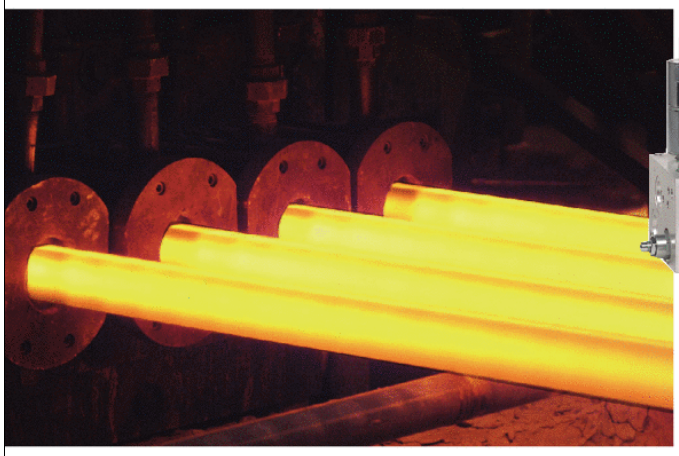
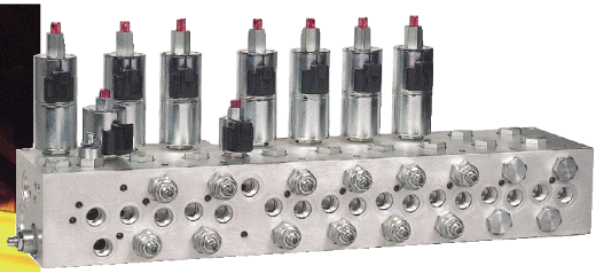
MOBILE HYDRAULIC SUPPLEMENT





The ever-increasing pressures found in more of today's mobile equipment have impacted many areas of mobile hydraulic component technology. HydraForce, a global manufacturer of cartridge valve systems, has found increasing application for continuous cast iron from Dura-Bar, which brings a new level of strength and durability to HydraForce's valve manifold systems.

A MATERIAL EDGE

HydraForce finds increasing application of Dura-Bar ready solution to steady increase of hydraulic system pressures

BY MIKE BREZONICK

It's an inescapable fact that change in one area inevitably begets more changes elsewhere. And while the ripple effects may take some time to manifest themselves, they often can have the most improbable impacts.

A good example is the trend toward increased working pressures in the hydraulic systems used in many types of mobile equipment. Over the last few years, driven by several factors — primarily a push toward more power-dense components and greater efficiency — system pressures have risen significantly. Nowadays, 4000, 5000 and even 6000 psi systems are becoming more commonplace in a wide range of equipment, everything from skid-steer loaders to heavy construction and mining machines.

The most immediate effects have been seen in components such as pumps, motors, seals and valves. Yet while not as obvious as those higher-profile products, hydraulic valve manifolds have begun to feel the pressure as well.

That's important because cartridge valves and manifolds have been a key factor in the increasing versatility and functionality of mobile hydraulic machines. Up until now, manifold blocks have often been little more than complex machined aluminum bricks into which the cartridge valves were threaded.

But as pressures have risen steadily, aluminum blocks have felt the strain — literally — and that's what has led companies such as HydraForce toward a greater use of continuous cast ductile iron bars from Dura-Bar for its manifolds.

"We have been using the Dura-Bar material for a number of years," said Paul Spratt, international sales and marketing manager for HydraForce, a global supplier of cartridge valve systems headquartered in Lincolnshire, Ill. "It has mainly been a supplement to our manifold business, which has been mostly aluminum, with some Dura-Bar and some steel.

"You can increase power by increasing flow or increasing pressures. With higher flow, you carry volumetric inefficiencies. The best way to transmit more power is more pressure.

"But basically, aluminum runs out of gas around 3000 psi. That can be stretched a little higher, depending on duty cycles and the expected life of the application, but by the time you get to 3500 psi, you have extended the durability of the material so you have to use something different."

The effects of higher pressure manifest themselves most commonly in cracks at port sections or threads or even in the walls between cartridge openings. "We design our manifolds with certain specs for wall thicknesses, in particular, to eliminate that problem," Spratt noted. "But as pressures go up, the walls get thicker and

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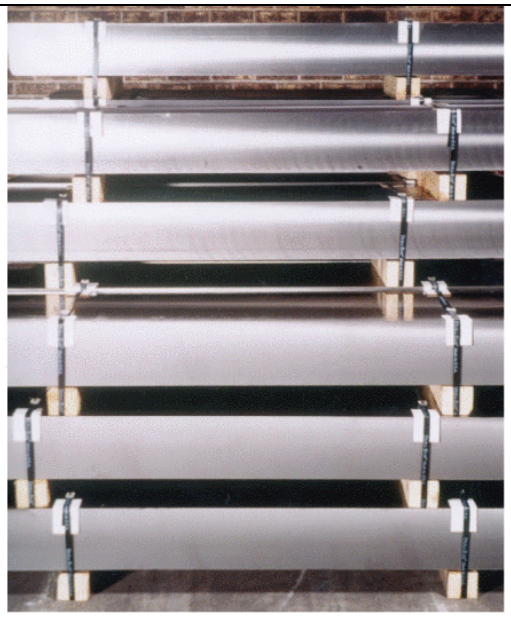

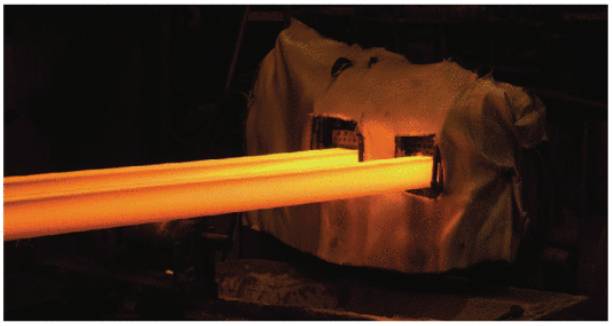

In the continuous casting process used by Dura-Bar, molten metal is gravity fed through water-cooled graphite dies in what resembles an extrusion process. While the outside rim of the bar is cool enough to be rigid, the inside remains molten and the gradual cooling reduces residual stresses and makes the material stable over a range of thermal cycling. When cool, the stock is typically cut into 6 and 12 ft. lengths.

thicker and the block gets bigger and bigger and at some point, it's just not practical to do that.

"You've also got the threads, and with aluminum the threads can only hold so much. You can go to larger valves, but that defeats the purpose. The best solution is to go to a different material that allows you to maintain the correct package size and prevents those cracks.

"In our current situation, we are applying our product more into main functions, not just auxiliary functions, and that gets us into higher-pressure applications. We're also supplying a lot more large vehicles, construction machines, wheel loaders and things like that.

"Because of material costs and fuel costs, power density has become more important, which has pushed the benefit to going to high pressure. We see that continuing and becoming more and more dominant. As we look

into the near future, the higher pressure capabilities become more and more prominent.

"We're starting to use the Dura-Bar product much more that we did previously and we see that continuing."

Dura-Bar, a division of Wells Manufacturing based in Woodstock, Ill., has operated a continuous casting foundry since 1961. The process was originally developed in Europe following WWII as an alternative method of producing cast-iron bar stock without patterns or other conventional mold technology. The company said it is the largest producer of continuous cast-iron bar stock in the world and the only one in North America.

"Conventional ductile iron castings are usually cast to near net shape, which benefits the customer by reducing the amount of machining," said Bob O'Rourke, product engineering manager at Dura-Bar. "We produce ductile iron in bar form and compete mainly against steel bar, where the amount of machining remains the same but the machining time is dramatically reduced. Because of the process we use, you don't have the gas holes, inclusions and the defects that are normally associated with an iron casting.

"You mention the term 'cast iron' and people think dirty, weak, brittle, a low-tech material, full of gas holes and fraught with problems. But a lot of the negative perception that people have with iron in general are more process related more than they are material related."

Process and metallurgy have played a big part in the advancement of continuous cast iron at Dura-Bar. In the continuous casting process, induction-heated furnace vessels hold 4000 lb. of molten metal. At the front of the lower end of the vessel is a water-cooled graphite die through which the molten metal is forced by gravity. "It looks like an extrusion process," said O'Rourke. "But there are a couple of advantages to the process.

"One, with the molten metal, all the slag, impurities, dross and things you don't want in the iron all float to the top of the vat. There is a 4 ft. head where all the undesirables are and the cleanest iron is at the bottom, so what comes out through the die is very clean iron.

"Ferrostatic head pressure forces the iron into the dies, so you eliminate things like shrinkage, porosity and other process-related things that could degrade the quality of the part.

"What's most unique is that when the bar comes out of the die, most of the bar is molten metal. There is just a thin solid rim around the outside. As it comes out, the heat from the molten core reheats the outer skin to a temperature well above the critical point of iron. So the whole bar is solidifying

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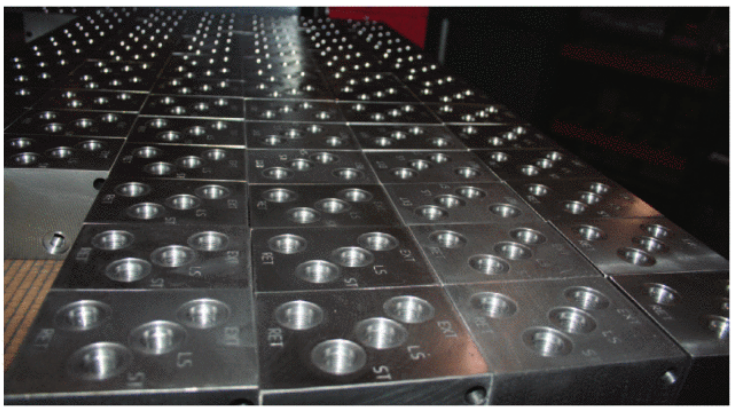

One of the key attributes of Dura-Bar's continuous cast iron is machineability. When machined, it produces short chips, which eliminate most deburring operations.

and cooling as it goes down the line.

"That results in a very uniform structure around the perimeter of the bar — what we call a normalized structure — which is very low in residual stresses, very stable over a range of thermal cycling."

Besides its process, Dura-Bar focuses significantly on the chemical makeup of its castings and can engineer a combination of various graphite and matrix structures. "Our company has always been heavily metallurgically oriented," O'Rourke said. "We look at things like the substrate structures and the amount of graphite in the material. Controlling the graphite — making the graphite nodules very small, very uniform, very round — has a direct correlation on material strength, machineability, reliability. That's the metallurgical part that not a lot of people understand. What are you going to do metallurgically to make it more machineable and make it last in the application? That's why we feel it's important to draw a distinction between generic, off-the-shelf ductile iron and Dura-Bar continuous cast ductile iron."

The result of all that attention is a combination of higher strength than aluminum — equal to many typical grades of steel, O'Rourke said — with a much greater degree of machineability.

"If you look at our product's price per pound compared to steel per pound, there's really not an advantage, O'Rourke noted. "The cost advantage is machineability.

"We promote our products as being 30 to 40% more machineable than steel, and if you compare it to more conventionally cast material and even other continuous cast products, it's going to be more consistent and reliable."

The machineability aspect also becomes important because of the increasing size and complexity of the valve manifolds HydraForce is producing, Spratt noted. "In the past, we would put four or five cartridges in a manifold and that was kind of average," he said. "Today, 10 to 12 is more the average and it's not unusual to go up to 30.

"The manifolds have gotten much bigger. They're used for many, many different purposes now, a lot of them being much heavier in terms of duty cycle and higher pressure."

A key aspect of the machineability of continuous cast ductile iron becomes even more obvious when used in products such as manifolds, noted Frank Abruzzo, Dura-Bar's vice president of sales. "One of the biggest impacts when comparing Dura-Bar to aluminum or steel is in drilling," Abruzzo said. "With Dura-Bar, you end up with a very short chip and with steel or aluminum, you get a longer, stringy chip.

"Where that pays dividends is in the deburring. There is very, very little deburring with Dura-Bar because of that short chip. With steel and aluminum, you have to go in and hand-deburr all of those holes, which is a costly process. But you can't afford to have one of those burrs in a hydraulic system — especially at the higher pressures."

Needless to say, ductile iron, while heavier, has higher yield and fatigue strength than aluminum, which O'Rourke noted "means you can create a manifold that's much stronger, but smaller and with thinner walls."

Dura-Bar offers a wide range of material sizes, with round bars from 0.625 to 20 in. in diameter. Cold finished bars are available up to 6 in. in diameter. Squares are available to 12.25 in. and rectangles as large as 18 in. thick and 24 in. wide are available. Bars are typically produced in 6 and 12 ft. lengths.

"It's like steel in bar form, but again, it's much more machineable," O'Rourke said. "Property-wise it's very similar to steel — there are hardly any tradeoffs at all in material strength between in steel and in ductile iron — and it has much higher fatigue properties than aluminum. That's the main limitation of aluminum, when you have manifold that's undergoing a lot of pressure over a long period of time, eventually it's going to fail because of fatigue. Ductile iron is going to have double the fatigue strength over an infinite number of cycles."

"Most of our product is still aluminum," Spratt concluded. "But as pressures keep increasing as we go into the future, will probably increase in favor of Dura-Bar." dp

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