

## Innovative chain drive powers world's fastest e-bike

Two German companies have developed an efficient electric drive system for bicycles and tricycles that uses precision industrial-type chains in an innovative configuration. A bike powered by the system has already won a major electric bike competition.

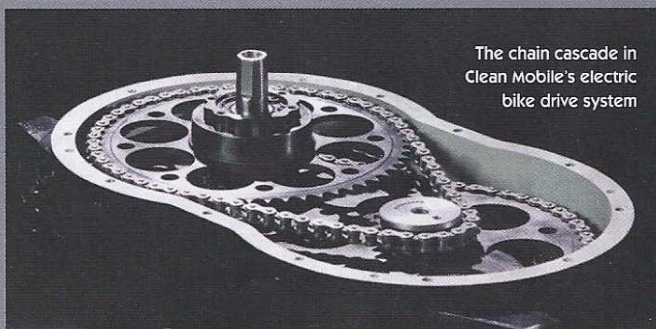
UNTIL RECENTLY, precision chains were uncommon in electrically powered bicycles. But this started to change about three years ago, when a company called Clean Mobile was founded in Germany to develop electric drive systems for two- and three-wheeled vehicles.

The company's idea was to power bikes using a tiny, but powerful, electric motor running at high speed. The design specification called for the motor to be mounted near the pedals, with its power transmitted to the rear wheel for optimum efficiency. The motor needed to run at high speed, even at slow riding speeds.

It quickly became clear that this could not be achieved using conventional reduction gearing. Munich-based Clean Mobile consulted its neighbour, the chain-maker iwis, which had many years of experience of engineering chain drives for motorcycles.

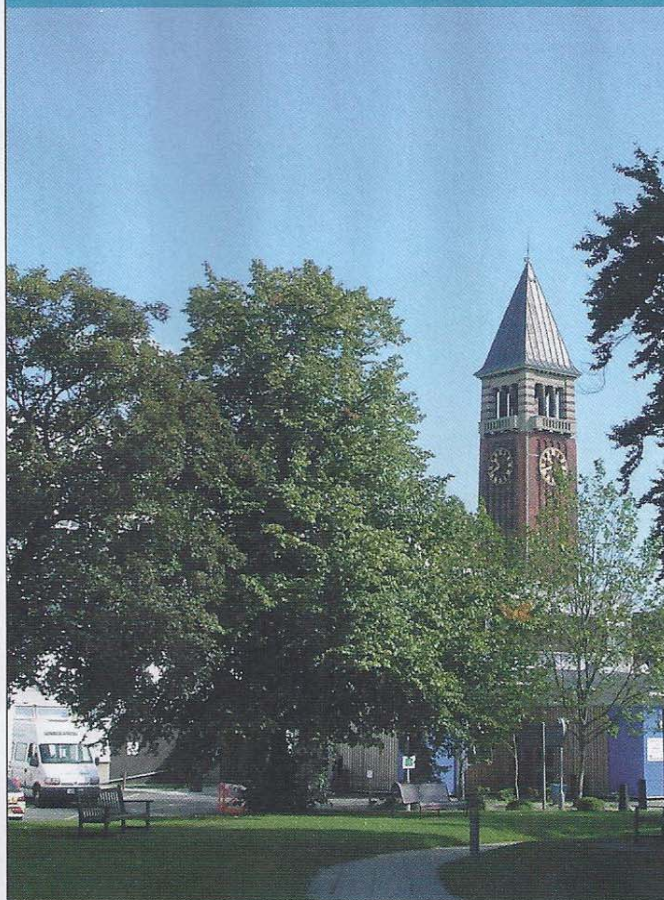
Working together, technicians from the two companies decided to split the gearing into a primary and a secondary transmission. They also decided that the primary (reduction) gearing should take care of the speed reduction to the pedal crank and allow standard components to be used for secondary power transmission.

The developers came up with a direct dual drive (DDD) system in which the pedal crank and adjacent motor shaft are connected by three chain arrangements, together yielding a reduction ratio of 1:38. The effect of the teeth of each sprocket on each chain, and the resulting overall transmission ratio were calculated in several



The chain cascade in Clean Mobile's electric bike drive system

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stages, and chains with the required fatigue strength were picked from iwis' range.

The three-chain arrangement reduces the motor speed from 3,600 rpm down to pedalling speed. A freewheel hub ensures that, if the battery fails, the pedal force exerted by the rider is transmitted to the wheel only, and not to the motor. A second idle arrangement disengages the pedals from the rear wheel, as on a conventional bicycle.

To the surprise of project partners, tests by the Department of Drive Control and Actuator Technology at the University of the German Armed Forces in Neubiberg, reported that the drive system operated an efficiency of around 80% across a broad speed range. To verify this figure, iwis repeated the measurements and was able to confirm the findings.

A major contribution to the drive's high efficiency comes from the chains, through which the tensile forces are transmitted only in the direction of travel. If a spur wheel with helical gearing had been used to reduce noise levels, this would have induced additional, lateral forces and thus reduced efficiency.

Originally, Clean Mobile focussed its efforts on developing a drive system for three-wheeled cargo cycles, for use by organisations such as post offices. Such heavy-duty vehicles can weigh about 400kg.

But the high efficiency of the system also made it attractive for use on electric bicycles. Last year, an electric bicycle equipped with the DDD system won the first official E-bike world championships, held at the world's largest bicycle and motorcycle show – Intermot in Germany. The hybrid bicycle called the eSpire and built by the German cycle developer Third Element won the competition with a six-lap lead.

The eSpire's hybrid drive uses a combination of the powerful electric drive and human muscle power, linked by fine-tuned mechanical and electronic components. A 1.2kW, 48V bottom bracket motor delivers up to 150Nm of torque at the chain. The



The direct dual-drive system is incorporated into Third Element's race-winning eSpire bicycle

bike carries an 820Wh lithium-ion battery which gives it a range of 65km when relying solely on the motor, or 90km when assisting the rider. A street-legal version of the eSpire has a top speed of 45km/h, while an off-road version can reach 65km/h.

Following their successful cooperation, iwis and Clean Mobile this year formed a strategic alliance, covering mainly industrial parts production and assembly of both the entire DDD system and the harmonic chain drive.

On its stand at this year's Hannover Fair, iwis demonstrated the drive system. With its efficiency of up to 80%, the drive provides effortless acceleration and riding, free from emissions or noise. It also offers a good range both in town and off-road.

"This is an ideal basis for future projects," says Michael Frank, project manager in iwis' new business development department. "We are developing both more powerful units and detuned versions that use plastic parts. Customer inquiries from the two-, three- and four-wheel industries are showing a keen interest in the new drives. The innovative drive concept has revolutionised the two-wheel market and now iwis is also moving the world of e-mobility!" 

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