Contents

the circuit

Jesper Christensen
Executive Vice President and
Chief Financial Officer

Count on a **Strong** Partner

When you choose your mobile hydraulics partner, you look for the best quality solutions and specialist support to ensure the optimum performance of your mobile equipment. What you also need is a partner that will remain at your side even when the world market is under severe financial pressure.

The deepest international recession in modern memory has taught us some important lessons.

At Sauer-Danfoss, we have used them to reshape our organization - enabling us to channel more resources into developing the best technology within our core business areas and established markets.

We are also committed to expanding our presence in growing customer markets, particularly within Asia. Already, plans are moving ahead to invest in production facilities and growing our team in China.

Preparing our business for the future means keeping your needs and values in sight at all times. As you can read in this issue of The Circuit, our recent customer perception survey has given us valuable input for continuing our strategy to be the strongest partner in the mobile hydraulics business.

Our organization has that strength, for today and for the future.

SAUER DANFOSS

Best Customer Connect

Strength in the Core

Unique Customer Experience

Going for Number One

The 2011 customer perception survey shows the Sauer-Danfoss strategy is well aligned with customer values. Major initiatives are underway in response to the feedback. Thanks go to the many customers who shared their views.

Understanding the customer is key to being the strongest partner in mobile hydraulics. Feedback from this year's customer perception survey indicates Sauer-Danfoss is moving in the right direction towards that goal.

Competent, reliable, friendly, committed and customer-focused are the top five words that customers say best describe Sauer-Danfoss. Marc Weston, Executive Vice President and Chief Marketing Officer, is pleased to see a general improvement since previous surveys in 2008 and 2009.

"The words that customers choose to describe us relate to their perception of our people. Customers are very happy with the support they receive and the people they work with," he says.

Strategic Fit

An above-average number of respondents found the time to provide valuable input about how they rate the company right now. A supplement to the feedback Sauer-Danfoss employees receive in their day-to-day contact with customers, the survey takes the temperature on customer values and expectations globally and evaluates the fit with company strategy.

Weston comments, "Our strategy is designed to deliver on what the customers tell us they value. The survey shows whether the strategy is working. This year's scores reveal we have made some meaningful improvement but there is still work to be done."

Capacity Readjustment

As can be expected, a number of the responses reflect the general state of the industry in the wake of the global economic downturn. Having downsized production capacity when the recession hit, Sauer-Danfoss is still in the process of adjusting to the renewed sales growth. Weston regrets that this has meant a few customers have experienced delivery delays in respect of certain products.

"One of the main elements of our strategy is about providing a reliable delivery experience, so capacity alignment is something we are working hard on. The fact that we have managed to reduce our debt considerably over the past year shows that we are a secure supplier with the financial strength to respond to the new, more positive market situation," he says.

This renewed vitality is now allowing the company to invest in additional capacity to meet growth demands around the world.

In respect of other strategic objectives – to have only best-in-breed products and secure the best customer connect – customers are positive. High product quality, value addition to the customer's own products, application expertise and technical support are all primary reasons why customers choose Sauer-Danfoss as their supplier.

Faster, Better Information

While good personal relationships are also valued highly, customers are currently less impressed by the information flow regarding, for example, updates on product changes and new part numbers. Sauer-Danfoss has launched a top-priority project to establish a new framework for resolving this major issue.

"At present, all the information customers require involves talking to a Sauer-Danfoss person, who may have to spend quite some time searching for the relevant information in our system," Weston states.

"Our objective is to improve the systems within our organization so accurate information is always easily accessible."

During 2012 and 2013, Sauer-Danfoss expects to introduce a new online setup that will give customers the option to source much of the information they need and download it directly in their own language.

Alignment with customer needs and market demands is key to position Sauer-Danfoss as the number one supplier of hydraulic power and electronic control solutions to the mobile machine industry. Over the past year, many exciting changes have been implemented to bring that ambition within closer reach. Inspired by the valuable feedback from the customer perception survey, Sauer-Danfoss is ready to do what it takes.

***Article 1**. For further information: TheCircuit@Sauer-Danfoss.com*

Greedy for Grime

An initial sweeper prototype based on an in-house design did not live up to expectations at Brodd Sweden AB. A trip to the Sauer-Danfoss test track and a hydraulic makeover later, and the compact, self-propelled Yess sweeper is the market's new high-performing dust-buster.

City grime is no match for the new Yess sweeper from Brodd. From the finest sand to large stones, leaves, paper and bottles, this small, agile machine has the capacity to suck up just about everything in its path.

Inside the cabin, the driver can sit in quiet comfort while the Yess tackles narrow sidewalks, underground car parks and many other areas – empowered by a complete hydraulics system developed by Sauer-Danfoss.

In Search of Performance

The first self-propelled member in the Brodd range joins a strong line-up of high quality, heavy-duty machines. Keen to maintain its enviable reputation, the Swedish sweeper company was committed to securing the right performance from the outset, but was having difficulties. A trip to the Sauer-Danfoss test track in Nordborg, Denmark, turned the tide.

"We invited Brodd to bring their machine to our facility, where we talked about what was important to them and measured the existing hydraulic system. Then we replaced the hydraulic parts with Sauer-Danfoss components and measured again. There was a big difference," recalls David Stålgren, PVG sales development manager at Sauer-Danfoss.

Smooth, Fuel-Efficient Sweep

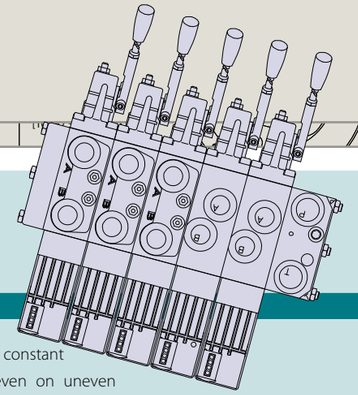
Two OMP 125 orbital motors have improved the efficiency, driving smoothness and control of the low-speed sweeper. For noiseless steering, an OSPC 80 ON steering unit with 17cc gear pump has been introduced.

"This is very important as the steering unit is inside the cabin," Stålgren comments.

Managing the sweeper's work functions are a TurollaOCG™ compact triple gear pump – comprising 33ccm, 7ccm and 8ccm displacements – and a five-section PVG 32 valve with integrated PVBZ low leakage module to keep the brushes at an optimum height when not in use.

Four of the sections are PVEO-R on-off valves with a delayed reaction time, an economical choice that secures a smooth start-stop action and reduced mechanical wear. AMP connectors on the PVE electrical actuators provide high water protection.

A Comatrol™ HIC block is responsible for controlling the two brushes in relation to the ground, ensuring a constant pressure even on uneven territory. As the brushes rotate, a 14ccm TurollaOCG SNM2 gear motor, with integrated anti-cavitation check valve and relief valve, sucks up dust and debris. This neat solution adds to the overall system compactness and fuel efficiency.



Professional Experience

On returning to the Sauer-Danfoss test track to see the Yess prototype in action with the new hydraulic system, Brodd CEO Per-Olav Brodd was delighted.

"All the old components were replaced by Sauer-Danfoss parts and tested in cooperation with our technicians. The whole experience was very professional. On that basis, we have decided to go over to Sauer-Danfoss entirely," he states.

The Yess self-propelled sweeper was launched on the market this spring and has been well received. From time to time, customers ask which supplier is behind the hydraulic system.

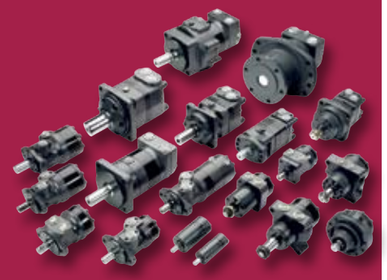
"When they hear that we use Sauer-Danfoss, they don't need to ask any more," says Brodd. "It is a sign of quality."

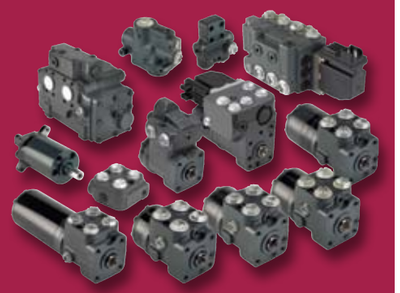
***Article 2**. For further information: TheCircuit@Sauer-Danfoss.com*

Core Technology Goes to Work

When Sauer-Danfoss realigned its leading technology with customer needs, five core product areas emerged.

Three of them are responsible for the efficient, high-performing work functions on customers' mobile machines. Sauer-Danfoss orbital motors, PVG spool valves and steering continue to raise the market standard.





Developing technology for orbital motors, steering units and load-independent spool valves has long been a priority at Sauer-Danfoss. Responses to a 2010 survey confirmed that these work function components have just as high priority for a large proportion of customers.

Orbital Motors – High Efficiency and Durability

For Paolo Fonio, Sales Director Motors, the identification of orbital motors as a core product group really came as no surprise. With close to 50 years' experience in producing robust, low-speed high-torque (LSHT) motors for all the mobile machine segments that Sauer-Danfoss covers, the orbital motors group has set the standard from the beginning.

"Our motors are known and chosen for their high mechanical and volumetric efficiency, giving smooth operation, excellent controllability and performance across the entire speed range," Fonio states.

"Minimized pressure drop contributes to reduced power losses and energy consumption, helping to compensate for the reduced power of new, emission-compliant engines. We supply best-in-class products, along with strong technical support and application knowledge," Fonio states.

The broad standard range, with an output of 1-80kW, is complemented by customized adaptations designed for specific application needs in open and closed loop hydraulic systems. This makes them well suited to both work functions and the propel function on slow-moving machinery.

Whatever the application, the thousands of configuration opportunities assure all customers exactly the right solution for their specific job – whether, for example, driving the feeding rollers on forestry machines, rotating the cutters on harvesters, powering the brushes on sweepers or propelling skid steer loaders.

"The robust design secures a high performance during many hours of operation throughout the lifetime of the motor. Durability is a key factor in reducing the total cost of ownership of our motors," Fonio adds.

PVG Valves – Flexible, Low-flow Performance

Just as with orbital motors, Sauer-Danfoss has always led the way with its electrically activated PVG spool valves, which today are all PLUS+1™ Compliant to allow advanced electronic control. Sales Director PVG, Steen Slot, sees that positive development continuing.

"Right now we have new projects underway to develop our technology further and provide even better performance and user-friendliness. An upgrade of our electric actuators will add more valuable features," he says.

Based on load-sensing technology, the PVG family – PVG 32, PVG 100 and PVG 120, with a maximum flow range of 130-240 l/min [34-63.4 US gal/min] – is a modular concept that allows easy selection and adaptation to any application requirement. Providing opportunities for an almost infinite number of configurations, the range is still one of the market leaders more than 30 years after its launch.

Anticipating the demands of new safety legislation, further products have been developed that help OEMs comply with these requirements. These include, for example, the SIL 2-certified PVED-CX digital actuator and the PVSK oil supply cut-off module.

"The trend towards higher performance with lower energy consumption and overall machine safety is very much in our favor. In this, we meet demands regarding emissions and functional safety," Slot notes.

Steering – Safe, Reliable, Responsive

Leading expertise is also a hallmark of Sauer-Danfoss steering solutions – expertise most recently demonstrated by the addition of the high-end OSPE steering unit to the broad range.

"Sauer-Danfoss is synonymous with hydraulic steering," says Jim Woodward, Director Steering Sales. "We are known worldwide for the innovation, reliability and quality that is built into every steering product."

Incorporating variable steering ratios, selectable steering modes, an integral priority valve and safe, load-sensing functionality, the OSPE optimizes steering for use with GPS systems. The compact steering unit is truly a system in itself – yet another example of industry-leading technology.

Understanding the end-user's needs is the first step in selecting the right steering unit for the job. Over the decades, customers have learned to rely on Sauer-Danfoss' strong technical support, which reduces their development time simply by getting it right from the start.

"As with our other core business areas, functional safety is paramount," Woodward adds. "Within steering, we are committed to providing our customers with the best knowledge available."

Refer to The Circuit no. 13 for the article on our two other core product areas – propel and electronic controls.

***Article 3**. For further information: TheCircuit@Sauer-Danfoss.com*

A Lifetime of **Robustness**

The JS7000 joystick sets a new standard in human-machine interfaces. Never has machine control been so responsive.

A whole lot of homework has gone into the design of the new Sauer-Danfoss JS7000 joystick. Insights gained from extensive interviews with operators and in-cab videos of operators in action have contributed to an innovative control solution where human and machine are seamlessly synchronized.

For performance, durability, flexibility and operator comfort, the JS7000 is quite simply in a class of its own.

"Our research was exceedingly thorough and gave us singular insight into the unique needs of off-highway machine operators," says Joseph Maher, product marketing manager. "Combining the research findings with our previous application experience and the industrial design expertise of our external partner, we developed a world-class joystick that the industry didn't realize it needed."

Lifetime Choice

Rigorous tests have proven the JS7000 a top choice for a wide range of machines required to perform in the harshest, most challenging conditions. Backhoe loaders, skid steer loaders, telehandlers, wheel loaders and dozers are just some examples.

Robust, dust-tight and water-resistant, the joystick is made to last the whole lifetime of the machine. Should the need for maintenance or repair arise, the design allows easy accessibility so the machine can quickly get back to work.

Flexible, Intelligent Control

The multiple options included in the modular design enable easy adaption to the requirements of individual customers and applications. Possibilities include single and dual-axis configurations, spring centering and an ergonomic vertical grip design for left or right-hand control. Various push button, trigger switch and proportional roller switch configurations are available on each grip. The JS7000 also supports analog and CAN-based communication.

With this high level of sophistication, OEMs will not be surprised to learn that the innovative joystick is compliant with Sauer-Danfoss PLUS+1™ technology. Seamless integration with the other components in the growing PLUS+1 family ensures intelligent, powerful and energy-efficient control of all machine functions.

An uncompromising commitment to the real challenges in the field has changed the game entirely within human-machine interface components. The latest addition to the Sauer-Danfoss joystick range is yet another differentiating solution designed to bolster every OEM brand.

***Article 4**. For further information: TheCircuit@Sauer-Danfoss.com*

One Success Drives the Next

Claas was the first customer to test servo-controlled H1 pumps from Sauer-Danfoss. Today, the leading manufacturer of agricultural machinery has upgraded its entire range of LEXION combine harvesters to a propel system based on H1.

The paint was barely dry on the new 32-tonne LEXION 600 when the new machine took the European market by storm. Within months, Germany-based Claas and Sauer-Danfoss were underway with the next major project – this time to design an advanced hydrostatic propel drive for the entire LEXION range.

At its launch, the LEXION 600 was the first mobile machine on the market with the Sauer-Danfoss servo-controlled H1 165ccm pump. Claas had offered valuable support during the testing of the compact, efficient pump, which is a primary component of the harvester's closed circuit propel drive system.

Cut the Noise, Save on Fuel

To follow up the success, the Sauer-Danfoss team was given the task of developing seven new propel systems that would bring similar drive performance to the rest of the range. This major undertaking bore fruit in the fall of 2010, when Class launched its new LEXION combines.

Björn Bullwinkel, project manager, explains the challenge involved: "The LEXION 600 was the first Claas machine to have a propel system with full electronic control. This has given more features, such as cruise control and the ability to calculate optimum speed for maximum harvest yield. When on the road, the driver can lower the diesel engine speed to reduce noise and emissions and save on fuel."

He adds, "What we had to do with the new project was to achieve the same behavior from the smallest to the biggest in the LEXION range with different propel systems. It was a challenging process."

Different Systems, Similar Performance

The seven systems are based on the same components as the original and comprise an H1 130ccm or 165ccm pump, motors with displacements ranging from 100ccm to 250ccm, and a microcontroller. Customised software secures the top-tuned performance of each one, including a top speed of up to 40km/hour.

"Our software development guys visited Claas often to optimize the machines. Claas also involved them and our field test team in the machine tests. We have always had a good relationship with them when discussing issues and resolving them," says Bullwinkel.

Outstanding Safety and Comfort

In addition to their convenient size and efficiency, H1 pumps have two outstanding safety features. As its name suggests, the integrated overspeed protection feature (ISL) prevents overspeeding in respect of the diesel engine, H1 pump and other components, extending their lifetime. The control override function (COR) is charged with taking the pump out of action should the controller fail, if supply voltage is lost or when braking sharply. This ability to bring the machine to a rapid halt ensures full compliance with international road safety laws.

Enhancing driver comfort, the bent-axis motor comes with a two-speed gear box. One gear for the road and one for the field reduce the need for gear-changing stops and starts significantly.

"Generally the driver can drive longer without getting tired because, apart from steering, all the functions are automatic. The high power means more can be harvested in less time," says Bullwinkel.

Securing a Strong Reputation

Claas spent many months testing each of the seven propel systems in turn, working with Sauer-Danfoss to ensure no expectation went unaddressed. This dedication to detail is why the LEXION range lives up to Claas' reputation for quality and performance in every way.

With that kind of a reputation, it is small wonder that the new LEXION continues to be the preferred combine harvester of farmers in Europe. Driven by H1 propel systems from Sauer-Danfoss, the range is now reaping growing sales on the North and South American market as well.

***Article 5**. For further information: TheCircuit@Sauer-Danfoss.com*

Sauer-Danfoss brings smart control and perfect alignment to independent left and right propel systems with the PLUS+1™ Generic Dual Path subsystem.

Dual Drive in Smooth Harmony

Any OEM working with twin propel systems must be familiar with the challenges of coordinating two independent systems that are never 100% the same. Now they can benefit from a new opportunity to integrate perfect propel control in an intelligent network that manages the performance of the whole machine.

The PLUS+1™ Generic Dual Path (GDP) subsystem offers advanced software that eliminates the shortcomings of manual control.

Converting Input to Output

To satisfy requirements for infinite variability, the application software block is adept at converting input from the human machine interface – the joystick – and CAN into differential output commands. These are transmitted to the variable displacement pump and motor in the two closed circuit propel systems, ensuring the left and right side of the machine are in accurate alignment.

"The application block is one of a series of validated component software blocks. Programmed using our PLUS+1 GUIDE tool, the software greatly reduces vehicle testing time, provides responsive control and, because it is based on our long experience with propel system control, reduces project risk," says Mike Weeks, senior product application specialist.

Flexible, Safe Operation

Given the advantage of infinitely variable steering, OEMs can choose between straight tracking, pivot steer and full counter rotation in either direction. Setting the dual path subsystem up to cater for differing machine needs could not be easier. For example, differential steering is available for a paver and non-differential for a crawler. The requirements of dual-path municipal vehicles, trenchers, rock cutters and cane harvesters are smoothly accommodated, too.

Of course, functional safety requirements have been another major consideration in the development of the PLUS+1 GDP. Through the coordination of the propel command with the brakes, machines gain full use of hydrostatic braking when stopping – an advantage that also minimises brake wear and tear.

Advanced Control

Optional plug-in modules add a series of advanced control features that make the degree of design flexibility outstanding. One of them, the antistall plug-in, monitors engine rpm and, in doing so, eliminates the need for the operator to make propel speed adjustments when machine loads vary. In conjunction with this, the trackstall plug-in limits the extent to which antistall can reduce propel command, ensuring motor torque is maintained.

"This keeps the vehicle tracks loaded while the machine undergoes heavy loading, which could otherwise cause hydraulic relief valves to open or reduce the hydraulic pressure to a level too low to maintain motor torque. In this way, maximum torque to the ground is sustained," says Weeks.

An additional temperature derate plug-in reduces the propel command relative to high temperatures, avoiding damage to hydraulic components.

Network Integration

Combined with the broad Sauer-Danfoss portfolio of PLUS+1 Compliant pumps, motors, microcontrollers, joysticks, displays and sensors, the PLUS+1 GDP is capable of almost every system customization. The dual path propel system is integrated in an efficient control network that manages and aligns the hydraulic functions on the entire vehicle.

***Article 6.** For further information: TheCircuit@Sauer-Danfoss.com*

Paving a Global Market

"Sauer-Danfoss is a very reliable partner. This is something we really appreciate," says Sany spokesman Thomas Mavrudis, who leads the company's road machinery department in Europe. "We need partners who are able and willing to support us. We appreciate the dedication of Sauer-Danfoss to being a leading supplier of hydraulic and electronic components."

Founded as a small welding material factory in 1989, today Sany is one of China's largest manufacturers of construction machinery, with growing worldwide operations. At the last count, the group had some 60,000 employees in 120 countries. The vast product portfolio includes road, excavating, pile driving, hoisting and port machinery, not to mention wind turbines.

Power-Dense Propel Systems

Sauer-Danfoss supplies propel systems comprising servo-controlled H1 pumps and bent axis motors to a number of Sany's machines. Robust, compact and low on fuel consumption, the H1 series delivers high power density and control in flexible system designs. The total installed lifecycle cost makes H1 an outstandingly high-value proposition.

Sany's asphalt pavers are one of the machine types fitted with an H1 propel system. Recently, the Sauer-Danfoss team in China recognized an opportunity to improve performance further by the addition of a PLUS+1™ electronic control system. Despite only having two months to test and fine-tune the system, the team successfully convinced Sany of the benefits.

"Our controller has helped them improve the resolution of the machine," explains James Ou, electronic control sales development manager.

PLUS+1 for Stability and Precision

Linked up to the two H1 80ccm bent axis motors and seven H1 pumps – five 45ccm and two 53ccm – a PLUS+1 MCO50-010 microcontroller is now a feature of Sany's most advanced paver, the SAP90C.

Thomas Mavrudis praises the supreme drive properties that PLUS+1 technology brings at speeds below seven meters a minute, where stability and smoothness are difficult to maintain.

"Precision and simplicity are essential. The machine must stay at a set speed, moving precisely in the chosen direction with less than 0.2% deviation. PLUS+1™ provides all the hardware and software to resolve the challenges. "It is easy to optimize the system on our prototypes. Fine-tuning can then be done in one to two days."

H1 Across the Board

Sany has decided to use H1 pumps and motors on, as far as possible, all its new generation machines. For the work functions on the SAP90C paver, Sauer-Danfoss also delivers two OMT orbital motors, with 250ccm and 315ccm displacements, and a two-section PVG 32 valve. The possible introduction of PLUS+1 for work function control is currently being evaluated.

"Sany is undergoing explosive growth. That requires huge flexibility from our partners," Mavrudis remarks. "My experience of Sauer-Danfoss is that we get excellent support on deliveries and educated, experienced technical personnel all round the world. Their experts talk the language of our local engineers."

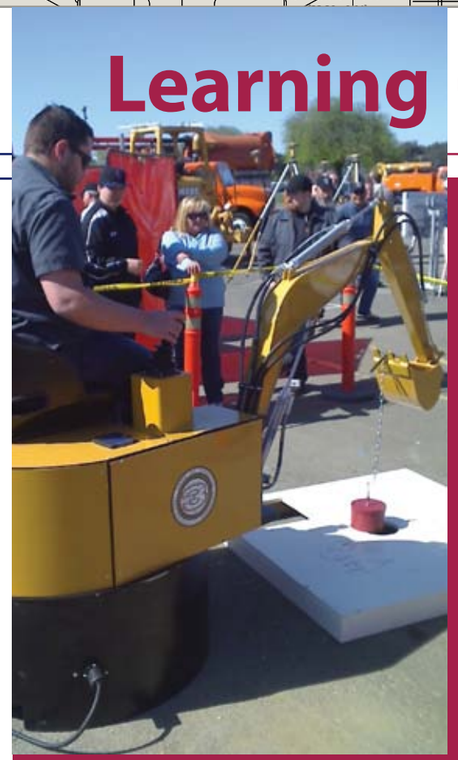
By all accounts at Sany, Sauer-Danfoss performs the role of responsive, global supplier well. As plans move ahead to develop operations in the world's fastest developing markets, it will soon be possible to do the job even better.

***Article 7**. For further information: TheCircuit@Sauer-Danfoss.com*

Chinese manufacturer Sany anticipates up to 90% growth on the global market for construction machinery in 2011. To achieve that, they need suppliers capable of delivering the necessary parts and specialist expertise – and delivering it fast. Sauer-Danfoss is a preferred supplier of electrohydraulic propel systems.

PLUS+1™ by SAUER-DANFOSS

Learning Comes to Life



KGM Simulation, based in Ontario, Canada, came to Sauer-Danfoss for support in developing a new mobile machine training tool that beats traditional computer programs by miles. With the Mini-XJB Simulator, learning to operate heavy machinery has never felt more real.

Whether they're five or 55, people love sitting behind the controls of the Mini-XJB Simulator from KGM Simulation and putting the heavy-duty work functions to the test.

The simulator is the ultimate tool for training new operators of heavy machinery quickly and efficiently, any day of the year. Plug it into any standard electric power supply, and it's ready to go.

It's also a lot of fun, says KGM Simulation founder Bill Manteuffel. "We designed the first machine in response to a request from the Operating Engineers Training Institute Ontario (OETIO). Today, our machines are used as training and promotion tools, which can also be used by colleges, high schools and at job fairs to attract interest in the heavy equipment trades."

He adds: "We also believe there is an entertainment value to the simulator. At trade shows, the kids line up all day to have a go."

Load-Sensing Intelligence

Over the past four years, Sauer-Danfoss has supplied the four-section PVG 32 valve bank, PLUS+1™ microcontroller and DP 200 display for the original simulator, the Mini-X excavator. The Mini-XJB with auxiliary backhoe function was launched this summer. This is further equipped with a JS6000 joystick, bringing the advantage of CAN-based communication and precise fingertip control. The new PVG 32 valve bank has five sections to manage the boom, arm, bucket, and front and back swing.

Manteuffel was well aware of Sauer-Danfoss' reputation as a leading supplier to the mobile equipment industry when he first designed and developed the hydraulic system for the Mini-X. He was not disappointed.

"We needed very small spools for precise metering and small flow. So we went with the proportional PVG 32 valve as this allows multiple functions independent of load and gives much smoother control," he explains. "Because we use it in conjunction with PLUS+1, we can easily make program changes. That enables us to switch between John Deere and Cat controls, which are the two market standards."

Adjustable to Skill Levels

Another PLUS+1 benefit is the opportunity to program slow, medium and fast work speeds, which can be selected according to the operator's level of competence. Just as with a full-size machine, safety is also paramount. The Mini-XJB has a number of safety interlocks, including a seat sensor so, when people get off or stand up, the machine functions automatically go into neutral.

This sophisticated functionality is enhanced by the system's lightweight compactness, which reduces the size and weight of the simulator overall. From the small DP 200 display, operators can start, stop, control and troubleshoot.

Hands-On Experience

Sauer-Danfoss electrohydraulics make operating the Mini-XJB just like the real thing – a far cry from the 2D computer simulators used for conventional training, Manteuffel notes:

"When you use a computer simulator, you may have the bucket at the wrong angle, and you'd never know. Our simulator gives you the full feel and hands-on experience – and saves wear and tear on a regular machine. PLUS+1 and PVG 32 are exceptional."

After several successful years, KGM Simulation has many other ideas up its sleeve for new additions to the simulator range. Sauer-Danfoss components are likely to be a common feature. So far, KGM Simulation has seen nothing that can compare.

***Article 8**. For further information: TheCircuit@Sauer-Danfoss.com*

Mission: Emissions

Demanding emissions legislation has put OEMs on the trail of high-performing hydraulic solutions. Sauer-Danfoss can assist with some of the most advanced, high-efficiency technology on the market.

At first, the design challenges felt like mission impossible. The environmental authorities' schedule for reducing emissions from off-road diesel engines was ambitious in the extreme. But after decades of developing fuel-saving components, Sauer-Danfoss was already well equipped to meet the new requirements. OEMs can today rely on efficient, high-performing hydrostatic technology to help them meet the challenges.

The Most Demanding Year

An estimated 10,000 to 15,000 mobile machines will have undergone a major redesign by the time the North American Tier 4 and European Stage IV emissions regulations are fully implemented in 2014. But, of the 15 years that have gone by since the first regulations were introduced, 2011 is the most challenging of all. This year manufacturers need to satisfy the requirements of Interim Tier 4/ Stage III B – the most significant step up yet in the ever-toughening campaign to cut off-road diesel engine emissions.

"OEMs are faced with rising energy costs and step increases in engine costs. These need to be offset with improvements to operating efficiency and vehicle system productivity," says Charles Throckmorton, marketing technical advisor.

Managing the Consequences

With the introduction of new low-emission engines comes a series of consequences for vehicle performance: a 10-20% increase in heat rejection, a 5-10% reduction in net vehicle power output, a 10% reduction in available hydraulic flow and less available installation space around the engine.

Sauer-Danfoss has adopted a vehicle-by-vehicle approach, analyzing and assessing technologies to arrive at the optimum solutions for propel, work function, control and vehicle management functions. Throckmorton is confident of the outcome. "Through putting the Tier 4/Stage IV requirements under intense scrutiny, we have identified the best-in-class products and solutions to meet the significant challenges," he states.

More Power to the Ground with H1

Many hours in the test labs have gone into developing Sauer-Danfoss H1 propel systems that maximize engine efficiency by combining the lower input speed of an H1 pump with the higher output speed of an H1 bent-axis motor. With their compact, forward-looking design, H1 pumps and motors address a number of issues by saving on fuel, reducing heat load and increasing power to the ground. At the same time, they free up power for other vehicle functions and space in the engine compartment, where bulky exhaust after-treatment devices are a requirement.

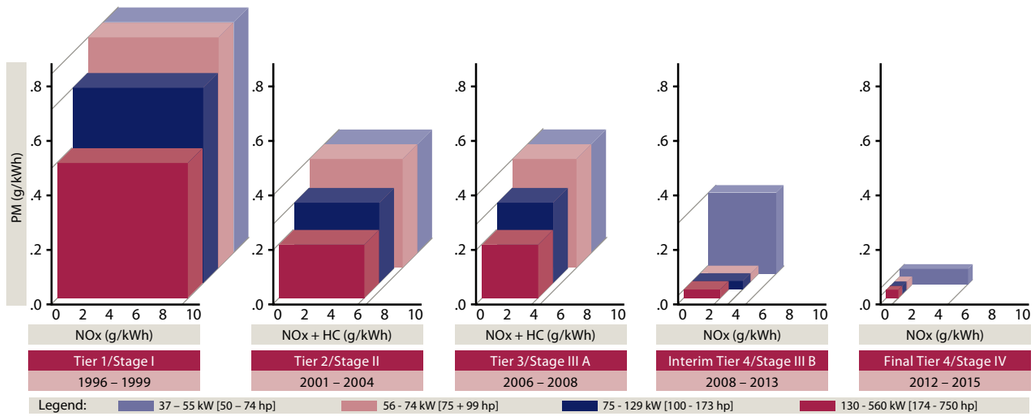
The research has also covered investigations of hydro-mechanical power split transmissions (HMT) based on 45-degree bent-axis technology. In tackling emissions regulations, HMT works particularly well as it allows the integration of a mechanical gear train with an infinitely variable hydrostatic transmission (IVT). This makes it possible to decouple engine speed from ground speed, enabling "best point" control for optimized fuel economy.

Sophisticated Cooling

Increased heat rejection has been an unavoidable consequence of the switch to low-emission engines, creating a need for more sophisticated cooling solutions to replace traditional fixed drive cooling systems.

Sauer-Danfoss' proportional control, variable speed fan drives are ready to do the job. With their "cool-on-demand" functionality, they regulate fan speed as necessary – using only the power required to maintain the optimum engine temperature.

EPA and EU Nonroad Emissions Regulations: 37 - 560 kW [50 - 750 hp]



"Many off-road machines that did not previously need a hydraulically-driven cooling fan will be required to have hydraulic, variable speed cooling fans in the future. Due to the major advantages the fan systems provide, some machines will require more than one," says Dieter Könemann, efficient & productive application solutions manager.

"Distributed cooling not only improves packaging and vehicle styling, but can further reduce the cooling power demand by as much as 50% over single fan solutions."

PVG 100 - Power for Multi-Tasking

Even with the most efficient propel system installed, the hydraulic flow demands of heavy-duty machines may push supply to the limits. That's where the flow-sharing technology of the Sauer-Danfoss post-compensated, load-sensing PVG 100 valve is a real bonus for multiple work functions.

With its proportional functionality, the PVG 100 distributes flow to each function in accordance with load and flow requirements. When demand exceeds supply, the valve still keeps each function up and running, just on proportionally less flow.

Könemann points out the opportunities this provides to reduce the overall cost of the system. "Flow sharing allows design engineers to reduce the size of the pump at no expense to machine performance," he says.

The full potential of the PVG 100 can be realized in combination with a load-sensing Series 45 open circuit axial piston pump, which is based on the same load-sensing principle, and a PVE electrical actuator. Together they secure maximum work function efficiency and energy conservation.

While the load-sensing valve and pump make the most of the available hydraulic flow, orbital motors compensate for the reduced power levels of emission-compliant engines by minimizing hydraulic pressure drops. Another key work function component, they, too, provide a high-efficiency performance that minimizes heat load, reduces fuel consumption and, subsequently, emissions.

Make It Smart

Gary LaFayette, senior engineer in the advanced systems engineering team, remarks, "The success of hydraulics solutions in the future will be evaluated by their ability to overcome the power limitations of low-emission engines and distribute the right amount of power where it is needed. Efficient power management is critical."

To this end, Sauer-Danfoss has ensured that all components designed for low-emission vehicles are compliant with its advanced PLUS+1™ electronic control technology. Intelligent power distribution is obtained by joining hydraulic functions together in a single network, where all propel and work functions are managed.

Affordable Solutions

To maintain cost transparency during the design process, Sauer-Danfoss has developed a hydraulic circuit cost analysis tool. This clearly demonstrates the cost benefits that the move towards low-emission machinery actually brings.

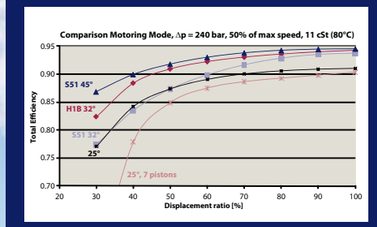
Dieter Könemann explains, "While the initial purchase cost of emission-compliant hydraulic systems will typically be higher, as the tool will show, this is more than offset by the reduction in annual fuel consumption and improved performance."

It seems that meeting the ambitious emissions demands is a manageable challenge after all. Advanced hydraulic technology is available to do the job, and OEMs can draw on the specialist support of Sauer-Danfoss to determine the right low-emission solution for their machines. Running mobile machinery is becoming both cleaner and cheaper. Who can say no to that?

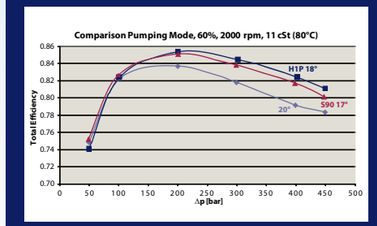
For more information about Sauer-Danfoss emission solutions, visit www.sauer-danfoss.com.

Article 9. *For further information: TheCircuit@Sauer-Danfoss.com*

Efficiency Testing



Bent axis motor comparisons, measured on the same test stand, with the same equipment. The graph shows the measured total efficiency advantage of Sauer-Danfoss bent axis motors (S51 32°/45° as well as the H1B motor 32°) compared to new, comparable products on the market with a lower angle range (25°). Note that both a reduced angle range and seven pistons instead of nine have a similarly negative effect on motor efficiency.



Swash-plate pump comparisons, measured on the same test stand, with the same equipment. The graph shows the measured total efficiency advantages of Sauer-Danfoss swash-plate pumps (S90 and H1P) compared to new, comparable products on the market with solid pistons and standard slippers (20°).

Stock Price Going Up

Investors can continue to enjoy the positive development in the Sauer-Danfoss stock price, which has moved steadily upward over the past months. Following the dramatic action taken in response to the world financial crisis, the stock price is a clear sign of the renewed market confidence in Sauer-Danfoss. At the time of going to press, the stock price was US$50 per share, highlighting the compelling turnaround since the price hit $3 at its lowest.

Expert Insights

Sauer-Danfoss has made an impact on the seminar scene this year, with no less than 13 expert presentations at the 52nd National Conference on Fluid Power (NCFP) in Las Vegas and a presentation on functional safety at the American Equipment Manufacturers (AEM) annual conference in Chicago.

Organized in conjunction with the International Fluid Power Expo, the NCFP provided a forward-looking picture of new technologies and methods for the future mobile and industrial machine designs. With 13 technical experts on hand to host sessions on power management, efficiency & fuel savings, heat management & electrohydraulic technology, Sauer-Danfoss was the most dominant contributor at the event.

Product safety and compliance was the focus of the three-day AEM conference. Here, Sauer-Danfoss attracted interest with a one-hour presentation of the practical solutions available to help OEMs live up to new international functional safety regulations and standards. Particularly the EU Machinery Directive, enforced at the end of 2009, and the ISO 13849 standard for safe electronic control systems call for design alterations.

See the events calendar on www.sauer-danfoss.com for information on coming seminars.

A Star in Minneapolis

Commitment to safety and health at the Sauer-Danfoss electronic controls plant in Minneapolis, USA, has brought national recognition.

Following an audit by the Occupational Safety & Health Administration (OSHA) under the United States Department of Labor, the plant is now officially recognized a Star site.

The Star award is the highest honor given by OSHA's Voluntary Protection Program (VPP), where OSHA works with plant management and employees to implement a comprehensive safety and health management system.

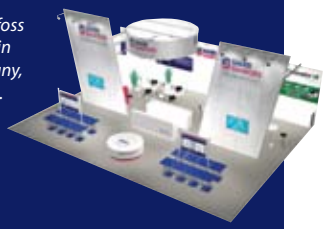
"This recognition means we are the best of the best when it comes to safety and health," says Dave Lamm, environmental, health & safety manager, who has high praise for the plant's efforts. "The success we share is not from one individual or team, it's everyone's involvement. They simply deserve this recognition for the hard work and dedication they continue to give to provide a safe work environment."

Two other Sauer-Danfoss production plants in the USA – at Freeport and Ames – also hold a VPP/Star award.

Exhibition Calendar

Visit Sauer-Danfoss at Agritechnica in Hanover, Germany, Nov. 13-19 2011.

Booth # 25-L11



Find out where you can meet Sauer-Danfoss representatives at exhibitions in 2011.

the circuit

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