

PHOTO CAPTION: Fallbrook Technologies' NuVinci CVT on bicycle. The company believes the design can be scaled-up to both automotive and utility-size wind turbine generators.

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Pedaling NuVinci

By Bill Moore

Fallbrook Technologies' Bill Klehm discusses his firm's new continuously variable transmission

As amazing as it may sound, Leonardo Da Vinci -- yep, the "Da Vinci Code" guy -- was messing about with the idea for a continuously variable transmission back in 1490.

Seriously.

Talk about a guy who was way ahead of his time.... or maybe everyone else was simply too far behind him. Just as intriguing, a drawing turned up not long ago that some claim is a sketch he made over 500 years ago of what looks like a modern, safety bicycle, which is sort of ironic, as you'll soon appreciate.

Taking their cue from the great Renaissance master, a San Diego company has set out to see Da Vinci's vision finally blossom, starting with the bicycle/light electric vehicle (LEV) sector and expanding outward and upward from there.

That company is [Fallbrook Technologies](#) and its president is Bill Klehm, once-upon-a-time with Ford. Now he and his year-old company are out pedaling, in both senses of the word, their new CVT design, which they say is more efficient and less complicated than previous or current designs like those used in the ground-breaking [Toyota Prius](#) and [Ford Escape](#) gasoline-electric hybrids.

Klehm explained that unlike conventional transmissions -- both manual and automatic -- which have fixed gear ratios, a CVT has an infinite number of ratio possibilities. He pointed out that in a conventional four-speed transmission, every time you shift between gears, there are energy losses as the engine has to slow down and then rev back up. A CVT allows the engine to avoid those losses.

"CVT enables you to seamlessly shift from ratio ranges. Instead of having four distinct gears,

literally you have a million gears or a million shift points because the transmission is constantly keeping up with how that motor, of all shapes and sizes, actually wants to run".

He pointed out that for the best efficiency and lowest harmful emissions, you want to keep an internal combustion engine (ICE) in its "sweet spot".

The same applies, but to a somewhat lesser degree, to electric motors under load. They too will tend to stall but before doing so will wastefully draw lots of current.

Klehm believes that his firm's CVT, which is currently sized and engineered for the LEV market, is the answer to making both electric and ICE vehicles, large and small, more efficient.

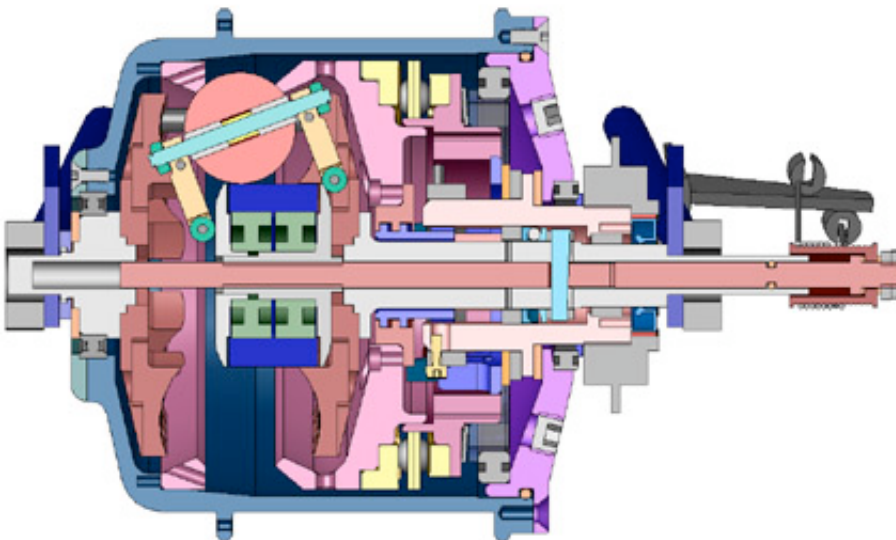
"We can take advantage of how the electric motor or IC (engine) wants to run," he told me. "So, we help optimize that while giving the consumer a great benefit... of solid performance".

He challenged my assertion that Honda, Toyota and Ford CVTs are, in fact, continuously variable transmissions. "They are fixed ratio gear drives in which there is a supplemental drive that happens off of an IC motor or electric motor. So, in essence, they don't really use a continuously variable transmission. They behave similarly". He noted that the Toyota Synergy Hybrid Drive uses a central planetary gear that is fed by either or both the IC engine and electric motors, which gives the car the "feel" of a CVT even though it technically isn't.

"The problem with CVT's today is that while they derive the benefit of fuel economy, [they are].. very expensive. They are very large; and they also have an inherent weakness in being able to control them and to manage the controls. The controls systems are very cumbersome and very expensive to implement".

This poses design problems for carmakers and helps account for why so few cars today, with rare exceptions, use this technology.

"The Fallbrook CVT is really about breaking those compromises," he said. "It is a relatively small package. The bicycle CVT, which will also be the derivative of the light electric vehicle CVT, has 25 unique components in it. So, it is a very small component".



Cross section of Nu Vinci bicycle/LEV CVT

Klehm explained that the NuVinci -- named in honor of the great man -- CVT is controlled down its center line, which makes it very stable and easy to control. The company has filed some one hundred patents on their technology. [[Click here to see animation](#)].

"Control is a very big issue", he emphasized. "We give designers the ability to do things that

they haven't been able to do because they've had to compromise by having to put in very sophisticated controls".

I asked Klehm to compare the number of parts in his CVT compared to the new Ford 500. He replied that since the company doesn't currently have an automotive model yet, only the bicycle and LEV version, he really couldn't comment other than to say that he believes there would be substantially fewer parts using the NuVinci design by "an order of magnitude".

Beyond the Science Experiment Phase

The NuVinci design is an outgrowth of the work of California inventor and cycling enthusiast Don Miller, who began work some eight years ago to come up with a more efficient way to transfer human power to the road on a bicycle. His technology was subsequently vetted by an independent testing group and the company was eventually formed just over a year ago to commercialize it.

"We have numerous prototypes with thousands of hours of ... testing on them. We are doing live implementations in a whole range [of applications]".

"We have projects under way in the small torque-capacity, medium torque-capacity, as well as over into the heavy torque-capacity". Klehm added that the company plans to demonstrate their technology in the coming years across this full range of applications from bicycles and LEVs to wind turbines.

Wind Power CVTs

Some eighteen months ago, the National Energy Renewable Lab (NREL) agreed to participate in a cooperative R&D program with Fallbrook to explore potential applications for their CVT in modern, utility-scale wind turbines. According to Klehm, the study indicated -- given an obvious number of assumptions -- that the NuVinci transmission could cut the cost of wind power-generated electricity by between two and six percent.

"In the wind turbine business and the energy-creation business, those are very big numbers", he told me, noting that NREL will present that paper next month at the Global Windpower 2005 conference in Colorado. He added that while the bearings that transfer power in the bicycle CVT are only 28 mm in diameter, the ones in a modern turbine generator would be the size of a bowling ball, but he is confident, based on computer models, that the technology will scale up to this size without trouble.

Hybrid CVTs Someday?

While Fallbrook has aspirations of licensing their technology to automotive OEMs, they don't at present have a design they can show the Toyotas, Fords and Hondas of the world. So, when I asked him how the NuVinci design might translate in terms of performance and cost to a carmaker, he replied that he simply couldn't say, but he did remark that one way to look at cost is the number of polished metal surfaces in a transmission. The more machining it takes to create that part, the more expensive; and the more polished parts, the higher the cost.

In the NuVinci transmission the largest polished surface are the bearings that transfer the power and these also happen to be the least expensive polished surface to manufacture.

"We believe from a fully-embedded cost-to-manufacture, our transmission will offer significant opportunities for vehicle manufacturers of all shapes and sizes". He stressed that LEV manufacturers won't have to change their products to accommodate this technology. The NuVinci CVT will fit in the place of a conventional rear hub.

"We offer a very nice blank canvas for OEMs and for manufacturers to partner and think about how they can do something differently.

Fallbrook has so far raised some \$12 million dollars from private investors. "They are people with a broad background and we have about 80 investors... I just wanted it clearly understood that this is a private round", he emphasized, explaining that getting the right team of "superstar" managers was probably more challenging than actually raising the money. The two tend to go hand-in-hand. You need the team to attract the money and the money to recruit the team.

"It's been a wonderful ride and quite a bit of fun. One of my friends who works at a large automotive company called me up and asked me how I was doing and I told him that I can't imagine doing anything else than having a great technology, having a great team, having a great set of investors and having a marketplace that is dying for something new."

Fallbrook has several agreements with non-automotive OEMs and a manufacturer, so expect the first bicycles or LEVs equipped with Nu Vinci drives to be available in the next twelve to eighteen months, Klehm told me. "We want to announce products, not deals".

A wise strategy considering the supposed Da Vinci bicycle sketch is, in all probability, a clever hoax. Leonardo didn't have graphite pencils in 1490.

You can't be too careful.



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