SHIP HYDRODYNAMICS

LECTURE NOTES OF PROPULSION

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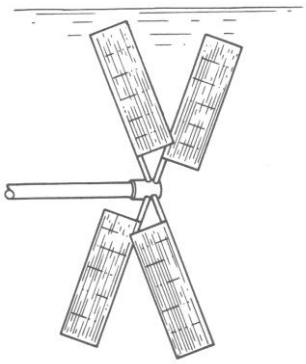
1. PROPULSION SYSTEMS

Propulsion is the act or an instance of driving or pushing forward of a body, i.e. ship, by a propeller (in our case a screw propeller).

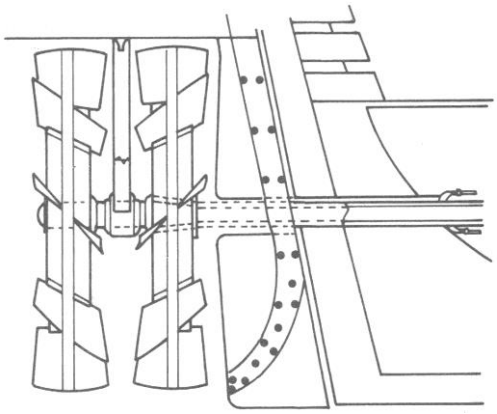
a) History and Development of Screw Propeller

Time period	Inventor
287-212 BC	Archimedes invented his "Archimedean Screw Pumps" to irrigate the field of Syracuse in Sicily.

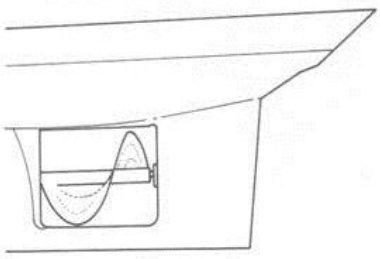
1452-1519	Leonardo da Vinci had sketches of screw principle to use as a helicopter rotor.
1661	Toogood and Hayes of Britain claimed patent for using helical surfaces (Archimedean screws) as a propeller
1680	Hooke the English physicist suggested to use Archimedean screw for ship propulsion



1802/04	C. Steves the American used a kind of screw propeller similar to today's screws to propel a 7.5 m twin screw steamer.
1828	R. Wilson the Scottish farmer successfully demonstrated the first principles
1836	P. Smith, the English farmer achieved the first practical application. He used single bladed screw of two turns made by wood.
1836	J. Ericsson, the Swedish engineer developed fore runner of contra-rotating propeller(i.e. two wheels of three helicoidal blades rotating in opposite direction)



1839	Smith equipped 237 ton of ship Archimedes with screw props having a great success and this led to Paddle propulsion systems to screw propulsion system



1840-1850	Development of steam engines contributed to effective use of screw propellers
1845	Great Britain was the first screw propeller acrossed the Atlantic
1880	Thornycroft designed propellers similar today's propellers
1880-1970	Basic shape of props remained unchanged
1970-1990's	Fuel crisis and environmental effects (low noise and vibrations) had an impact on propeller shape and stern configurations as well as the developments of unconventional propellers

b) Modern Propulsion Systems

i- Fixed pitch propellers (FPP)

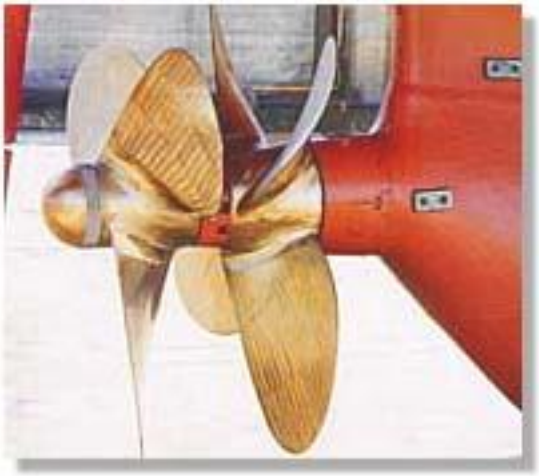
- This kind of propellers has traditionally formed the basis of propeller production.
- They cover the majority proportion of propellers and design types and sizes, ranging from propellers for small powerboats to those for large tankers and bulk carriers.
- It is easy to manufacture.

ii- Ducted propellers

- Ducted propellers consist of two components
  1- An annular duct having an aerofoil cross section
  2- A propeller inside the duct
- The presence of duct would reduce the pressure forces induced on the hull
- This kind of propellers sometimes is referred to as Kort nozzles by way of recognition of the Kort Propulsion Company's initial patents and long association with this type of propeller.
- Propeller efficiency is increased depending upon the propeller loading.
- A duct protects propeller against damage.

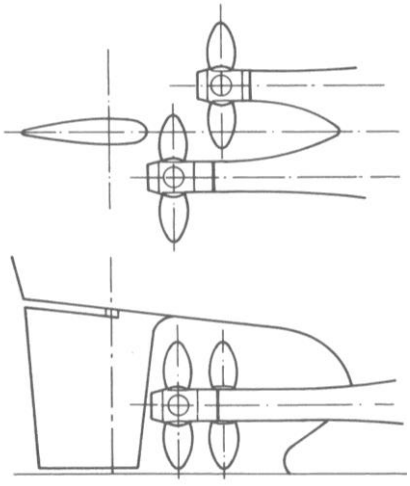
iii- Contra-rotating propellers

- This kind of propellers has two coaxial propellers sited one behind the other and rotating in opposite directions.
- They have the hydrodynamic advantage of recovering part of the slip stream rotational energy which would otherwise be lost to a conventional single screw system. This leads to an energy saving about 15% in power.
- Improved efficiency but higher drag and cost
- It is usually applied to small outboard units operating at around 1500 to 2000 RPM due to the mechanical problems associated with longer line shafting systems of larger vessels.



iv- Overlapping propellers

- Two propellers are not mounted coaxially but are each located on separate shaft systems.
- The system has rarely been used in practice
- Although the propulsion efficiency of this system is higher than a single propeller, this system causes vibration and cavitation

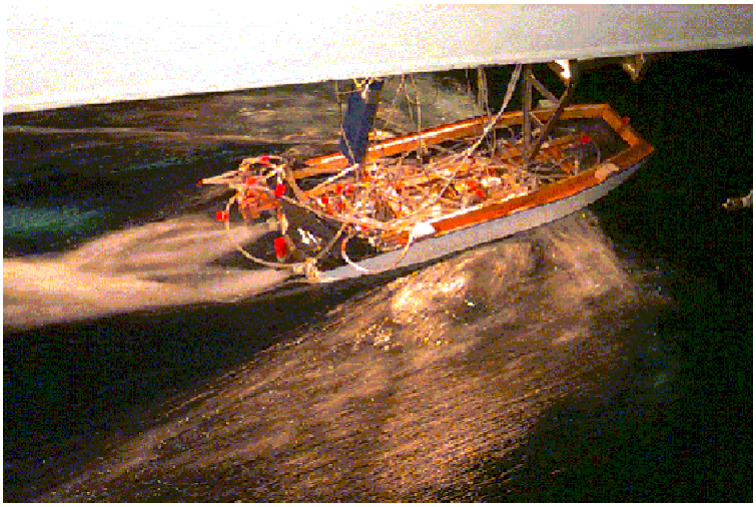


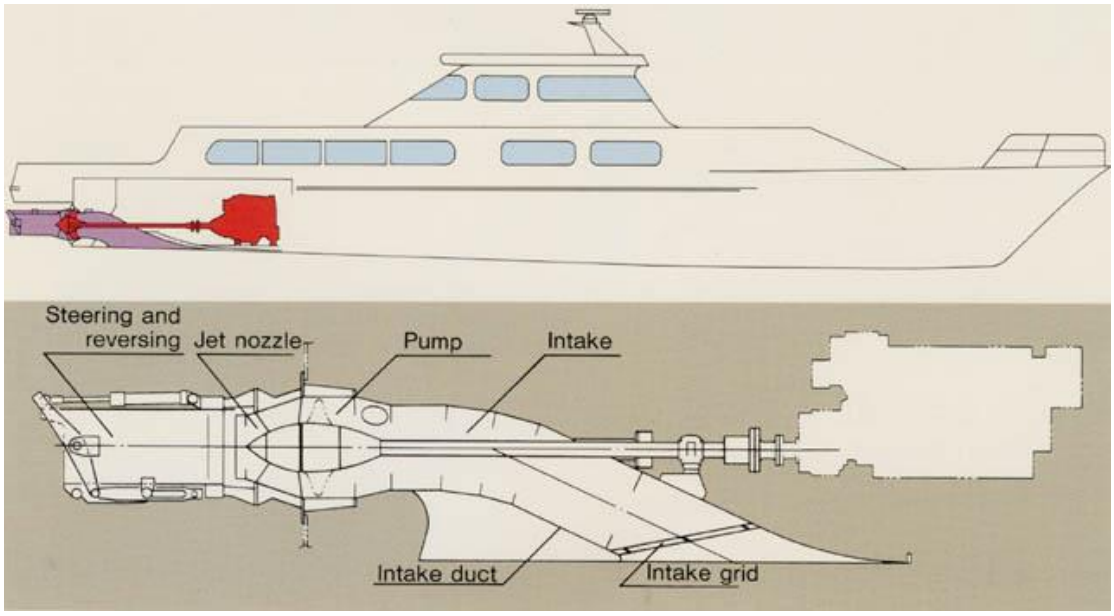
v- Controllable pitch propellers (CPP)

- The choice of a CPP to a FPP is due to flexibility of its control rather than propulsion efficiency at service condition.
- CPP provides an extra degree of freedom in its ability to change blade pitch.
- It is especially used for ferries, tugs, trawlers, and fisheries due to better manoeuvrability than FPPs.
- Manufacturing cost is very high and it requires more maintenance and repairment.

vi- Waterjet propulsion system

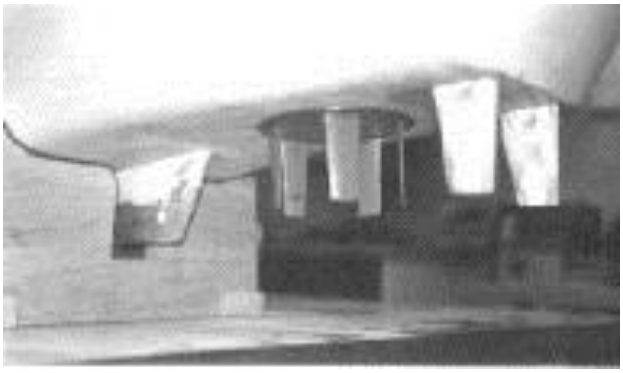
- This system has found considerable application on a wide variety of small high speed craft, although it is also used for larger ships.
- The operation principle of waterjet is that water is drawn through a ducting system by an internal pump adding energy and the water is expelled aft at high velocity. The unit's thrust is primarily generated as a result of momentum increase given in the water.
- The system is preferred to a conventional propeller. Because a conventional propeller experiences cavitation at very high speeds (45 knots), but in the waterjet unit the pump should not cavitate.
- It has a good manoeuvrability

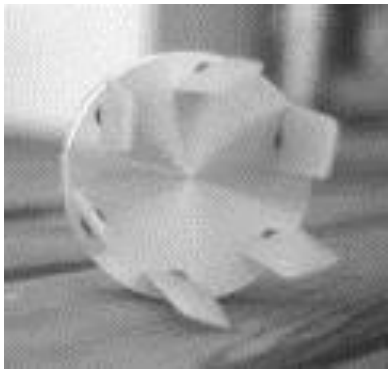




vii- Cycloidal propellers

- The system is also called vertical axis propellers which comprise a set of vertically mounted vanes, six or eight in number, rotating on a disc mounted in a horizontal or near horizontal plane.
- The system has considerable advantages when manoeuvrability or station keeping is an important factor in the ship design.
- A separate rudder installation on the vessel is not required.
- The system provides with guards to help protect the propulsor from damage from external sources.
- Vertical axis propellers are fitted in tugs or other cases where low speed manoeuvrability is desired.



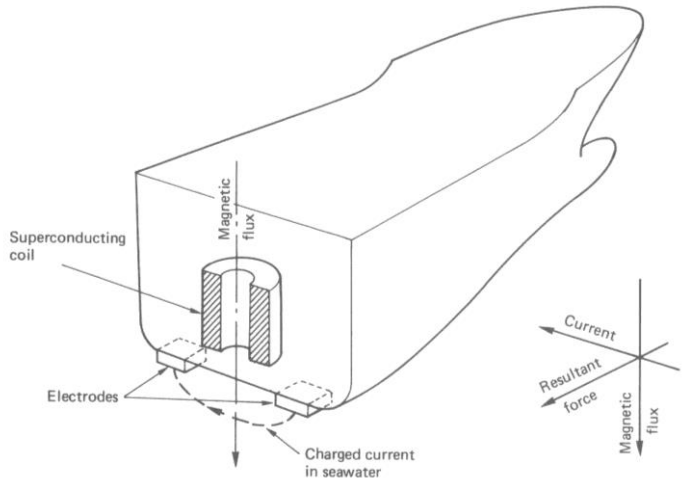


viii- Paddle wheels

- It is a predator of screw propulsion system.
- Used largely on lakes and river services or where limited draughts are encountered.

ix- Superconducting electric propulsion

- The system provides ship propulsion without the aid of either propellers or paddles.
- The fundamental principal of electromagnetic propulsion is that of interaction between a fixed coil inside the ship and an electric current is passed through the sea water from electrodes in the bottom of the ship.
- A force is produced orthogonal to the magnetic field and to the current as a result of Fleming's right-hand rule.
- It provides noise and vibration free hydrodynamic propulsion so that it is found some applications in navy vessels.
- One of the major problems in this propulsion system is the difficulty to maintain superconducting coil zero resistance property, which is required, to be kept at the temperature of liquid helium (-268 °C).



x- Azimuth podded propulsion system

- It provides propellers with high manoeuvrability, low fuel consumption, high efficiency, low noise and less cavitation
- Today, the major users of pod units have been cruise liner operators.
- The introduction of pod propulsion, which will allow the propulsion unit to be placed without considering any shaft arrangements or space for machinery will, of course, give the naval architect many new opportunities to design the 'ultimate hullform'.