# Interview: Scott Bailey, President and Chief Executive, Tula

***Michael Nash** talks to Tula's Scott Bailey about dynamic skip fire and the optimisation of internal combustion engines*

Engine management systems (EMS) are evolving, becoming increasingly advanced and sophisticated. EMS technology controls the nature and characteristics of the fuel injection process within an internal combustion engine (ICE).

With the rise of trends such as downsizing, turbocharging and electrification, the use of EMS is changing to allow for greater benefits in terms of emissions reduction and fuel economy improvements. One example is dynamic skip fire (DSF) – a cylinder deactivation strategy that allows engines to be displaced during operation.

This technology has been co-developed by Delphi and Tula, and could soon reach the market. Speaking to *Automotive World*, Scott Bailey, President and Chief Executive, Tula, describes how the technology works and why it should have a place in the powertrain of the future.

**Can you please outline both the role that Tula plays and the role that Delphi plays in dynamic skip fire?**

Tula is a tools and software company. Our focus is really on the control algorithms and the control methodology. We view DSF the ultimate cylinder deactivation strategy. As our partner, Delphi focuses on integrating our controls into complete engine management systems (EMS) and provides some optimised cylinder deactivation technology to allow the DSF system to work.

**What makes DSF stand out from other cylinder deactivation techniques?**

Every time a cylinder is coming up in the firing order and is preparing to fire, we make a determination of whether we need to fire that cylinder or not based on the driver's demand for torque. This is what is so important – the firing decisions are made on an event-by-event basis. We don't determine in advance that we're going to run three out of four cylinders for the next 26 cycles or anything like that. It's a real-time algorithmic-based decision driven primarily on torque demand; the torque requested by the driver or the engine control unit. And then the other consideration, obviously, is the impact on NVH. That's a very key aspect and attribute of the technology.

**Can you give me an example of a typical DSF scenario in action?**

At 1,500 rpm, which is a reasonable cruise speed for a four-cylinder engine, there are 50 firing opportunities every second. We may only need to fire, let's say, 20 of those 50 from a torque demand standpoint. With the algorithms, we decide which are the best 20 to keep the vibrations well controlled and, basically, imperceptible to the driver.

So the nature of the technology is to sort out exactly which cylinders to fire for torque, and then which are the best cylinders to fire to maintain a very transparent vibration scheme for the driver and make sure there is no negative impact on driveability.

**How does DSF differ from other cylinder deactivation techniques?**

There's been a major trend to downsize and boost engines across the industry for many years now, but I think this trend is starting to plateau because of real world driving emissions concerns.

However, a 2.0-litre engine, for example, is somewhat oversized for steady state cruising and many other driving conditions. This is where DSF and dynamic downsizing comes in. In some cases, a driver may need the 2-litre engine for torque, acceleration or hill climbing, but the rest of the time we can downsize the engine. We're continually adjusting the effective displacement of the engine so that we can optimise efficiency, and that's something that a conventional deactivation system cannot do.

**What will drive adoption of DSF?**

The number one driver is $CO_2$ reduction. In a larger displacement engine, like a V8, DSF may provide a $CO_2$ reduction benefit of 15%, which is very significant compared to other powertrain technologies for internal combustion engines. At the 2017 Vienna Motor Symposium, we had

DSF fitted to a 1.8-litre four-cylinder engine that was already efficient to begin with, but we showed a further 8% $CO_2$ reduction.

**Is this $CO_2$ reduction alone enough to warrant the widespread use of DSF?**

I think another important factor is the cost. We think that one of the best benefits of the technology is the value proposition. DSF will cost around €40 for each percentage point of $CO_2$ reduction, which is quite a bit lower than most of the competing technologies that are being considered or adopted at this point.

**Is the rise of electrified powertrains a cause of concern when you consider the future of DSF?**

They are actually complementary technologies, but complementary in a way that maybe isn't quite so obvious. Let me back up to a point I made earlier when I said we need to ensure that firing frequency doesn't impact the driver. At a lower RPM you end up with lower frequency, so by pairing DSF with mild levels of electrification, we can modify the frequency signature that the driveline will see. We use the electric motor to absorb a little torque from one of the firing events, and put that torque back onto the crankshaft during a non-firing event, and we smooth the overall torque distribution so we can open up the fly zone of DSF.

**Will this result in additional $CO_2$ reduction?**

Yes we'll see a further two or three percentage points of $CO_2$ reduction on top of that 8% in a 1.8-litre engine without really adding any appreciable

cost to the system. It comes with the coordinated control of the electric motor and DSF. As we look ahead, we need to integrate the engine management system, DSF and the electric machine, but that's part of the challenge of electrified powertrains anyway.

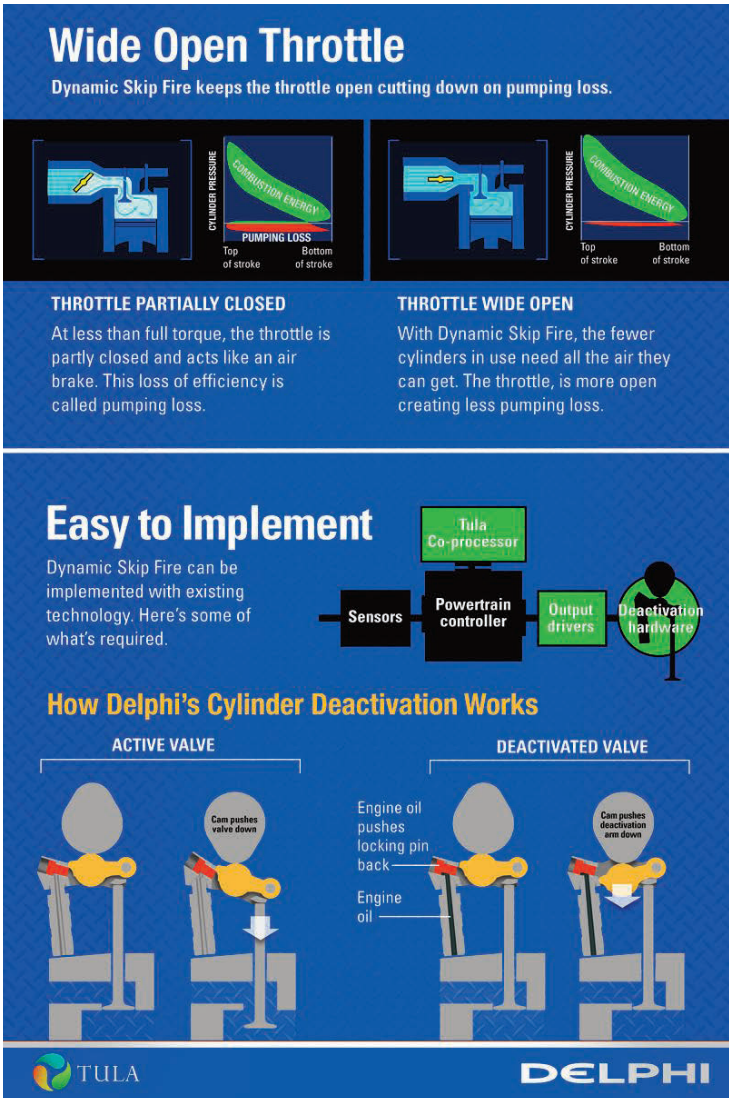
But there's another benefit – one of the attributes of DSF is that, when the vehicle is slowing down we basically deactivate all the cylinders in the engine. During this coast mode, we can dial in as much regenerative braking or as little as we want during any given situation. We call this deceleration cylinder cut off, or DCCO, and it's another scenario during which there are synergistic benefits.

**Do you think there are certain markets that could adopt DSF before others?**

From my perspective, I think it is a pretty wide-reaching technology, but that's not to say it will create benefits on every single application. And I've got to be a little careful because of customer confidentiality, but I can say that we have pre-production projects in North America, Europe and Asia. We're seeing a great deal of interest from a significant number of OEMs, but DSF is a high value technology.

**When will we see DSF in production?**

We will be in series production before 2021. In fact, I think that within the next two years we'll have significant production numbers.




**How important will software be in the powertrain of the future?**

We couldn't do DSF without a reasonably fast computing capability. There have been tremendous improvements in engine hardware over recent years, but it is reaching a very refined point. The real capability is now coming from the compute cycles that are now available, where we can just do far more with the hardware than we ever could in the past.

If you think about the pairing of DSF with electrification as an example. It's centred upon the integration of some very sophisticated systems, and that's only been made possible with the computing power and the software.

**Could the rise in demand of connected car technology and the realisation of autonomous driving have an impact on demand for DSF and other up-and-coming powertrain technologies?**

With almost all powertrain technology on the market today, we respond and react to what the driver is doing with the right foot. Looking forward, if you know where you're going and what's coming and what you need to be doing with the vehicle, we can just be that much more efficient in how we control the engine.

For example, if we know there is a hill, a descent or a traffic light coming up, we can optimise the engine control and the cylinder firing density. This kind of scenario will be vital as the human passes control over to the machine, and self-driving vehicles come to market.