Controlled Power Technologies

TIGERS®
Turbogenerator Integrated Gas Energy Recovery System

FEDERAL-MOGUL POWERTRAIN
TIGERS® (Turbogenerator Integrated Gas Energy Recovery System), is a water cooled Switched Reluctance (SR) generator coupled to an exhaust driven turbine. It converts energy, otherwise lost through the exhaust system, into electrical energy. By harvesting electrical energy from the exhaust stream, less mechanical loading is required to drive the engine alternator system.

The fully integrated bespoke software for TIGERS® monitors back pressure in the exhaust to actively adjust generation and exhaust pressure; TIGERS® uses electronically controlled bypass valves to ensure that power is generated only when there is a net benefit.

TIGERS® uses Switched Reluctance Motor technology for a low rotating mass of inertia resulting in excellent dynamic response.

TIGERS® can be mounted anywhere in the exhaust system, more commonly following the after-treatment systems.
Specification

Based on a 6/4 Switched Reluctance (SR) Generator

- A range of low pressure drop turbines available, optimised for gas flow and engine back pressure
- Bespoke turbine designs for specific flow rates possible
- Range of voltages - 12V/24V/48V (custom electrical configurations can be considered)
- Flexible installation strategy - can be mounted anywhere in the exhaust system

Twin Valve Active By-Pass Control System

- Requires fast-acting, high temperature control valves
- Enables management of gas flow through the turbine to ensure that energy is harvested only when generated energy is greater than incremental pumping losses
- Protects machine from over-speed

Liquid Cooling - for bearing, generator winding and electronics protection

- Utilises engine cooling circuit
- Cooling jacket flow optimised using CFD
- Moderates thermal loading, particularly on the front bearing close to the hot exhaust gas

Low Inertia and High Speed

- Rapid transient response
- Energy harvesting strategy can be optimised

Integrated Control and Power Electronics

- All electronics assembled into a sealed housing at the rear of the machine
- Significantly reduced electrical losses and improved EMC
- Monitors and controls against over-speed and over-temperature operation, utilising both current in the machine and the by-pass control valves
- Communicates with vehicle control systems over CAN
Benefits

30% - 40% of fuel energy is lost as waste heat through a vehicle’s exhaust system. By recovering a percentage of this lost energy, Exhaust Heat Recovery Systems (EHRS) aim to reduce the amount of fuel consumed and improve the thermal efficiency of the engine. The recovery techniques are applicable to all fuel burning engines and vehicle types including hybrids.

The technologies can be used to enhance engine warm up or provide additional power to the engine in the form of electrical or mechanical energy. Implementing an EHRS requires careful consideration because each solution has a different set of specific requirements with varying levels of complexity, performance and constraints. EHRS selection depends on the cost and benefits required for the target application.

EHRS technologies include:

- Exhaust Gas Heat Recovery (EGHR) - a heat exchanger is simply used to heat up the engine coolant
- Organic Rankine Cycle (ORC) - an intermediate fluid with appropriate properties is expanded and condensed to convert the energy into mechanical energy
- Thermo-Electric Generator (TEG) – uses the ‘Seebeck effect’ to produce electricity from differential temperatures across different materials / conductors
- Turbo-Generator (TG) – converts the kinetic energy of the exhaust gas flow into mechanical energy by expanding the gas through a turbine

Each technology has its merits but TIGERS®, a turbo generator, offers specific benefits including:

- System simplicity – a single unit installed in a conventional exhaust system with potential benefits for integration and unit costs
- System maturity – not dependent upon new material development and associated costs
- Controllability – the SR generator technology is readily controlled for optimised energy harvesting and self-protection
- Operating range – optimised for back pressure but not limited by temperature
- Proven energy recovery effectiveness - specific systems adopted by F1 racing cars to provide power boosts
- Off cycle real world driving benefits have been measured and demonstrated on light to heavy duty vehicle applications
By extracting kinetic energy from the exhaust gas flow, a back-pressure on the engine is created. The various TIGERS® turbine geometries to-date have been designed to minimise the pressure drop across the turbine and hence the back pressure. Other geometries could create more power by accepting a greater pressure drop if the air loop concept supports this (e.g., engine concepts with very high boost pressures).

A TIGERS® unit typically has to endure exhaust gas temperatures through the turbine of up to 850°C, depending on where it is located in the exhaust system and whether it is applied to a diesel or gasoline engine. Coolant flow around the cooling jacket has been optimised using computational fluid dynamics to protect the bearings, windings and electronics.

The primary method for regulating the power generated by the TIGERS® unit is through control of the by-pass control valves. These divert the exhaust gas through the turbine when the energy generated will be greater than the pumping losses resulting from the increased back pressure. This closed loop control system is executed by the micro-controller integrated into the TIGERS® unit. CPT has developed specific control algorithms to support such installations.
CPT participated in the Innovate UK funded collaboration to develop a vehicle with a 48V architecture, “ADEPT” (Advanced Diesel Electric PowerTrain), fitted with both CPT’s SpeedStart® motor generator and CPT’s TIGERS® unit.

The vehicle has undergone extensive NEDC, WLTP and RDE drive cycle testing with very favourable results. This is likely to form the basis of an Eco Innovation emission credit claim.

On the road the TIGERS® unit is capable of generating in excess of 2kW electrical energy from the waste exhaust gas.

TIGERS® is now forming the basis for more advanced emission control studies.
Founded in 2007, UK-based clean-tech developer Controlled Power Technologies (CPT) was acquired by Federal-Mogul Powertrain in 2017. The CPT product range with innovative electrification and hybridization systems enables the development of reduced-emissions powertrains with: 12V, 24V and 48V electric motor-generators for stop-start and mild hybridization applications, exhaust-driven electrification technologies, combustion engine e-boosting and fuel cell e-compressors.

As one of two independent divisions that constitute Federal-Mogul LLC, Federal-Mogul Powertrain designs, develops and manufactures original equipment engine components and sealing and systems protection products. Federal-Mogul Powertrain is committed to delivering superior quality through innovation and engineering excellence enabled by cutting-edge proprietary technologies. The division works in partnership with its customers to meet increasingly demanding targets for fuel economy and emissions performance without compromising affordability or reliability. As one of the leaders in the passenger car, light commercial, heavy-duty and off-highway markets, Federal-Mogul Powertrain also supplies related technologies to the power generation, aerospace, marine, rail and industrial sectors.