Product information

Variable Turbine Geometry
VTG – The Blades of Flexibility
Variable Turbine Geometry

With benefits that include fuel saving and emissions reduction, Variable Turbine Geometry (VTG) increasingly is being seen as a technology that addresses the key challenges facing the diesel and gas engine industry.

The combination of internal combustion engine and turbocharger brings together two mechanical devices with totally different operating characteristics. Whereas the engine – a reciprocating machine – cyclically transfers power between translational and rotational motion, the turbocharger supplies power continuously. To maximize engine performance, these two very diverse machines have to be optimally matched over the entire operating range.

Stricter emissions legislation and growing user demand for reduced fuel consumption moreover place new emphasis on the need for optimal matching. Additional flexibility in air and fuel management is needed. One way to achieve this is by turbocharging with controlled, variable turbine-side components.
Why Variable Turbine Geometry?
Variability on the exhaust side of the turbocharging system can of course be achieved by means of a waste gate, partial admission or sequential turbocharging. However, the most efficient way to achieve a “flexible” turbine is to make the nozzle vanes adjustable. This allows the turbine’s flow area, and therefore its mass flow, to be optimized, practically without losses, at every point on the engine’s load profile. As a result, the supply of air or air/fuel mixture to the engine can be matched exactly to all loads and ambient conditions.

A proven technology
ABB has considerable experience with turbocharger turbines featuring variable geometry, having built and tested prototypes for the VTC 254 as early as 1989. These were followed by a prototype VTG for the RR 151 in 1993. In 1996 a TPS 50 turbocharger with VTG was tested on a three-cylinder experimental gas engine, and just a few months later first field tests with a TPS 57-VTG took place on a gas engine operating in a commercial power plant. As a result of the demonstrated benefits of VTG, 26 TPS 57 units with VTG were delivered for 18-cylinder engines in two Spanish power plants in 1999. In the intervening years, ABB has made other series turbochargers available with VTG, including the TPS 61, TPL 65, TPL 67 and TPR 56.
VTG offers flexible air management
Benefits across the board, for all sectors
Variable Turbine Geometry offers important benefits for large numbers of engines in many different applications – gas as well as diesel, 4-stroke and 2-stroke. VTG’s key benefit, however, is that it allows flexible adjustment of the air-fuel ratio for optimized combustion – allowing emissions to be lowered while maximizing engine efficiency and improving part-load behavior.

4-stroke engines: part-load fuel consumption and emissions are key issues
Variable Turbine Geometry can play an important role in the 4-stroke diesel engine sector by saving fuel at part load, thereby also lowering emissions, especially of soot. When VTG is used, higher power outputs are possible at lower engine speeds. And by reducing temperatures VTG contributes to longer service lifetimes for those engine parts subjected to the highest thermal loading, in marine, stationary power plant and rail applications.

Additional benefits for diesel locomotives include a substantial saving in fuel and optimal adjustment to changing ambient conditions, such as temperature fluctuations and differences in altitude.

A further advantage of VTG is the emissions reduction potential it offers in the area where the turbocharger and engine interact. This applies particularly to NO\textsubscript{x}, especially in combination with exhaust gas recirculation (EGR). NO\textsubscript{x} increasingly is becoming an important focal point of emissions legislation.

Variable Turbine Geometry for a TPS turbocharger
Optimized performance

Fuel-saving the main benefit for 2-stroke diesel engines
The main benefit of VTG in the 2-stroke diesel engine sector is the substantial fuel-saving it makes possible by increasing the pressure in the cylinders at part load. Further benefits lie in the optimal adjustment to changing air-intake temperatures as well as compensation for contamination in the exhaust-gas system during HFO operation.

Used in combination with electronically controlled engines, VTG allows overall optimization of the system and reduction of unburned hydrocarbons (UHC) and carbon monoxide (CO) as well as NOx. Added to this is the possibility of shifting the engine regulation from variable valve control to the VTG – an option that also simplifies the overall system. As a further benefit for 2-stroke engines, VTG allows the auxiliary blower to be switched off at lower loads.

VTG and gas engines
VTG also has benefits for gas engine applications in stationary power plants. Gas engines depend very much on an optimized fuel-air mixture to prevent “knocking” and also to avoid misfiring. While VTG meets the growing need to save fuel in this sector too, it has the added benefit that it allows adjustment for varying gas compositions and gas qualities. And it also dispenses with the need for a waste gate. Last but not least, all the turbochargers can have the same standard configuration since the VTG can always be adjusted for matching to the actual operating conditions.

How VTG works
Variable Turbine Geometry (VTG) is a turbocharger technology which, by using movable inlet guide vanes to regulate the speed and angle at which the exhaust gas flow strikes the turbine blades, controls the gas mass flow and with it the turbine power. A unique, patented ABB design reduces the clearance between the movable nozzle vanes and the casing wall to almost zero. An actuator controlled by the engine management system adjusts the angle of the vanes, turning them to the exact position required to maintain the optimum boost pressure and air-fuel ratio at every engine operating point.
A large experience base
Since introducing VTG a decade ago ABB Turbocharging has delivered more than 1000 turbochargers with this innovative technology, providing the company with a large experience base. The majority of the turbochargers, most of them of type TPS, run on gas engines. Over 20 million running hours have been accumulated with these units, and the first ones delivered have passed the 75,000 hour mark.

High fuel prices and ever-tighter emissions regulations, as well as user demand for higher engine performance, call for new future oriented solutions. ABB has committed to expanding the range of turbochargers it offers with VTG.