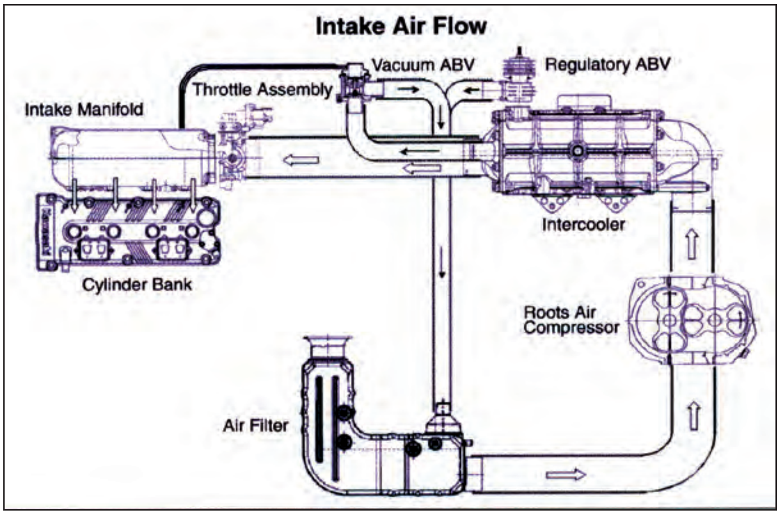



A cutaway of the supercharger used on the Kawasaki 250X personal watercraft, along with a schematic of the engine system. Two air bypass valves balance air flow upstream, downstream or wastegate air under various conditions of load and speed.

# SUPERCHARGERS COMING BACK INTO FOCUS?

With engine efficiency demands growing and new design concepts, superchargers are getting another look

*BY ROB WILSON*

When the subject is superchargers, the knee-jerk response by motorheads far and wide is "parasitic losses." That simple phrase often puts consideration of superchargers to rest in the current era where emissions, efficiency and fuel economy are the drivers for engine manufacturers. But new technology and more efficient designs seem to be prompting another look.

The Roots blower design on which many superchargers are based, actually predates the internal combustion engine, and these devices were being used to optimize blast furnace output in the 1870s. Uses have abounded over time.

Two-cycle diesels, of course, use them to scavenge exhaust gas. For aggressive air handling in tight spaces, the reputation of Roots blowers was never in dispute.

The same can be said for high performance and for power density. In many ways, superchargers were just that — super.

So perhaps it comes as no surprise that for the 2007 model year, Kawasaki is launching a high-performance personal water craft (PWC) called the Ultra 250X that derives some of its "hair on fire" capability through a supercharger. The Roots-blown, 1.5 L, inline four-cylinder, intercooled gasoline engine produces 250 hp remarkable for an engine that size. That's 166 hp per L, which is nothing short of astonishing.

Kawasaki claimed the 250X is the most powerful PWC in the world. The supercharger produces large boost even at low rpm, the company said, and acceleration from idle is not hampered by turbo lag.

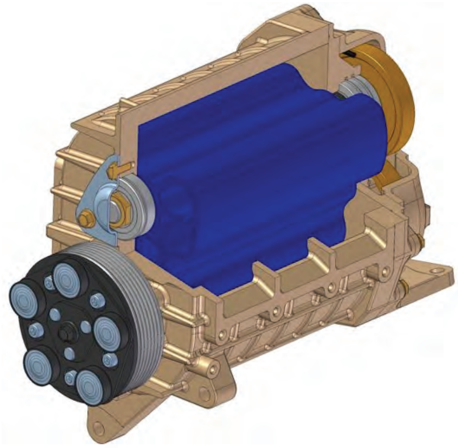
The blower for the 250X force-feeds 2 L of air for every revolution, yielding high-pressure intake air at all engine speeds and a flat, beefy torque curve over the operating range. Air pressure is managed, balanced upstream or downstream or dumped under various conditions of engine speed and load by two air bypass valves.

The Roots blower used in this application is produced by Ogura Clutch Co. in Japan, with U.S. headquarters of Ogura Industrial Corp. in Somerset, N.J.

"The Kawasaki application is certainly high profile and Ogura is excited to be a part of it," said Frank Flemming, president of Ogura Industrial. "With the 250X, the use of supercharging is strictly performance driven and the results speak for themselves.

"High performance has also characterized most applications for supercharging but there is an evolution happening where other factors are now coming into play. And the supercharger we are bringing to the market today has far more flexibility and capability."

Jim Ebisawa, engineering manager at Ogura Industrial, pointed out that the Ogura TX series has adopted Wankel rotary geometry design, which increases the working or



**Ogura has adopted Wankel-type geometry to improve volumetric efficiency. The twin counter-rotating rotors have a cross-section shaped like a figure eight. The rotors are hollow from end to end for low inertia.**

sealed displacement of the pumping area and also improves volumetric efficiency of the blower over the operating range.

Ebisawa said the TX volumetric efficiency advantage over other Roots blower designs can be more than 20% at low speed and 10% on the top end. The design has fewer parts and is lightweight throughout its design.

Twin counter-rotating rotors blowing the air within the supercharger housing are hollow from end to end, resulting in a very lightweight design, reducing their moment of inertia and thus the energy required to make them rotate.

The TX series superchargers are designated by their theoretical discharge per revolution. Thus the smallest, the TX04, has a discharge volume of 0.4 L/rev, while the largest, the TX28, has a discharge volume of 2.8 L/rev. The smallest weighs 11.6 lb. and the largest 31.3 lb.

Maximum continuous speeds for the TX series range from 9000 to 12,000 rpm and the maximum pressure ratio is given at 1.8:1.

It happens that Ogura Industrial is actually better known for its capabilities in clutches, but it has combined this capability with the Wankel supercharger design, and this is what results in a completely new tool for engine aspiration.

"On the Kawasaki 250X jet ski application, the only interest is high performance and so that unit does not incorporate a clutch," said Flemming. "There, the supercharger is driven all the time, but that need not be the case.

"For most of the pilot programs and inquiries we are currently pursuing, a clutch is certainly a big motivator of the interest level. Almost all of our superchargers have electric clutches mounted on the front end and the engine management system turns the power on and off as needed."

This capability is probably the real game changer. When torque is not required, the supercharger is switched off in milliseconds and only a belt and idler pulley remain as parasitic losses, very small ones at that. At any rate, the drive belt is there driving other accessories. When not required, the supercharger is completely out of the circuit.

To give an idea of response time, engagement time is about 50 ms on the smallest superchargers, on the largest about 50 ms. Disengagement is 30 to 50 ms for all models.

When torque is required, the engine management system cues the electromagnetic clutch to pick up the low inertia supercharger, producing a burst of power on demand.

Where Flemming and Ebisawa see the best fits are:

- vehicles requiring high torque at low speed, with stop-and-go driving, hilly and poor road conditions;
- wherever large engine performance or burst power is required from a small engine and where weight limitations might call for a small engine;
- in combination with turbocharging on larger engines to optimize low-speed and high-speed performance;
- as an additional, fast acting, air-handling device to help emission compliance, improve fuel economy or both.

Ogura has been working on development programs for diesel and gasoline engines, mainly with engine displacements smaller than 5 L, but a few upwards of 10 L.

One program involves the KAD42 Volvo Penta marine diesel. Powered by a turbocharged 3.6 L engine, the boat simply couldn't get up on plane due to low torque at low speed. The addition of the Ogura supercharger to the 3.9 L diesel raised the torque at 100 rpm by a factor of three and the boat came up on plane. At 2500 rpm, the turbocharger takes over and the boat remained on plane.

Europe is described as somewhat ahead in active development programs for supercharger application. There is also greater recognition in Europe that supercharging has great potential for coming emissions hurdles. Better combustion on diesel engines at lower speed is of particular interest.

And perhaps it can now be called adaptive supercharging. Why not? The modus operandi is completely changed. Parasitic losses are now filtered out when the supercharger is disengaged. Now the supercharger can bring a lot more air into play on demand without the traditional turbo lag.

Or maybe the requirement is for more cool air to keep combustion temperature in the correct zone where $NO_x$ generation remains under control.

For many compelling reasons, it seems the time for re-examination of supercharger technology is at hand. The potential is much changed. dp