Dynamic downsizing

An electric supercharger can offset the need for a further stage of turbocharging. This enables further engine downsizing and CO_2 reduction using a simpler charging system

In the face of increasingly stringent worldwide legislation, the auto industry continues to explore ways to reduce fuel consumption and CO_2 emissions. Gasoline engine downsizing has long been recognized as an effective means of engine CO_2 reduction. Further improvements in fuel economy have been achieved through continual engine downsizing.

Gasoline engine downsizing enables the engine operating point to be shifted to a higher, more efficient region, through the reduction of engine swept volume, while maintaining the full load performance of the original engine via pressure charging. However, as specific output increases, so do the challenges associated with developing and refining these systems, which include abnormal combustion (pre-ignition and detonation), low-speed torque, transient response and engine durability.

Now 48V mild-hybrid architectures are paving the way for increased levels of engine downsizing, with electrically powered superchargers (eSuperchargers) providing a virtually instantaneous and continuous supply of boost air for the engine, even at low engine speeds.

Mahle Powertrain has pushed the level of engine downsizing with its revised turbocharger, which is coupled to an eSupercharger to further enhance the low-speed torque characteristics of the engine. A higher specific power output has been achieved through the use of a carefully chosen larger turbocharger, which, without the eSupercharger, would have had a detrimental effect on the low-speed torque and transient response of the engine.

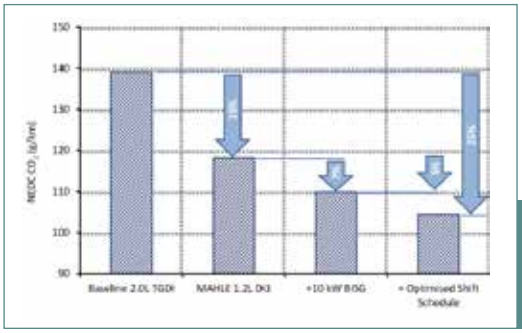
Aeristech's 48V eSupercharger is ideally suited to this application with its compressor, which can provide the desired pressure ratio and mass-flow rate. The unit is capable of running continuously at high boost pressures and can accelerate from its idle speed to its maximum speed of 120,000 rev/min in under half a second. These characteristics enable the engine to produce very high torque at low engine speed and thus achieve an excellent transient response.

Unlike conventional mechanical superchargers, which require power taken directly from the engine to drive them, eSuperchargers can use energy that is recovered during vehicle deceleration through recuperation. The degree to which it is possible to mitigate the electrical consumption of the eSupercharger depends on the proportion of engine operating time for which the eSupercharger is required, how much energy recovery is available during driving, and the storage capacity of the 48V power supply.

The technology applied in this demonstrator is expected to yield a combined CO_2 reduction of 25% (based on compound percentages)

Mahle Powertrain has integrated a 48V Aeristech eSupercharger into its latest downsized engine, along with a conventional exhaust-driven turbocharger for high-speed, full-load performance. A maximum power level of 193kW has been achieved during dynamometer testing, resulting in an increase in specific power output from 100kW/liter to 161kW/liter, while also achieving high torque at low engine speeds, enabling major fuel economy improvements. This represents a new development in engine boosting technology by hybridization of the air intake system, making the electrical charging device a fundamental part of the enabling technology. The eSupercharger is, in this application, no longer simply a transient device, but a key contributor to steady-state engine performance.

This eSupercharged engine has been installed in a demonstrator vehicle developed by Mahle Powertrain. The 48V platform used in this application comprises a three-cell advanced lead-acid battery pack, a DC/DC converter to maintain the state of charge of the 12V battery (which supports the existing 12V systems), the eSupercharger and a 10kW BISG (belt integrated starter generator) from Controlled Power Technologies. The latter provides continuous electrical power to the eSupercharger, even when the 48V battery is depleted.



Cumulative reduction in CO_2 emissions with the adoption of 48V technologies

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