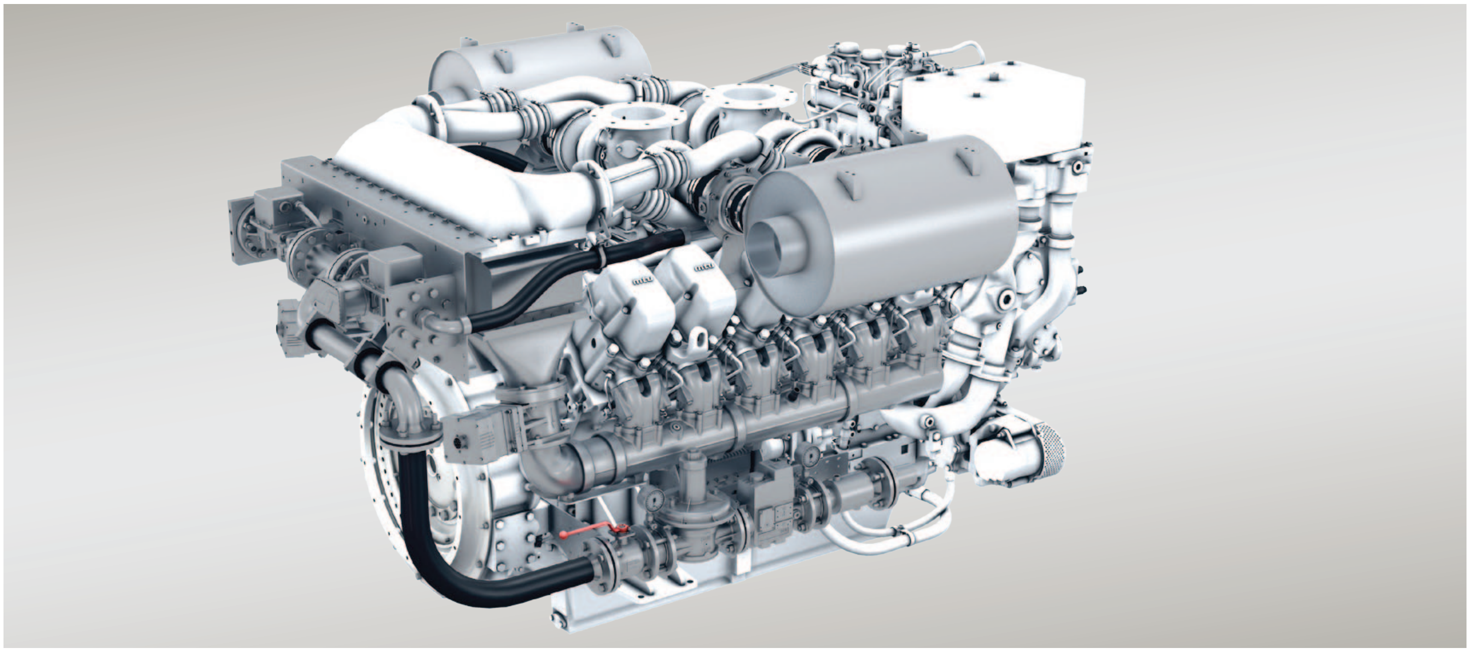
Engine Technology

MTU-integrated bi-fuel engine technology to reduce fuel costs



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Fuel expense for diesel-powered fracking engines represents a significant portion of total operating costs within a typical onshore well stimulation spread. Accordingly, with the increased availability of lower priced and environmentally friendly natural gas, aftermarket-installed bi-fuel systems have rapidly intensified the interest of well service operators seeking reduced operating expense through utilization of well-site field gas. Through use of integrated bi-fuel engine technology, MTU is able to meet the specific demands of well servicing in a field installable kit, which retains all internal diesel engine components and ensures safe and reliable operation at original engine performance and emissions specifications.

Bi-fuel versus Dual Fuel: Terminology

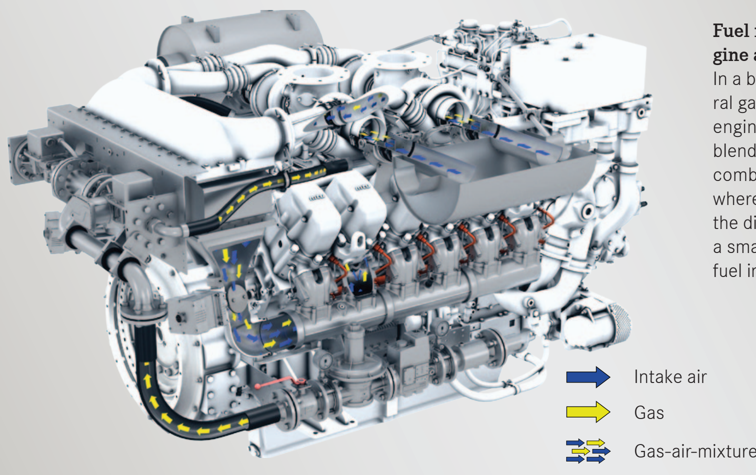
MTU defines bi-fuel as the partial substitution of diesel fuel with natural gas fuel on an original compression-ignition engine; therefore bi-fuel engines utilize a gas/diesel fuel mixture, with the goal of minimizing the amount of injected diesel required across operating conditions.

While the terms bi-fuel and dual fuel are often used interchangeably, MTU defines them differently: dual fuel diesel engines are – unlike bi-fuel engines – specifically optimized for the combustion of natural gas using diesel as ignition source only. Dual fuel does not pertain to gas-diesel mixing and thus does not offer the fully similar advantages of bi-fuel capable engines.

Two primary advantages of bi-fuel technology systems are the ability to retrofit an existing diesel engine for fuel cost reduction while also retaining the high torque characteristics of 100% diesel mode. Due to the different combustion characteristics of natural gas compared to diesel fuel, a bi-fuel engine cannot safely achieve complete diesel fuel replacement rates at low or high rated loads and still achieve satisfactory performance at the same time. Therefore, by optimizing the timing of the diesel injection, these extremes can be fine-tuned to achieve both safety and expected performance.

Economic and environmental benefits of bi-fuel solutions

There is significant opportunity for operating



Fuel flow in bi-fuel engine after conversion
In a bi-fuel system, natural gas is pre-mixed with engine intake air. The blend is delivered to the combustion chamber where it is ignited when the diesel injector sprays a small quantity of diesel fuel into the chamber.

cost reduction through use of bi-fuel technology, especially when retrofitting an existing field engine with a retrofit bi-fuel kit. Many of the sites where well service and pressure pumping (frac) units operate already contain natural gas deposits. The bi-fuel kit provides a practical solution to lessen the environmental impact of waste gas (from well heads) by productively utilizing the otherwise wasted gas.

Retrofitted engines comply with EPA Tier 2 through approval by the California Air Resources Board (CARB). The bi-fuel operation will reduce the emitted NOx emissions, because of the cleaner combustion of gaseous fuels, and will reduce the CO values as well, because of the use of a mandatory CO catalyst. Emissions for non-methane hydrocarbon (NMHC) stay on the same level as before while emissions of unburnt methane ("methane slip") are minimized.

Engine monitoring and control

The shortfall of currently available systems is primarily caused by the incomplete integration between the aftermarket installed bi-fuel electronic control unit and the pre-existing OEM engine control unit, which prevents implementation of a bi-fuel specific control loop. In contrast, MTU employs a completely integrated bi-fuel control architecture designed specifically for the company's frac engines.

A primary factor for efficient bi-fuel operation is determining the exact air-fuel ratio for a given load, speed and gas quality. MTU achieves optimal control with engine mounted sensors, and a fuel gas metering valve controlled by the ECU 9, an electronic engine platform developed and produced by MTU. ECU 9 is the new basis for controlling MTU Tier 4 engines and is utilized on this Tier 2 type bi-fuel engines using state of the art technology.

The ECU 9 / EMU 9 monitors and controls exhaust gas temperatures to ensure temperatures remain within valve and valve seat limits. SAE J1939 communication is supported including diagnostic messages (DM1). The engine controller does not depend on an external hydraulic horse-power signal to fully support shift energy management used with transmissions.

In addition to gas control valves and the variable diesel fuel injection systems commonly seen in bi-fuel engines, MTU utilizes throttle flaps: they allow control of air-to-fuel ratio independent of engine load, thus resulting in increased substition rates at part loads typical for frac operations.

Also, with automatic adaption to changing gas qualities, there is no need for site specific setups for fuel qualities ranging between 905 and 1250 BTU/SCF. This range ensures the use of pipeline quality as well as field gas quality gases. Some sour field gases need special treatment up front: because of the possible hydrogen sulfide content, they may harm external and internal engine components, such as bearings, intercooler and exhaust gas catalysts.

Engine Safety Features

A thorough risk assessment based on analyses and test was carried out by MTU during the design process. Based on these results, MTU chose to upgrade the cast-iron air-intake manifold to a more ductile material. This includes flame arrestors in front of every cylinder head for added safety in the unlikely event of a valve failure – a design already in use on stationary gas engines which prevents the potential risk of backfire and has been type-approved. In addition, an integrated knock control is used to detect knocking combustion based on the individual cylinder condition. The exhaust gas temperature of these individual cylinders is continually monitored, thus completing the diagnosis of safe and controlled engine operations. All these measures ensure maximum replacement rates at all times with changing gas qualities and prevents uncontrolled combustion on a high compression base diesel engine.

Summary

To date several examples of suitable aftermarket bi-fuel systems are readily available for diesel genset, diesel-electric and freight vehicle applications. However, the highly dynamic torque response demanded by fracking operations, coupled with the desire to utilize cheap yet variable quality field gas, has thus far challenged third party bi-fuel suppliers to provide a satisfactory and safe solution.

To meet the specific demands of well servicing, MTU integrated bi-fuel engine technology in a field-installable kit, which has been specially designed for MTU's frac engines and retains all internal diesel engine components while ensuring safe and reliable operation at original engine performance and emissions specifications. After its conversion, a bi-fuel engine is able to operate completely on diesel fuel, or alternatively, on a mixture of diesel fuel and natural gas or other methane based fuels. No alterations to the engine itself are necessary to achieve the highest possible diesel replacement rate. Should a fault occur within the natural gas flow at any time, the engine management software will reduce the gas fuel flow rate while at the same time increasing diesel fuel flow. The switch between fuel types is seamless with no interruption in torque, allowing operators to focus on the real job at hand, well head servicing.

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