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Axial flow pumps are used in high volume, low head, applications such as evaporators, crystallizers, and municipal water treatment. The principles of propeller design and operation are similar to that of radial impellers although the geometry is quite different. This issue presents a brief history of the axial flow propeller and an overview of the design.

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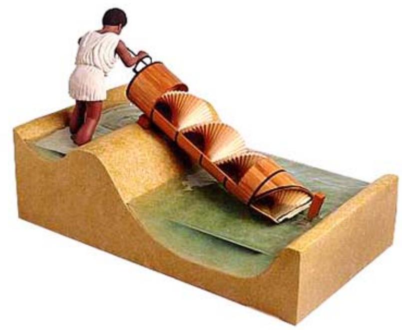
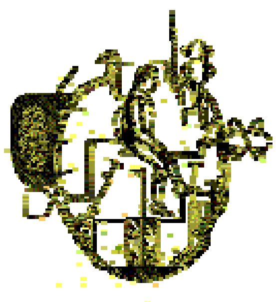
The helical screw, originally designed by Archimedes around 250 BC to lift water for irrigation, is the precursor to the marine propeller and the modern axial flow pump. The first practical application of the concept to propulsion was by David Bushnell in 1776 who used a hand operated screw to propel The Turtle, the first submarine. Through the mid 1800's the use of the Archimedes screw as a method of propelling vessels was neither efficient nor widely used.





The future of marine propulsion was changed in 1835 by Francis Petit Smith while testing a new Archimedes screw on his boat. The screw consisted of a single wooden blade that wrapped two complete turns (720^o) along its hub. As he navigated along a waterway a large portion of the screw broke away leaving behind a section not unlike today's modern propeller blade. To his surprise, the vessel gained speed and the modern propeller was born

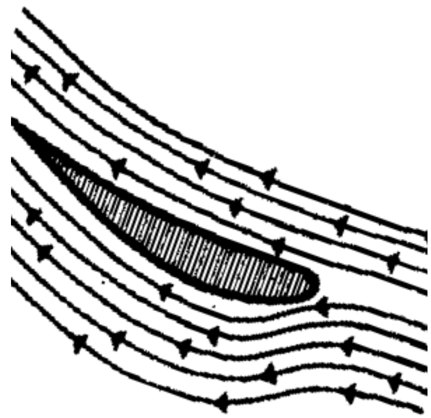
In the modern marine industry a propeller is often referred to as a screw. A propeller blade is similar to a section of a screw thread. The pitch of the thread, expressed in threads per inch or cm, describes how many wraps the thread will make over a specified distance. For a marine propeller pitch is expressed as the distance a propeller would move through a solid object in a single revolution[1]. The difference between the distance that a propeller will actually move through water in a single revolution and the pitch is referred to as slip, and is an indication of efficiency.

The major difference between pumps and boats is that, in a pump, the liquid moves through the propeller whereas in a boat the propeller moves through the liquid. When designing a propeller for a

[1] How fast might your boat go? If the propeller had zero slip speed in knots would be equal to the output shaft RPM x 60 x Pitch(ft)/6036 ft per nautical mile.

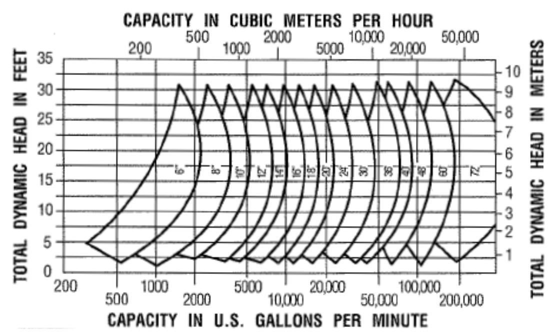
particular flow the pitch is set by the engineer so as to displace a certain amount of liquid with each revolution of the shaft[2]. This is also the same way that a radial centrifugal impeller inlet is designed.

The head generated by a radial impeller is a function of rotational (angular) velocity and throughput (meridional) velocity. Meridional velocity is the velocity of the liquid moving from the inlet to outlet of the impeller channel. Propellers are much the same. The significant difference is that the liquid path from inlet to outlet in a propeller is at a constant radius with respect to the shaft centerline. Modern propeller designs accelerate the liquid as it moves through the propeller by increasing the blade angle from inlet to outlet. The curvature of the blade forms a hydrofoil that is similar to the sectional view of an airplane wing. Head and flow can be accurately manipulated by varying the inlet blade angle and the curvature of the propeller blades.



Most radial impeller pumps operate at synchronous speeds where the pump is adapted to meet varying application conditions by trimming the impeller diameter. In an axial flow pump the outside propeller diameter and the eye diameter are one and the same. Additionally, the propeller relies on a close clearance to the casing wall to minimize recirculation losses. Propellers cannot be trimmed without a serious impact on performance. Consequently, with the exception of certain very specialized applications, axial flow pumps are almost always driven by belts or variable speed controls.

Specific speeds[3] for axial pumps typically range from 190 - 290 SI units (10,000 – 15000 US units). The chart at the right shows a performance range for a family of general industrial axial flow pumps such as the style shown above. However, some specialized axial pumps, such as those used in the manufacture of polyolefin resins are capable of attaining heads many times higher than that depicted here.



Axial flow pumps handle multi-phase mixtures well and are reasonably efficient. Axial pumps are available in most metallurgies and are applied both in horizontal and vertical configurations. Although not a common pump design, axial pumps are applied in niche applications across many industries and touch everyone's daily lives in the form of a broad range of commodities such as table salt, plastics, and paper.

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[2] after adjustment for efficiency losses have been made.

[3] Specific speed is an index number that characterizes a pump's geometry and performance characteristics. For more information see our August 04 newsletter on the topic.

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