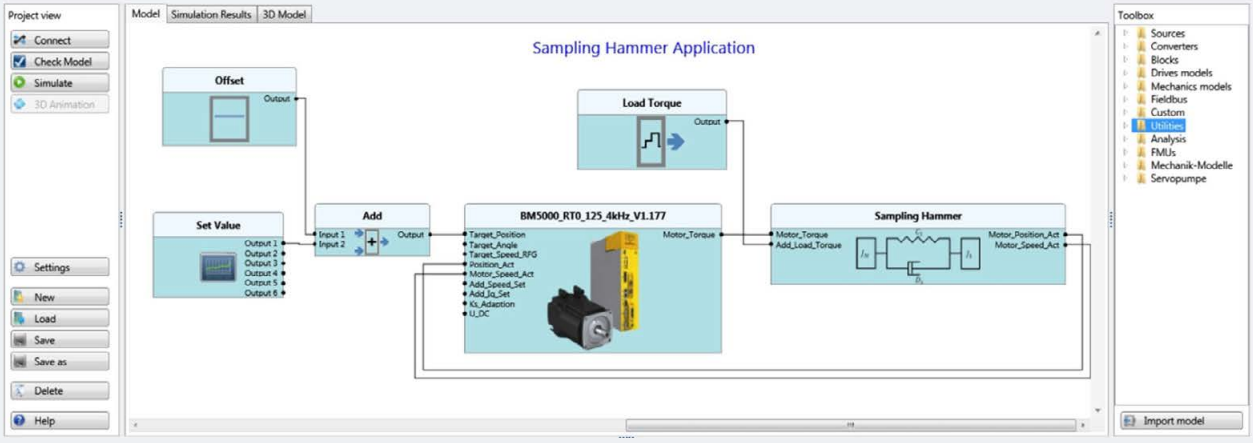


Fig.: Simulation model of the sampling hammer in ProSimulation.

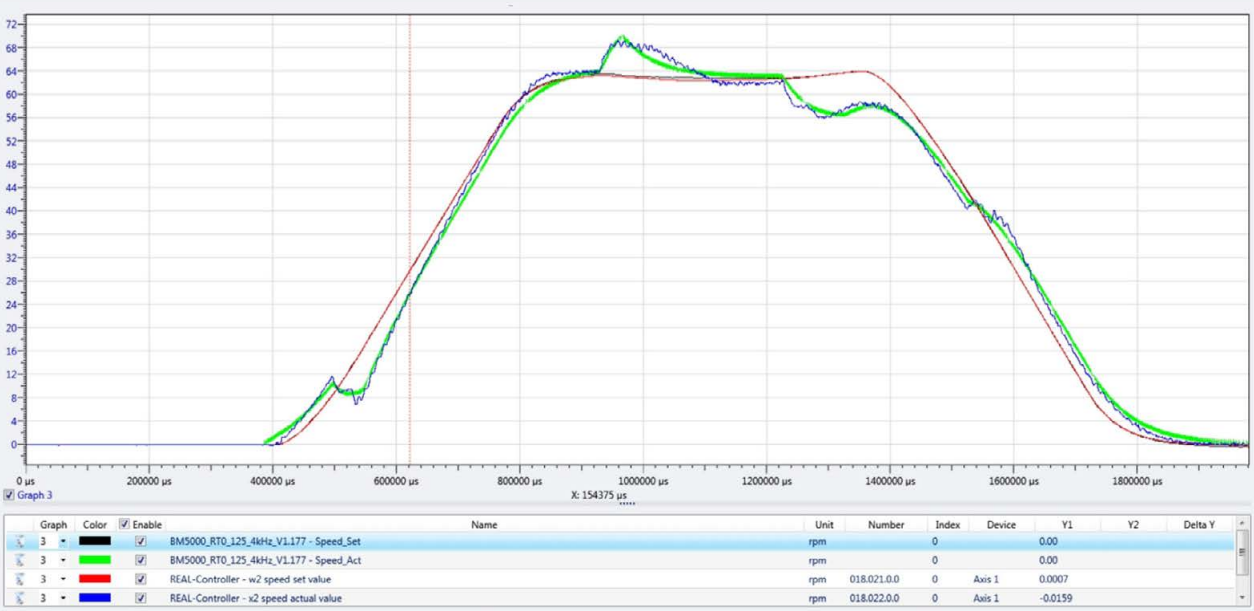


Fig.: A comparison between the real (blue) and simulated (green) torque list value shows good correspondence between the two.

Motion Tronic also praised the easy and user-friendly operation of ProSimulation: "Thanks to the complete integration in ProDrive, I was able to use the simulation even without prior knowledge and thus test the drive behavior of the hammer virtually", said Potgieter.

5.3 Grinding machine

A decisive criterion for grinding machines is the speed accuracy. The workpiece can be machined optimally with only a small difference in the grinding process. Due to the large grinding rolls and vibratable coupling elements it is often difficult to make the controller setting at the machine. In the past, situations have repeatedly occurred during start-up in which the speed accuracy could only be achieved with a great deal of work and machine damage occurred.

This problem can be solved by ProSimulation. Why? Because the software enables the drive behavior to be tested virtually. "That's great! On the one hand we can test new settings quickly and easily, on the other hand there is no risk of damaging the machine", explained applications engineer Timotheus Eidher.

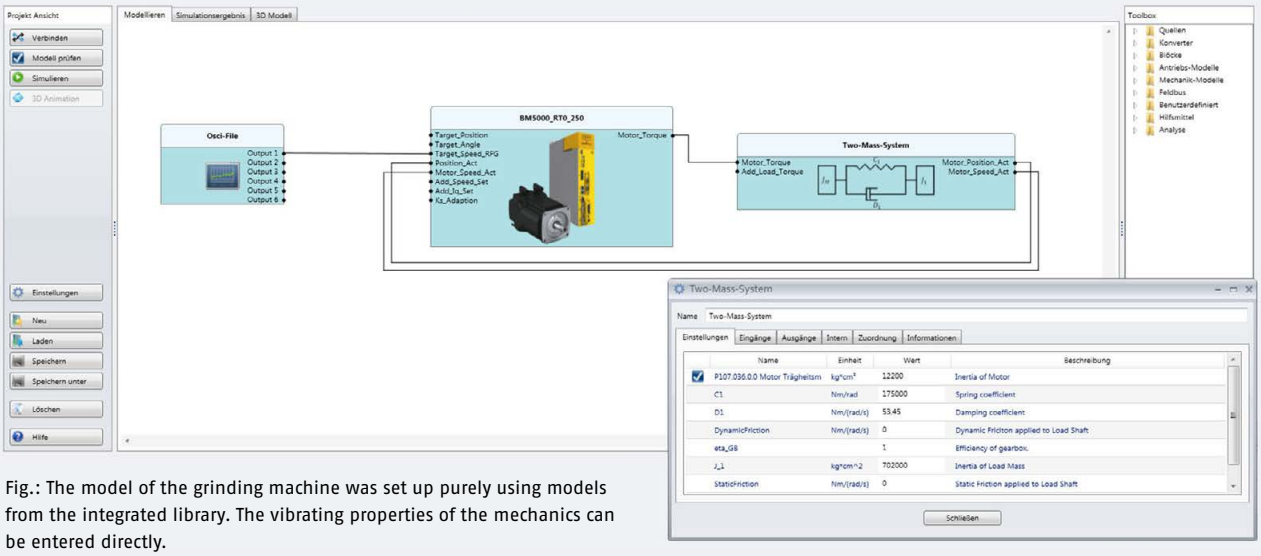


Fig.: The model of the grinding machine was set up purely using models from the integrated library. The vibrating properties of the mechanics can be entered directly.

The settings found in ProSimulation were able to increase the speed accuracy in the production process by a factor of 7. This meant a significant improvement of the grinding result. The virtual data set optimization produced a large reduction in the commissioning time, since the settings could be tested quickly and easily in ProSimulation even without the real machine. Further, the system limits could be explored through to overloading and swinging up, without running the risk of affecting the mechanics.

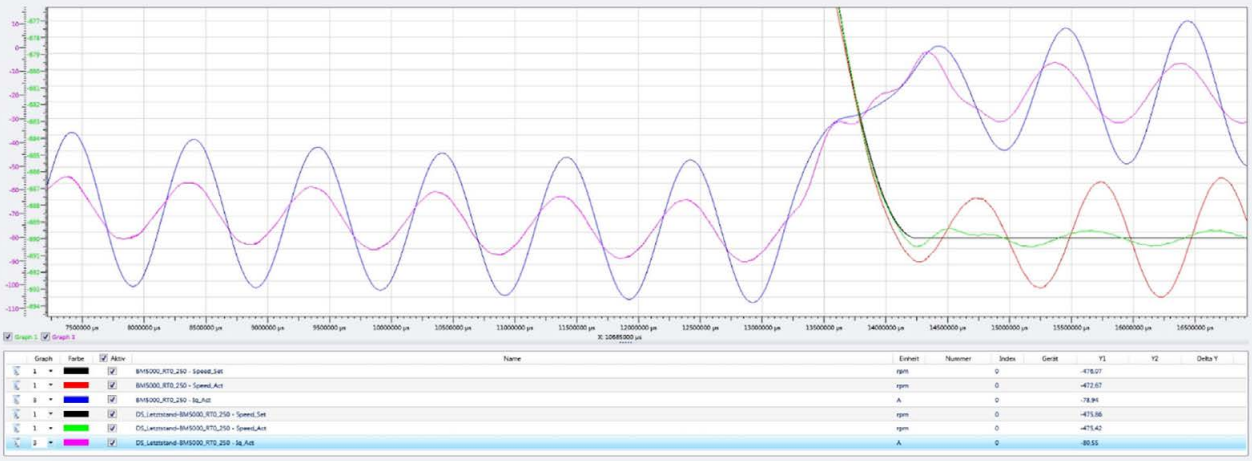


Fig.: Comparison of speed behavior before (red) and after the optimization (green)

5.4 Hydrogen compressor

A large connected load is expensive and in most cases is required for a short time only. The simulation can be used to create an energy management model, in order to reduce the connected system load of the machine. This was implemented for a customer in southern Germany. The high input was buffered by an electrical energy store. The crunch point here lies in the dimensioning of the capacitors. This is complex and time consuming.

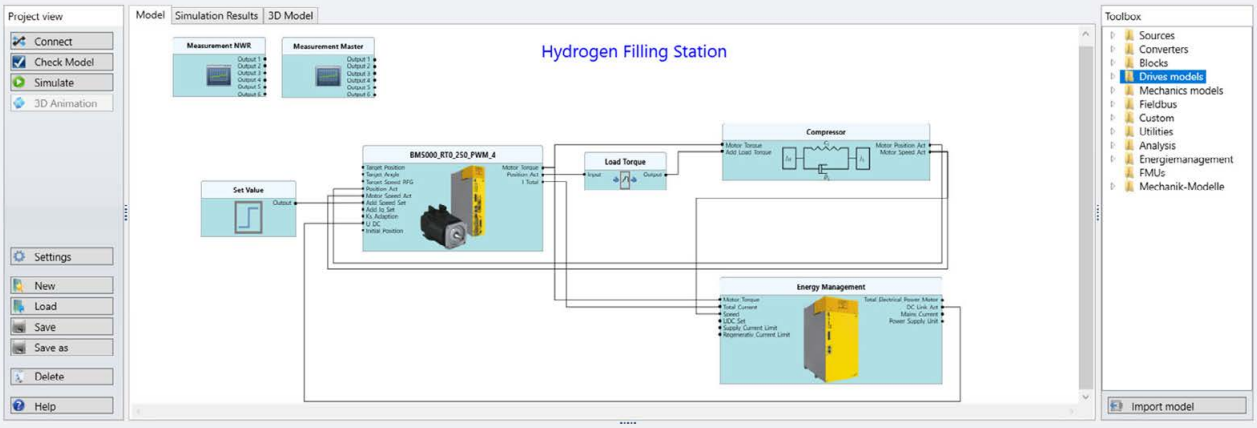


Fig.: The extensive library also contains a model of the energy management.
This can be used to model the hydrogen compressor quickly.

The application involves a hydrogen compressor. In simplified terms, it functions in the same way as a reciprocating compressor: The higher the pressure becomes the more power is required.

Michael Stiegler received the required movement and load profile from the customer and used it to calculate the necessary power profile. "The objective is to reduce the machine's connected load to keep the costs for the machine operator as low as possible. With the simulation, I was able to find the most economical solution for the customer easily and quickly. I simulated the load cases to find out which ratio of link capacitors and installed connected load is most efficient. The simulation shows that by installing only 50 mF link capacity, the connected load is more than halved from 106 to 50 kW", summarized Michael Stiegler.

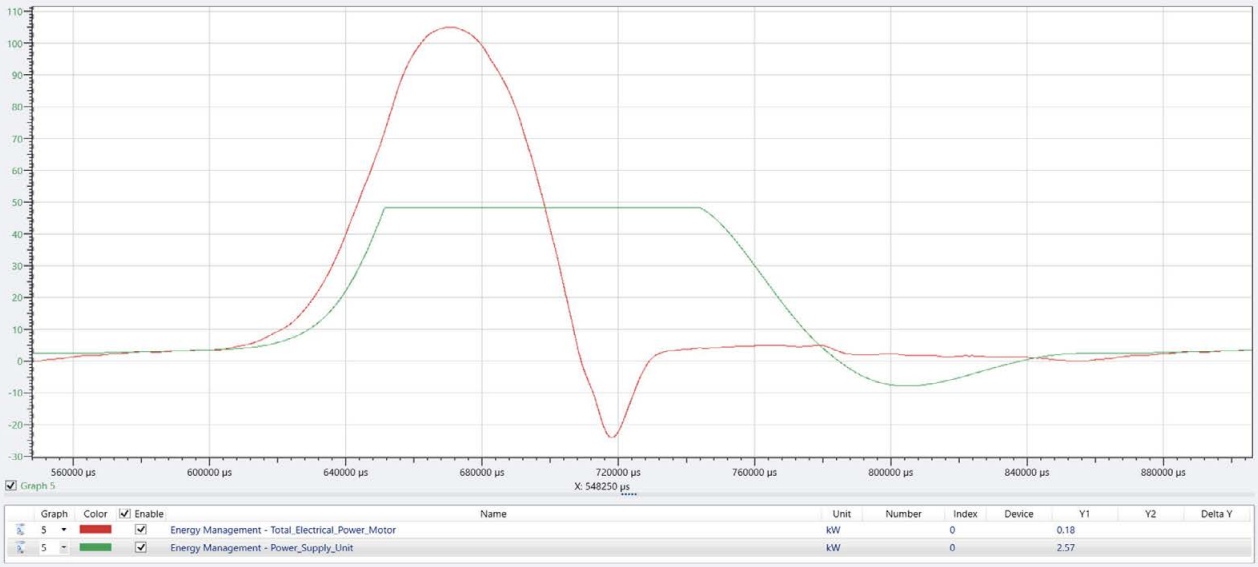


Fig.: Comparison of the electrical load of the motor (red) and the system power (green).
The peak system power can be halved by intelligent energy management.

5.5 Design of a turntable

"Attention – Load inertia ratio exceeded!" – This was the error message in the conventional design tool, as the Baumüller engineer, together with the customer, carried out the design of a turntable that was to be driven by a high-torque DST2 motor. The recommended load inertia ratio is 1:10, i.e. the moment of inertia of the load should typically be maximum ten times that of the motor. However, the moment of inertia of the turntable is 500 times larger than that of the motor!

"In the past, in such cases we have often used a larger motor with higher moment of inertia, although this higher power wasn't required. Such a safety buffer was however necessary to prevent unpleasant surprises during commissioning", explained the Baumüller engineer Stefan Hecht.

ProSimulation provides the possibility of testing the drive behavior realistically during the design phase. To this end, the customer provides the required movement profile and the mechanical data of the mechanics. Based on this data, it was possible to create a simulation model.

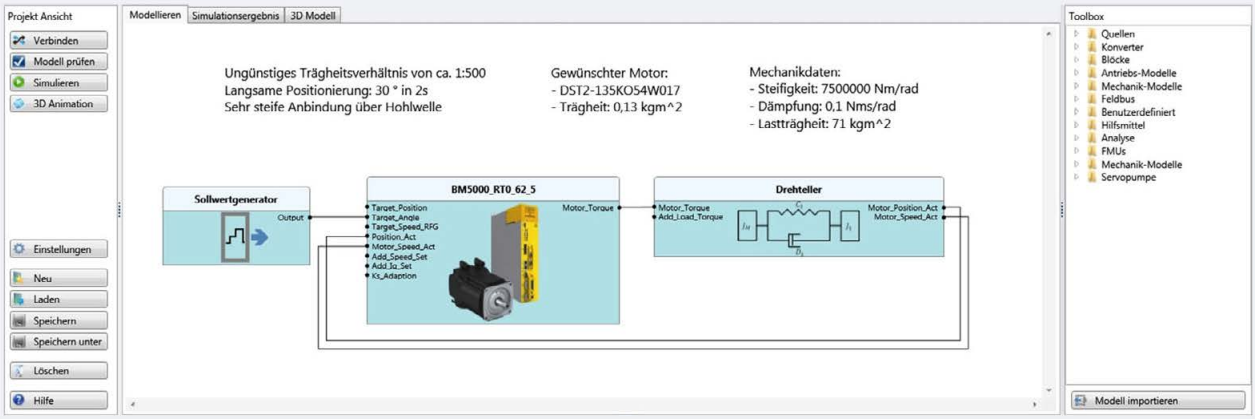


Fig.: Simulation model of the turntable

The drive behavior could therefore be evaluated – although the machine didn't even exist.

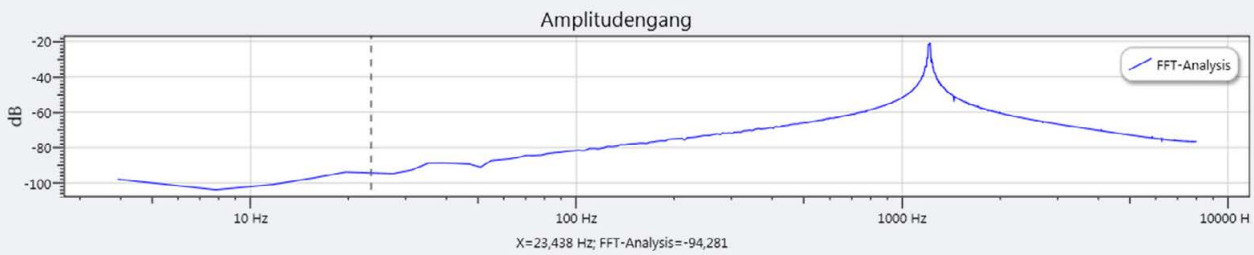


Fig.: FFT analysis of the turntable model

The integrated FFT analysis function was used to evaluate the mechanism, identify the characteristic natural frequency and make the relevant filter settings in the data set.

The simulation results show that due to the mechanically very stiff link between the turntable and the motor and the associated high natural frequency, the required dynamics and accuracy are achieved despite the high load inertia ratio.

The simulation enabled precise motor dimensioning. The customer therefore benefits from a cost and installation space-optimized drive system. And incidentally, the drive had already been optimized virtually, which saves valuable commissioning time for the real plant.

6. An overview of five problems

The application cases presented above are highly different. In the roller drive the plant swung up and the transmission and coupling were damaged. ProSimulation was used to create a virtual model to prevent risk to other machine parts. The cause for the swinging up was a load-inertia ratio of 1:218, which is very difficult to control. The optimum controller setting was found by the virtual parameterization. And was achieved without running the risk of causing mechanical damage to the machine.

In the case of the sampling hammer the commissioning took place while the machine was in operation. The commissioning was carried out virtually using ProSimulation to extend the extremely limited time at the machine. The major advantage of this is that production could simply continue.

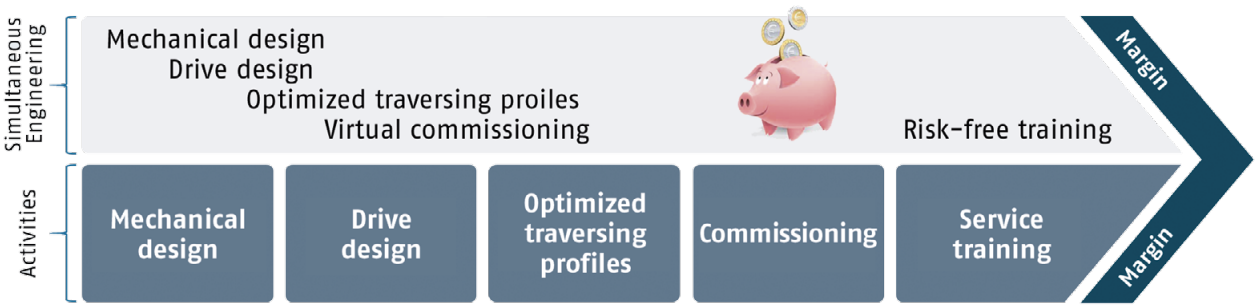
The grinding machine is difficult to adjust. Yet precision is very important, particularly in the grinding process. A uniform, precise speed can be achieved with the help of ProSimulation. The customer benefits from a more exact grinding result and thus from improved quality.

In the case of the hydrogen compressor, the topic of reducing the system power input plays a decisive role. It was possible to reduce the connected load by half by installing an energy store. The dimensioning was easy and paid for itself, because the streamlined design meant that the customer was able to benefit from a minimum peak system power input, which saved him lots of money.

The design of a turntable was optimized using ProSimulation even though the machine didn't even exist. This is made possible by creating a simulation model. The integrated FFT analysis function was used to evaluate the mechanism, identify the characteristic natural frequency and make the relevant filter settings in the data set. The customer benefits from a cost and installation space-optimized drive system and saves valuable commissioning time on the real machine due to the virtual drive dimensioning.

7. Further application cases in the engineering process

The engineering process starts with the mechanical design, i.e. any existing module is used to put together the mechanical components of the machine, match and evaluate them. The drive train's drive is then actually designed on the basis of the mechanical circumstances, for example, the inertia and movement profile. The gearing, motor and converter are dimensioned for the necessary performance. The actual programming is carried out and the processes are created in the machine program, and the traversing profiles are defined accordingly. The commissioning then takes place directly at the machine or plant. Finally, the actual function of the machine is tested in real operating conditions. The acceptance inspection and training of the customer's personnel closes the engineering process.



One case for the first phase, the mechanical design, is the application of a cutter, i.e. A highly dynamic cutting unit which is used, for example, in packaging machines. The simulation can be used to assess at an early stage whether the project is feasible. Pick-and-place applications, such as a Dualpod, i.e. a system with non-linear mass moments of inertia, can be designed optimally with the help of simulation. Optimized traversing profiles are used for presses to achieve a minimum peak system load. The movement profile is optimized so the plant operates with greater energy efficiency and the power loss is reduced by an exact design. This saves costs and has a positive effect on the commissioning time, since virtual commissioning can be carried out in advance. The last phase, i.e. the service / training process step is implemented, for example, for the servo pump. Here it is possible to examine and check the parameterization regularly.

These are only a few examples of application cases in the engineering process. There are, of course, numerous other applications in which simulation can be used.

8. Conclusion

ProSimulation helps to increase the efficiency and precision of machines. The software makes it possible to test settings at the drive without risk and to represent results realistically.
In ProSimulation, the drive can be configured virtually and compared to actual conditions. The graphic representation simplifies the interpretation of results. ProSimulation is fully integrated in ProDrive and uses the same operating sides. Thanks to the new simulation tool, users can start parameterization at an early stage and change it quickly and easily. Once a machine has been commissioned or for existing machines and systems, the simulation software also offers the option of troubleshooting and optimization. Users can test parameter settings quickly and directly on the digital twin in ProSimulation without having to use the system directly on site.

ProSimulation simulation software offers mechanical engineers a shorter development and commissioning time, supports the engineering process, improves energy management, lowers costs and enables reliable controller parameterization for precise results. A tool that astonishes engineers.

"The drive simulation is the missing link in the optimization of machines and plants. ProSimulation can be used in the development process in diverse ways and enables you to find the right solution to your problem in a targeted way and with little effort." Markus Jaksch, Head of Systems

Arrange an expert meeting now!

Contact our simulation team:

Michael Stiegler

Stefan Hecht

simulation@baumueller.de

Further information can be found here:
www.baumueller.com/en/insights/drive-technology/machine-optimization-in-simulation
www.baumueller.com/en/software-tools/prosimulation

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Baumüller Nürnberg GmbH, Ostendstraße 80–90, 90482 Nürnberg, Phone: +49 (0) 911 5432 - 0, Fax: +49 (0) 911 5432 - 130 **www.baumueller.com**
Baumüller Anlagen-Systemtechnik GmbH & Co. KG, Ostendstr. 84, 90482 Nürnberg, Phone: +49 (0) 911 54408 - 0, Fax: +49 (0) 911 54408 - 769
Baumüller Reparaturwerk GmbH & Co. KG, Andernacher Straße 19, 90411 Nürnberg, Phone: +49 (0) 911 9552 - 0, Fax: +49 (0) 911 9552 - 999
Baumüller DirectMotion GmbH, Flugplatzweg 2, 37581 Bad Gandersheim, Phone: +49 (0) 5382 9805- 0, Fax: +49 (0) 5382 9805 - 55

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