Making the leap from **remanufacturing** to **new manufacturing**

Next-generation straddle carrier has intelligent controls, electrohydraulic braking.

There are plenty of roles to be filled in the world of industrial equipment, including end users who need specific types of machinery to run effective operations. There are also distributors and dealers who supply and service a variety of products. And, of course, there are manufacturers who engineer and develop equipment in the first place. Most companies are perfectly content to put their full energies into successfully serving only one of these purposes, but other businesses may find themselves branching out from one area to another.

In the case of **Great Lakes Power** (GLP), an Ohio-based company founded in 1973, it began primarily as a franchised distributor for **Twin Disc** Inc., a manufacturer of transmissions, clutches, and powertrain components. Through organic growth and strategic acquisitions, it has evolved into an organization that focuses not just on service and distribution but on engineering and manufacturing as well.

"We are problem solvers," said Harry Allen III, Vice President of Sales for Great Lakes Power and one of five family members actively involved in the second-generation family business. "We pride ourselves on developing and sustaining long-lasting relationships with

Above: Great Lakes Power introduced significant technological integrations into the ST35 but entrusted the design of the machine's electrohydraulic brake system to MICO Inc.

Left: The MICO electrohydraulic brake system provided Great Lakes Power with the flexibility to make simple parameter changes based on a customer's request, with no need to modify components.

our customers and suppliers, and they trust us to deliver solutions."

A rather notable demonstration of GLP's customer commitment took shape in 1989, about five years after the company began distributing **Hyster** material handling equipment, when Hyster announced it would discontinue its straddle carrier product line. While the move by Hyster closed off a supply chain, it also served to open the door for GLP's remanufacturing business.

"Ever since Hyster's Legacy straddle carriers have been out of production, we have been rebuilding and upgrading these units for our customers," said Allen. "These machines were originally manufactured anywhere from the 1960s to about 1990, so there are some challenges in providing obsolete spare parts and servicing vehicles of that age and condition."

Some of the potential applications for straddle carriers include material handling in steel mills, refineries, and lumber mills, as well as transporting goods and components for shipbuilding, steel erection on construction projects, wind turbine assembly, and military activities. With such a wide range of possible uses for the machines, there was a diverse population of customers looking to keep their older units up and running.

In recent years, as it became apparent that the Hyster straddle carriers were reaching or exceeding the point where rebuilds were still economically viable, GLP began to explore the possibility of engineering and producing its own new replacement option.

"Bringing our own product to market is important to our company's future for two key reasons," said Allen. "First, we are not geographically limited to a regional, domestic customer base as is the norm for a distribution business. This is particularly crucial because we think a significant percentage of sales for the new straddle carrier will come from outside North America. Second, as a distributor we can only be as successful as our partners allow us to be, but as the manufacturer we can control how we market and sell the product."

Development of a new straddle carrier was naturally assisted by 20 years of experience remanufacturing the Hyster product, during which time GLP had incorporated various engineered upgrades of its own to address weak points or chronic problem areas.

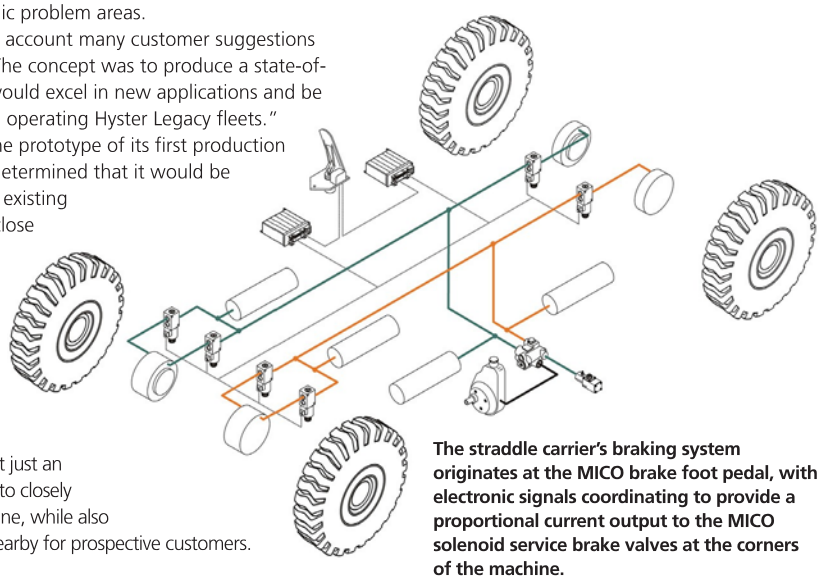
"We were able to take into account many customer suggestions and wish lists," said Allen. "The concept was to produce a state-of-the-art straddle carrier that would excel in new applications and be compatible for customers still operating Hyster Legacy fleets."

As GLP prepared to build the prototype of its first production straddle carrier, the ST35, it determined that it would be advantageous to seek out an existing customer partner located in close proximity to the company's manufacturing facility. They found such a collaborator in **Timken**, not just a global manufacturer of bearings and alloy steels but a longtime user of Hyster straddle carriers.

With Timken running the unit just an hour away, GLP would be able to closely monitor and support the machine, while also having a demonstration area nearby for prospective customers.

As is the usual case with straddle carriers, the ST35 was engineered to provide certain advantages over alternative types of material handling equipment—such as forklift trucks—in regard to factors such as travel speed, adaptability to road conditions, and the ability to efficiently move long and heavy loads in intra-plant transport.

Where the new design took on what the company describes as "a revolutionary look" was in its ambition to "drastically improve upon several



The straddle carrier's braking system originates at the MICO brake foot pedal, with electronic signals coordinating to provide a proportional current output to the MICO solenoid service brake valves at the corners of the machine.

aspects of the Hyster Legacy," from improved safety and operator ergonomics to higher performance and lower operating costs.

"One of the factors that sets a straddle carrier apart to begin with is the ability to pick up and deliver a load with only one operator," said Allen. "We focused on furthering this advantage by enhancing the operator experience."

This effort can be seen quickly in the ST35's center-mounted panoramic view operator cabin, which offers improved visibility of the load and surrounding area. Roof-mounted windows also make it possible to see overhead cranes and suspended loads in the operating area. The operator's seat itself is also more practical, enabling 180° rotation so the operator can always face the direction of travel—although this functional requirement dictated that GLP would have to think outside traditional means when it came to the machine's braking system.

"A conventional hydraulic brake system would have required two sets of fixed pedals due to the operating fluid connections," said Allen. "So using a brake-by-wire, or electrohydraulic, system was definitely on our radar screen because that would allow the brake pedal to be mounted so it would rotate with the operator."

There was no question that GLP was undertaking a huge project introducing significant technological integrations, but braking was one endeavor they felt was best left to a dedicated expert.

"We did not want to be 'pioneers' with a safety-critical system like the brakes," said Allen. "So we connected with **MICO**. I've known them to be a high-quality supplier of brake systems for off-highway equipment, and by partnering with them we were confident we would provide a reliable and efficient braking system for the ST35."

Not only did the MICO electrohydraulic brake system allow GLP to design the operator's cab as desired, but it also was inherently consistent with the wide array of sophisticated electronic control functions built into the machine.

"This electrohydraulic system provides a lot of flexibility," said Allen. "It simplifies the hydraulic plumbing that would otherwise be required. It eliminates the need to protect the operator from pressurized hydraulic lines in the cab, and we can more easily remove the cab for vehicle transport.

"Overall, it's compatible with our goals of being able to monitor complete machine performance at one location, that being our master controller. There is no need to modify components. All it takes is simple parameter changes in the master controller to tailor a machine's braking requirements to a specific customer's request."

The ST35 can handle loads of up to 35 t (38 ton). Because the straddle carrier has a lifting capacity in excess of its own empty weight, the brake system must have the ability to modulate the applied braking pressures, especially when the machine is unloaded.

Traditionally, straddle carriers used air over hydraulic systems, but operators often complained about overly aggressive braking performance when the unit was empty. Additionally, sometimes straddle carrier loads can shift under aggressive braking conditions. According to Allen, the electrohydraulic system on the ST35 provides faster and smoother brake response for better control of the situation.

As rebuilds of Hyster straddle carriers were becoming less economically viable, Great Lakes Power decided to produce its own new replacement option, the ST35.

Electrohydraulic braking also makes it easier to adjust the machine for specific uses.

"All straddle carriers are custom built with regard to the inside frame height and width dimensions to accommodate a particular bolster or pallet size," said Allen. "These dimensions can vary greatly from one

customer to another. This electrohydraulic system can be easily adapted to the range of frame sizes we expect to build."

As for how the electrohydraulic braking system actually works, it originates at the MICO brake foot pedal, where two crossing outputs from the pedal are monitored by the straddle carrier's master controller, which in turn sends a message via an **SAE** J1939 CAN bus network to the I/O modules mounted in the side frames. These modules provide a proportional current output directly to the MICO solenoid service brake valves, each of which is located at a corner of the machine as close as possible to the service brake it controls.

The ST35's 365-hp (272-kW) **Cummins** engine includes an auxiliary PTO location with a dual section gear pump. One section of the pump supplies the accumulator charging valve to provide 2500 psi (172 bar) of pressure to both sides of the braking system.

Once charged, the excess flow from this circuit combines with pump flow from the second gear pump section and then is equally distributed to provide cooling for all four brakes. Brake valve and brake coolant returns are combined and filtered to 10 microns before passing through an oil to brake cooler and returning to the tank.

"The brake system has a separate reservoir for two reasons," said Allen. "It prevents any brake friction media from contaminating the hydraulic system, and it enables us to use a specific specialty brake fluid with friction modifiers to optimize wet disc brake operation."

Another key design consideration in the ST35 braking system was redundancy.

"In wired systems there is no mechanical connection between the brake pedal and the service brakes," said Allen. "We need a level of redundancy to ensure that control is maintained and the system is safe against any one failure. The braking system must continue to function in the event of something like a loss of power to the master controller."

To ensure braking function is never lost, GLP added a redundant brake controller (RBC) to the ST35. The RBC is very similar to the I/O modules that supply current to the hydraulic brake valves. It provides reference voltage and monitors a third voltage output from the brake pedal. The RBC is always active but is placed in "standby" mode when a digital input is received from the master controller.

In addition to advanced braking technology, the straddle carrier also features a steer-by-wire system with four different steering modes—four wheel coordinated, two wheel front, two wheel rear, and crab steering. The electronically controlled steering restricts the steering angles of the rear wheels at high travel speeds to improve stability.

The machine's electronic controls system also monitors operating conditions and alerts the operator if any maintenance is required. A telematics package transmits information such as load weights, GPS-based location, and alert messages to a dispatch office. Future enhancements will allow remote monitoring and parameter changes to the straddle carrier, eliminating the need to send a service technician to the job site.

Timken took delivery of the first ST35 in April. "This machine is state of the art compared to the vehicles we already have," said Howard Millar, Timken's Material Movement Training Coordinator. "The brake system provides controlled braking in a straight line, and the variation in brake modulation is excellent."

GLP intends to develop two additional straddle carrier models in the near future, the 20-t (22-ton) capacity ST20 and the ST50, which will offer a 50-t (55-ton) capacity. "We feel that our design is scalable to meet the requirements for efficiently handling these load capacities," said Allen. ***SOHE***

This article was written for *SAE Off-Highway Engineering* by Mike Crummy, The Promersberger Co.

Materials

Solegear develops 100% natural, biodegradable polymer

Researchers at a start-up green-chemistry firm in British Columbia have come up with an all-natural, biodegradable engineering polymer—a family of filled polylactic acid (PLA) thermoplastics—that offers greater strength, flexibility, and resistance to impact stresses than previously available PLA materials.

"We've developed the ability to combine novel, bio-based additives with PLA in such a way that maintains biodegradability of the final material," said Toby Reid, Founder and President of **Solegear Bioplastics** Inc. in Vancouver. "Traditionally, polymer compounders have added synthetic or mineral inputs to PLA," which often undermines the purpose of using the starch or sugar-based plastic. "Our innovations in formulation and processing will allow [OEMs] to do things with PLA that were previously believed to be impossible."

Solegear's extra-durability Polysole XD grade, which is suitable for film, sheet, blow-molding, and injection-molding applications, "offers performance that is comparable to nylon-6 in terms of tensile, flex, hardness, and impact properties at a cost premium of only 6 to 8%," Reid said. As a creator of intellectual property and a specialty compounder, the Canadian company plans to market its proprietary bioresins directly to manufacturers in the form of meltable pellets.

The business research and consulting firm **Frost & Sullivan** recently recognized Solegear with its 2010 North American Award for New Product Innovation of the Year.

For transportation applications, the new biodegradable plastic is aimed at "interior semi-structural or decorative applications such as inside door-trim components," said Ed Trueman, Solegear's CEO. "We've looked, for example, at a wood-grain overmolding for a steering-wheel application with several Tier 1 suppliers." Polysole XD is also applicable to electronic parts and fasteners. Trueman reported that "mechanical engineering groups at North American OEMs are now writing new specs" for the biodegradable bioplastic in preparation for efforts to get its material properties approved and prove part performance for eventual use in vehicles and equipment.

As with most other plastics, the Polysole XD is unsuited for high-temperature, under-the-hood applications or exterior uses that involve direct exposure to sun and atmosphere, Reid noted. "We're not making mud flaps with it," he quipped. "Like any polymer, our material suffers from UV exposure, but it's not going to fall apart."

Reid explained that PLA breaks down only through a catalytic process that requires four conditions: the presence of soil, heat, moisture, and certain microorganisms. "Without one of the four conditions, the material retains its integrity," he said. Once exposed to all four simultaneously, however, Polysole XD decomposes in 6 to 14 months.

Polysole XD, an all-natural, biodegradable plastic that could find use in interior parts, comes as meltable pellets.

The new material formulation stems from the work of a team of five scientists who came together four and a half years ago in an R&D program to develop a truly biodegradable engineering plastic that suffers no performance penalty. The effort received support from both the **University of British Columbia** and the **National Research Council of Canada**. Reid has since assembled a management team to commercialize the enterprise, which to date has arranged about $4 million of business for 2011.

"PLA is essentially hydrophilic, while the inputs are somewhat hydrophilic, and water, which is a contaminant in polymers, is a challenge to remove,"