Bernoulli equation etc:
ship propellers and tidal turbines

In case of potential, *i. e.* vortex-free flows the Navier-Stokes equation for incompressible Newtonian fluids reduces to the Euler equation for ideal fluids and hence to the Bernoulli equation

$$\partial_t v_i = -\partial_i (v_j v_j /2 + p/\rho + u^f) ,$$

if a body force potential exists

$$f_i = -\partial_i u^f .$$

Thus the energy density is constant in regions of stationary flow, and can only be changed in regions of instationary flows, *e. g.* in turbo machines, maybe ship propellers, *i. e.* pumps, or tidal turbines. To simplify computations fields of instationary motions are often replaced by more or less equivalent stationary body force fields.

According to the Bernoulli equation ideal ship propellers or tidal turbines are conceived as rotors producing potential vortices, followed by stators 'absorbing' the potential vortices, both together in ducts with vanishing net longitudinal forces. Equivalent pre- and/or post-swirl configurations may readily be envisaged. The sole purpose of the ducts is to permit flows as close as possible to the ideal, not to 'produce' thrust in case of propellers.

In practice the advantages of the ducts and stators have to be larger than their frictional losses, which is hardly possible at low propeller loading, unless the hull itself is serving as stator as in very successful pre-war Star-Contra configurations without ducts, widely applied in the commercial fleet those days, and later the more expensive twisted after-bodies of Ernst Nönnicke, recently re-analysed by Dr. Karsten Hochkirch at DNV GL taking advantage of CFD methods.

Any claim to have designed propellers or turbines 'better' than ideal is based on ignorance of the elementary theory of continua and its application in cases of real boundary conditions.

For propulsors in the behind condition the rotors have of course to be adapted to the non-uniform energy wake. Further it has to be kept in mind, that thrust at ducts and suction at hulls constitute hydro-dynamical short-circuits causing additional losses. Thus designing ducted propulsors for open water is non-sensical.

Accordingly an energy wake adapted propulsors has been designed and successfully tested at VWV Berlin without any reference to the concept of the thrust, the naïve concept of propulsors overcoming the resistance of hulls. Friedrich Mewis' ducts, marketed by Becker Marine Systems, not including the propeller, are a successful compromise.

Turbines are different from propellers as there exists an optimum loading. As ship propellers wind turbines are usually designed without stators and ducts. Concerning tidal turbines Dr. Reinhard Schulze at SVA Potsdam has considerable experience.

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