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Simcenter news

Heavy equipment edition

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Award-winning innovation with Simcenter

Siemens Digital Industries Software

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Quite a lot has been happening with the Simcenter™ portfolio the past year and you will certainly notice a change or two in this issue, which is dedicated to the heavy equipment industry.

Our cover story highlights Dr. Anna-Gret Borchert, a calculation engineer responsible for computer-aided engineering (CAE) and design optimization at AMAZONE, a fourth-generation, family-owned manufacturer of agricultural equipment. Her groundbreaking work with Simcenter resulted in the company's UX 01 trailed crop protection sprayer, which won a 2018 Machine of the Year award at Agritechnica, a leading trade show for agricultural technology.

And this isn't the only award-winner in this issue. The French company Mecalac has launched the Mecalac e12, an innovative 100 percent electric, wheeled excavator. The Mecalac research and development team credits Simcenter Amesim™ software for the product's success. Unveiled at the INTERMAT 2018 trade show in Paris, France, the Mecalac e12 won the Energy Transition Award, which recognizes technological and environmental performance.

That being said, we can see that there is an evolution brewing across the heavy

equipment industry with more electric, automated and high-performance products entering the market. And this evolution extends to the Simcenter portfolio as well. Besides advanced 1D and 3D modeling, testing continues to be a mission-critical step for the industry. There is an excellent article about how Hidromek uses Simcenter simulation and testing solutions to meet strict design and durability requirements.

We are also seeing an increase in advanced computational fluid dynamics (CFD) work. There is an excellent interview about this CFD evolution at CNH Industrial. And speaking of evolution, we are especially pleased to feature two additional CFD stories from the Simcenter portfolio: The Austrian company SYN TRAC created a new concept in agricultural products, and Liebherr Cranes, where the engineers appreciated the fact that Simcenter offers a CFD solution that can be embedded in computer-aided design (CAD).

Before you get started reading, let me personally congratulate the engineering teams at both Mecalac and AMAZONE for their award-winning work as well as all the engineers around the world who continue to innovate using the growing Simcenter portfolio. ■

In this issue

In just 100 years, this replaced the horse.

It is bit crazy to think that a self-driving tractor like CNH Industrial's autonomous concept vehicle replaced the humble horse in just 100 short years. But what is also mind-blowing is that innovation like this goes hand-in-hand with a deep underlying sense of tradition in the agricultural and heavy equipment industry.

Even if the future of the heavy equipment and agricultural industry is full of supercomputer harvesters and Industry 4.0 process improvements, this inherent sense of tradition and dedication to innovation will continue to drive the industry forward.

Reflecting the balance between tradition and innovation, we whipped up a great read for you, including stories about Mecalac's revolutionary electric wheeled excavator and SYN TRAC's reinvented tractor concept.

Today, as companies like AMAZONE, JCB, John Deere and Hatz Diesel celebrate centennials and decades of successful product development, take a moment to really think about what the industry has accomplished in a short 100 years, and where will it be in another 100 years.

That's hard to say, but what we do know is that the Simcenter portfolio will continue to provide all types of simulation and testing tools to help engineers get a tough job done right.

↗ **Dana Hybrid prototypes page 40**
↗ **SYN TRAC page 20**

Image courtesy of CNH Industrial

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Heavy equipment Industry 4.0

The heavy equipment industry is still quite traditional compared to the automotive or aerospace industries. That being said, heavy equipment manufacturers face many of the same challenges brought on by new technology and innovation. The Internet of Things (IoT) is introducing self-repair and digitalized maintenance programs while smart infrastructure has impacted efficiency and best practices in agriculture, fleet management and construction, to name a few areas. For example: Integrated advanced farming systems and support are no longer just nice extras; they are part of the package when purchasing new farm equipment. These types of solutions generate huge amounts of big data that can be used to improve the overall efficiency of the farm, port or construction site, including the tools, fleet, processes and operators on hand.

More than other sectors, heavy equipment tools, like tractors, front-end loaders and diggers, are intertwined with professional livelihoods and in many cases, there is a lot of pride in what is made, produced, built or harvested. To maintain brand loyalty, machine productivity and performance needs to be emphasized as does maintenance and cost of ownership.

Heavy equipment users all over the world place an enormous amount of emotional value on the equipment they depend on every single day – no matter if it is a single tractor for a farming village in Africa, or a fleet of mega-harvesters in the American heartland. This emotional link is why it is so important for heavy equipment manufacturers and suppliers to remain close to the customer and listen to their input when creating the next generation of products; products that will need to be tough and durable yet configurable and customizable. These industry and customer partnerships will be a key competitive advantage in the future.

In addition to dependability and customer partnerships, it is important to understand that safety and comfort as well as operational cost factors like fuel consumption, spare parts and oil are important issues. It is important to make the right type of product that meets all regulations and offers the perfect balance between technology, innovation and cost according to specific market regions. Successfully striking this balance will be the differentiator between market success and failure. This is why the Simcenter portfolio offers specific tools for engineers in the heavy equipment industry to develop and solve the problems at

hand, from a standard noise and vibration test to highly advanced control integration.

The bigger picture: global trends and challenges
Currently, the world population is about 7.5 billion people. By 2030, the United Nations (UN) predicts we will reach a global population of 8.5 billion. By 2050, this could hit 9.7 billion, of which 66 percent, or roughly 6.5 billion people, will live in cities.

Three questions come to mind immediately: Where are we going to put all those people? How are we going to guarantee a basic quality of life, and most importantly, how are we going to feed them without destroying the planet? Although the trend continues towards urban development, one-third of the world's population will remain rural and one of the most important industries in the rural economy will be agriculture.

There are quite a few challenges for the agricultural industry to figure out: The demographic challenge of how are we going to feed everyone properly, especially with accelerated urban development; how to efficiently balance the loss of food biodiversity, poor or unequal farming practices, distribution and food waste issues; and most importantly for our conversation, the environmental cost of agricultural production worldwide. The United Nations states the entire agrifood chain accounts for around 30 percent of the world's total energy consumption, and more than 70 percent of this occurs beyond the farm gate. You can think distribution. This also means the agriculture industry is a rather large creator of greenhouse gas emissions, accounting for approximately 20 percent globally.

So most of the additional food production needed to feed the world in 2050 will have to come from agricultural intensification and the best way to do that would be by using better farming practices and better, more efficient machines. We will need to deliver more food using less and cleaner energy and more innovative machines that are adaptable to the various agriculture markets of the world. This includes everything from the modern megafarms of North and South American and Europe to the rural farms of sub-Sahara Africa.

Going from an operational focus to a customer-centric approach
Although the agriculture industry is focusing on feeding the world, the heavy equipment subsegment of diggers, excavators and bulldozers is also heavily involved in developing the expanding global urban infrastructure. As is true with other industries, globalization plays an important yet seemingly contradictory role in heavy equipment: In order to remain competitive, heavy equipment manufacturers must be global. Yet the industry is so diverse that product lines must be developed to be highly adaptable to local markets. This is why the major industry trend is a swing from operation-focused to a customer-centric approach.

The case for configurability
From a pure product development point of view, the answer is configurability. For example, noise and vibration regulations are different around the globe. Regulations in Europe are stricter than many other countries or regions, so when you want to import your products to Europe, you need to make sure your equipment meets the stricter noise and vibration performance requirements.

But that's only part of the story: Your product meets the noise and vibration norms, but how does it do with fuel consumption and emission regulations? Finding the right engineering balance early in the design cycle can be tricky to manage. Heavy equipment today needs to do it all: good fuel efficiency, low operational costs, high levels of durability, performance and comfort – all while still having a configurable and competitive product. For heavy manufacturers, there is clearly pressure to maintain global productivity while reducing operational costs. One answer to this is to reduce the work force or move it to more cost-effective regions to balance market fluctuations, like the current global downswing in mining and exploration equipment. But there are better ways of doing this. Taking breakthrough approaches to product development and process management can be the next important step towards true innovation and market leadership.

What we see today with many heavy equipment companies is the product development process is quite old fashioned. Test and simulation data is spread all over the organization and quite a few processes are disconnected. One of the first issues to tackle is connecting the two worlds of simulation and test to optimize the product development process and maintain a focus on key product lines, including the need for more extensive configurability. Effective connections between simulation and testing teams that work in an optimized product development environment are what the Simcenter portfolio is all about. With Simcenter products, users can create, share and update digital twins of current or future products while using the predictive engineering analytics built into the Simcenter products to tackle specific design and engineering issues during the simulation phase. This enables manufacturers to strike the right balance between various attributes within a managed and efficient process.

With efficiency playing such a big roll in maintaining market share and a competitive edge, there is a big need for the heavy equipment industry to move closer to the customer, creating interactive products that solve the issues at hand. This means partnering with third parties to create integrated systems that can manage, for example, crop and field rotation, fleet management and maintenance schedules. These strategic partnerships will require change in order to develop a more agile and flexible industry segment that not only understands the issues and is able to meet various regulations, but offers the right product. This product not only needs to be tough enough to get the job done, but flexible enough to get the job done in the best possible and most efficient manner.   ∎

Image courtesy of Amazonen-Werke H. Dreyer GmbH & Co. KG

The latest in crop protection technology

Family-run for four generations, AMAZONE is one of those companies that just breathe quality and innovation. That is how it develops agricultural technology like the new UX 01, a trailed crop protection sprayer, which won the machine of the year award at Agritechnica 2017. A step ahead of the game, the company promotes a digitized AMAZONE 4.0 approach throughout all stages of product development from the initial concept to the final product in the field.

diverse agriculture markets, from the mega farms of Russia to the rural family farms in Bavaria, Germany.

This is where Dr. Anna-Gret Borchert, a calculation engineer in Hasbergen-Gaste, Germany, comes into the story. Borchert is responsible for computer-aided engineering (CAE) and design optimization at Amazonen-Werke H. Dreyer GmbH & Co. KG (AMAZONE), a fourth-generation, family-owned manufacturer of agricultural equipment. The company's product range is diverse, ranging from self-propelled crop protection sprayers, active and passive cultivators and precision air seeders to landscaping and grounds-keeping equipment. AMAZONE offers a full-range of farming information technology (IT) packages that work with its equipment to improve efficiency and automation processes in the field.

Driving agricultural innovation
A pioneer in agricultural machines and automation, the firm is known for its vertically folding Super-S spray boom, which it introduced in 1994. The company was an early adopter of field automation, offering the first satellite-controlled fertilizer spreader via an on-board computer in 1995. One of the secrets to its success even back then was a customer-centric approach.

Thinking about how the product will be used daily is an important part of the AMAZONE culture. Will the spray boom be able to fit down a narrow farm alley or country lane? How accurate will it be in hilly fields? Does it drip when bouncing over public roads at high speeds?

Today Borchert and her colleagues continue to take a customer-centric approach to every product they work on. They are also championing new technology, like the

Here's a bit of food for thought. Right now the world population is around 7.5 billion people. By 2030, the United Nations predicts it will hit 8.5 billion. By 2050, this could reach 9.7 billion, of which 66 percent, or roughly 6.5 billion people, will live in cities.

This is a massive population burst in a relatively short time. One of the many questions is how are we going to manage this? Clearly, the additional food production needed to feed the world in 2050 will have to come from agricultural intensification. This translates into the need for better farming practices using more efficient and automated machines that can deliver more food. Agricultural equipment companies will be challenged to invent more innovative machines and systems that are adaptable to

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>
> **Dr. Anna-Gret Borchert**
> Calculation Engineer,
> Amazonen-Werke H. Dreyer GmbH & Co. KG

simulation tools in the Simcenter portfolio, to help maintain AMAZONE's tradition of innovative, efficient and precise products.

"My main task is to simulate and optimize all types of products, but I mostly work on crop protection sprayers, like the Pantera 4503 self-propelled sprayer or the UX 11200 trailed sprayer," says Borchert. "My job is to study the motion behavior. With a price tag that starts around €100,000 and can go up past €300,000, these big and complex machines are serious investments for our customers."

With such serious investments, AMAZONE knows their products have to deliver efficient and precise performance to compete in the market. Taking a customer-centric approach and creating interactive products that readily solve the issues at hand has always been part of the AMAZONE philosophy.

"You might actually say that some of our products are like a Porsche because you can really customize these machines," says Borchert. "That could apply to what type of radio you would like, what size and type of sprayer or seeder you need and if you want an active or passive suspension, to what type of computer-controlled or active system is required. We try to consider every type of customer and make sure our products offer above-average performance and precision so they can benefit from their investment."

The secret is simulation
Like many other industrial manufacturers, the simulation and testing process has recently changed at AMAZONE. Just four years ago, it was common to have two or three

product prototypes when designing a new agricultural machine. Today that has been reduced to one by improving the simulation process.

When designing a new product, AMAZONE CAE and computer-aided design (CAD) engineers work iteratively to improve the design. The first steps take place in NX™ software, where the geometry is created. After the initial NX CAD work is completed, the CAE guides the design decisions. And that is where the Simcenter portfolio comes into play.

"We use the Simcenter product portfolio for coupled FEM, multi-body and hydraulics simulation," says Borchert. "For controls, we tend to use Simcenter Amesim or MATLAB, whichever works the best for the job."

The engineering team counts on Teamcenter software as well to organize and control the product development and production workflow.

Make the mistakes in simulation, not in reality
The job of the CAE team, including Borchert, is to make sure the machines perform as they should, focusing on durability, efficiency and precision.

"Besides durability the main challenge is the motion behavior of the sprayer boom," explains Borchert. "If it is not set correctly, the crop spraying can be uneven. From an engineering perspective, the motion of the sprayer boom is not rigid; it is a flexible motion. To simulate this, we had to combine the multi-body systems with the finite element method. We do this in Simcenter 3D Motion because it works really well."
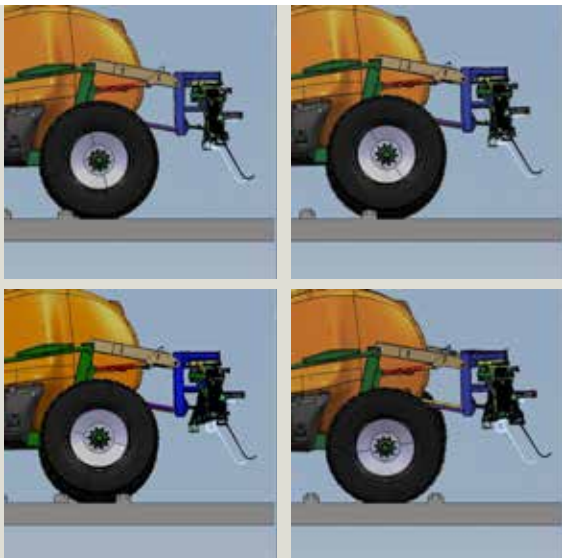
" With Simcenter 3D, I have all the joints exactly at the point where they are in reality. I can model the flexibility with FE models with millions of nodes. You have a more precise model and it is easier to model."

Dr. Anna-Gret Borchert
Calculation Engineer,
Amazonen-Werke H. Dreyer GmbH & Co. KG

When Borchert analyzes the flexible body of the spray boom dynamically, she is looking specifically at vibrations and deflections. She models everything involved in the motion of the boom to create a virtual test track. This includes the tires, the tractor and everything else involved in the motion of the boom.

"When we simulate, our first aim isn't necessarily to save time or money," Borchert says. "This is what most people say, isn't it? Our first aim is to see what is happening and discover the physics behind the design. We make all the errors in simulation and not in reality. This saves a lot of time and money."

By adapting the new simulation process, Borchert discovered that working with prototypes has its disadvantages. Of course, with a real-life machine, engineers can examine it and take measurements, but they can't see every detail.

"Solving this issue was our main goal when starting with multi-body simulation," says Borchert. "Simulation lets you see what you want to see. You can look inside and measure what you think might be causing the issue in the model.

"Because of the complexity of our machines, it is much easier to simulate with Simcenter 3D Motion than MATLAB, a platform I used previously. It is not as detailed as in Simcenter 3D. With Simcenter 3D, I have all the joints exactly at the point where they are in reality. I can model the flexibility with FE models with millions of nodes. You have a more precise model and it is easier to model."

Model validation and testing
Even though AMAZONE has shifted toward more simulation, testing remains an important part of the process. For Borchert, testing is a vital way to validate her models.

"We did some tests on the test bench to identify the motions and high frequencies," says Borchert. "This is what we use for validation. Of course, we also do field tests on the test track. That is the main way we validate our models."

From concept to production in three months
"Now after four years we are saving time by reducing the prototypes to one," says Borchert. "This is the same for product development. In the past, it took us about one year from concept to production, and today we have cut that down to three or four months.

"For me personally, the jump to Simcenter 3D was the biggest step in my career so far. While I was starting my PhD work in 2012, I only had MATLAB. In 2013, I started using LMS Virtual.Lab and that was a revelation. I was able to model the whole machine, the test track, and all the motion behavior. It is just perfect."

Borchert and her colleagues will continue work on innovative and efficient Amazone products, like the recently launched SwingStop pro used in the UX 01 trailed sprayer. The product won the machine of the year award at Agritechnica for its unprecedented spraying accuracy and is just one example of how AMAZONE helps farmers all over the world by supplying tools with the most precision possible, thus contributing to a more efficient and productive global food chain. ■
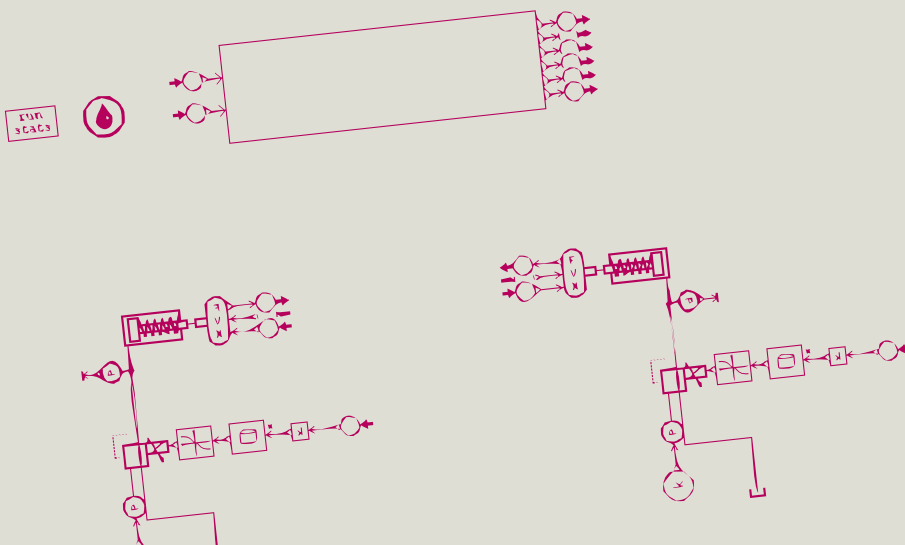
The digital journey interview

A while back, we spoke to Dr. Anna-Gret Borchert, a calculation engineer responsible for computer-aided engineering (CAE) and design optimization at AMAZONE, a fourth-generation, family-owned manufacturer of agricultural equipment.

Image courtesy of Amazonen-Werke H. Dreyer GmbH & Co. KG

Her groundbreaking work with Simcenter 3D resulted in the company's innovative UX 01 trailed crop protection sprayer, which won a 2018 Machine of the Year award at Agritechnica, the world's leading trade show for agricultural technology. Digitalization and simulation played a key role in this success and this is what she had to say about her digital journey...so far.

AMAZONE produces quite specialized agricultural machines. What makes the company so exceptional?
I think because AMAZONE is still a fourth-generation, family-run company, we can be quite specialized in what we do. We have an excellent reputation for developing customized seeding, fertilization and crop protection machines. And we do this at production sites close to our customers. There are four sites in Germany and also one each in France, Russia, and Hungary.

Just how specialized are we talking about?
If we look at some of the huge trailed sprayers or self-propelled sprayers, it is a bit like a high-end German sports car. You can choose practically everything for this machine.

You can choose which sprayer, which nozzles, and which type of farming or crop protection technology. You can even choose if you want to have an active or passive suspension.

What are some of the main challenges that you face?
One of the main trends that we are seeing is that the machines are becoming bigger and bigger. We want to increase the area performance and add more precision, so that the customers can reduce their costs. Electrification and automation are going to continue to play important roles as well. And you have autonomous vehicles on the horizon, too.

What is your main focus as an engineer?
I concentrate on simulating machine performance and optimizing it. My main challenge is to reproduce motion behavior correctly. I have some colleagues who work on strength calculations and durability. Especially with agricultural equipment, you have to be sure that all the machines meet the design durability requirements before you start optimizing. In regards to specific motion behavior,

Dr. Anna-Gret Borchert, a calculation engineer responsible for computer-aided engineering (CAE) and design optimization at AMAZONE

one of the bigger challenges is the sprayer and how to account for uneven application issues due to the motion of the machine. You need to take everything into consideration – even the tires.

What exactly makes a sprayer simulation so tricky?

The motion of the spray boom is not a rigid motion. It's a flexible motion. The simulation is a multi-body system running in Simcenter 3D with the hydraulics coming from a Simcenter Amesim model.

So you start this work in Simcenter?

No. Our digital twins are based on NX CAD. We have about 50 engineers designing in NX CAD. We only have about 3 people doing analysis work in Simcenter. For manufacturing, we organize everything in Teamcenter for the bill of materials and construction. From a simulation perspective, we are based on NX CAD. We aren't 100% seamless between Teamcenter, NX and Simcenter yet, but it is going in the right direction. It works very well.

Everyone is quick to say that Simcenter saves time and money, but this wasn't the only positive point, was it?

Unlike most everyone else, our first aim wasn't to save time and money – although Simcenter and the Siemens tools definitely do that – we wanted to see what happened before you actually made a prototype. How would a machine physically behave if you applied certain parameters? Sure if you have a machine outside, you can observe it and you can take some measurements, but you can't explore every detail. You don't really have true insight into the performance. We knew that using multi-body simulation would work here. You can see everything you want to see. You can look inside the design. You can never get this from just test measurements. Of course, four years into the project, we definitely have saved time and reduced the number of expensive prototypes as well.

So have you given up prototyping altogether?

If we look back a while, in 2013 for example, we probably made two or three prototypes to reach the final design. For new designs, it could take up to one year to go from concept to production. Today, we have shortened that to three or four months. With simulation, it is correct the first go. We make all the errors in the simulation not in reality.

> " *The types of machines we need to simulate at AMAZONE are quite complex. Working with Simcenter, you have all the details.* "

Dr. Anna-Gret Borchert,
Calculation Engineer,
Amazonen-Werke H. Dreyer GmbH & Co. KG

You have tried a variety of simulation packages. What works for you personally?

The types of machines we need to simulate at AMAZONE are quite complex. Working with Simcenter, you have all the details. I can look at all the joints and attachment points – just like it is in reality. I can model the flexibility and this requires millions of points. With Simcenter, it is easy to model on your personal level and it helps achieve your daily goals and targets. Today, I can model all the details of a complete machine including how it acts on the test track. I can actually see how the machine will be spraying. This is an excellent tool for this type of work because you become faster and more precise and there is a nice seamless connection between NX and Simcenter.

How do your digital twins match up? Do you still test?

Definitely. Definitely. We run tests on a test bench to gather data to identify the frequencies and validate our models. We also test on our test track. We find that we have reached a very good level of accuracy with our simulation models. Of course, sometimes you don't need a very accurate model, you just want to see the problems. Sometimes I just need to check if an idea will work and I can use a quick simulation to do that. Or you notice something in the NX CAD design that seems like a problem and you need to model something quickly in Simcenter 3D to solve the issue. This is where we are gaining lots of time and flexibility in our process. So yes, we have reduced the number of tests we use, but testing is still so important. Our machines have to be certified for a certain level of accuracy prior to market approval. This just doesn't happen without testing.

What do you think the future looks like in your field?

We don't make tractors so autonomous driving isn't really our main issue, but we do have to develop machines that can be used along with an autonomous machine so, our machines will have to be autonomous, too. So I think this is the next big thing we have to work on in years to come.

The communication protocol will need to be defined so our products could guide the tractor. For example, if an autonomous tractor is going too slow or fast for one of our sprayers, our products will need to "talk" to the main tractor to optimize the operation. Someone is going to have to measure, collect and analyze all this situational data and define how to use it for autonomous work. This is a big industry discussion and even a bigger project for everyone in the industry to get right. ■

Amazonen-Werke H. Dreyer GmbH & Co. KG

Image courtesy of Mecalac

Mecalac's first electric wheeled excavator

Innovation comes to light

The Paris city council adopted the Territorial Air Energy Plan in 2018 to reduce pollution, protect its citizens' health and fight climate change. Through this plan, Paris hopes to be a carbon neutral city by 2050, and before then expects to be diesel free by 2024 and rid of gasoline engines by 2030.

Cognizant of these ambitions, the Mecalac Group (Mecalac) has designed and built machinery to align with the city's clean air desires, with the Mecalac e12, an innovative, fully electric wheeled excavator, representing the company's shining jewel in that initiative. Unveiled at the INTERMAT 2018 trade show, the Mecalac e12 earned the event's Energy Transition Award, which recognizes technological and environmental performance.

"We have reached what we consider to be a crucial milestone with the launch of the first 100 percent electric excavator, which will help attain the zero diesel objective by 2024," says Max Boni, research and development director, Mecalac. "With zero emissions of carbon dioxide and other harmful pollutants, this new excavator heralds a new era in Mecalac's history. It ties in perfectly with our innovation strategy for urban work sites that are increasingly compact, high performance and environmentally friendly."

Three major design challenges, one breakthrough innovation

To develop its electric excavator, Mecalac defined an optimal architecture to meet three underlying requirements: range, performance, and compactness. To
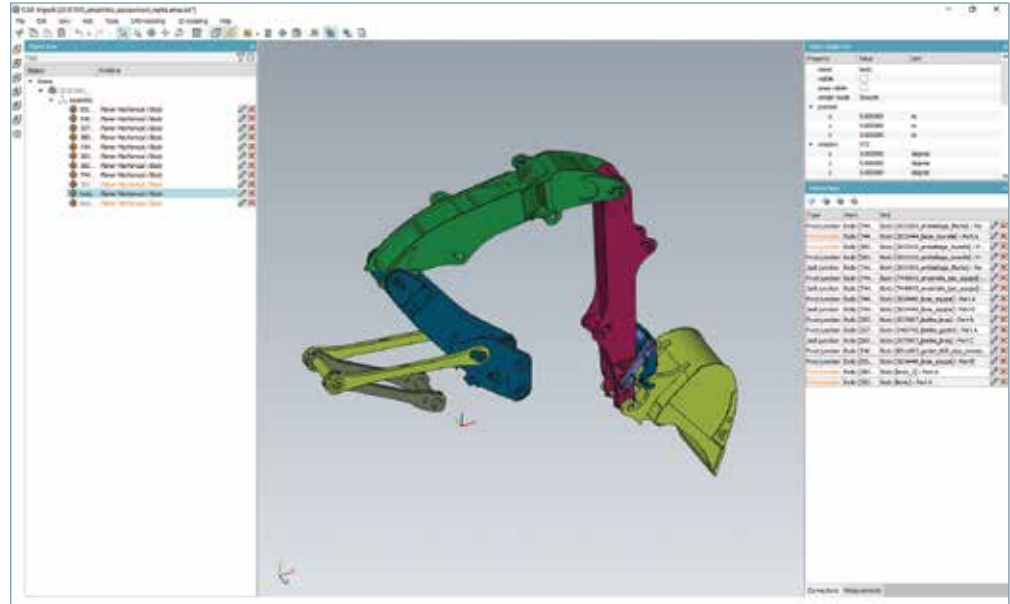
accomplish this, accurately sizing the battery was a primary challenge. This meant solving a difficult equation with a number of parameters, but one that was attainable.

"For us, this was about developing an initial working prototype while anticipating future serial production," says Thomas Schaep, mechatronic systems engineer, Mecalac. "We were not looking for a specific, tailor-made battery solution. Instead, we sought to combine off-the-shelf battery modules while optimizing the machine's overall range, cost and footprint."

Selecting Simcenter Amesim

To research its new electric excavator model, Mecalac's research and development (R&D) team sought to adopt a modeling and simulation solution capable of analyzing and predicting system performance on the mechanical, hydraulic, thermal and electrical levels.

The company chose Siemens Digital Industries Software's Simcenter Amesim software for its ease of use, openness and extensive range of ready-to-use multiphysics libraries. Schaep was familiar with the solution and ready to use it. The modeling phase was completed in a three-step process and lasted approximately three months.

The first step was mechanical modeling, where the dimensions taken on the 2D plans were fed into Microsoft Excel spreadsheet software. The synchronous, two-way connection between Simcenter Amesim and Excel used the values entered in it as the simulation parameters for Simcenter Amesim. When/if these parameters are changed in Simcenter Amesim, they are automatically updated in Excel, allowing both data sources to update simultaneously. This method allows a larger number of users to use the information in Excel without having familiarity with

"Simcenter Amesim allows us to proactively explore new innovative designs."

Max Boni
Research & Development Director
Mecalac Group

Simcenter Amesim. In addition, the computer-aided design (CAD) import function in Simcenter Amesim makes it possible to automatically generate the kinematic/mechanical model of the excavator in just a few clicks from any CAD file.

Hydraulic modeling was the next step in the process. Hydraulic distribution is modeled using super components and is continuously repeated. Considering the high cost of hydraulics for construction equipment, this step required very granular, detailed modeling. To ensure the model's optimal representativeness, the results obtained by simulation were compared with real, physical measurements. An approved correlation was observed.

The final step was electrical modeling, where a detailed model of the permanent magnet synchronous motor (PMSM) is associated with its controller, an inverter and the battery.

Creating a first time right prototype of the e12

Using the Simcenter Amesim model, Mecalac simulated various architecture options and analyzed multiple parameters to size the electrical power system and produce a first time right prototype. This represented a significant gain in terms of cost and time. In fact, Mecalac believes that without Simcenter Amesim they would have needed two or three prototypes to create an optimized architecture in terms of range, performance and congestion.

"The Mecalac e12 battery offers a record capacity of 146 kilowatt hours with an unequaled range duration of 8 hours and possesses a battery life three times greater than that of conventional batteries," says Boni. "These performances were widely acclaimed by professionals at the INTERMAT 2018 trade show."

A creativity boost

Simcenter Amesim made an immediate impression on Mecalac's R&D department through its ease of use and rapid implementation thanks to its proven libraries, easy adoption and robustness.

"We now have a better understanding of certain phenomena such as energy losses, where previously we were unable to quantify something like that; now we can put our finger on it," says Schaep. "We can quickly perform several simulations with a

Image courtesy of Mecalac

high level of confidence as to the predictability of the models. This frees up time to examine more creative solutions and devise options which we would not otherwise have had time to explore. In short, Simcenter Amesim boosts our creativity."

An open door to new concepts

Mecalac is already using an advanced version of the Simcenter Amesim model as it works on the e12's serial production phase. In fact, the engineering department plans to combine the Simcenter Amesim model with control law models to ensure proper behavior. The next step for this Simcenter Amesim model will be to validate the battery's cyclic and calendar aging. Finally, the use of an optimization solution such as HEEDS™ software from Siemens Digital Industries Software will help automate and accelerate the design exploration process.

"Simcenter Amesim allows us to proactively explore new innovative designs," says Boni. "This first study with the e12 is like a suggestion box to trigger new ideas for future developments. We are very much a source of proposals for the marketing and purchasing teams."

This approach keeps with the genesis of the Mecalac Group which, for the past 40 years, has adapted to the needs of the urban work sites of the future and provided innovative solutions. ∎

Sorting the wheat from the chaff

In order to understand how CFD has affected vehicle development at CNH Industrial in Zedelgem, Belgium, we spoke to Luc Dupon and Pieterjan Platteeuw, who are members of the engineering team responsible for design analysis and simulation. Having worked for the company for over 30 years, Dupon has witnessed the growth of CFD in the industry first hand, starting off 10 years ago as a mere curiosity, to today when it plays a central role in vehicle development programs.

"In the past few years, CFD has become very important to us, especially in helping us to design products that meet and exceed the requirements on new emissions regulations," says Dupon.

"Before the arrival of CFD, we had no choice but to rely on experimental testing, and a process of trial and error. Our success in those days relied heavily on the experience of our engineering team, with product development driven as much by engineering intuition as hard data."

Dupon remembers, "Although this process delivered some excellent

products, the cost of making the wrong design decision that would only be exposed by testing late in the cycle, was very high. CFD allows us to mediate that risk through building virtual prototypes early in the design process."

However, before CFD could be considered a serious alternative to physical testing, it first had to overcome some credibility issues. "When we started using CFD a decade ago, people were not confident in its capabilities or in the accuracy of its results. They would tell us: 'We can do this faster by experimenting than you can in your simulation,' or 'You have to

estimate your parameters' or even, 'You don't know what you are doing,'" says Dupon, before adding with a smile, "No doubt, in the very early days, they were often right. However, by consistently delivering high-quality results that correlated well with experiments, we managed to gradually challenge that perception. Today the mood is rather different, and there is real belief in the power of engineering simulation."

Despite this success, both Dupon and Platteeuw are anxious to point out that CFD has not replaced physical testing in their product development process. "CFD and experimental testing are complementary tools, they work best

when used together," says Dupon. "At CNH Industrial, we continue to correlate our CFD models against data from physical tests to make sure that we can continue to be confident in our future simulation results. I firmly believe that testing and CFD will always go together."

"You have to see how the product performs out in the field," adds Platteeuw. "In our case, that literally means standing in the field, as we have to understand the role that weather, terrain and crop type have on our CFD models. In order to properly simulate the physics, we have to understand all the boundary conditions, especially as the demands of the commercial vehicle industry constantly drive us to using bigger, more complex models that more accurately capture all the relevant physics."

"We have a very good relationship with the Siemens Digital Industries Software team behind Simcenter STAR-CCM+ and, in particular, with our dedicated support engineer (DSE), who has worked closely with us to understand our applications and the many ways in which the Simcenter CFD tools can help us meet the engineering challenges that we face," says Platteeuw. "One example of this is the way that we have used the unique coupled DEM capability of Simcenter STAR-CCM+ to directly model crop processing and management. We are also working closely with our DSE to implement overset meshes into our process."

In just over 10 years, CFD simulation has evolved from being an "interesting curiosity" to occupying a central role in the CNH Industrial development process. "We cannot imagine a world without CFD here in product development. There is no way back!" confirms Dupon. ∎

Image courtesy of CNH Industrial
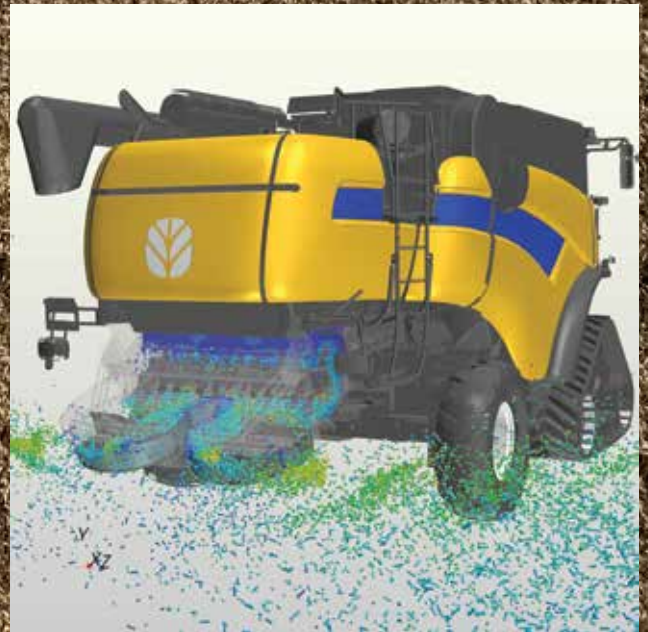
On the right track with SYN TRAC

Mentor Graphics is one of the newest members of the Siemens Simcenter family and we are proud to present a feature article about some cutting-edge CFD work in powerpack thermal simulation and cooling air requirements that resulted in a unique and innovative vehicle concept.

Kolio Kojouharov, general manager, termoflow.com, contributed to this article.

Image courtesy of SYN TRAC GmbH
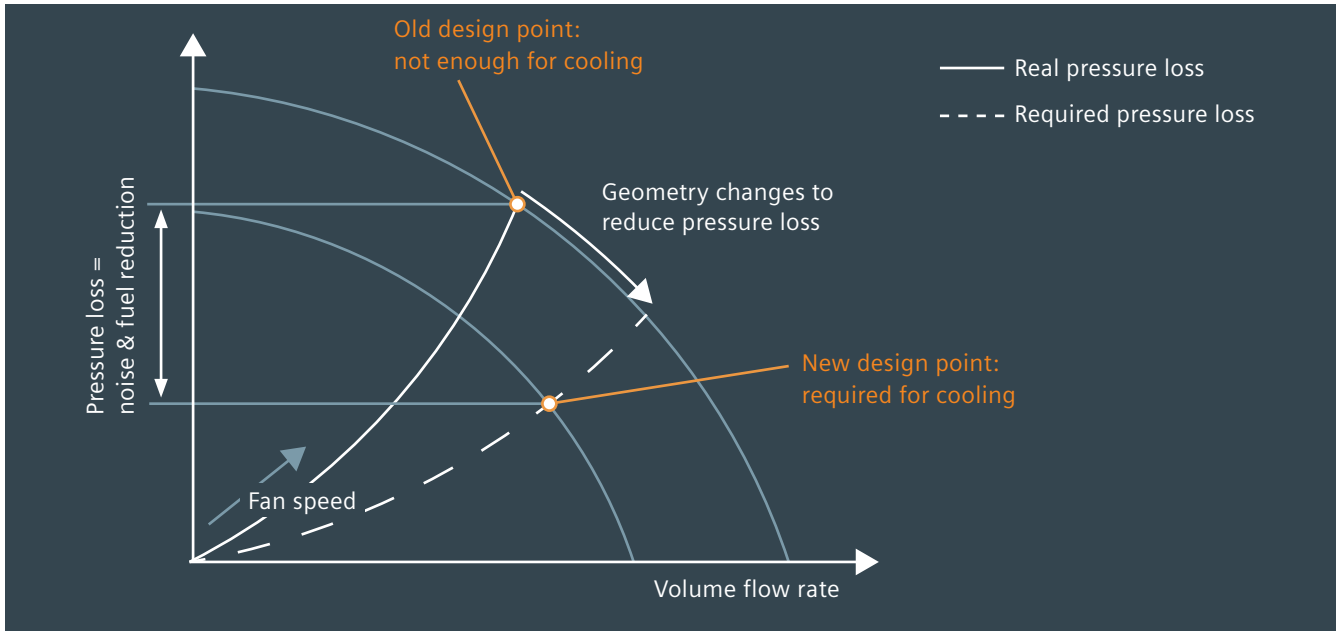
The SYN TRAC is a new type of vehicle suitable for a variety of application areas, such as agricultural and forestry. The idea was developed by SYN TRAC GmbH in Austria. The SYN TRAC is a more advanced and flexible vehicle than previously offered on the market. Its innovative coupling method facilitates an automatic connection for hydraulics, pneumatics, electronics/CAN-bus, ground speed power takeoff (PTO) and general operating concepts without leaving the vehicle.

The combination of the vehicle and the various attachments form an optimal synergy. The engineers realized a wide range of possible configurations and flexible applications; for agriculture, transport infrastructure, municipal services and forestry, and special applications such as disaster control. Due to the automation of the coupling process, the operator does not have to enter the danger zone. They can remain in the vehicle cab, and simultaneously save considerable time.

"With Simcenter FLOEFD, we were able to fulfill the challenge of a short schedule and supported the design with a high degree of digital prototyping," says Kolio Kojouharov, general manager, Termoflow.com.

Being a new product, there were high expectations in terms of reliability, robustness for agricultural demands, costs and series-production readiness, being comparable to series automotive demands. This required enormous efforts from all participating disciplines. For this reason, the SYN TRAC engineers had to employ a significant amount of digital prototyping and simulation from the very beginning. One major issue was the thermal management of the powerpack/powertrain and the heat balance of the engine compartment. Cooling airflow, fan performance and an appropriate cooler integration are strongly influenced by complex geometries and decreased available design space. Considering all these factors is crucial for the correct determination of the volume-flow-dependent pressure drop in the engine compartment (system impedance) and thus for the selection of a suitable fan.

" With Simcenter FLOEFD, we were able to fulfill the challenge of a short schedule and supported the design with a high degree of digital prototyping."

Kolio Kojouharov
General Manager, Termoflow.com
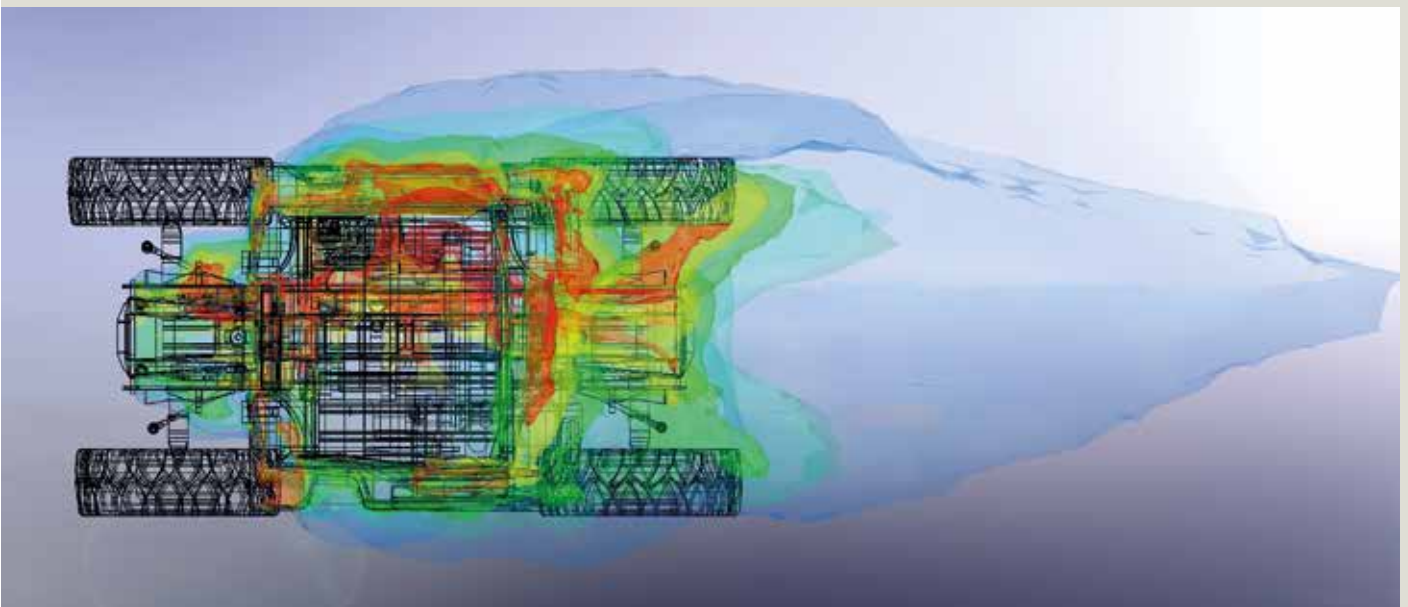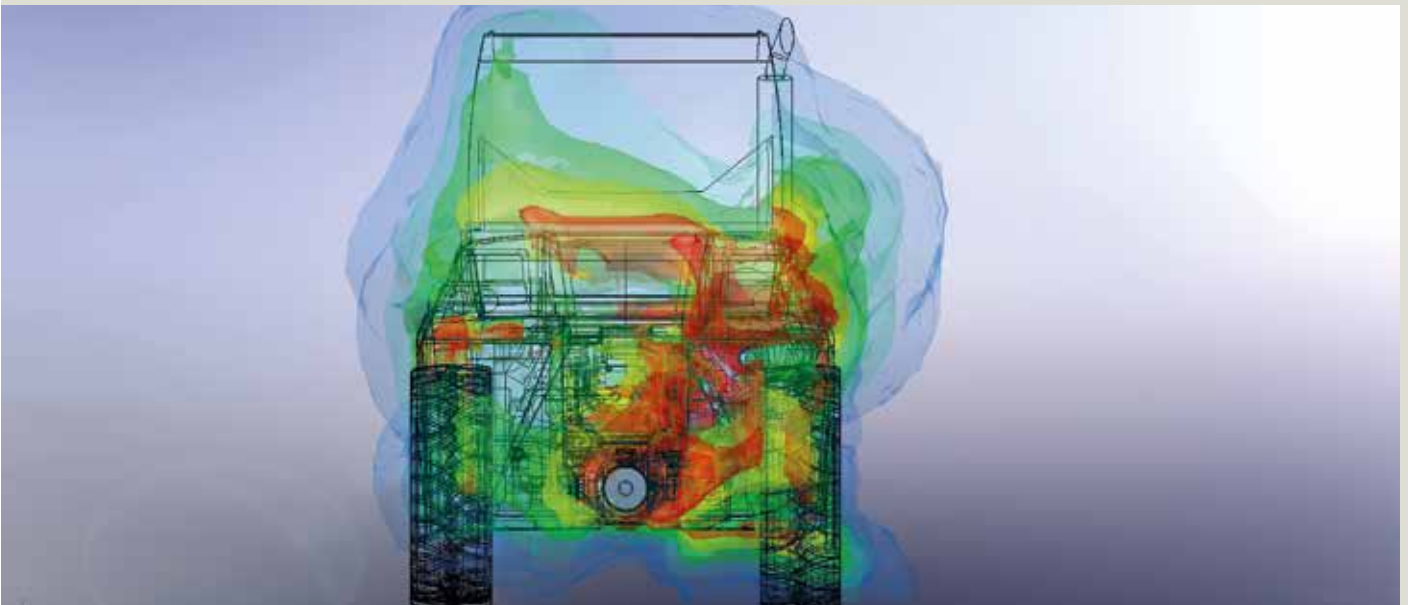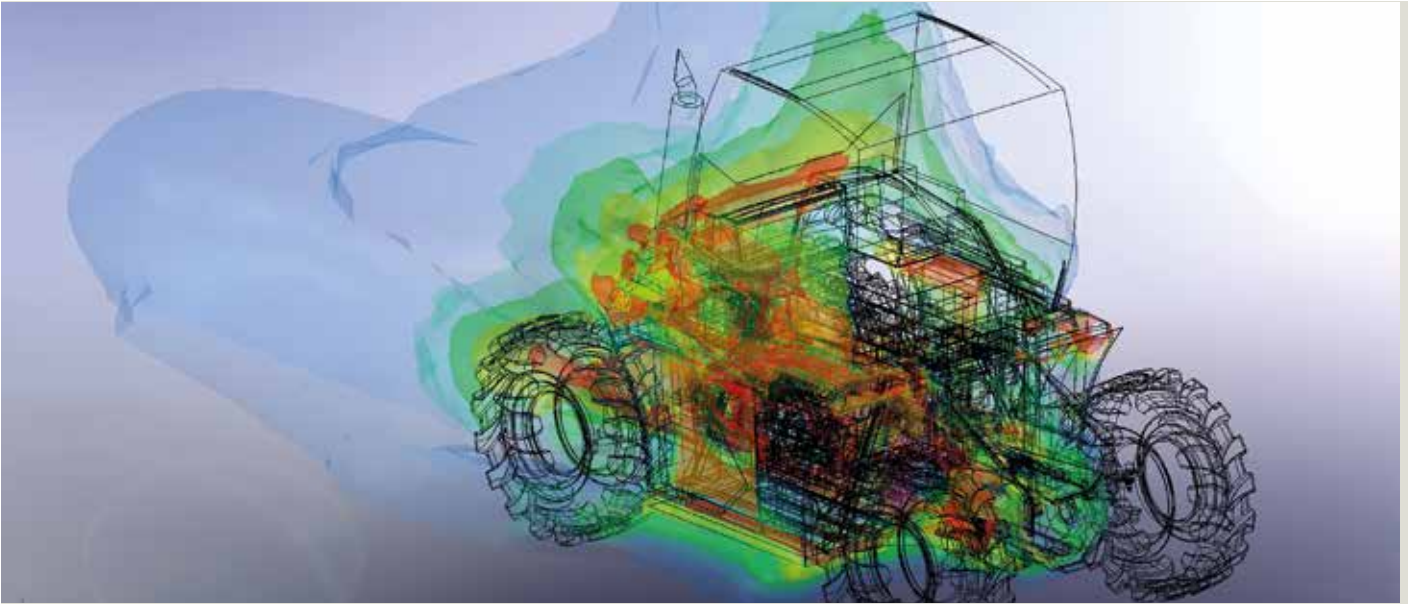
One of the key benefits was the ability to predict system impedance, which helped them find the optimal design point of the cooling system. Because of the dusty operating environment, the engine bay has to be capsuled as much as possible, though it needs to provide the required airflow for appropriate cooling across the entire engine operating range.

In this respect, the team at SYN TRAC worked with Kolio Kojouharov from termoflow.com, an experienced consultancy in powerpack/powertrain thermal management and state-of-the-art CAE computational methods. Termoflow.com introduced CFD into the design process and worked on a simulation program in partnership with the SYN TRAC design team. In the course of this project, a heat balance study and simulation of the cooling air of the engine bay for the two operating conditions was conducted at 0 kilometer (km) / per hour (h) and 10 km/h ambient velocity to identify improvement areas.

The vehicle standstill condition (0 km/h) is always one of the most critical for thermal management because no ambient air for cooling is moved. Vehicle standstill and low speeds, with simultaneous full thermal loads, are crucial for application areas, like agricultural activities in fields, working on trees and municipal services on roads. In addition, due to the dusty air in the application areas, overpressure should be present in important engine regions and short circuits in the airflow distribution should be avoided whenever possible.

During the study, the following factors were identified: velocity distribution of the cooling air in the machine; pressure distribution of the cooling air in the machine; temperature distribution of the cooling air in the machine; pressure losses and cooling air pressure drop versus volume flow rate; cooling air inlet temperature and velocity distribution at cooler outlet.

Dealing with highly complex geometry on a tight schedule, Termoflow.com used Simcenter FLOEFD™ software, which it had a lot of experience with in previous projects, with its efficient mesh generation capabilities and broad range of physical models.

One of the key benefits was the ability to predict system impedance, which helped them find the optimal design point of the cooling system. Because of the dusty operating environment, the engine bay has to be capsuled as much as possible, though it needs to provide the required airflow for appropriate cooling across the entire engine operating range. The CFD simulation was conducted in an ambient temperature of 45 degrees Celsius (C), with the temperatures of the motor, etc., being defined as boundary conditions. One of the main tasks was the design of the coolers for charge air, cooling water and oil with a cooling capacity between 30 and 120 kilowatts (kW). The air intake and exhaust should be as free as possible. For reliable operation, it is important to avoid an intake of air that is much hotter than the ambient air. The engineers compared a large number of result output images and investigated the flow distributions and temperature fields based on the two operating stages simulated in Simcenter FLOEFD.

The flow field at the back view is shown for the ambient velocity of 10 km/h. When the vehicle comes to a standstill, the air is only moved by the fans. The different flow profile of the moving vehicle is clearly visible in the image. With these results, the pressure resistance curves (cooling air pressure drop depending on volume flow rate) were generated for several operating conditions. Based on this, the design specifications for the fans could be determined by also taking into account the installation conditions and space requirements. Another aspect the engineers considered at an early stage was the drive power for the fans, which also influences the overall vehicle efficiency. The SYN TRAC engineers in collaboration with Termoflow.com gained a deep understanding of the flow distribution and the temperature fields, even for areas that are not visible without simulations, and were able to develop the unique SYN TRAC vehicle as we see it today. ∎

Design anywhere, build anywhere

With its global footprint, AGCO has pursued a design-anywhere, build-anywhere strategy in tandem with a platform product architecture.

Image courtesy of AGCO Corporation

AGCO: A global leader in agricultural solutions

Founded in 1990, AGCO has grown dramatically through a series of acquisitions that have brought together decades of collective agricultural equipment history and know-how, and now has a strong global presence with more than 40 manufacturing sites around the world.

Even though you might not know the company, you definitely know its brands: Challenger®, Fendt®, GSI®, Massey Ferguson® and Valtra®. AGCO products are distributed by approximately 3,000 independent dealers and distributors in more than 140 countries.

With its global footprint, AGCO has pursued a design-anywhere, build-anywhere strategy in tandem with a platform product architecture. The goal is to more efficiently develop, manufacture and manage the company's large portfolio of products. With that objective in mind, AGCO adopted Teamcenter® software for product lifecycle management (PLM) and Tecnomatix® software for digital manufacturing, both from Siemens Digital Industries Software. The company first deployed the software at the company's Hesston, Kansas facility in the United States.

Several factors influenced AGCO's decision to deploy Teamcenter and Tecnomatix in manufacturing, including the need for standalone, paper-based manufacturing work instructions; the need to better manage design engineering process changes; issues with the use of the engineering bill-of-materials (EBOM) in the company's manufacturing resource planning (MRP) system and manufacturing execution system (MES); and the ability to better serve the needs of manufacturing engineering in developing the manufacturing bill-of-materials (MBOM) and process plans.

"We build the same product at various sites," explains Susanne Lauda, global project lead, manufacturing automation at AGCO. "We want to re-use the bill-of-process, we want to re-use the MBOM and we want to re-use the majority of our electronic work instructions, so it makes a lot of sense that our manufacturing engineers are working on a common global platform, which for us is Teamcenter. With the use of Teamcenter, we are able to have one site basically doing 80 percent of the work that is necessary for all sites that are building the same product, so that's a huge savings."

"In the case of design anywhere, build anywhere, all of our new product introductions are going to be platform-oriented, and will re-use data," says Gary D'Souza, manufacturing engineering lead, global manufacturing PLM at AGCO.

"In our design engineering, we're trying to standardize the part numbers, the designs of parts so we can re-use them from platform-to-platform and from module-to-module, region-to-region," says D'Souza. "In the manufacturing world we use that same data to build robust processes that can be standardized through the regions. The idea is that any module that we use should be built the same way in any factory to help us ensure quality."

"Teamcenter helps us to meet the objective of design anywhere, build anywhere by allowing us to take the rich data that is created by design and expose it to different users in manufacturing at multiple sites around the world. The process that we are trying to use to achieve that is to have a single bill-of-material that we use as our master data, and then have multiple ways of building that product in the bill-of-process, which is essentially the digital twin of the real-world production process represented inside of Teamcenter."

Streamlined creation of BOMs and process plans

Working from the EBOM, AGCO manufacturing engineers use Teamcenter and Tecnomatix to create a separate MBOM, reorganizing components and configuring subassemblies that can be sourced externally, or for key components like cabins or engines, from AGCO's internal supply chain. When developing MBOMs and process plans, manufacturing engineers take advantage of the capability to view a multilevel product structure with live links to the 3D CAD model displayed on the same screen. Using the intuitive user interface of Teamcenter, building a BOM or process plan can be as simple as copying and pasting, and engineers can visually validate the accuracy of the steps in a process. "Using a system like Teamcenter that understands where each of the parts came from in the EBOM, where they're going to go in the MBOM, where they are going to be produced globally, and weaving that thread all the way through the structures is a key requirement for us," says D'Souza.

Electronic work instructions for global manufacturing

One of AGCO's first initiatives using Teamcenter and Tecnomatix was aimed at providing electronic work instructions (EWIs) to replace hardcopy work instructions at its manufacturing sites. "We begin by getting the engineering data into Teamcenter using the tools that Siemens provides, then hand it over to a manufacturing engineer," explains Anvesh Kulkarni, a manufacturing engineer at AGCO's Hesston plant. "Then we audit the EBOM and start creating the MBOM, and then go to the bill-of-process – the replication of what we do on the shop floor – and then start creating the work instructions for the bill-of-process."

The goals of providing EWIs are to achieve more traceability for model year changes, to provide a better understanding of the product structure, and to better manage different structures at different manufacturing sites. Using Teamcenter, the manufacturing engineers create work instructions that include a list of steps in each operation, along with a text version of the instructions, the BOM for the active task that includes a change log, and multiple visual depictions of the process and components, taken directly from CAD models of the product. "This is a detailed step-by-step process of how to assemble a machine, which gives the operator better visibility of the process," says Kulkarni. "The new operators coming in can pick up very easily compared to what it was when we had paper bundle work instructions. These electronic work instructions have created better training material, not just for the shop floor, but they are also used in new product introductions to analyze and establish a better process."

Simcenter in the AGCO Picture

In addition to the use of Teamcenter and Tecnomatix, many specialized engineers around the world count on the tools from the Simcenter portfolio to design and develop the various AGCO products in the company's diverse brand portfolio.

The AGCO Challenger RoGator 600
One example of the high-end side of this is high-performance, all-in-one equipment, like AGCO's Challenger RoGator 600, which was developed in The Netherlands using Simcenter simulation, testing and engineering services.

Image courtesy of AGCO Corporation

Valtra CVT tractors
Although advanced concept machines help large-scale farmers maximize efficiency, not every farmer needs an AGCO Challenger RoGator. Sometimes a farmer in Africa just needs a dependable, simple tractor that can do a small job done and is easy to fix. Or a farming business in remote northern Sweden needs a tough but efficient continuously variable transmission (CVT) tractor, like the ones Simcenter Engineering and Consulting services helped Valtra develop using Simcenter testing solutions over a decade ago.

Image courtesy of AGCO Corporation

Simcenter STAR-CCM+ for a safe and comfortable ride

Increasingly, agricultural vehicles have to provide a comfortable and safe working environment for operators, some of whom will spend their entire working day inside one. AGCO recently found itself in need of a simulation tool that would allow them to provide comfort and safety by creating a superior design in a short amount of time.

AGCO saw that the Simcenter STAR-CCM+™ software simulation of underhood modeling provided their engineers with a fast, efficient and cost-effective solution. But Simcenter STAR-CCM+ isn't a one-trick pony; AGCO also realized that Simcenter STAR-CCM+ could add value in a variety of applications.

Petri Hannukainen, AGCO's global simulation lead, says, "Simcenter STAR-CCM+ is an ideal solution for our engineers as it accelerates the design process without compromising quality. For many applications, we require the use of engineering software, and Simcenter STAR-CCM+ offers an equally efficient workflow across the board."

For example, in addition to underhood modeling, AGCO is also using the software for combustion engine analysis, heating, ventilation and air conditioning (HVAC) duct and defrost performance, as well as cabin comfort.

The engineering solutions offered by the Simcenter portfolio allowed engineers across the AGCO group to replace rounds of early physical prototyping, solve tricky engineering challenges, provide additional operator comfort as well as drive innovation across a global organization. ∎

Image courtesy of AGCO Corporation

Making light work of lifting

Liebherr-Werk Nenzing GmbH uses Simcenter FLOEFD with PTC Creo in their mobile harbor crane designs.

We spoke to Kolio Kojouharov, CFD expert, about his work at Liebherr Werk-Nenzing GmbH, a leading manufacturer of maritime cranes, crawler cranes and foundation equipment. The project demonstrates the importance of frontloading simulation tools, which go far beyond classic finite element analysis (FEA) in the heavy equipment industry.

From your experience, how is the heavy equipment simulation world doing at the moment?

The simulation world is more than ever dominated by strict regulation due to emissions, performance and comfort. It has become more and more important over the years to think beyond classic FEA, which most people immediately associate with our industry and applications.

Recognizing the potential for FEA analysis, how does CFD fit into the picture?

From a simple hydraulic block to a full power pack, there are an almost infinite number of tasks waiting to be analyzed. There were a large number of potential cases, which might have consumed needless power, which have been realized over the past years. However, external simulation services to solve this soon turned out to be not efficient enough and too expensive. At Liebherr, they have high standards, so finding the tools to meet their challenges was not an easy process and took a long time.

Why was Simcenter FLOEFD chosen?

Liebherr is aware of Simcenter FLOEFD and indeed the approach of this technology. The overriding reason was the strong pre- and post-processor in combination with the efficient meshing. There was also the advantage of full CAD integration with the PTC CREO® software environment, allowing a quick analysis of full power packs in their CAD system. This gives them the ability to analyze more projects at the same time, something competitors are not able to achieve.

**How does Simcenter FLOEFD help with the complex structure of power packs?**

Power packs basically contain everything below the engine hood, and typically include many devices, such as a cooler (diesel, water, air and oil), fans, exhausts and hydraulics. This means that CAD models can be rather large, with up to tens of thousands of components, including all the screws.

A lot is required of the CFD software so it became apparent that most commercially available codes were not able to handle this kind of complexity, hence the need to turn to Simcenter FLOEFD. The entire development cycle is influenced by this, and the flexibility that Simcenter FLOEFD allows means the team could make decisions before it was too late.

There are many examples of how Simcenter FLOEFD has helped with the design of Liebherr's mobile harbor crane, the LHM 550, and the inlet section of the power pack. We wanted to look at the efficiency and optimization of the protective grids. The basic inlet hood contains two rows of baffles to avoid unwanted particles, such as dust or rain being inhaled by the engine. On the other hand, a set of baffles means that we have a potential performance loss between the environment and the engine. The idea is that we can save energy when we reduce the resistance.

Image courtesy of Liebherr-International Deutschland GmbH
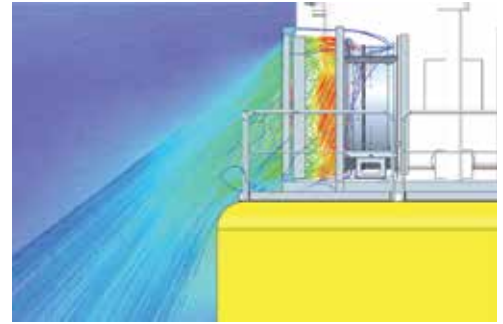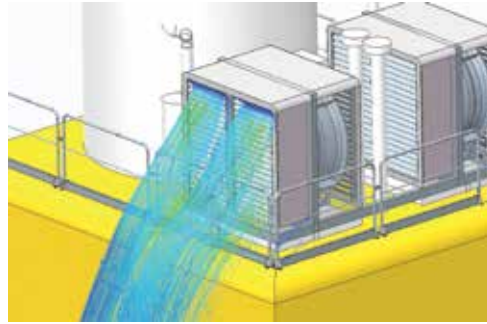
Did you use the full CAD crane model to set up the Simcenter FLOEFD project?
Theoretically, with Simcenter FLOEFD we could do that, but in this context it was not required. For the first step, it was sufficient to have the coolers with two fans and the grids. The exhaust system was also integrated so we could see thermal effects near the sheet metal walls. We soon realized the angular position of the baffles was not optimal, so we needed to locate the optimum. We used the Simcenter FLOEFD parametric study feature to let the software find the best angle position with the lowest pressure loss. However, this was done with respect to acceptable protection against particles.

We also removed the middle beam, which obviously represents a barrier for airflow. The whole process, including meetings, documentation and decision-making, took two working days.

Are you experienced in transferring such geometry and generating the mesh?
No, not really. However, unlike the other CFD tools, Simcenter FLOEFD follows a completely different approach by being embedded in the CAD, which allows users to fully skip the transferring geometry step. With regards to the mesh, people typically struggle with body fitted meshes and the manual creation of boundary layers, etc. Indeed, it takes much less time for the mesh generation compared to classic CFD


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approaches. It saves not just hours or days, but weeks. This in turns gives us the benefit of not only saving time, but money too. The amount we save with the reduction of man-hours spent on the project can be easily put into numbers, not to mention the manufacturing cost savings per unit and year. The target for increasing the performance and reducing emissions was achieved. A very welcome side effect was that we automatically improved and simplified our manufacturing process, which saves further costs. We now glue the baffles onto the frame instead of welding them.

Did you face any problems following this change in design?
We didn't face any real problems, other than the assembly team told us that removing the beam from the middle results in one single baffle for each row, instead of the initial two, so now the team has to carry double the weight while mounting the baffles. ■
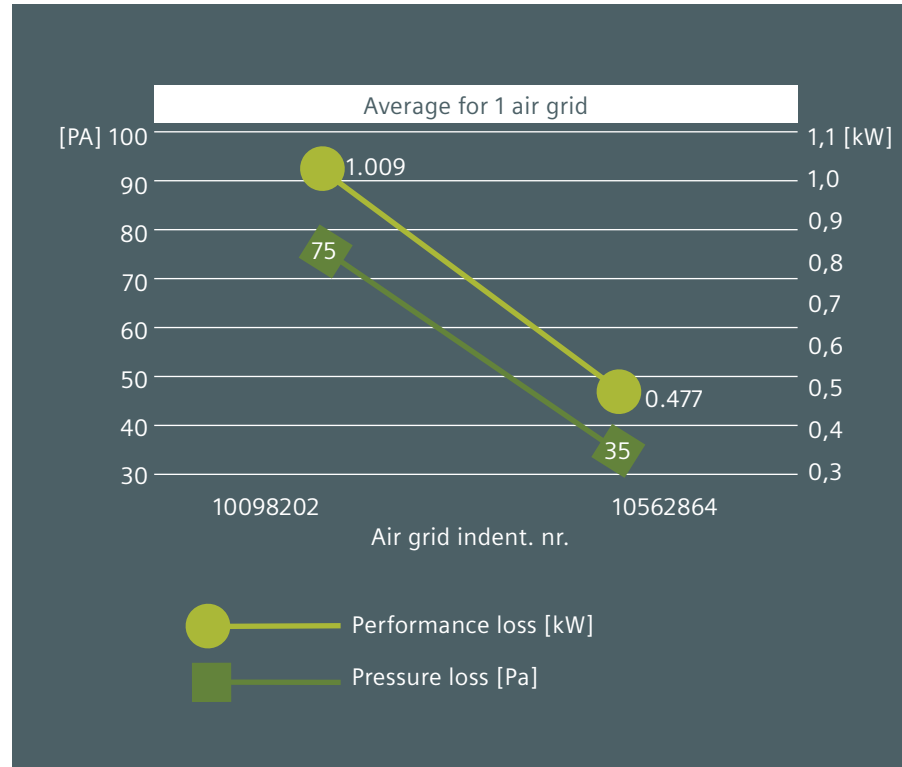
The Simcenter FLOEFD parametric study feature let the software find the best angle position with the lowest pressure loss.

Industry 4.0, digital twins and the smart port

Optimizing a digital twin of a mobile harbor crane, like the one in this Liebherr feature story, is quite a feat, but think about what can happen when you make a digital twin of an entire port.

Industry 4.0 and the digital twin are changing the way ports work. By combining available data, video imagery and 3D models, ports like the Port of Antwerp in Belgium, are creating real-time digital twins to assist with the complexity of the entire transportation chain within a port's infrastructure. When you consider that most ports feature a combined international transportation grid of roads, barges, rails and pipelines – not to mention all the on-the-ground transportation for loading and unloading, this makes one heck of a digital twin.

Today Antwerp and many other ports around the world monitor everything from the status of the container ship in a dock to the water levels in the lock. And a digital twin of the entire port can help make sure that when a mega-container ship like the Madrid Maersk (the second largest in the world) shows up to add 7,000 containers to reach its 20,000 plus capacity, the 300 dockers working non-stop can load 7,000 containers in record time. (Antwerp is renown for the high productivity of its container handling with 45 moves per crane per hour.)

Although it is early days for the smart port, many people are already seeing the benefits of a digital twin in the daily working activities. Instead of guessing or calling for an update, today port employees just refer to the real-time information on a digital 3D map. The digital twin knows which ship is approaching which dock or where a particular pilot boat is at the moment. Everything is visualized on a gigantic 3D map located in the port which translates into an enormous improvement in efficiency, communication and situation management capabilities. ■

Rising global popularity

Backhoe loaders are the most popular construction equipment on the market, primarily because they are so versatile. They can be used to perform a variety of tasks, from earthmoving and landscaping to small demolition projects, equipment transportation and even paving roads. Owners of backhoe loaders usually don't need to own another piece of construction equipment, and most don't. But what they do is put their equipment through its paces. Backhoes must be rough-and-tough enough to handle any type of job on any type of terrain, and they must be durable and versatile enough to perform job after job.

With the demand for rock-solid durability, backhoe engineers clearly need to lock into load capabilities early in the development cycle. And they need to look at a variety of usage scenarios: high loads for hauling heavy equipment and variable loads for different types of earthmoving tasks, such as soft ground compared to rocks and gravel. As a durability engineer, you need to understand complex load distribution as well as guaranteeing the machine can handle the heaviest lifting time after time without mechanical failure.

Designing it right has always been the motto of Hidromek, a leading Turkish construction equipment manufacturer. Founded in 1978, this family run backhoe loader and hydraulic excavator manufacturer is headquartered in Ankara and employs about 2,000 people. Today the company makes machines ranging from four to 54 tons, including the design award-winning Alpha and Supra-series backhoe loaders, GEN-series excavators, wheel loaders and motor graders created by the company's in-house Hidromek DesignStudio.

The firm is seeing a rise in worldwide popularity as it is selling in over 80 countries and producing more than 5,000 backhoe loaders and excavators annually. The challenge for the owners, Hasan Basri Bozkurt and his two sons, Ahmet and Mustafa, is to maintain the momentum, making sure Hidromek products maintain a high standard for aesthetics, ergonomics,

quality and performance. One way to do this is by focusing on durability engineering.

Engineering for durability
Durability plays a mission-critical role when designing any type of vehicle, especially off-road construction equipment, which puts the laws of physics to the ultimate test. From an engineering perspective, much can be done upfront in the development process to explore the workability of the final design, but the main difficulty in durability issues is gaining a realistic understanding of the loads the equipment and its components can handle. Normally, steps in the development process to check design durability include obtaining on-site measurements, quickly and accurately processing the data and feeding it back into the respective test rig or simulation model to confirm design feasibility.

Rather than offering just a basic data acquisition tool, the Simcenter portfolio provided Hidromek with a durability solution that covered the complete development process.

"The Simcenter portfolio is better for our design vision and helps us to understand the real loads capability," says Ferhan Ficici, backhoe loader and wheel loader engineering manager at Hidromek. "In the end, this translates into improved equipment performance, better ergonomics and longer lifecycles."

Images courtesy of Hidromek

The Simcenter SCADAS Durability Recorder mounted right under the frame can withstand the toughest conditions and is Ingress Protection (IP) 54 certified.
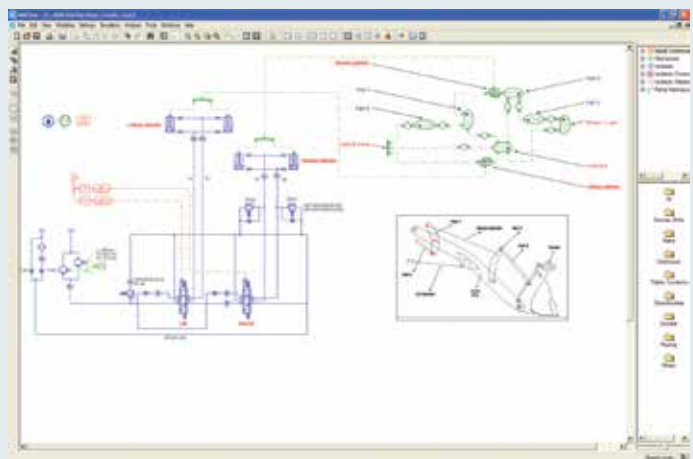
Hidromek also uses Simcenter Amesim to simulate the behavior of the hydraulic systems.

Simcenter tools support Hidromek's efforts to better understand realistic loads for improved equipment performance and a longer lifecycle. Hidromek uses the Simcenter portfolio to build multiple possibilities for dynamic fatigue assessment, block-cycle test definition, accelerated testing and fatigue life prediction.

Across-the-board improvements

By using the Simcenter system in-house, Hidromek's team has taken durability engineering to the next level with across-the-board improvements not only in the overall process, but also in the quality of the measurements, more thorough data analysis and faster processing times. During a normal durability test cycle, the first task at hand for the engineering team is to acquire real-life operational data. For this, Hidromek engineers can access a total of 112 channels by combining the power and capacity of their two Simcenter SCADAS Recorder hardware data acquisition systems. One Simcenter SCADAS Recorder measures strains, stresses and other loads in the cabin, and the other Simcenter SCADAS Recorder, mounted under the machine's frame, acquires the real workaday load data.

The two systems remain synchronized thanks to Global Positioning System (GPS) time data, which eliminates the clutter of additional cables between units. With simultaneous personal computer (PC) free data acquisition, the Hidromek engineers can easily acquire all the durability data they need in a single test run.

"The Simcenter solutions are very user friendly, especially the Simcenter Testxpress data acquisition software," says Ficici. "Tests are quickly set up so the overall test preparation time decreases. Just one click is enough to balance all channels. Before, test preparation and execution used to be a lengthy process. I felt the time we spent in measuring data was out of proportion to the results we got. Today with Simcenter solutions, overall measurement times are reduced by half."

" The Simcenter solution is easy to use in every way and has really helped us exceed our goals relating to durability, performance and ergonomics."

Ferhan Ficici,
Backhoe Loader and Wheel Loader Engineering Manager at Hidromek

Heavyweight champions

Durability testing is already a tough job. When you consider Hidromek manufactures machines that weigh anywhere from four to 54 tons – that is almost the weight of six adult elephants – you can understand why the testing hardware needs to be tougher than tough. The team at Hidromek didn't hesitate to mount its Simcenter SCADAS Durability Recorder right under the frame of its heaviest machines since the reinforced case on the Simcenter SCADAS Durability Recorder can withstand the toughest conditions and is Ingress Protection (IP) 54 certified, so dust, dirt, mud and water on the construction test site don't affect it.

Crunching the data

Once the team obtained the data and validated it, Simcenter Tecware software was used to analyze and compare the measurements with previous ones.

"Thanks to the data management and durability specific characteristics of Simcenter Tecware, it is really easy to create an overview report that can be used by other departments for simulation or studies on hydraulic test rigs," says Ficici. "We also appreciated the fact that Simcenter Tecware accelerated the testing phase without having to omit nondamaging events from the measured loads, or oversimplifying a test to a uniaxial block cycle test.

"Today we base our design criteria for structural parts on some assumptions and then perform strength analyses and calculations. The new process, implementing the Simcenter SCADAS Recorder and Simcenter Tecware, allows us to verify if these assumptions are true or not. Hence, it is possible to validate the structural parts of our products. This results in truly more reliable products. Our Simcenter durability solution is very versatile. Even our noise and vibration engineering team uses it to perform human body vibration measurements and confirm ISO compliance for sound power. The Simcenter solution is easy to use in every way and has really helped us exceed our goals relating to durability, performance and ergonomics."

For development studies, octave-band analysis and fast Fourier transform (FFT) analysis are performed. Similar spectrum analyses in frequency domain are performed for vibration measurements. FFT and power spectral density (PSD) graphs are generated by using time-series data. Also, weighted root mean square (RMS) values are calculated for different maneuvers of earthmoving machines. Using the same hardware and software platform for different types of applications saves both costs and time, but not at the expense of job-specific tasks that are fully supported by the platform. ∎

Image Courtesy: Hatz Diesel

Brute clean force

Diesel engine manufacturer, Hatz Diesel, boosts ability to meet emissions regulations and enhances engine performance with Simcenter Amesim.

Behind every great piece of heavy equipment is an even better engine. Although many of the major heavy equipment manufacturers make their own engines, there are many who don't or at least don't make all of them. Hatz Diesel (Hatz) has been busy for over 110 years providing specialized single- to four-cylinder engines for a variety of customers in construction machinery, compressors, commercial vehicles, agricultural machinery, systems, material handling equipment, ships and even heavy duty wood choppers. Hatz develops and manufactures diesel engines in a power spectrum from 1.5 to 62 kilowatts. The company employs about a 1,000 employees, over 5 percent of them in research and development (R&D). Production is carried out in the company's headquarters in Ruhstorf, Germany.

Altering engine design

Diesel engine emissions have been regulated for more than four decades, and the standards are about to get even more daunting. Although emission limits have become one of the most important innovation drivers for diesel engine manufacturers, they have to take many other important aspects into account, including performance, fuel efficiency, noise and vibration, engine weight and cost of ownership.

Grasping the issues

Hatz faced these market changes, which raised a lot of engineering questions, most prominently: What could they do to develop powerful engines while satisfying low nitrogen oxide (NOx) emissions?

In addition, when choosing an engine, customers take into account issues such as the maximum power needed to satisfy the application, weight and fuel consumption, so Hatz engineers needed to understand how customers use their machinery. They asked questions such as: How long are engines used in applications? How much time is spent on full load operation? How long is the duration of full load events?

Hatz realized that peak power consumption as well as the duration of the application was the vital criteria for choosing an engine. For instance, the time shares of full load operation are rather small for some applications, such as wheel loaders, while shredders have considerably higher time shares for heavy duty operation, but the duration of a single event is rather short. As a consequence, for a number of applications, it would be possible to replace a larger, higher-rated power engine with a smaller system that could provide an over boost for a limited period of time; in other words, complementing a downsizing strategy with a boosting technology.

As a result, Hatz decided to design a new engine family, the 4H50, in order to expand its engine lineup. Based on extensive research, Hatz chose to use Simcenter Amesim software from Siemens Digital Industries Software in the concept phase of the hydraulic power boost system.

Enhancing customer value
"We're now able to compare different architectures within five minutes, whereas it takes days for the test department to set up and run several sessions," says Tobias Winter, manager of the simulation department at Hatz. "Simcenter Amesim enables us to design more robust products,

" With the help of Simcenter Amesim, we're able to evaluate different possible architectures and come up with a new system using engine oil that is usable for a wide scope of applications."

Tobias Winter
Manager of the Simulation Department, Hatz
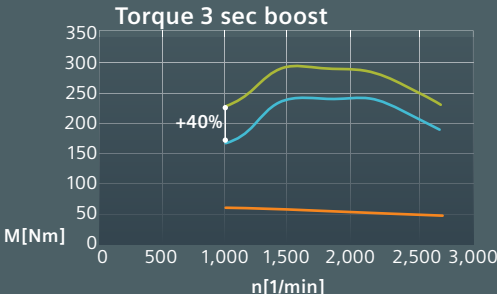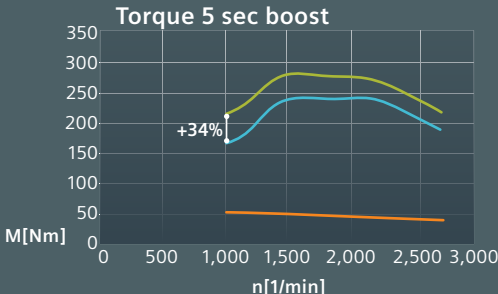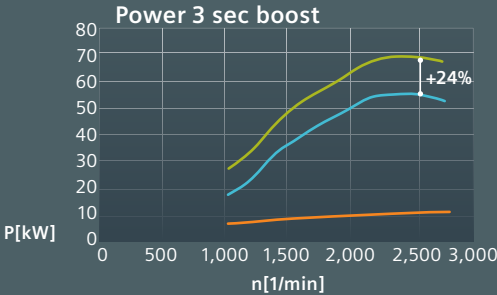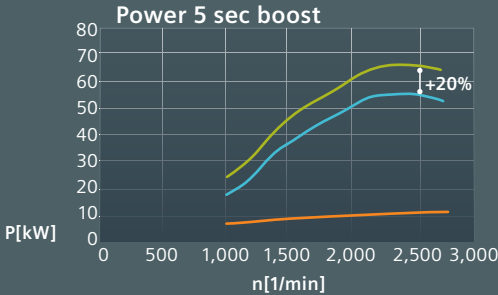
eliminate guesswork and respect time-to-market. We're confident that our new engine will be a success, bringing high value to our customers. Simcenter Amesim will be one of the reasons for that success.

"We've been using Simcenter Amesim for four years and started with fuel injection systems design in which Simcenter Amesim was the reference. But we understand that the power of Simcenter Amesim goes beyond the pure hydraulics: its unrivaled multi-domain approach enables you to build one complete engine with one model, taking into account all parameters of the physics."

The Hatz 2-liter diesel engine, intended to support the 4L43 series, brings a number of technical advancements with it as it is the most compact engine in its class, and has the best power density compared to its competitors. With 1,951 cubic centimeters (CC), the engine has a maximum power of 56 kilowatts (kHz) and a maximum torque of 240 Newton meter (Nm), which is already available from as low as 1,600 revolutions per minute (RPM).

Besides a main power takeoff, an auxiliary power takeoff will be provided with a hydraulic power boost system that can be permanently loaded with up to 130 Nm. Efforts have also been made on combustion chamber geometry as well as one common rail system, enabling considerable reduction in particulate emissions. The 4H50 was the first engine at Hatz to be designed using extensive simulation techniques including Simcenter Amesim and CFD optimization. As a result, Hatz was able to achieve the exhaust emissions standards for European Union (EU) stage IV and U.S. Environmental Protection Agency (EPA) Tier 4 Final without the use of a diesel particulate filter. This new line of engine also has the advantage of low cost of ownership since it consumes only 210 grams of fuel per kilowatt hour and because of a service interval of 500 hours.

Reducing complexity

In the first step of the simulation project, a model was built using Simcenter Amesim, enabling the accumulator and pump sizing to define boost times and torques. But the main objective was to install smart, controlled systems that would know when to boost and how to recharge the system. As
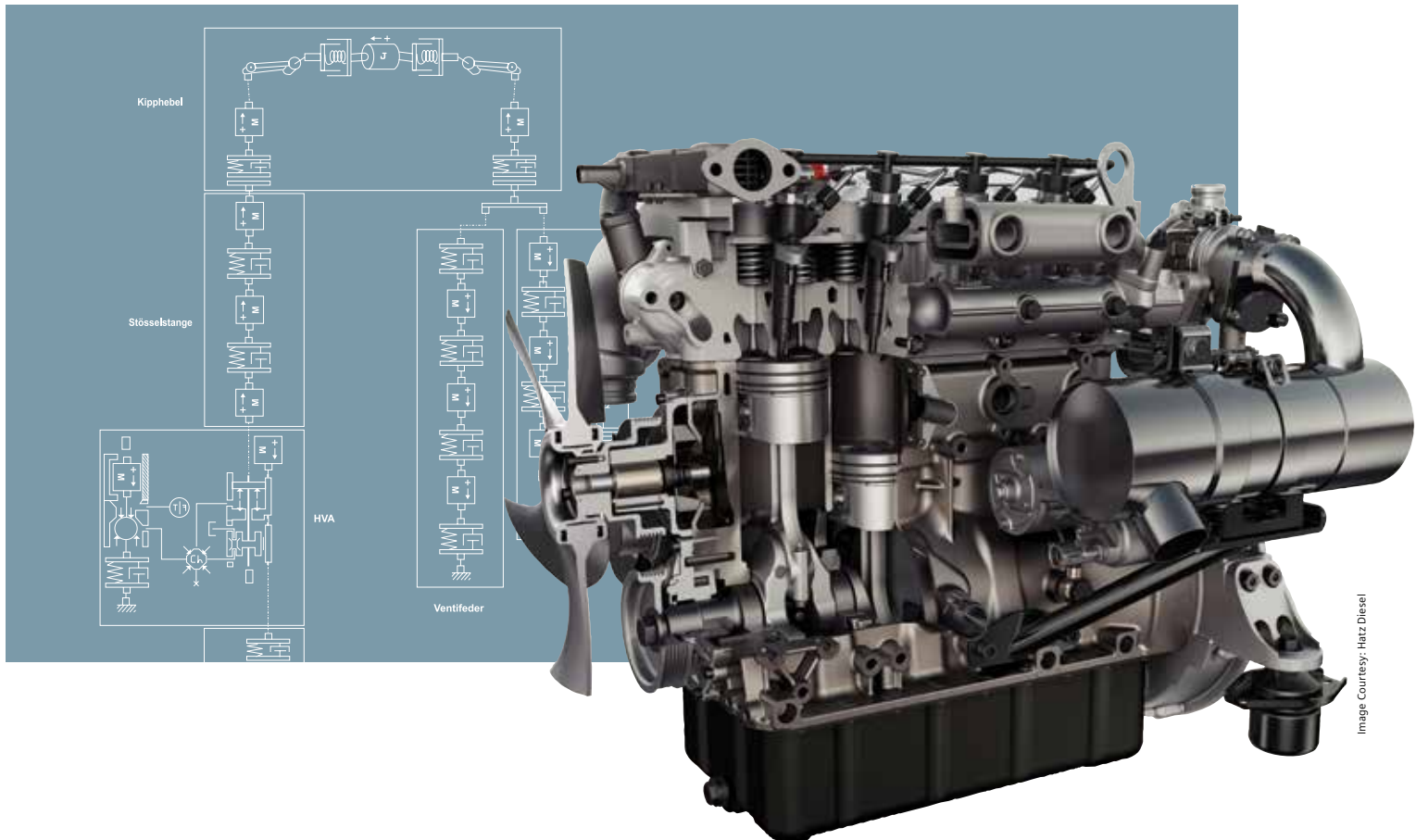

Kipphebel

Stösselstange

HVA

Ventifeder

EPA non-road emissions regulations

kW	hp	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
0-7	0-10					7.5 / 0.80			7.5 / 0.40							
8-18	11-24					7.5 / 0.80			7.5 / 0.40							
19-36	25-49				7.5 / 0.60				7.5 / 0.30					4.7 / 0.03		
37-55	50-74				7.5 / 0.40				4.7 / 0.30 Option1*					4.7 / 0.03		
37-55	50-74								4.7 / 0.40 Option2*				4.7 / 0.03			
56-74	75-99				7.5 / 0.40				4.7 / 0.40				3.4 / 0.19 / 0.02			0.40 / 0.19 / 0.02
75-129	100-174			6.6 / 0.30				4.0 / 0.30					3.4 / 0.19 / 0.02			0.40 / 0.19 / 0.02
130-224	175-299			6.6 / 0.20								2.0 / 0.19 / 0.02			0.40 / 0.19 / 0.02	
225-449	300-599	6.4 / 0.20					4.0 / 0.20									
450-559	600-749		6.4 / 0.20													
≥560	≥750						6.4 / 0.20					3.5 / 0.19 / 0.10				3.5 / 0.19 / 0.04

* In the 50 to 75 horsepower category there are two options. Option 1 requires a reduced PM level (.30 vs .40) but allows Final Tier 4 to be delayed one year (2013). NOTE: The vertical dashed lines separating the years shows when the seven-year life of the Tier 2/3 Equipment Flexibility Provision ends and engines can no longer be placed in vehicle production.

Legend

EPA	Tier 1	Tier 2	Tier 3	Interim Tier 4	Final Tier 4
EU	Stage I	Stage II	Stage III A	Stage III B	StageIV

New emissions regulations take effect January 1 of the year indicated by color change unless otherwise noted.

a consequence, Simcenter Amesim will be used to support the design of governance and intelligence thanks to model-in-the-loop (MIL) on the engine test bench.

The next step is to install the complete hardware on the engine. This will enable Hatz to validate the hydraulic control unit (HCU) by simulating the presence of the control unit on the test bench. Without the simulation provided by Simcenter Amesim, this step would be quite complex as two governances are working against each other: the engine control unit (ECU) is trying to keep engine revolutions per minute (RPM) constant, and when the loads demand is higher than the engine power output, the RPM starts to decrease, making the HCU start to fire the hydraulic motor and support the engine.

"With the help of Simcenter Amesim, we're able to evaluate different possible architectures and come up with a new system using engine oil that is usable for a wide scope of applications," says Winter. "We're very confident in the fact that Simcenter Amesim will help us to design a system that exceeds what is expected as far as NOx regulations and power demands."

Speeding product development

Simcenter Amesim has been the mechatronic system simulation platform of choice for the new engine design project. The unique and user-friendly modeling environment, application-oriented validated libraries of components (mechanical, thermal, and thermal-hydraulics) as well as powerful analysis tools and real-time capabilities have helped Hatz develop the engine in an expedited timeframe. Hatz also appreciates the excellent support provided by Siemens Digital Industries Software.

In addition, the 3D animation tool is a useful tool that can be widely used during management validation meetings as it enables Hatz to highlight the main results and empowers engineers to make smarter architectural decisions. Even if the engine prototype testing has not been completely removed, system simulation has enabled them to dramatically reduce the effort required for testing, especially different topologies of systems required by a variety of customer configurations. ∎

A hybrid happening?

Siemens Digital Industries Software technology helps Dana develop a powertrain system that delivers between 20 to 40 percent fuel savings and reduces operating costs for off-highway vehicles.

Making the delivery of high power for a downsized engine a reality

Construction and material-handling vehicles have to carry heavy loads from point A to point B, requiring frequent and intense bursts of acceleration, deceleration, lifting and lowering. On the other hand, environmental regulations push for lower emissions, while the market wants lower operating costs. Combining all these design requirements is a daily challenge for off-highway vehicle manufacturers. In an attempt to downsize engines while still guaranteeing maximum power when it's needed, original equipment manufacturers (OEMs) and suppliers are constantly looking for next-generation powertrain architectures that deliver maximum performance with a minimum amount of fuel.

For this purpose, Dana, the world-leading supplier of driveline, sealing and thermal management technologies, developed the Spicer®

PowerBoost Hydraulic-Hybrid System™. This integrated powertrain concept for the off-highway market captures kinetic energy, otherwise wasted throughout the drivetrain, and uses this recuperated energy to help power the vehicle when in operation. An advanced energy management system evaluates the levels of power needed in the entire vehicle system, predicts operating demands and determines the most efficient means of operation. The system captures energy from the powertrain during low-power operation, and recuperates it from braking and working cycles as hydrostatic energy in an accumulator. This storage is then released when additional power is required; for example, when accelerating from rest, lifting a load, or driving into a pile. Prototype tests on a front-end loader and a telescopic boom handler promised from 20 to 40 percent fuel savings, reducing operating costs and providing scope for a downsized engine.

Powerful simulation tools that model all components together

"While developing this groundbreaking system, Dana Advanced Engineering, a cross-business unit of specialists within Dana Holding, extensively employed simulation by implementing model-based systems engineering approaches," says Dr. Lorenzo Serrao, senior system engineer at Dana. Simcenter Amesim from Siemens Digital Industries Software was the crucial tool for modeling all components together, including mechanical elements, hydraulic machines, control circuits and accumulators. "The simulation model was essential in all phases of the development cycle, and a necessary complement to the test lab, where we have a prototype of the isolated system in an experimental setup, and the vehicle lab, where we have integrated the prototype in a front-end loader," adds Serrao. "We used the model during the concept phase to

" *Solutions based on increased system integration, such as powertrain hybridization, are definitely the way forward for optimized vehicle efficiency. Model-based systems engineering has definitely contributed a lot to the success of this and it will play an even greater role in the future*"

Dr. Lorenzo Serrao
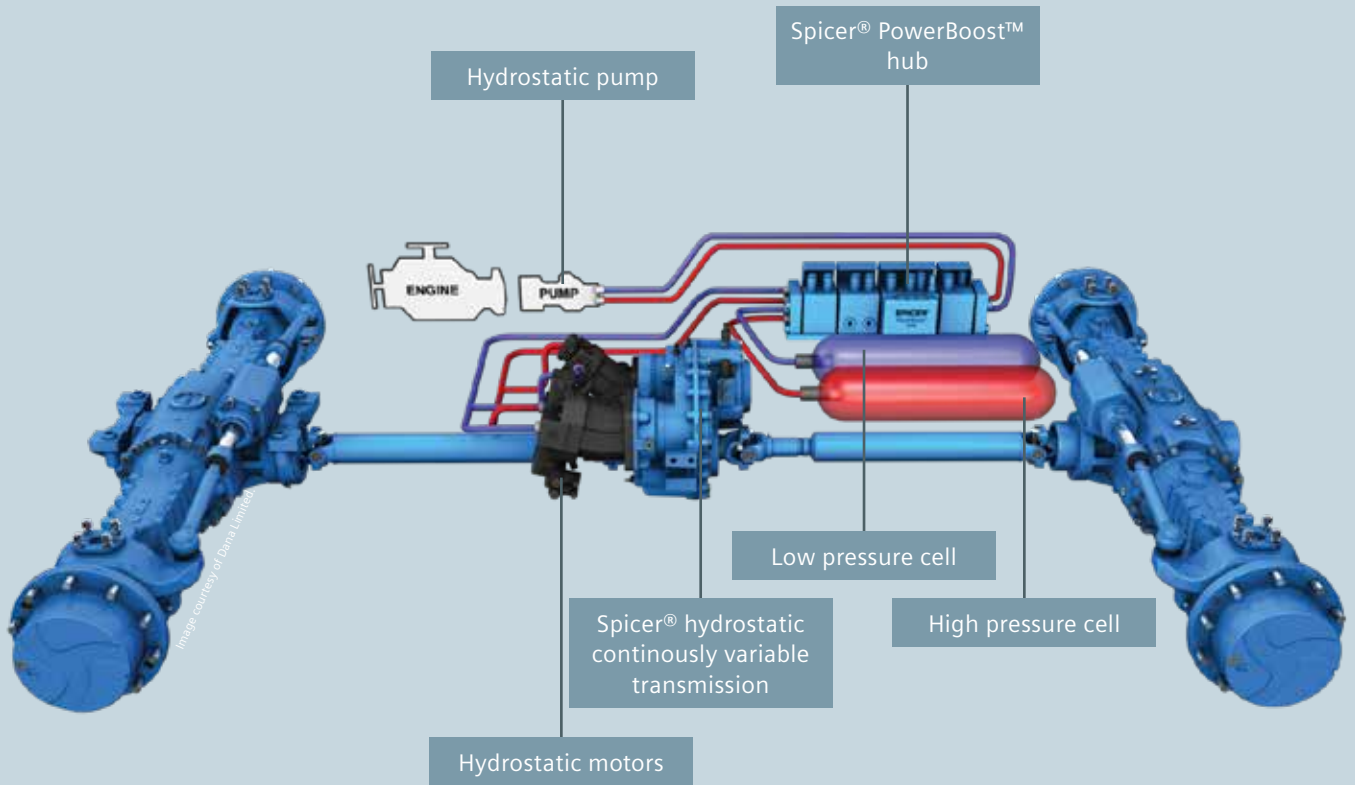Senior System Engineer, Dana

Hydrostatic pump

Spicer® PowerBoost™ hub

Low pressure cell

Spicer® hydrostatic continously variable transmission

High pressure cell

Hydrostatic motors

Image courtesy of Dana Limited

Image courtesy of Dana Limited.

evaluate design alternatives, effectively integrate subsystems within the vehicle for controls development and test control functionality and assess performance through simulation prior to physical testing."

Dana engineers are especially satisfied with the ease-of-use of and powerful solver capabilities of Simcenter Amesim. The models can be run extremely fast and the presence of extensive libraries allows the team to prepare complex multi-domain models with physical and geometrical component parameterization much faster than using traditional methods based on coding the differential equations. The control strategy can be easily included thanks to seamless co-simulation using the MATLAB® environment and Simulink® environment, both from The MathWorks Inc. With standard libraries and parameters, Dana builds models that are more than 90 percent correct. "We have not yet reached the limits of Simcenter Amesim. We will continue using the standard libraries. Only

" We can definitely say that using Simcenter Amesim reduced a considerable part of the development time by a factor of five, and then we are not even talking about cost."

Dr. Lorenzo Serrao
Senior System Engineer, Dana

in the very last steps we will use customized ones," says Serrao.

Thanks to the use of Simcenter Amesim, Dana saved both time and money developing the PowerBoost system. System simulation reduced the need for physical testing, and the ability to debug system integration issues and controls in simulation avoided damage in the system hardware. "Thanks to our modeling in Simcenter Amesim, we could reduce the number of loops," says Serrao. "The entire development project took three years. The first year was mainly about simulation. Then the second year we started to work more and more on the vehicle. If we want to evaluate a modification, it only takes us about a day on the simulation model, whereas on the test bench or on the real vehicle, this takes us one or two weeks. We can definitely say that using Simcenter Amesim reduced a considerable part of the development time by a factor of five, and then we are not even talking about cost."

**Simcenter Amesim is a
go-to tool in Dana's future**

Dana's advanced engineering group further integrated Simcenter Amesim into development processes, and appreciates the value the solution has provided. Given increasing market and legislative pressure to achieve more efficiency and consume less fuel, the importance of Simcenter Amesim is expected to increase even more in future projects. Dana engineers realize that if they want to keep ahead of the competition, they will need to continue increasing product efficiency and production processes, and creating higher product value in terms of integration and variety. "Solutions based on increased system integration, such as powertrain hybridization, are definitely the way forward for optimized vehicle efficiency," notes Serrao. "Model-based systems engineering has definitely contributed a lot to the success of this and it will play an even greater role in the future." ∎

Already thinking about the next 100 years...

Although the verdict is still out in regards to autonomous driving in the heavy equipment industry, an inventive autonomous truck called Vera is already in the works at Volvo Trucks in Sweden. We heard from Mikael Karlsson, vice president, autonomous solutions at Volvo Trucks, about how Vera might affect the transport industry and other commonly asked questions.

How did you come up with a solution like Vera?
Bold innovation and a willingness to be daring is part of Volvo Trucks' DNA. Traditionally, we have taken a step-by-step approach to product development, but as someone once said to me, 'You cannot build a ladder to the moon.' It might feel like you're getting closer, but you will never get there. You need to do something radically different. When we started this project, we began by putting ourselves in a future scenario and asking what would be the ideal transport solution. We then used a rubber band approach, where we stretched our insights back and looked at what we could do today to reach our vision. Vera is essentially our way of building something that can take us into the future.

Is Vera just a concept, or is it something we're likely to see in real operations?
Vera is a complement to increase our current offering. It is still under development, as we need to take steps to secure safety aspects and can deliver a premium experience to our customers.

What does Vera offer customers?
For Volvo Trucks it is important to offer a premium experience, giving our customers peace of mind and trouble-free transport solutions. We believe that Vera can take us further on this journey.

Images courtesy of Volvo Trucks

Mikael Karlsson,
vice president, autonomous
solutions at Volvo Trucks

How will it impact the transport industry?

In places like ports and megalogistics centers, I think we will see much higher delivery precision, as well as improved flexibility and productivity. Today's operations are often designed according to standard daytime work hours, but a solution like Vera opens up the possibility of continuous round-the-clock operation and a more optimal flow. This in turn can minimize stockpiles and increase overall productivity.

How will it impact society?

Round-the-clock operations could mean faster delivery times for consumer products. Moreover, since the vehicles are electric, society can benefit from reduced noise, road congestion and exhaust emissions.

Is the technology proven?

In creating Vera, we are integrating new technology, both in the vehicle and in the surrounding infrastructure, which involves a lot of testing to ensure it works together. However, since a lot of the base technology comes from our platform approach at Volvo Trucks, it has to a large extent already been tested. For instance, the electric driveline is the same driveline used in our electric trucks, which has been presented to the market.

How will this affect truck drivers?

Obviously, this will affect drivers in these applications, but in the big picture we foresee an increased need for skilled drivers. I strongly believe that technology drives prosperity and takes society forward. In many factories today, some parts of the production are highly automated while some still need to be operated by people. I believe that the transport industry will evolve the same way. I foresee that there will be an increased level of automation where it makes sense, such as for repetitive tasks. This in turn will drive prosperity and increase the need for truck drivers in other applications.

Is Vera safe?

Everything we do is engineered to be safe, and we are taking all necessary precautions. We are looking at what is needed in terms of infrastructure, on the vehicles and in a control tower. The vehicles have a lower operating speed, and they are equipped with a number of sensors, radars and cameras. By starting with slower speed in a clearly defined area and then gradually increasing speed and building infrastructure, we are confident that we are taking a safe path towards automation.

What is the next step for Vera?

To begin with, we will operate over short distances in repetitive flows. As we gain more experience, we can look into expanding into other applications. However, Vera is not intended to be a solution for everyone, everywhere. It is a solution that we will adapt and tailor from user to user, depending on their unique needs. ∎

News from the Siemens Simcenter Community blog

Around 500 engineers joined Siemens Simcenter Connection Korea 2018 in order to share the results on their use of the Simcenter product portfolio. About 60 presentations were delivered over two days, with topics ranging from system simulation and acoustic testing benchmarking to 3D and CFD simulation, and spread across five industry tracks. This report is reprinted from the Simcenter Community blog.

Right before kickoff of the Simcenter conference, we made a trip to Doosan, about an hour drive from downtown Seoul (assuming your taxi driver doesn't get lost). After meeting our local Siemens colleagues, the first order of the day was getting fully informed about the Doosan official security rules before entering the premises. Once we were aware of where to walk or not, and when to wear a security hat (something that we did not have the chance to do) our host Kang Byeong IL, a senior research engineer at Doosan, welcomed us.

Even though I don't speak Korean – except for: anyoung haseyo which is 'hello' – what I will retain from this meeting is that improving energy efficiency is a major challenge the mobile machinery manufacturers, such as Doosan, face today. Kang Byeong IL explained how he proceeds to boost the market competitiveness of the excavators produced by Doosan. This is a complex task! Indeed, improving the energy efficient (but still getting a powerful machine) means providing best-in-class hydraulic systems while ensuring vehicle dynamics, all in a controlled environment.

This is the engineering challenge that Kang Byeong IL has been tackling for over 10 years and he decided to solve it using Simcenter Amesim by developing new technologies for excavators. Indeed, over the years the Simcenter system simulation

solution has helped him understand the behavior of the excavators he has developed with his team, and enabled him to balance all these attributes in an optimal way.

We cannot say it better than he did: "Simcenter Amesim is indispensable software for the development of our hydraulic systems, especially at the early design phase, when various design concepts are derived to achieve the target performance."

The other interesting thing worth retaining from his presentation was the digital twin they created with Simcenter Amesim has helped them verify overall controls logic and its impact on system performance. ∎
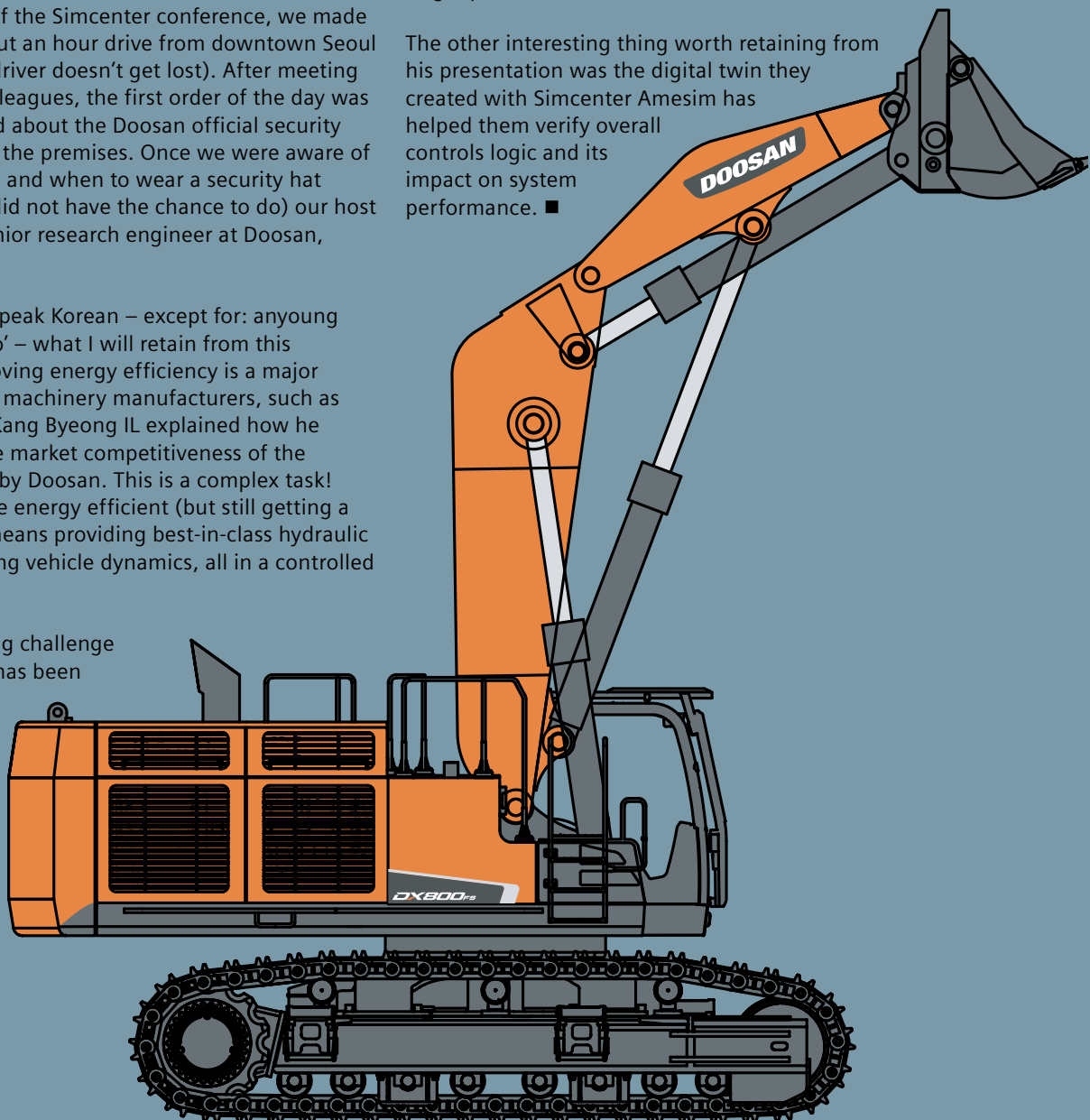
Image Courtesy: Doosan

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