Air-independent Propulsion

Any maritime propulsion system that permits a non-nuclear submarine to function without exposure to atmospheric oxygen (by surfacing out or by utilising a snorkel) is known as an air-independent propulsion (AIP), or air-independent power. Non-nuclear submarines can use AIP to supplement or substitute their diesel-electric propulsion technologies. Newer non-nuclear vessels may be more stealthy than nuclear submarines; while some newer submarine reactors depend on naturally circulating coolant, most other naval nuclear reactors utilise pumps to circulate the core coolant on a continuous basis, creating some noticeable noise. Non-nuclear submarines that operate on battery systems or AIP, on the other side, may be almost completely quiet.

About AIP Technology

- AIP is often used as a backup supply, with surface propulsion handled by a standard diesel engine. The majority of these systems produce energy, which is then used to power an electric engine or recharge the vessel's batteries.
- By installing an extra hull segment, AIP may be integrated into preexisting submarine hulls.
- The AIP system doesn't generally have the endurance or energy to substitute atmospheric propulsion, but it does allow for deeper submersion than a traditionally driven submarine.

Types of Air-independent Propulsion Systems

Following are the different kinds of air-independent propulsion (AIP) technology systems that have traditionally been used and are currently in operation in different countries around the world:

- **Open-cycle systems**
  Submarines which employ concentrated hydrogen peroxide as a source of oxygen below the water surface. They utilised steam turbines, which used steam heated by diesel fuel in a water vapour/oxygen environment generated by a potassium permanganate catalyst decomposing hydrogen peroxide.
- **Closed-cycle diesel engines**
  This technique makes use of a submarine diesel engine that can be used on the surface but could also be supplied with oxidant, which is typically kept as liquid oxygen, whilst underwater. Because pure oxygen can scorch the metal inside an engine, the oxygen is normally mixed with recovered engine exhaust gas. Whenever the engine starts, argon substitutes the exhaust gas.
- **Closed-cycle steam turbines**
  It's basically a reworked nuclear propulsion technology that uses ethanol and oxygen to create heat. A standard steam turbine power facility, for example, is operated by steam produced at a pressure of sixty atmospheres from the burning of ethanol and compressed oxygen. Without the need of an emission compressor, carbon dioxide from the exhaust may be released overboard at any depths.
- **Stirling cycle engines**
  An additional Stirling engine burns liquified oxygen as well as diesel oil to power the electricity generators, which can be used for propulsion or battery charging.
- **Fuel cells**
  A technology that converts chemical energy from a fuel as well as an oxidizer into electrical energy. Fuel cells are distinguished from batteries in that it requires a constant supply of fuel

(like hydrogen) and oxygen, both of which must be carried in pressurised tanks inside the submarine to keep the chemical reaction going on.

- **Nuclear power**
  The terminology "air-independent propulsion" is usually associated with increasing the effectiveness of traditionally driven vessels. Nuclear power, on the other hand, fits under the technical definition of AIP as an additional power source.

DRDO's AIP Technology

DRDO's Naval Materials Research Laboratory (NMRL) is developing the technology. It uses a Phosphoric Acid Fuel Cell as its foundation. Many non-nuclear vessels can operate without using atmospheric oxygen because of this advancement in marine propulsion systems. This is accomplished via snorkelling or surfacing. India employs a fuel-based AIP technology, which is special in that hydrogen is produced onboard. With the help of industry collaborators L&T as well as Thermax, this solution is being successfully implemented. Towards 2023, Kalvari will be modernised.