RICHARD CARR, *iVT International*

PNEUMATIC FEVER

Sick of discovering their electronic components rotting away, one company's self-propelled sprayers made a remarkable recovery after being prescribed a good dose of common sense

If there is one trend that characterises the development of off-highway equipment over the past couple of decades, it must surely be the overwhelming adoption of electronics. So after I decided to interview the people behind the SAM SLc range of self-propelled crop sprayers – which a colleague had described as 'the most technologically advanced machines on the market' – I was more than a little taken aback to discover that most of its functions were operated by…air.

It does initially seem a ludicrously simple way to operate; almost at odds with the emphasis on superior quality that is evident throughout the machine. But for these hard-working vehicles – most average 800 hours per year, with some regularly clocking up 2,000 hours – routinely operating in incredibly tough environments involving liquid nitrogen, for instance, reliability is paramount.

"In the early days of crop sprayers, it was common for the wiring on the rear lights to short out," says Bari Cotter, design and technical manager at Sands Agricultural Machinery (SAM). "All that would be left was a pretty coloured sleeve – the copper cable inside had been eaten away. Every solenoid is a potential corrosion point too.

Air has been so reliable over the years – it costs more because we have to provide a compressor and run it, but the pros far outweigh the cons."

As the tour around the vehicle continued, my attention was continually being drawn to one pneumatically controlled function after another – such as the hydraulic valves that operate the transmission and brakes.

By nature, crop sprayers need to have high ground clearance (950mm in this case) which automatically calls for hydrostatic drive – nobody manufactures axles with a steep-enough dropbox for the purpose. So Sands fabricates its own portal axles, attaching a pair of Poclain two-speed wheel motors to each one, for which it dictates its preferred displacements. Permanent four-wheel drive produces better stopping power and handling characteristics while on the road. "We've looked into high-speed machines but nobody seems to know which regulations we have to comply with," says Cotter. "It's a bit of a grey area and until it's sorted we can't really go above 40km/h."

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Even the transmission system can be a tough environment, with lots of chafing and moving of pipes. So mindful of quality, pipes with a PTFE coating are used, enabling them to slide past each other without chafing. But not content with this, the Sands engineers wrap them up in spiral Armour guard just to make doubly sure. "We use 42MPa pipes from Gates," reveals Cotter, "which are some of the most expensive but we know they're well-proven; they don't have quality problems and are the best we can buy. We had a disastrous experience many years ago when we tried cheap pipes – they dripped and leaked, which is the last thing a farmer wants running through his crop. We could save £100 on just one pipe, but how much would it cost to send a service guy to northern Scotland to change it over?"

To adapt to a variety of tramline widths out in the field, a sliding axle is essential for this type of vehicle. "We first developed a cast-iron version, which was manually pulled out to the desired position," explains Cotter, "but over a season this would fill up with mud, making it hard to push it back. So the next stage was hydraulic assistance, with a ram between the two sliding legs. We use the steering wheel as the motive power – throwing a valve and turning it one way or the other moves the axle in or out. We've further improved upon it by setting a stop at the bottom – once the end of the axle reaches the desired point, you put the bolts back. You don't have to crawl underneath with a tape measure anymore!"

In conjunction with quite a short wheelbase, two-wheel steer can provide a very tight turning circle. The company's 'intelligent four-wheel steer' provides exactly the same turning circle, but with the rear wheels exactly following the front, creates less mess. "We call it intelligent because we only use it when we need it," says Cotter. "So we run in two-wheel steer in straight-line mode, and when the operator comes to the headland he puts his foot on the 4WS switch, engaging the rear axle. The two axles will turn in sync until the rear axle sensor sees the straight-ahead position and cuts out – so, in effect, every operation with 4WS realigns the system. And, of course, everything is selected through pneumatic switches."

SAM SLc crop sprayers specifications

Power source: Deutz Tier 2 BF6L 914 diesel engines delivering between 150-175hp

Transmission: Hydrostatic permanent 4WD with torque-split capacity. Field speeds up to 16km/h available; road speeds up to 44km/h. Poclain's SmartDrive two-speed wheel motors provides precision traction control

Axles: Self-produced sliding portal axles adapt to a variety of tramline widths

Steering and suspension: Intelligent 4WS on demand. Hydro-pneumatic self-levelling suspension with swinging-arm arrangement ensures stability on slopes of up to 1:3

Hydraulics: Gear pump dedicated to rear-end hydraulics. Spray pump speed takes priority oil and is governed to 540rpm. Surplus oil goes to boom control

Cab: Front-mounted, ROPS, with KAB seat as standard

Spray pack: Tank capacities range from 2,500-4,000 litres. Pump delivers 280 l/min. Seven-section sprayline

Inside track

One of the most striking features of crop sprayers in general is the front-mounted cab. This concept was developed in the 1960s when the company's founder realised that the bulk of the weight of the machine (i.e. the tank contents) was best carried over – and between – the wheels. This would eventually result in a 50/50 weight distribution over the axles with booms open and a half-full tank, although Sands is now promoting the benefits of a 5% bias at the back (more of which later).

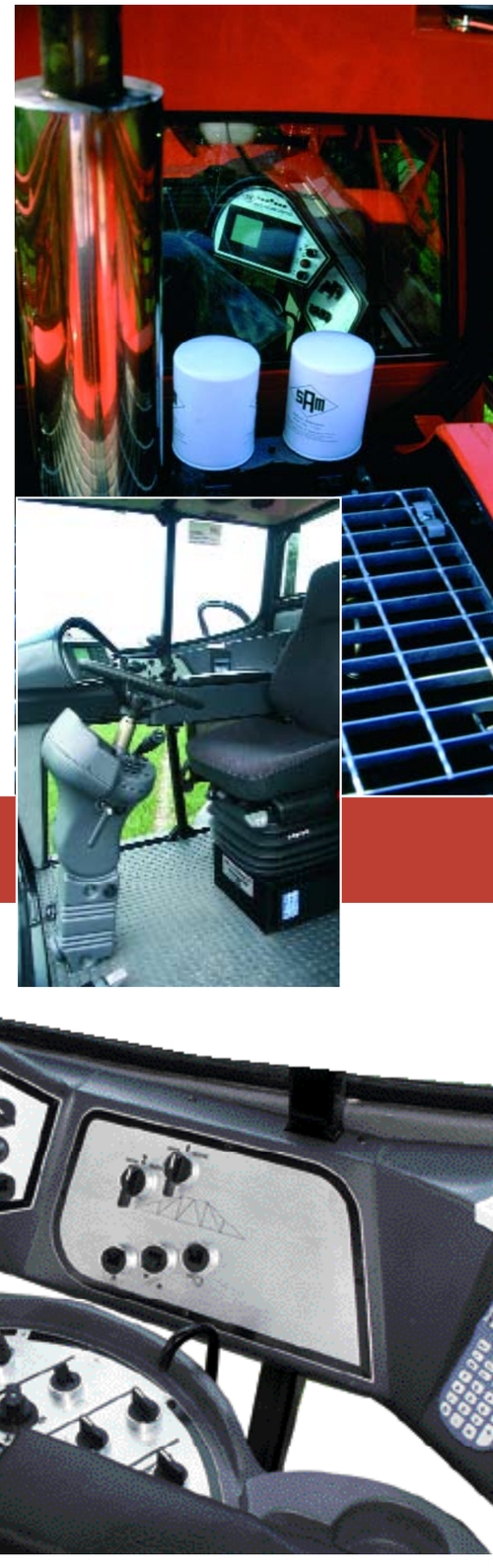
This configuration, with the driver sitting in front of all four wheels, also makes following narrow tramlines a much simpler task. The current third-generation cab, with its distinctive lozenge-shape, has been widened further to accept a buddy seat. Although not officially required of crop sprayers, the cab has been certified as ROPS by Taylor Woodrow – with customers occasionally trailing attachments behind, tractor-style, it was another example of Sands' emphasis on quality. Made by RS Taylor of Hertford, a small company specialising in prototype cabs, they incorporate Sands' own air-con design in a plenum box so that vents can be placed exactly where required. The roof lining is made in-house and covers the slanted interior roof panel that allows access to the full cab height through the door.

A large one-piece front windscreen provides outstanding visibility, while the double-glazed rear windscreen rejects noise and heat. Seated in the KAB seat that provides air suspension, mechanical damping and fore and aft antishock as standard, the operator can benefit from a very bright internal light when filling in paperwork, or subdued interior lighting for night work.

The Hillsider model can safely traverse a 1:3 slope and – thinking of a Mulag mowing machine with a cab that tilts up to 45° for work on similar gradients – I ask what provision is made for the driver in this case. "A seatbelt!" grins Cotter. "If the operator feels uncomfortable on a steep slope, he'll be more careful. The first Hillsider we sold went to a farm where my boss's Range Rover couldn't even manage the slope that the machine was destined for!"

Joking aside, an inclinometer in the cab displays the current gradient, with a buzzer sounding at 1:3, although the machine can run to almost 1:2.5 before it becomes dangerously unstable. A crank fitted into the chassis is what puts the 'c' into 'SLc', and greatly improves stability by allowing the spray pack to be mounted 150mm lower than previous models. And what makes the Hillsider noteworthy is the hydraulic rams that keep the spray tank level – vitally important when it is holding as much as 3,600 litres. "On a conventional machine, all the weight is on the downhill side and, because the wheelbase is essentially triangular due to the pivoting front axle, there's not much room before the centre of gravity moves outside it and tips the machine over," explains Cotter. "Therefore, by tipping the tank, we can keep its centre of gravity within that area. We also moved it back a bit, by increasing the wheel base to create a very stable machine."

This is aided and abetted by a self-levelling suspension system, which uses a swinging-arm arrangement to trigger a hydraulic valve that operates the two



rams on each axle. “The problem with independent suspension is that on a side slope, the most heavily loaded springs will compress the furthest, so on a 1:3 hill, the cab could be 1:2,” adds Cotter. “With our set-up, the chassis follows the lead of the rear axle. It’s a very simple system that’s fed off the steering circuit.”

The secret is out

When spraying booms can reach up to 36m long, a good suspension is just as important for them too – if they were ‘fixed’ the ends would hit the ground every time the machine rocked. “You could now drive a figure of eight with the boom as low as it could go and the tip would never touch the ground – a boom has no inherent motive power and weighs a lot so it doesn’t want to move. We therefore make it totally divorced from the machine, it’s essentially free-floating. The ‘secret’ is to put a pivot very close to the centre of gravity in the boom and allow gravity to hold it square.”

Said to be unique to Sands, the seven-section gullwing boom – as opposed to the four sections typically employed by other manufacturers – increases accuracy when spraying in irregular-shaped fields. The driver can avoid overlapping by shutting off individual 3m sections from inside the cab, whereas competing models may require the closure of a whole 6m section.

Bizarrely though, as spraying operations have become more complex over the years, the number of switches controlling them have been reduced by an estimated 60% on the SLc, largely through integrating systems into other sequences. A bank of solenoid valves was previously used to transmit water to the spray lines, but these have now been replaced with air valves made to Sands’ own design, which provides a quicker response as well as increased reliability.

My attention was drawn to the circuit board in the cab, which exists purely to change the electronic signal from the ITT Cannon joystick buttons to an air signal for operational purposes. It’s a simple rule – keep all electronics inside the cab, and make everything outside it pneumatic. “You only need to unscrew two airplugs to remove the spray pack off the back. We’d never go back to electronics. Air is so reliable because it’s not affected by anything. One or two other manufacturers use part-air systems but we’re the only total-air system.

“In fact, we like compressed air so much that we used it for an automatic volume control,” continues Cotter. Only provided on special request due to it being more expensive than electronic control systems, the AirPam system is claimed to be faster and more accurate, and works by balancing up travel speed against the air pressure acting on the butterfly valve that governs the amount of liquid passing to the spray lines. A pump on the spray pack delivers a constant flow of liquid, regulated by a bleed pipe that bleeds water back into the tank to adjust the pressure at the nozzle tip.

Working on the theory that coarse droplets do not drift, are lighter and fall more slowly – exploding into smaller droplets on hitting the leaf – the optional air-jet system pumps air into the nozzle, mixing it with the water inside. “It’s not unique to us, but our customers get a better system than anyone else’s – it’s where we put the valves, size of pipework, how we transmit air, and the speed of response.” In a similar vein, Cotter describes the airstream system as “like a windsock along the boom, with holes in the bottom to blow air over the droplets.”

Clean machine

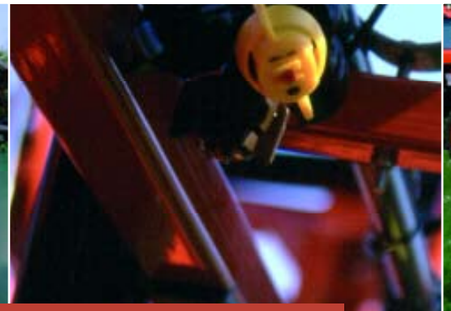
To prevent operators emptying countless litres of liquid into the hedge to expel all the air in the system at the start of a shift, the company developed the Prime & Purge system. Small air cylinders in the nozzles help maintain a residual pumping pressure of 0.5-0.75 bar, so water continually flows through the spray line, resulting in instant spray. The old problem of end caps being clogged up by powders in suspension after flow is switched off can also be avoided.

To ease compliance with the groundwater regulations, external decontamination can be achieved in the field using the built-in pressure washer which draws just 8 l/min from the clean- water tank. The fully baffled spray tank can be cleaned out by dumping into it the 300 litres of clean water that the vehicle holds, circulating this via the 12 washing nozzles of the ‘golfball’ cleaner which throw water into every nook and cranny, and then disposing of it through the spray lines onto the field. By circulating the washing water round the spray lines, Prime & Purge is able to make the machine 99% clean before its return to the farmyard.

Pneumatic operation has extra benefits, such as keeping the hydraulic and water pipework short, which, in the latter case, further reduces contamination. By fitting the hydraulic valves high up on the spray pack, and therefore out of the spray drift, they avoid rot.

The company therefore uses GRP for its external panels and tanks – it may be expensive but by avoiding chemical attack, it lasts longer. Spray lines are available in stainless steel as well as plastic, to effectively combat corrosion. Finding the correct paint was an ongoing challenge for years, but a special two-pack system developed for Volvo Trucks by Akzo Nobel has finally provided resistance to fertilisers and the constant brushing through crops. And just to make sure, all gaps between welded assemblies are sealed with mastic prior to painting, effectively preventing the penetration of rot.

“It all adds up to a unique marketing angle,” concludes Cotter. “The biggest problem with crop sprayers in general is that most of them rot before they wear out. All of our machines wear out.” It may not be something you’d hear most OEMs bragging about, but in this case, it does seem strangely appropriate. ***iVT***



What’s so good about Poclain Hydraulics’ SmartDrive system?

The SmartDrive off-road system uses state-of-the-art electronics and regulation valves to provide precision traction control and ground protection for vehicles operating in difficult terrain. Active only when slippage conditions are detected, this system offers significant advantages over traditional flow divider systems that unnecessarily eat up horsepower and generate heat.

Constantly monitoring the rpm of each wheel motor, SmartDrive can be used on vehicles with wheels of various diameters or motors of different displacements. Software algorithms can be easily adjusted to match the exact machine performance requirements in terms of precision, response time, or steering input.

The system can be installed upon initial vehicle assembly or as an aftermarket option, provided the motors can accept the speed sensor option. Typical applications among agricultural and construction vehicles include crop sprayers, harvesters, compactors, and wheeled loaders.