Technical Review of Nuclear Technology as the Advanced Ships Propulsion

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ABSTRACT--- ***Advance Ships Propulsion Nuclear Technology as The Answered. With the development of technology, the need for breakthrough in the of Maritime, especially the advance ship propulsion. Results : There have been more reactor concepts investigated in the naval propulsion area by different manufactures and laboratories than in the civilian field, and much can be learned from their experience for land applications. Conclusion: For these two considerations, it is recognized that a nuclear reactor is the ideal engine for naval advanced propulsion***

Keywords--- Advanced ship propulsion, diesel engine as an prime mover, nuclear technology

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1. INTRODUCTION

Marine transport has generally been seen as having a lower environmental impact than other forms of transport. The increasing demand for economical yet rapid movement of both passengers and freight has brought renewed momentum to the development of marine propulsion systems. New technologies are aiding the production of propulsion systems that are capable of driving vessels at higher speeds; that are more efficient; that provide better maneuverability; and are quieter, with less vibration. Here, the latest developments in marine propulsion are brought into focus [1].

Mechanical transmission from energy source to thruster, e.g. animal power, wind energy. Steam engine, an external combustion engine, working in a Rankine cycle, with water as working fluid, used in practically all ships in the 19th century, initially with reciprocating pistons and later with turbines (the first in 1897 with the Turbinia steamer), and on a few vessels since then (in some very large ships, and in nuclear submarines [2].

Diesel engine, an internal combustion engine (ICE), working in a Diesel cycle, using marine diesel or heavy fuel oil, and used in most ships since 1930s. Diesel engines were limited in power for many decades, but nowadays there are no limit in practice[2]. Gas turbine, an internal combustion engine, working in a Brayton cycle, derived from aviation turbines, able to burn marine diesel, kerosene, or jet fuel, are used in some fast ships (e.g. hydrofoils), warships (for quick action), and large cruisers[3]. LNG engine, an internal combustion engine working in a Diesel cycle, using liquefied natural gas (LNG) as main fuel, sometimes working in dual-fuel mode with partial marine-diesel injection [3-29].

Gasoline engines (ICE) are used in small outboard motors. Electric motors, used alone to convert an electrical source (e.g. batteries, photovoltaic panels) to mechanical work, or used as an intermediate conversion energy (jointly with an electrical generator), between diesel engines and propellers [3].

Force on the sail with water forces on the keel and rudder, and tacking (i. E following a zigzag course). Secrew propellers by far the most used, either in bronze, stainless steel, of fiber reinforced polymers for small duties. Different types are : Fixed pitch propeller, variable pitch proppeler, ducted propeller, azimuth propeller. Water jets used in some fast ships, either powered by gas turbines or by diesel engines [1] .

Diesel engine as an prime mover, concerning development trends of marine propulsion plants, in the future the following can be found : Natural gas will be commonly used as marine fuel, Central on board electric power station will dominate as seagoing ship engine room configuration, Natural gas fuelled medium speed diesel engines with mechanical gear will be used on smaller ships, Natural gas fuelled, spark ignited engines will replace and dual fuel diesel engines, Natural gas fuelled combined turbine energetic plants with electric gear will be used on large ships, Computerized engine room control systems will be commonly used on seagoing ships [30].

Mechanical shaft, supported and kept aligned by the spring bearings, the stern tube bearings, and the strut bearing.Thrust is transmitted to the ship at the axial thrust bearings [3].

The type of ship propulsion plant, which can be used in the future, will effect on the course of marine energetic plants development. The development of hybrid propulsion, electric propulsion, diesel engines fuelled with natural gas and turbine propulsion driven by natural gas. The paper includes proposal of combined turbine propulsion plant fuelled with natural gas, which according to authors can be leading type of marine propulsion plants in the future the standard propulsion system in submarines is diesel-electric [30].

Several trends may end up shaping the future of naval ship technology, the all electrical ship, stealth technology, Unmanned Aerial Vehicles (UAVs), water jet propulsion, littoral vessels and moored barges for power production. The all electric ship propulsion concept was adopted for the future USA surface combatant power source. This next evolution or Advanced Electrical Power Systems (AEPS) involves the conversion of virtually all shipboard systems to electric power, even the most demanding systems, such as propulsion and catapults aboard aircraft carriers. It would encompass new weapon systems such as modern electromagnetic rail guns and free electron lasers as well as flywheel and super capacitors energy storage systems [31].

Advance ship propulsion, sea transport has been the largest carrier of freight all throughout history because it is the cheapest way (passenger transport was taken over by aviation because the saved time was more valued). The term watercraft covers a range of different vehicles including ships, boats, hovercraft, submersibles, and submarines. A boat is a vessel small enough to be carried aboard another larger vessel (a ship) [3].

The continuing internationalization of trade and production, combined with increasing congestion on land and in the air, is generating interest in novel concepts for fast cargo and passenger vessels. In the naval arena, a requirement for rapid force deployment capability, while avoiding the need to station troops close to sensitive areas, is providing further stimulus and funding for fast vessel developments [1].

Natural gas is a feasible substitute for current marine fuels with low emissions to air. When the shipping sector considers its options to comply with current and planned restrictions on environmental grounds natural gas, in particular as Liquefied Natural Gas (LNG), promises solutions with few technical obstacles, but with a number of logistical and economical challenges to overcome. The drive toward mechanisms to decrease emissions to air is borne out of the limits and timelines set in International Maritime Organisation (IMO) MARPOL Annex VI. The reductions are further accelerated in Sulphur Emission Control Areas (SECAs) [32].

Natural gas as propulsion fuel in ships: Advantages: provide solution to present air emission challenges, barriers: capital investments large, synergies: developments in Norway and Baltic Sea area Economy: positive case for operation for large consumers, future: develop bunkering options for short sea shipping and LNG [32].

Propulsion technology in ships is mature and proven, Distribution network not yet developed for use in ships, Safety concerns are demanding but manageable, can enter existing bunkering value chain [32].

Nuclear technology, nuclear energy has been used to power warships since the mid-fifties. It operates similar to power station reactor, the heat generated by a nuclear reactor is used to raise steam to drive a turbine. The turbine can drive the ship directly or be used to generate electricity to drive the prop shaft[7]. The warships of many of the world's navies are powered by nuclear energy, normally provided by a Pressurized Water Reactor (PWR) [33-36].

Table 1. Composition of highly enriched fuel for naval and space reactors design [31]

Isotope	Composition (percent)	Activity (curies)	Decay Mode	Exposure Contribution (μR/hr)
U^{234}	0.74	6.1	Alpha decay	Unappreciable
U^{235}	97.00		Decay gammas	Appreciable
U^{238}	2.259		Spontaneous fissions	Appreciable
Pu^{239}	0.001		Alpha decay	Unappreciable
Total		6.5		19.9

At this point the submarine had to resurface to recharge its batteries and become vulnerable to detection by aircraft and surface vessels[5]. Even though special snorkel devices were used to suck and exhaust air to the submarine shallowly submerged below the water's surface, a nuclear reactor provides it with a theoretical infinite submersion time. In addition, the high specific energy, or energy per unit weight of nuclear fuel, eliminates the need for constant refueling by fleets of vulnerable tankers following a fleet of surface of subsurface naval vessels. On the other and, a single refueling by fleets of vulnerable tankers following a fleet of surface or subsurface naval vessels. On the other hand, a single refueling of a nuclear reactor is sufficient for long intervals of time [31].

The higher power density decrease not only size but also enhances quiet operation through the elimination of bulky control and pumping equipment. It would be superior to any Russian design from the perspective of noise reduction capability, with 30 units planned to be built [31].

Tabel 2. Power Ratings of Naval Reacor [31]

Reactor Type	Rated power	
	Shaft horse power, (shp)	(MW)*
A2W	35.000	26.1
A4W/AIG	140.000	104.4
C1W	40.000	29,8
D2G	35.000	26.1
S5W	15.000	11.2
S5G	17.000	12.7
S6W	35.000	26.1
S8G	35.000	26.1
S9G	40.000	29.8

*1shp = 745.6999 Watt = 0.7456999 kW

The heat generated in nuclear reactors is used to raise steam to drive steam turbines. The turbine can either drive the ship's shafts through a gearbox, or use the electrical power to drive the propeller shaft [33, 36]. Large submarines use nuclear energy because of its high power output coupled with the length of time between refueling. These submarines are able to cruise around under the world's oceans without surfacing for many months. Other naval ships such as cruisers and aircraft carriers are also powered by nuclear energy [33]. Size, weight, and operations influence a ship's demand for power as well as the propulsion plant and fuel that supply the power. For example, a Nimitz-class carrier, weighing nearly 100,000 tons, requires far more shaft horsepower from its propulsion plant than is necessary for a submarine or surface ship that weighs about 8,000 tons. Similarly, there is a difference in the amount of nuclear fuel that is burned. We calculated the weighted average for each nuclear ship's demand for power, as measured by: shaft horsepower requirements and uranium burn [33].

Nimitz-class carrier's demand for power is about equal to that of eight SSN-688s. Nuclear carriers accounted for about 35 percent of the nuclear power used by the fleet and are expected to account for nearly 60 percent by 2015 based on current force plans [37].

Nuclear power is particularly suitable for vessels which need to be at sea for long periods without refuelling, or for powerful submarine propulsion. Over 140 ships are powered by more than 180 small nuclear reactors and more than 12,000 reactor years of marine operation has been accumulated, Most are submarines, but they range from icebreakers to aircraft carriers. In future, constraints on fossil fuel use in transport may bring marine nuclear propulsion into more widespread use. So far, exaggerated fears about safety have caused political restriction on port access. Work on nuclear marine propulsion started in the 1940s, and the first test reactor started up in USA in 1953. The first nuclear-powered ubmarine, USS Nautilus, put to sea in 1955. This marked the transition of submarines from slow underwater vessels to warships capable of sustaining 20-25 knots submerged for weeks on end. The submarine had come into its own. Nautilus led to the parallel development of further (Skate-class) submarines, powered by single pressurised water reactors, and an aircraft carrier, USS Enterprise, powered by eight Westinghouse reactor units in 1960. A cruiser, USS Long Beach, followed in 1961 and was powered by two of these early units. Remarkably, the Enterprise remained in service to the end of 2012. By 1962 the US Navy had 26 nuclear submarines operational and 30 under construction. Nuclear power had revolutionised the Navy. The technology was shared with Britain, while French, Russian and Chinese developments proceeded separately. After the Skate-class vessels, reactor development proceeded and in the USA a single series of standardised designs was built by both Westinghouse and GE, one reactor powering each vessel. Rolls Royce built similar units for Royal Navy submarines and then developed the design further to the PWR-2. Russia developed both PWR and lead-bismuth cooled reactor designs, the latter not persisting. Eventually four generations of submarine PWRs were utilised, the last entering service in 1995 in the Sever odvinsk class. The largest submarines are the 26,500 tonne (34,000 t submerged) Russian Typhoon-class, powered by twin 190 MWt PWR reactors, though these were superseded by the 24,000 t Oscar-IIclass (eg Kursk) with the same power plant. The safety record of the US nuclear navy is excellent, this being attributed to a high level of standardisation in naval power plants and their maintenance, and the high quality of the Navy's training program. However, early Soviet endeavours resulted in a number of serious accidents

– five where the reactor was irreparably damaged, and more resulting in radiation leaks. There were more than 20 radiation fatalities. Nevertheless, by Russia's third generation of marine PWRs in the late 1970s safety and reliability had become a high priority. (Apart from reactor accidents, fires and accidents have resulted in the loss of two US and about 4 Soviet submarines, another four of which had fires resulting in loss of life.) he K-19 accident at sea in 1961 due to cooling failure in an early PWR resulted in 8 deaths from acute radiation syndrome (ARS) in repairing it (doses 7.5 to 54 Sv) and possibly more later as well as many high doses. The K-27 accident at sea in 1968 also involved coolant failure, this time in an experimental lead-bismuth cooled reactor, and 9 deaths from ARS as well as high exposure by other crew. In 1985 the K-431 was being refuelled in Vladivostok when a criticality occurred causing a major steam explosion which killed 10 workers. Over 200 PBq of fission products was released causing high radiation exposure of about 50 others, including ten with ARS. loyd's Register shows about 200 nuclear reactors at sea, and that some 700 have been used at sea since the 1950 [33, 35, 36].

Nuclear Naval Fleets, Russia built 248 nuclear submarines and five naval surface vessels (plus 9 icebreakers) powered by 468 reactors between 1950 and 2003, and was then operating about 60 nuclear naval vessels. At the end of the Cold War, in 1989, there were over 400 nuclear-powered submarines operational or being built. At least 300 of these submarines have now been scrapped and some on order cancelled, due to weapons reduction programmes. Russia and the USA had over 100 each in service, with the UK and France less than 20 each and China six. The total today is understood to be about 120, including new ones commissioned. Most or all are fuelled by high-enriched uranium (HEU) [35, 36].

India launched its first nuclear submarine in 2009, the 6000 dwt Arihant SSBN, with a single 85 MW PWR fuelled by HEU (critical in August 2013) driving a 70 MW steam turbine. The INS Aridaman SSBN is under construction at the Ship Building Centre in Visakhapatnam, and was due to be launched in 2015. Another six SSBN twice the size of Arihant class and six nuclear SSNs powered by a new reactor being developed by BARC are planned, the latter being approved by government in February 2015. They will be similar size to Arihant class SSBN. India is also leasing an almost-new 7900 dwt (12,770 tonne submerged) Russian Akula-II class nuclear attack submarine for ten years from 2010, It has a single 190 MWt VM-5/ OK-659B PWR driving a 32 MW steam turbine and two 2 MWe turbogenerators [33].

The USA has the main navy with nuclear-powered aircraft carriers, while both it and Russia have had nuclear-powered cruisers (USA: 9, Russia 4). The USA had built 219 nuclear-powered vessels to mid 2010, and then had five submarines and an aircraft carrier under construction. All US aircraft carriers and submarines are nuclear-powered. (The UK's new large aircraft carriers are powered by two 36 MW gas turbines driving electric motors) [33]. Late in 2014 the US Navy had 86 nuclear-powered vessels including 75 submarines [35].

The Russian Navy has logged over 6000 nautical reactor-years. It appears to have eight strategic submarines (SSBN/SSGN) in operation and 13 nuclear-powered attack submarines (SSN), plus some diesel subs. Russia has announced that it will build eight new nuclear SSBN submarines in its plan to 2015 [36].

The TYPHOON class at a 25.000 tons displacement twice the size of the DELTA III with a length of 170 m and tubes carrying the SS-NX-20 missile each with 12 RVs, has even greater range at 8,300 kms, higher payload, better accuracy and more warheads. Figure 1 shows the known Russian nuclear Ballistic submarines and their missile system [31].

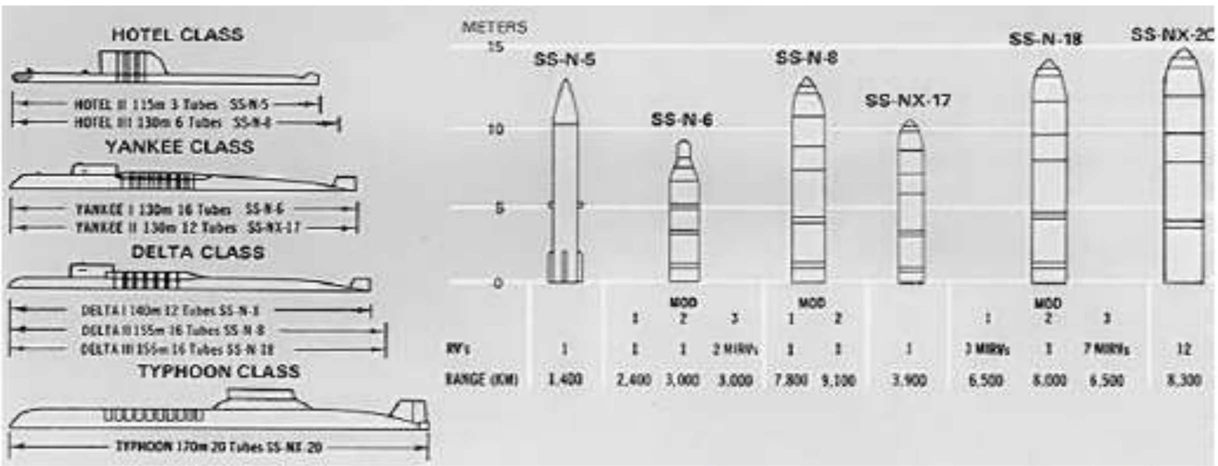


Figure 1. Russian Nuclear Ballistic Missile Submarines and their missile characteristics

The icebreaker Lenin, launched in 1975 was the word's first civilian vessel to be propelled by nuclear power. It was commissioned in 1965 and retired from service in 1989. Eight other one container ship. The nuclear icebreaker Yamal, commissioned in 1993, is the most recent nuclear powered vessel to the fleet as shown in Table 3 [31].

Tabel 3. Russian civilian ice breaks operated by the Murmansk Shipping Company

Ice Breaker	Lunch/Decommisioning Dates	Class or Type
Lenin	1959 / 1989	Ice breaker
Arktika	1975	Arktika
Sibir	1977	Arktika
Rossiya	1985	Arktika
Sevmorput	1988	Container ship
Taimyr	1989	River icebreaker
Sovyetskiy	1990	Arktika
Soyuz	-	Soyuz
Vaigach	1990	River icebreaker
Jamal	1993	Arktika

China has sabout 12 nuclear-powered submarines (7 SSN, 4-5 SSBN), and isn February 2013 China Shipbuilding Industry Corp received state approval and funding to begin research on core technologies and safety for nuclear-powered ships, with polar vessels being mentioned but aircraft carriers being considered a more likely purpose for the new development. Its first nuclear powered submarine was decommissioned in 2013 after almost 40 years service [36].

France has a nuclear-powered aircraft carrier and ten nuclear submarines (4 SSBN, 6 Rubis class SSN). The UK has 12 submarines, all nuclear powered (4 SSBN, 8 SSN) [33].

Three trends are shaping the future of naval ship technology, the all electrical ship, stealth technology and littoral vessels [31]. The all electric ship propulsion concept was adopted from the propulsion system of cruise ships for the future surface combatant power source. It would encompass new weapon system such as modern electromagnetic rail guns and lasers under development [38].

Planned as an all electric ship is the CVN-21 next generation USA Navy aircraft carrier, scheduled for launch around 2011-2013 to replace the then half century old USS enterprise CVN 65 [31].

The CVN-21’s new nuclear reactor not only will provide three times the electrical output of current carrier power plants, but also will use its integrated power system to run an Electro Magnetic Aircraft Launch System, EMALS to replace the current steam-driven catapults. Combined with an electromagnetic aircraft launch and recovery operations consistently with system recovery or maintenance downtime [31].

To store large amounts of energy of energy, flywheels, large capacitor bank or other energy storage system would have to be used [39].

A typical ship building experience involved the design conversion of class of submarines to an all electric design. The electric drive reduced the propulsion drive size and weight, eliminating the mechanical gearbox. However the power system required extensive harmonic filtering to eliminate harmonic distortion with the consequence that the overall vessel design length increased by 10 feet [2].

Test have been conducted to build stealth surface ships on the technology developed for the F-117 Nighthawk stealth fighter. The first such system was build the USA Navy as “The Sea Shadow” [31].

Civil Vessels Nuclear propulsion has proven technically and economically essential in the Russian Arctic where operating conditions are beyond the capability of conventional icebreakers. The power levels required for breaking ice up to 3 meters thick, coupled with refueling difficulties for other types of vessels, are significant factors. The nuclear fleet, with six nuclear icebreakers and a nuclear freighter, has increased Arctic navigation from 2 to 10 months per year, and in the Western Arctic, to year-round [37].

The icebreaker Lenin was the world's first nuclear-powered surface vessel (20,000 dwt), commissioned in 1959. It remained in service for 30 years to 1989, and was retired due to the hull being worn thin from ice abrasion. It initially had three 90 MWt OK-150 reactors, but these were badly damaged during refueling in 1965 and 1967. In 1970 they were replaced by two 171 MWt OK-900 reactors providing steam for turbines which generated electricity to deliver 34 MW at the propellers. Lenin is now a museum [33].

Water jets constitute a simple and reliable propulsion system, with the pump impeller turning at a constant speed and flow in one direction. The engine loading is constant and in most cases a gearbox is not required. The entire propulsion system receives less stress and requires less maintenance [40].

Water jets have plenty of pickup, can sustain high speed operations, but can stop on easily by receiving the thrust. They are responsive and ideal for precise maneuvering or station keeping. They can be used in very shallow water and there is no screw that gets fouled [40].

It led to a series of larger icebreakers, the six 23,500 dwt Arktika class, launched from 1975. These powerful vessels have two 171 MWt OK-900A reactors delivering 54 MW at the propellers and are used in deep Arctic waters. The Arktika was the first surface vessel to reach the North Pole, in 1977. Rossija, Sovetskiy Soyuz and Yamal are in service (launched 1985, 1990, 1992 respectively),wth Sibir and Arktika decommissioned in 1992 and 2008. Soyuz has been in reserve but is being restored for service from 2017. Nominal service life is 25 years, but Atomflot commissioned a study on Yamal, and confirmed 30-year life for it. Atomflot has a service life extension program to take them up to 175,000 - 200,000 ours. Arktika class are 148 m long and 30 m wide, and designed to break 2 metres of ice [31].

The seventh and largest Arktika class cebreaker – 50 Years of Victory (50 Let Pobedy)-was built by the Baltic shipyard at St Petersburg and after delays during construction it entered service in 2007 (twelve years later than the 50-year anniversary of 1945 it was to commemorate). It is 25,800 dwt, 160 m long and 20m wide, and is designed to break through ice up to 2.8 metres thick. Its propulsive power is about 54 MW. Its performance in service has been impressive [31].

For use in shallow waters such as estuaries and rivers, two shallow-draft Taymyr-class icebreakers of 18,260 dwt with one 171 MWt KLT-40M reactor delivering 35 MW propulsive were built in Finland and then fitted with their nuclear steam supply system in Russia. They – Taymyr and Vaygach – are built to conform with international safety standards for nuclear vessels and were launched in 1989 and 1990 respectively. They are 152 m long and 19 m wide, will break 1.77 metres of ice, and are expected to operate for about 30 years or 175,000 hours [31].

As new submarine classes achieve ever increasing levels of acoustic quieting and operational performance, tracking submarine has become more difficult. Some modern diesel electric submarines are able to challenge conventional tracking approaches, risking future USA capability in the undersea battle space. This creates the incentive for the anti-submarine Warfare, ASW continuous trail unmanned vessel, ACTUV program [41].

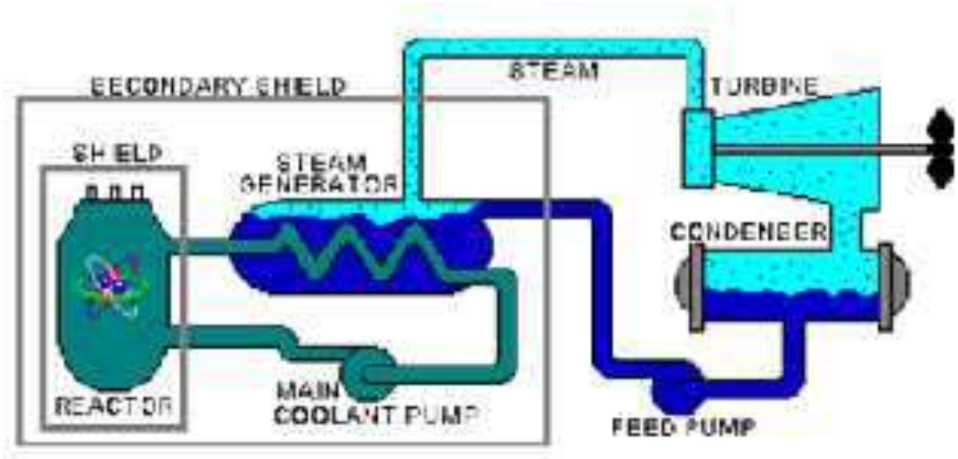
Directed energy weapons deliver large levels of energy on a target in a short period of time. That is to say that they are characterized by high power delivery, in the case of a laser, you high power of coherent photons are used. When a rail-gun is used, it is high kinetic energy delivery with a relatively small metal mass moving at a high speed [42].

Directed energy weapons are also cost-effective against the advent of cheap drones or low cost cruise missiles. Instead of shooting expensive rounds at the cheap drones, with laser and rail gun technology, those shots cost just a few dollars for the electricity generated [31].

The free electron laser is contemplated as a directed weapon system that can replace in the 2020s, the radar-guided Phalanx gun use for close in ship defense and used against rocket and mortar attacks [31].

Lasers require a medium to turn light into a directed energy beam. Solid state lasers use crystal and glass. Chemical lasers use gaseous media and toxic liquid materials. These two types generate the lasers at a specific wave length. The chemical lasers use toxic chemical reactants such as ethylene and nitrogen trifluoride [31].

Free Electron Lasers (FELs) do not need a gain medium and use a stream of energetic electrons to generate variable wave length lasers. An FEL system can adjust its wavelength for a variety of task and to cope with different environmental conditions. It can it can also run from a vessel's electrical power supply rather than its own and does not need to stop and reload. Such a system for naval vessel needs to have a power of 100 kW. More than that would be needed to counter anti-ship ballistic missiles [31]. Nuclear propulsion system for ships (Nuclear Ship Propulsion) is a drive system that uses nuclear fuel for energy resulting in heat, while to produce mechanical energy or output power required to turn the propeller used steam turbine [35].



Fugure 2. Indicated Sytem Consisiting of Two Part [35]

In the figure 2 indicated system consisting of two parts, the first "heat energy generation", including the reactor in which the reaction process occurs nuclei releasing some heat energy. The heat energy absorbed by the media / fluid which then flowed into the steam generator or boiler that will turn the water into vapor (steam). Shield and secondary protective shield is a function primarily of safeguards against the negative effects of the reactor, such as radiation and also to isolate the heat generated. While the second part serves to change the heat energy contained in the steam as the working fluid into mechanical energy or power through the expansion process in the turbine. Former steam from the turbine in condensation in the condenser to further channeled back into the steam generator [35, 36].

The figure 3, shows the construction of different systems, that there are two steam turbine units, the first unit to drive the electrical generator, while the second unit to drive the propeller [35].

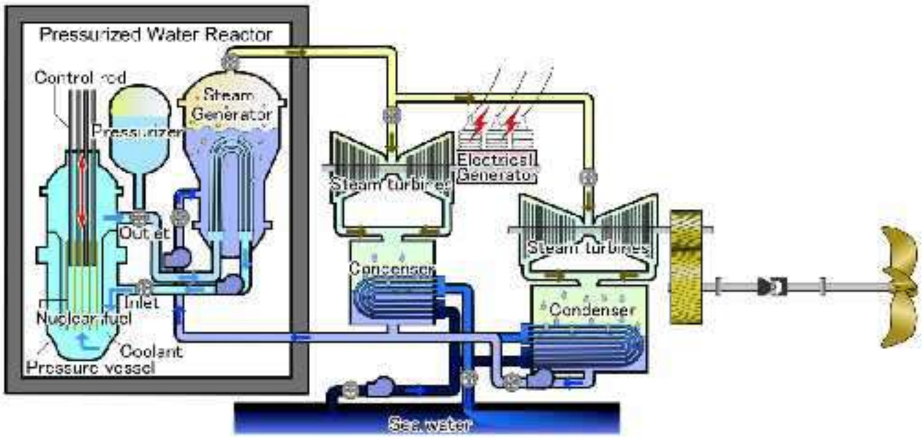


Figure 3, shows the construction of different systems, that there are two steam turbine units [35]

With increasing attention being given to greenhouse gas emissions arising from burning fossil fuels for international air and marine transport, particularly dirty bunker fuel for the latter, and the excellent safety record of nuclear powered ships, it is quite conceivable that renewed attention will be given to marine nuclear powered ships, it is likely that there will be renewed interest in marine nuclear propulsion. The world's merchant shipping is reported to have a total power capacity of 410 GWt, about one third that of world nuclear power plants [42].

In 2014 two papers on commercial nuclear marine propulsion were published* arising from this international industry project led by Lloyd's Register. They review past and recent work in the area of marine nuclear propulsion and describe a preliminary concept design study for a 155,000 dwt Suezmax tanker that is based on a conventional hull form with alternative arrangements for accommodating a 70 MWt nuclear propulsion plant delivering up to 23.5 MW shaft power at maximum continuous rating (average: 9.75 MW). The Gen4Energy power module is considered. This is a small fast-neutron reactor using lead-bismuth eutectic cooling and able to operate for ten full-power years before refueling, and in service last for a 25-year operational life of the vessel [42].

The UN's IMO adopted a code of safety for nuclear merchant ships, Resolution A.491(XII), in 1981, which is still extant and could be updated. Also Lloyd's Register has maintained a set of provisional rules for nuclear-propelled merchant ships, which it has recently revised [31].

Apart from naval use, where frequency of refueling is a major consideration, nuclear power seems most immediately promising for the following: arge bulk carriers that go back and forth constantly on few routes between dedicated ports – eg China to South America and NW Australia. They could be powered by a reactor delivering 100 MW thrust. ruise liners, which have demand curves like a small town. A 70 MWe unit could give base-load and charge batteries, with a smaller diesel unit supplying the peaks. (The largest afloat today – Oasis class, with 100,000 t displacement – has about 60 MW shaft power derived from almost 100 MW total power plant.) Nclear tugs, to take conventional ships across oceans ome kinds of bulk shipping, where speed is essential [42].

The introduction of the PWR concept for nuclear propulsion is credited to Admiral Hyman G. Rickover, who is considered as the father of the USA's nuclear navy [31].

The 60 MWe Shipping port power station, first operated in December 1957 and was the first USA's commercial nuclear power reactor operated by the Duquesne Light Company. It was meant to demonstrate both civilian and nuclear propulsion power application. It was a pressurized water reactor with the first two reactor cores as "seed and blanket" cores. The seed assemblies had highly enriched uranium plate fuel clad in zirconium, similar to naval propulsion cores, and the blanket assembles had natural uranium in the first two core. The last core used Thorium and U233 and demonstrated the possibility of breeding in a thermal neutron spectrum with a breeding ratio of 1.014 with 1.4 percent more produced fissile fuel that consumed. The plant was retired after 25 years of operation [36].

There exist no agreement that would the creation of unmanned submarines, not is there an agreement on the limitation of the power of nuclear weapons. Such a submarine should be a robotic submarine capable of traveling under the water at a large depth, escape from enemy vessels and maintain combat readiness for years [31].

The hull of an unmanned could be made of high strength titanium or titanium alloy. The material would ensure a diving depth of more than 1,000 meters. The biological shielding protection of the reactor on board an unmanned submarine would be decreased considerably. The construction will thus be lighter, whereas the warheads would be more powerful. The size of the submarine can be made smaller in comparison with manned submarines, and the walls of its hull can be thicker, thus increasing the immersion depth to 1,000 – 3,000 meters [31].

Doomsday unmanned submarines would be able to approach the coast of an opponent in strategic areas and rest dormant at the bottom of the seafloor awaiting tringgering. An order via a satellite or deep-sea communication system would cause their simultaneous explosion and tringger giant tsunami waves along the coast [31].

The first "heat energy generation", including the reactor in which the reaction process occurs nuclei releasing some heat energy. The heat energy absorbed by the media / fluid which then flowed into the steam generator or boiler that will turn the water into vapor (steam). Shield and secondary protective shield is a function primarily of safeguards against the negative effects of the reactor, such as radiation and also to isolate the heat generated. While the second part serves to change the heat energy contained in the steam as the working fluid into mechanical energy or power through the expansion process in the turbine. Former steam from the turbine in condensation in the condenser to further channeled back into the steam generator[9] [10]. The different systems, that there are two steam turbine units, the first unit to drive the electrical generator, while the second unit to drive the propeller [35].

CONCLUSIONS

Nuclear propulsion system for ships (Nuclear Ship Propulsion) is a drive system that uses nuclear fuel for energy resulting in heat , while to produce mechanical energy or output power required to turn the propeller used steam turbine.

Naval reactors use high burn-up fuels such as uranium-zirconium, uranium-aluminum, and metal ceramic fuels, in contrast to land-based reactors which use uranium dioxide UO2. These factors provide the naval vessels theoretical infinite range and mission time. For these two considerations, it is recognized that a nuclear reactor is the ideal engine for naval propulsion.

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