Insight Article

Marine diesel engines - A bluffer's guide

Next in Gard News' non-mariners' guide to ship construction and operation is a basic guide to diesel engines, as a follow-up to the guide to ship propulsion published in issue No. 210.

Ships are visible and one can not but notice how different they are in size and shape – those factors being determined by the particulars of their trade. What you do not see, other than smoke from the funnel, is what is propelling those vessels. The propulsion systems of vessels are as varied as the vessels themselves and have evolved immensely over the last 200 years. Initially steam-powered, this has now been superseded, largely, by diesel power. Diesel engines were first introduced to merchant shipping in 1912 and it is estimated that approximately 85 per cent of merchant vessels are now powered by them. The supremacy is due, largely, to the superior thermal efficiency of diesel engines over other forms of propulsion; in other words, you go further for less fuel.

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In 1892 Rudolf Diesel invented the engine that is named after him: a compression ignition engine which weighed five tons and produced a mere 20 horse power. Engines are defined as external combustion (such as a steam boiler) or internal combustion, which are then sub-divided into spark ignition or compression ignition. They are principally classified as follows:

i) Two or four stroke operating cycles;

ii) Crosshead or trunk engines;

iii) According to their rotational speed.

Two or four stroke

Whilst marine diesel engines may look similar and, indeed, share a number of like components, the operating cycle of the two-stroke engine is entirely different from that of the four-stroke. In a two-stroke engine it takes, unsurprisingly, two strokes to complete the power cycle – one up and one down, resulting in one turn of the crankshaft. In a two-stroke engine the piston is at the bottom of the cylinder at the start of the cycle. Air is allowed into the cylinder and the exhaust valve (usually in a cylinder cover) is open. The piston moves up the cylinder and covers the inlet ports in the cylinder liner and the air is then trapped and compressed to a fraction of approximately 20:1. As the air is compressed it heats up and, just before the piston reaches the top of the cylinder, fuel is injected. The fuel burns as it is injected by the high temperature of the air. As the air/fuel burns, it increases the pressure in the cylinder until it reaches approximately 180–200 bar. This pressure acts upon the piston and pushes it down and the force is transmitted to the crankshaft – either by a connecting rod or by a piston rod to a connecting rod. This continues until the inlet ports are uncovered and this then allows fresh air into the cylinder to scavenge the exhaust gases.

The four-stroke, on the other hand, has no inlet port on the cylinder. The inlet port, actually a valve, is in the cylinder head. With a four-stroke you only get one "bang" every other rotation of the crankshaft; in other words, the crankshaft rotates twice for each combustion. The four-stroke engine acts positively by the displacement of the piston in the cylinder. The piston draws air into the cylinder as it descends, the air inlet valve closes and the piston then ascends the cylinder and the trapped air is compressed and heated. Injection then takes place and, again, the pressure increases dramatically and forces the piston down. Lastly, the piston positively clears the cylinder exhausts gases on the next upward stroke – the exhaust gases are allowed to escape by another valve in the cylinder head. There is, however, a much easier explanation: "suck, squeeze, bang and blow"! It can be seen that you get two bangs on a two-stroke for every one that you get on a four-stroke and, as such, in practice a two-stroke engine, size for size, is roughly 1.8 times more powerful than a four-stroke.

Crosshead or trunk engines

Essentially the distinction depends on whether the piston is directly attached to the connecting rod or not. In a trunk engine, where the piston is attached to the crankshaft via the connecting rod, the piston skirt is much longer than on a crosshead engine and the purpose of this is to act in a similar manner to a crosshead:

it takes the thrust caused by the connecting rod angularity. The crosshead engine allows the piston/ cylinder to be isolated from the crankcase of the engine. The disadvantage is that a crosshead engine would be nearly twice as tall as a trunk engine.

The engine speed

This is generally categorised into three groups: low, medium and high. Most low speed engines have a top speed of something in the region of 100-120 rpm. This allows the engine to be directly connected, via the propeller shaft, to the propeller. Such slow speed engines are two-stroke crosshead designs.

Medium speed engines, usually four-stroke, rotate at around 400-600 rpm. One of the limitations is that at such speeds propellers are not that efficient and in order to overcome that inefficiency the engine is usually geared down; that, of course, introduces efficiency losses by way of the gearbox.

As for high speed engines, the only place that you will probably see these on a merchant vessel is on the lifeboats, so they will not be discussed in this article.

Turbocharging

Reverting, albeit briefly, to lifeboat engines, these will be the only normally aspirated engines found on a vessel (with, perhaps, the exception of the emergency generator). Otherwise, engines, whether two- or four-stroke, are likely to be turbocharged, meaning that the exhaust gases are used to power an air compressor. You could power the air compressor mechanically, but the exhaust gas is “free”. If you increase the amount of air into the cylinder then you increase the amount of oxygen and if you increase the oxygen then you can burn more fuel. By burning more fuel you get an increase in power and/or you can reduce the size of the engine (an important element in that this means you can carry more freight).

Conclusion

Today, a century after their introduction, diesel engines predominate in powering merchant vessels. However, in those 100 years many types of engines have come and gone. Whether, in another 100 years, diesels will still be powering the majority of the world’s vessels remains to be seen. What is not so uncertain is that goods will still be traded by sea.

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