Turbo-compound engines

There is increasing interest in the use Turbo-Compound Engines (TCEs) for trucks. In this article we will explain the principle behind these engines, their history and use in heavy vehicles.

Energy losses

Research suggests that less than 50% of the potential energy in the fuel that is used in a diesel engine is used to power the vehicle. In 2010 *Oil & Gas Science and Technology - Revue d'IFP Energies Nouvelles*, published an article "*Energy and Exergy Balances for Modern Diesel and Gasoline Engines*"[i]. This suggested only approximately 30% of the energy content of the fuel burnt in a diesel engine was used for work i.e. to move a vehicle. In 2013 the International Council on Clean Transportation, ICCT,[ii] suggested that around 43-44% of the energy in diesel fuel is used for useful work.

Rudolf Diesel, 1858 – 1913, the inventor of the compression engine that we now know as diesel engines, said *"The automobile engine will come, and then I will consider my life's work complete."* Rudolf's early engines were only using about 26% of the energy content of the fuel they burnt.

For many years' engineers have been striving to make use of this wasted energy to improve the overall efficiency of the engine and the vehicles they are fitted to. Turbo-chargers, using the energy in the exhaust gases is one way this otherwise wasted energy is used, so is using this energy to drive a turbine that can increase the engine's power output, a turbo-compound engine.

History

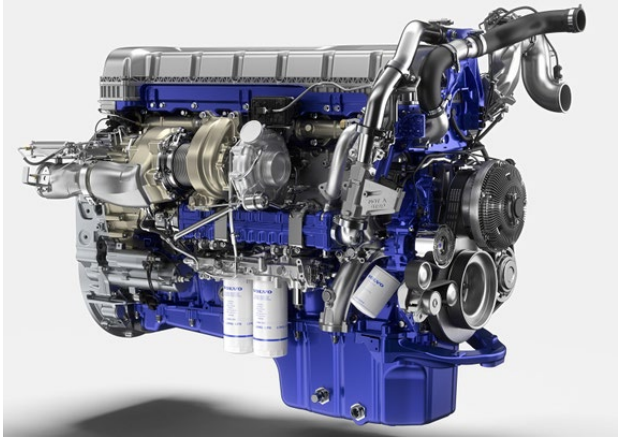
The need to increase the power output of internal combustion engines, particularly in aircraft, was highlighted during World War 2. A number of aircraft engine manufacturers developed prototypes including Rolls Royce in 1941 but none went into serious production.

Post war some development continued with Napier producing the Napier Nomad in 1949 and a variation, the Wright Duplex-cyclone used in many commercial passenger and military aircraft such as the Lockheed Super Constellation and Boeing B29. However, the rapid development of pure jet and jet turbine engines resulted in the development of TCEs for aircraft all but ceasing.

In 1987 Scania announced that they were producing a TCE variant of their popular 11 litre engine[iii]. Scania claimed that this engine would have a power output of 400 HP compared to 356 HP from a similar engine without TCE. They also claimed that efficiency of the TCE was 2% greater that the non TCE engine with a resulting reduction in fuel consumption of around 5%.

In 2007 Detroit Diesel announced a TCE engine, the DD15, also claiming around 5% improvement in fuel consumption.

In 2017 Volvo launched their TCE, the DC13. The claim was that this engine could deliver 6.5% fuel savings over a similar engine without a TCE. In 2019 a second generation of this engine was launched delivering a potential for a further 3% in fuel savings.



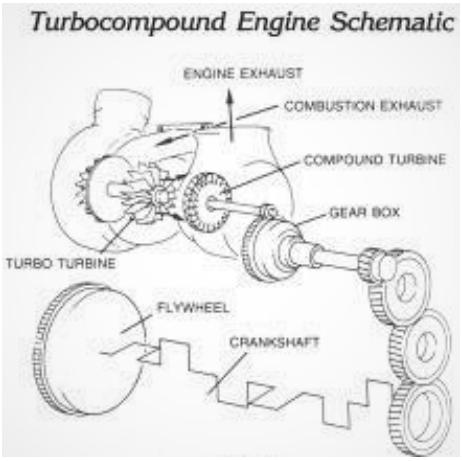
Volvo turbo-compound engine[iv]

How does a Turbo-Compound Engine work?

A typical TCE uses some of the energy content that is present in the exhaust gases after combustion is completed drive a turbine. This turbine is connected by a gear train to the engine's crankshaft supplementing the energy produced by the combustion process at the crankshaft to power the vehicle.

Instead of connecting directly to engine's crankshaft some turbo-compound engines use the energy to power an alternator producing electrical energy which can be used to charge batteries and/or power on-board auxiliary equipment.

Schematic layout of a Turbo Compound Engine[v]



Although positioned in-line of the exhaust system TCEs have shown not to increase exhaust system back pressure. There is a marginal increase in engine weight however.

Why Turbo-compound engines?

During development, and in field testing, TCEs have shown to increase the energy produced by a diesel engine that is used to drive a vehicle and its accessories. These same tests have also shown that a TCE truck has the potential to use approximately 5% less fuel for the same task compared to a similar engine truck that does not have a TCE.

[i] *Energy and Exergy Balances for Modern Diesel and Gasoline Engines (ifpenergiesnouvelles.fr)*

[ii] *International Council on Clean Transportation (theicct.org)*

[iii] *Turbo-compound diesels coming from Scania | 17th September 1987 | The Commercial Motor Archive*

[iv] *Retrieved from https://fleetimages.bobitstudios.com/upload/trucking-info/content/news/volvo-d13tc- -720x480-a.jpeg*

[v] *Retrieved from https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.jstor.org%2Fstable%2F44721670&psig=AOvVaw0bl8_U6UrvTUNEC-XCx1fG&ust=1610412624334000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCPDxn9nUku4CFQAAAAAdAAAAABAD*