WARDS INTELLIGENCE

Tula Technology Ahead of the e-Motor Curve

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Executive Summary

Tula Technology unveils its latest innovation, Dynamic Motor Drive (DMD). The software is used to pulse electric motors in a way that improves efficiency 3%, according to the company.

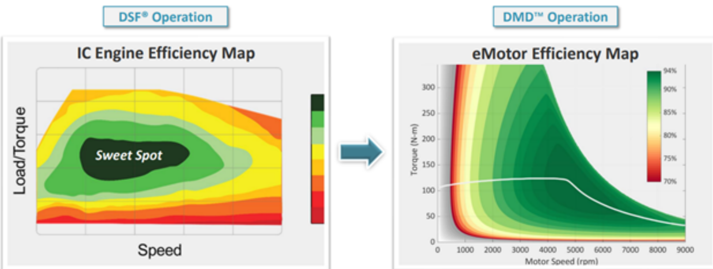
TULA'S DMD TECHNOLOGY BOOSTS BEV EFFICIENCY 3% *Source: Tula Technologies*

Tula Technology, the company behind Dynamic Skip Fire (DSF) which, according to R. Scott Bailey, Tula president and CEO, is used in "two General Motors' engines that are in, frankly, most of their large (gas-powered) SUVs and full-size pickup trucks," is turning its attention toward electric motors with the unveiling of its new Dynamic Motor Drive (DMD) technology.

At a recent media event at the company's headquarters in San Jose, CA, Bailey and John Fuerst, senior vice president-DMD & Engineering, presented the company's latest innovation, their strategy for bringing it to market and their vision of the future for electric motors.

What Is DMD?

The system operates on the idea that every internal-combustion engine (ICE) or electric motor has a "sweet spot" for operational efficiency.



Tula Technologies

TULA SWEET SPOTS FOR MOTOR EFFICIENCY

In gas and diesel engines, the company's DSF technology turns on engine cylinders only as needed to produce the desired torque output, or conversely, drops out up to seven cylinders in a V-8 when full power isn't needed. This is at the heart of how most GM large SUVs and full-size pickup trucks equipped with 5.3L and 6.2L V-8s meet emissions regulations and improve fuel efficiency. GM dubs the technology Dynamic Fuel Management.

But in an electric propulsion system, it's a little different. Electric motors have a very narrow efficiency band (white line in chart). Tula engineers found they can provide the most value when the engine is operating at torque loads less than 89 lb.-ft. (121 Nm) and mostly when speed is constant.

Dynamic Motor Drive essentially is proprietary software that "overlays the standard algorithms" for battery-electric-vehicle (BEV)+motor controls but provides "highly efficient 'digital' output pulses to the motor at the highest efficiency point for a given speed load condition," says Bailey.

The company claims it can improve drive-cycle efficiency by 2% or 3% depending on which standard you use to measure it – Europe's Worldwide Harmonized Light Vehicle Test Procedure (WLTP) or the U.S.' Multi-Cycle Test (MCT). The company admits 2% or 3% doesn't seem like a lot but contends it could save 22.5 billion kWh of annual electricity usage by 2030. Moreover, the company says DMD can reduce vehicle costs by $216 for OEMs using externally excited synchronous motors (EESM).

Tula's Sweet Spot

The company has some very specific segments in mind for DMD. The technology works best and is mostly targeted at EESM in passenger vehicles. These are magnet-free and therefore rare-earth-element (REE) -free motor designs where Tula software can provide that 2%-3% efficiency gain. Currently, only BMW and Renault are using this type of motor in their BEVs. Instead, over 90% of BEVs use an electric motor with internal permanent magnets (IPM).

Tula execs admit "IPM motors will continue to play a significant role in the market given their efficiency and power density." But they argue IPMs' dominance is unsustainable. They see the cost of IPMs becoming a "big issue" as demand for the REEs that go into the motors is predicted to outstrip mining capacity by 33% by 2035. And that one-third gap, the company argues, will be filled by EESM motors.

Fuerst also point out the mining and processing of REEs, of which China controls 91%, have a high environmental cost. The company maintains those factors and the widening political divide between Washington and Beijing will facilitate the transition away from IPM motors over the next several years. The Tula team believe – and it helps that their OEM partners have told them this is the case – the logical alternative is the EESM topology and their software is well-positioned to be part of that transition. "We have a high-value technology that is very cost-effective and can be implemented in a straightforward manner via software. We developed a proven control approach that the patent office recognizes as novel and unique, and we have built a multilayered patent strategy to protect that space," the company says.

Tula isn't betting the farm on EESM. "While DMD works best on EESMs, it also improves efficiency of IPMs, and based on customer feedback, we anticipate applying DMD to permanent magnet machines," says the company.

But, but, but…

Yet DMDs' incremental benefit (the 2%-3% gain) is whittled away by the efficiency gains of other technologies, such as silicon carbide (SiC) or gallium nitride (GaN). This becomes especially important for IPMs as DMDs' benefit there already is less than 1%. "The benefits can only add up to some fraction of the current losses, and as the losses are reduced, what you can improve upon shrinks," says the company.

Tula's business case is tied directly to the cost savings of reduced battery-pack size. More specifically, the company argues they can charge 25% to 50% of the roughly $216 (assuming a 60-kWh pack at $120 per kWh) OEMs would save by reducing the battery pack by 3%. It's between $54 and $108 per vehicle, which is about the same price the company charges for DSF.

Similarly, however, technical gains in battery chemistry could quickly erode the benefit DMD provides. For example, BEVs that use a silicon-anode battery instead of graphite stand to gain a 20% to 40% boost in efficiency. That can mean either a smaller pack size with similar range (as graphite-anode batteries), to a similar pack size with more range, or anything in between. Yes, DMD could add an additional 3% in efficiency, but will the 1.8 kWh saved be worth it?

Fortunately, DMD is not just for BEVs. The software can be applied to industrial applications that use magnet-free motor topologies. These include synchronous reluctance machines (common in milling and manufacturing) and inverter-controlled induction motors like those found in on-shore wind-power generation.

Fuerst says they have already introduced DMD to companies in the commercial-vehicle and off-road space and are working with universities that are active in wind generation to better understand current technology and expected trends.