- ✓ High output;
- ✓ Compact dimensions;
- ✓ Low weight;
- ✓ High torque;
- ✓ Low noise and vibrations;
- ✓ Low emission;
- ✓ Low lube oil consumption;
- ✓ Low maintenance;
- ✓ Rapid on-site engine module change-out;
- ✓ Rapid engine exchange.

6.2 Advantages of Marine Aero-derivative Gas Turbines:-

6.2.1 Operation:

- ➢ Gas turbines do not emit black smoke during transient loads;
- ➢ Gas turbines pick up load very rapidly, at a rate of about 1 MW per second;
- ➢ Turbines are "hands-off" machines, if the control system does not indicate any problems, it does not need any maintenance activity. During start-up, operation and shut-down, the gas turbine is operated through the turbine control system, which controls fuel management, but also monitors turbine condition. If any parameter exceeds pre-set limits, the turbine control system will give and alarm and reduce turbine load to avoid damage. In case of serious problems, the control system will shut down the engine.

6.2.2 Maintenance:

- ➢ Gas turbine control system monitors engine performance and condition "on-line";
- ➢ "On-condition" maintenance avoids unnecessary scheduled maintenance, replace what needs to be replaced;

- Modular gas turbine construction allows for rapid exchange of engine modules, avoiding lengthy on-site repairs;
- Gas turbine size and weight allows for a complete engine change-out on-site within hours, without dry-docking or extended stays in port;
- Gas turbine and spares can be air freighted worldwide.

6.2.3 Reliability and availability:

- Aero-derivative gas turbines provide the very high reliability (> 99.5%) and availability (97.5%) associated with aero engines;

6.2.4 Environment:

- Low NOx and SOx emissions;
- Low particulates emission;
- No visible smoke during transient loads;
- No fuel sludge from heavy fuel oils.

6.2.5 Noise and vibration:

- Gas turbines are rotary machines, inherently low structure borne noise;
- Gas turbines packages feature an acoustic enclosure, reducing engine room noise levels and improving the quality of the working environment in the engine room;
- Resilient package mounting reduces structure borne noise even further;
- High pitched air borne noise is easily attenuated;
- Lower investment in air borne and structure borne noise insulation.

6.2.6 Vessel design:

- Low weight and compact dimension of gas turbine and ancillary systems allows design freedom in terms of location of engine room in the vessel;
- Smaller engine room leaves more space for revenue making purposes;
- Low weight allows the engine room to be moved away from the bottom of the vessel;
- Low noise and vibration levels improve crew and passenger comfort, allowing engine room spaces to be located closer to accommodation areas;

6.2.7 Propulsion plant design:

- Gas turbines have exhaust gas mass flow and temperature, which makes exhaust gas heat recovery both technically and economically feasible.

6.2.8 Installation:

- Gas turbine, control system and ancillaries are packaged on skids, ready for installation in the building blocks in the shipyard, speeding up the construction process;
- Gas turbine package with ancillaries are factory tested, reducing commissioning time in the shipyard;
- Gas turbine packages and ancillaries are assembled in the factory by specialized personnel, avoiding assembly problems and delays in the shipyard;
- Gas turbines are air cooled, eliminating the need for elaborate high and low temperature cooling water systems;
- Gas turbine lube oil is not exposed to the combustion process, resulting in very low lube oil consumption and eliminating the need for extensive lube oil conditioning systems;
- Gas turbines operate on MDO, obviating the need for fuel bunker heating, fuel line tracing and fuel conditioning systems

6.3 Disadvantages of Marine Aero-derivative Gas Turbines:-

6.3.1 Thermal efficiency:

- Gas turbine thermal efficiency is lower than the thermal efficiency of comparable diesel engines. Thermal efficiency of aero derivative gas turbines in the 20 - 30 MW class ranges from 36.5 to 40%. This makes the single cycle fuel consumption of a gas turbine about 20% higher than that of a caparable diesel engine;
- Gas turbine thermal efficiency is proportional to gas turbine output. Thermal efficiency of small gas turbines, in the 2 - 5 MW class, hardly exceeds 30%;

6.3.2 Liquid fuel quality restrictions:]

- Gas turbines can operate on either gaseous fuel or liquid fuel or both simultaneously, without any restriction in the ratio between fuels. However there are some severe restrictions on the quality of the liquid fuel. Vanadium and sulfur content should be kept within the specified limits in order to avoid high temperature corrosion of the turbine blades, which leads to loss of engine performance. In practice, the fuel specification completely rule out the use of any residual fuel and the cheaper distillates as well. ISO 8317-1996 Class F Marine Fuels MDO-DMA and DMX are suitable, but DMA might be a bit high on Sulfur.

6.3.3 Initial investments:

- Initial investment for a gas turbine engine in the 20 - 30 MW class is approximately 15 - 20% higher than in diesel engines of comparable output. For smaller gas turbines, especially derivatives of helicopter engines, the price difference is even higher;

All the above reasons might spell doom for many a marine gas turbine project. An rightly so, if the advantages do not offset the disadvantages of the use of gas turbines, the vessel will be an economic disaster. When the first series of gas turbines for cruise vessels were contracted in the late 1990s, some people temporarily lost their sense of perspective. All kinds of projects traditionally featuring diesels as prime movers, were suddenly re-engined with gas turbines of all makes and sizes. None of them made it through the project phase. Many of these projects failed because of the low thermal efficiency of smaller gas turbines. Even projects involving large gas turbines failed, mainly because of the high specific fuel consumption of the gas turbine and high fuel cost. With residual fuels usually being between USD. 60 and USD. 100 cheaper per ton than MDO and diesels being 20% more fuel efficient, single cycle gas turbines have a hard time competing.

6.4 Gas Turbine Myths and Misunderstandings

In the marine community there are still a lot of myths and misunderstandings about gas turbines.

Myth:
Gas turbines have very low torque and cannot be used in mechanical drive applications.

Fact:
Gas turbines can develop a very high torque, because the gas generator is aero-dynamically coupled to the free power turbine. This allows the gas generator to spin up even when the free power turbine is stationary because moment of inertia of the propeller. When the gas generator develops sufficient air flow, the torque of the free power turbines overcomes the inertia of propeller.

Myth:
Gas turbines are unable to take instant load application.

Fact:
The design of the gas turbine, with the gas generator aero-dynamically coupled to the free power turbine, lends itself very well to instant application of heavy loads, which occur when a generator suddenly trips off-line. The speed of the

free power turbine might drop momentarily, but the gas generator will generate sufficient airflow to correct free power turbine speed almost instantly.

Myth:

Gas turbines only run on jet fuel.

Fact:

Gas turbines are perfectly happy to run on any liquid fuel available, as long as the combustion properties are all right. Technically it is possible to burn well seperated residual fuels. However, commonly available residual fuels have high contents of Sulfur, Vanadium and alkali metals. The marine liquid fuel specifications of the gas turbine manufacturers have been compiled to ensure satisfactory hot section replacement intervals. Distillate fuels, such as MDO DMX and DMA (ISO-8217:1996(E), Category ISO-F) are acceptable, provided the Sulfur content is below 1.0%. Higher Sulfur and alkali metals content will reduce hot section lifetime accordingly. Vanadium content is given as 0.5 ppm maximum to reach a satisfactory lifetime. Higher Vanadium content will accellerate high temperature corrosion of the turbine blades. The replacement cost of a prematurely worn hot section will definitely offset the gains of using non-compliant fuels.

6.5 Marine Gas Turbine Applications

There are indeed some commercial marine applications in which gas turbines perform very well:

Fast ferries:

Low weight and small size of gas turbines, as well as simple arrangement of ancillary systems, leave more space for revenue making purposes;
High gas turbine output makes it possible to satisfy high speed required. In some cases one fast ferry can replace two conventional ferries.

Cruise vessels:

- Combined cycle operation reduces specific fuel consumption to more competitive levels. Usually one gas turbine can service the power requirements of the entire vessel;
- Lower engine room space requirements allow for an increase in passenger capacity within the same dimensions;
- Low noise and vibration enhance passenger comfort;
- No visible smoke makes operations in Alaskan water possible;
- Low NOx and SOx emissions allow operations in environmentally sensitive areas.

CHAPTER 7

GAS TURBINE ELECTRIC DRIVE LNG CARRIER

The gas turbine electric drive power plant is the power plant that allows most flexibility in the design and layout of the vessel. The gas turbine drives the propeller shaft by way of an electric shaft. This arrangement allows the gas turbine generator power plant to be located away from the tank top. In this case, the power plant is housed in the superstructure, located over the mooring winch deck. The engineroom size can therefore be reduced substantially, increasing cargo capacity by approximately 19,000 cubic meter. The traditional LNG carrier hull can be maintained, to minimize redesign costs.