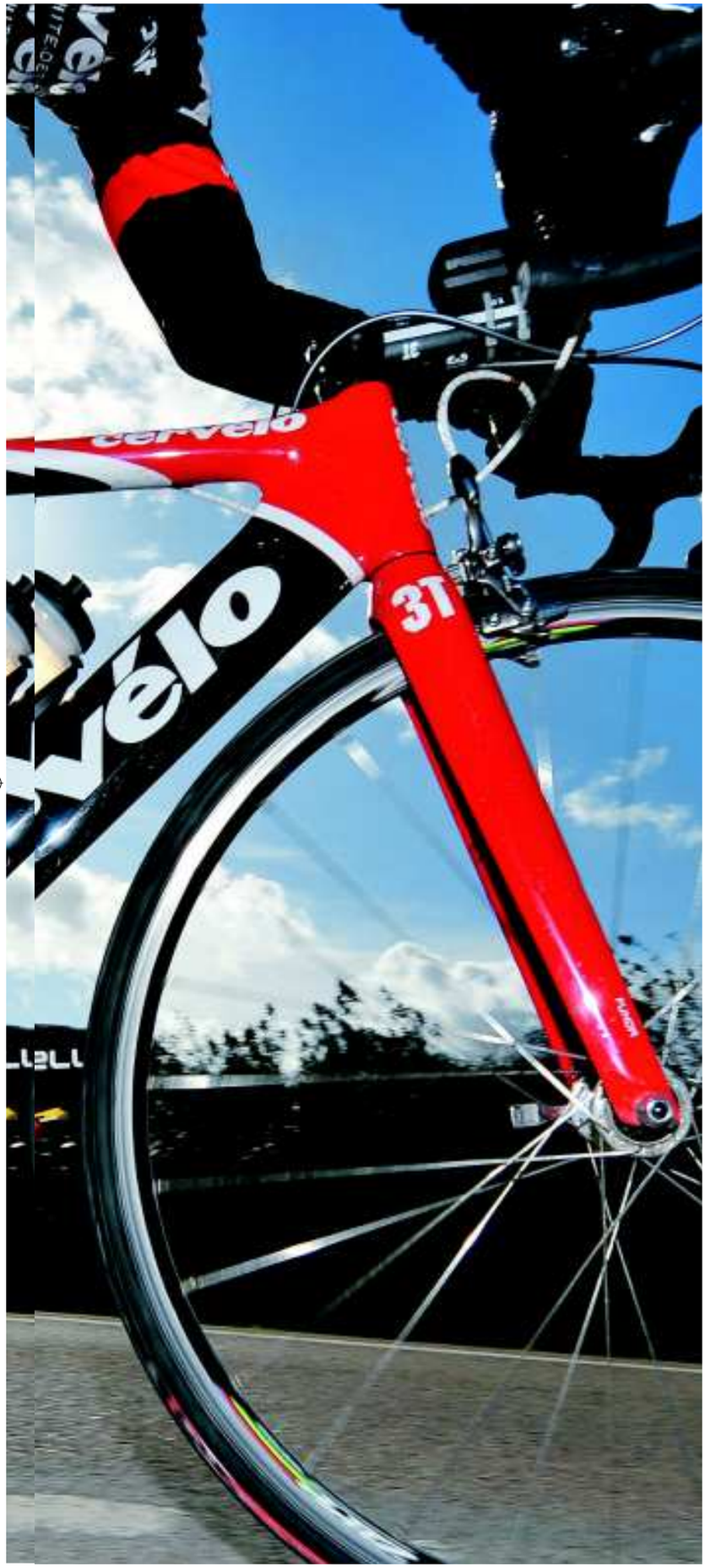
Race Tech

The science that drives the sport



Non-round Chainrings

Defeating the dead spot

Independent tests show that ovalised chainrings increase power output. So why don't more riders use them?

Writer: Jamie Wilkins ||| **Photographer:** Tim De Waele

Professional cyclists are not given to allowing new technology to pass them by. Clipless pedals, carbon fibre frames, time trial bars – if something might make them faster, they want it. Yet despite having been around for years, non-round chainrings haven't seen any major uptake in usage. In 2008, Carlos Sastre won the Tour de France using Rotor Q-Rings. A year later, Bradley Wiggins placed fourth overall at the Tour using radical O.Symetric Harmony chainrings. So why do non-round chainrings continue to divide opinion?

To understand the controversy, we must first see why they are considered necessary at all. The problem that they have been designed to overcome is the 'dead spot' – a point in a pedal's axis or rotation that's been known about almost since the birth of the bicycle itself. The dead spot is the point at which the cranks are vertical and neither leg is generating any significant power. Engineers and scientists have been aware of the dead spot since the 19th century, and there have been many attempts to solve it.

The traditional answer is for the rider to develop a beautiful and efficient spin, but this only masks the dead spot. Your legs do not produce the same strength throughout a pedal rotation and are so much better at pushing down on the pedals that

◀ The Cervélo TestTeam are the first to embrace oval chainrings. Will other squads follow their lead?

all coaches and physiologists agree that attempting to pull up through your cleats is a waste of effort. The best pedal spin comes from simply unweighting the rear, upward-travelling pedal and making small horizontal contributions at the top and bottom of the stroke.

This doesn't increase power output directly. Rather, it improves efficiency, like reducing the friction in a car engine. With a good spin, the leg in the power stroke neither lifts the rear foot as it rests on the pedal nor provides the inertia to carry the pedals through the dead spot. More of the power produced goes into driving the bike forwards.

Modern studies of biomechanics and physiology have enabled design engineers to revisit the concept of non-round chainrings and create ergonomic solutions to better harness a rider's power. The two main products currently available, French-made O.Symetric and Rotor from Spain, use approximately the same idea but look very different.

Rotor identify three key factors in non-round chainring design – orientation, ovalisation and form. Orientation is the position of the largest point of the chainring relative to the centreline of the crank. Ovalisation is the simple ratio of the largest to the smallest diameter of the ring. Form is the combination of shapes used. Rotor state that, of the many previous attempts to make effective oval chainrings, none achieved the correct combination of these factors. Predictably, they also claim that their Q-Rings are the first to do so.

Both the Rotor and the O.Symetric designs are based on the idea of using a larger gear during the downward power phase of the pedal rotation and a smaller gear when the cranks are in the dead spot, positioned vertically. This capitalises on the point of maximum power output and helps to preserve leg inertia through and out of the dead spot.

O.Symetric insist their design, originally developed in the late '80s, is neither oval nor elliptical, but 'twin cam' because their diameter ramps up progressively and drops more sharply. The large peaks arrive when the pedals are horizontal, which is when you have the full length of the crank acting as a lever and you can apply the greatest torque (force x lever length) to the chain. From this point there is a flat section that shrinks the diameter as quickly as possible without actually dropping the chain, followed by the gradual ramp back to the next peak.

The O.Symetric rings have a large ovalisation ratio – a 54T ring is equivalent

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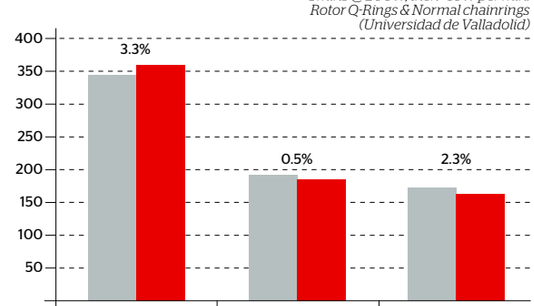
Carlos Sastre's Tour de France win in 2008 was a landmark for oval chainring technology

Threshold power

Ramp test to exhaustion. 5mins @ 200W, then +10W per min. Rotor Q-Rings & Normal chainrings (Universidad de Valladolid)



	Max Wattage	Max HR	Average HR
Std	349	191	170
Oval	361	190	166

Q&A

Procycling talks with 2008 Tour winner Carlos Sastre and sprinter Theo Bos

What benefits do you feel from racing with Rotor Q-Rings?

Carlos Sastre: Well, I can pedal the bike [more]easily, and saving energy during a big tour is a big advantage.

Theo Bos: You must give power at the moment you CAN give power

How difficult was the transition from round rings to Q-Rings, especially after many years of racing at the highest level?

Carlos Sastre: In three weeks I was riding the Q-Rings with no problems. In the beginning I had some small issues, but with calm and patience everything was resolved, and now I am really happy.

Theo Bos: No Problems, only be careful with the big gears.

Do you think you will always continue to use Q-Rings, given a free choice?

Carlos Sastre: Yes, of course. Why not? This is my third season with the Q, and in 2008 I won the Tour de France using the Q. It has always been a free choice.

Theo Bos: Yes, it's going to be the future!

to 58T at its peak and 50T at its low point. This creates more sudden changes to leg speed which demands more concentration and adaptation from the rider. Also, the 90° orientation may be where the greatest torque can be applied but it is not where the greatest power (torque x revs) is produced once riding with an ideal cadence. That's because the faster moving crank is already past horizontal once the leg muscles are pushing with full force.

At a lower cadence, maximum leg force can be applied earlier in the pedal stroke, so it follows that the O.Symetric rings suit those who generally ride with a lower leg speed. Practically, this means taller, heavier and/or more powerful riders.

Rotor, with the advantage of many years of further scientific development, placed the greatest diameter of their Q-Rings 20° beyond the crank's horizontal position to seize what they understood to be the maximum power from the rider at a brisk cadence. Their Optimum Chainring Position adjustment caters for higher and lower cadences and a range of riding positions. The smaller ovalisation factor means that a 53T Q-Ring varies between the equivalents to a 51T near the dead spot and a 56T at the maximum power point, aiding a smooth and quick cadence.

THE DATA APPEARS CONCLUSIVE ENOUGH THAT YOU EXPECT TEAM MANAGERS TO BE CAMPED OUTSIDE THE FACTORIES

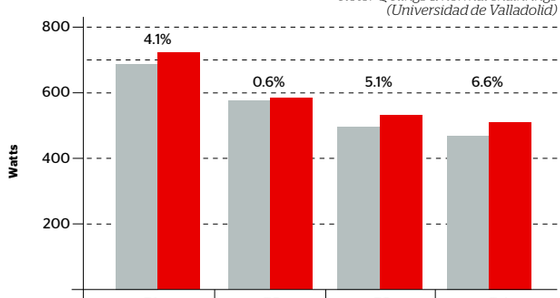
But do they work? The simple answer is yes they do. Both products have been subject to numerous independent scientific studies into their effectiveness. When the O.Symetric Harmonic rings were tested in 1993 by the Institut des Techniques d'Optimalisation des Pratiques, France, the 16km road test showed an increase of 33W and 1.5kph, a saving of 45 seconds. On average, power increased by 7W on the static bike tests.

Rotor Q-Rings were tested most recently by the Universidad de Valladolid, Spain. Their 2006 study used elite U23 amateurs for a series of precisely controlled blind tests against round chainrings over the course of three weeks. Comparisons were made for sprinting power, sustained power output at aerobic threshold and subsequent lactate concentration in the blood.

The Q-Rings proved superior to conventional rings in every test, delivering gains of three per cent (+12W) in sustained power, four per cent (+30W) in sprinting power and a reduction in measured lactate concentration of nine per cent.

Sprinting power

20-second sprints, 40-second recovery, preceded by ramp test to exhaustion. Rotor Q-Rings & normal chainrings (Universidad de Valladolid)



	S1	S2	S3	S4
Std	685	578	499	476
Oval	715	582	526	510

Rotor System Cranks

The Rotor System crank was the company's original innovation that led to Q-Rings. The cranks do not stay at 180° to each other, eliminating the dead spot by mechanically accelerating each crank through the top of the stroke and into the power phase. Independent scientific studies have shown huge power gains of up to 16 per cent. The downside is that the system comes as a complete crankset with the rings and bottom bracket and it's heavy too, at 1,150g even in titanium. However, pro bikes can now undercut the UCI's weight limit so easily that the difference could be hidden. The £500 price, though dear, is only a small amount more than Campagnolo Super Record. For now, teams are reluctant to try the Rotor System but it may yet have its moment. Q-Rings were developed by Rotor to give most of the same benefits with none of the negatives.

The data appears sufficiently conclusive that you would expect team managers to be camped outside the factories, cheque books in hand, begging for permission to load every last chainring into the team van. Yet the tech-obsessed Cervélo TestTeam is the only professional road outfit to use Rotor and no one but Wiggins currently rides O.Symetric rings. Bobby Julich was a longtime O.Symetric fan during his career and Alexandre Vinokourov used them for the 2004-5 seasons but that's pretty much it.

Why don't more riders use non-round chainrings if there is an advantage to be gained? The biggest reason is team sponsorship. Every squad has a groupset or drivetrain sponsor so running different chainrings, a very visible component, would create an obvious clash. Cynicism and older riders stuck in their ways can also be obstructive, plus many people still associate the concept with the doomed Shimano Biopace, which ceased production in 1993. The only downside to which Rotor and O.Symetric readily admit is a slight reduction in front shifting quality.

Even if the pros don't wake up to them soon, the rest of us should. Highly trained riders actually get the least benefit because they already have the most efficient spin. Less trained riders – that's to say, the rest of us – will get even bigger improvements than the test subjects.

Like several innovations in the past, the converts and manufacturers are adamant that non-round rings are the future. "The comparison we make is to clipless pedals and mountain bike suspension," says Robin Corder from RotorUK. "When they were first seen, most people said they were unnecessary but now we can't imagine being without them."