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Society of Naval Architects
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Sub.: SNAME 1996 Annual Meeting New York
here: **Discussion the paper No 4 by Triantafyllou, M. S. et al.:**
A New Paradigm of Propulsion and Manoeuvring for Marine Vehicles
Ref.: Preprint received August 22, 1996

Exactly one year ago I wrote a very thorough discussion on the paper by the Triantaffylou brothers published in Spektrum der Wissenschaft (August 1995, 66/73), translated from Scientific American (March 1995, 40/48). So far I have not received an answer neither from the Scientific American nor the authors.

So I was eagerly looking for their new publication, wondering what might be new and how they may have utilized the input I provided. To my great disappointment there is nothing new, exept that the flapping foil propulsion has been promoted to a new paradigm. This terminology is fashionable and everybody uses it nowadays, including the present discusser. At this stage of affairs it may be appropriate to repeat some of the earlier discussion.

One major disadvantage of intermittent propulsor operation is the higher loss as compared to steady operation. The reason is the concentrated vorticity shed. In the present case efficiencies are conveniently and correctly compared on the basis of the theory of vortex streets generated.

For periodically operating propulsors the average thrust is the reaction of the change of momentum per cycle multiplied by the frequency of operation. The integrating factor to obtain the power necessary is the group velocity V_{Gb} of the vortex street generated in the coordinate system (b) moving with the ship. Consequently the propulsive efficiency of the propulsor moving with speed V is the ratio

$$\eta = V / V_{Gb}$$

or, using the group velocity V_{Ga} in a coordinate system (a) at rest in the indisturbed fluid,

$$\eta = 1 / (1 + V_{Ga} / V) .$$

More efficient are steadily operating propulsors shedding uniformly distributed vorticity. The technical solution approaching ideal propulsion is the ducted propeller with an actuator consisting of two counter-rotating rotors or, much simpler, of rotor and stator, provided the loading is sufficiently high to warrant the extra friction at duct and stator.

When we want simple propulsors we will certainly not copy whole fishes in view of the high mechanical complexity, but better check with nature and the patent literature. The simplest propulsion mechanism found in nature is the systole and diastole of medusas. In technical terms a piston oscillating in a cylinder open in thrust direction does the job. Due to the different flow patterns at suction and ejection, i. e. due to the nose effect saving us from being poisoned by our own exhaust fumes, such sytems work very effectively, but clearly not with the highest possible efficiencies.

As every other propeller design is now wake adapted, ducted propellers can be perfectly adapted to the wake of the hull, i. e. recovering energy not only from different sources, e. g. some other vehicle moving somewhere ahead, but the vehicle's own losses. This was known to naval architects since R. E. Froude presented his famous paper: A Description of a Method of Investigation of Screw Propeller Efficency. Institution of Naval Architects (INA) 24 (1883) 231/255, now Royal Institution.

Sailors have always taken advantage of the trade winds and everybody knows that geese and swans are taking advantage of the vortices shed by their predecessors. And of course sailors take advantage of the vortices shed by their competitors’ sails.

Sailing in ones own wake, as the naval architects do, is of course tricky. Everybody has to go through the mental exercise himself, that the creation of extra wake, to be utilized with advantage, does not pay. The increase in the configuration factor of merit is by far outweighed by the additional power needed.

A change of paradigm in the theory of ship propulsion based on an axiomatic model of hull-propeller interaction permits a wake adapted design approach treating all interactions between hull, duct, and actuator implicitly without approximations; Schmiechen, M.: Design and Evaluation of Propellers as Pumps. Centenary of the Krylov Ship Research Institute, St. Petersburg, 1994.

Such an approach and the corresponding evaluation methodology are necessary for advanced hull integrated propulsor configurations not permitting the physical separation of hull and propulsor traditional model testing is based upon; Schmiechen, M.: 2nd INTERACTION BERLIN ’91; Proceedings of the 2nd International Workshop on the Rational Theory of Ship Hull-Propeller Interaction and its Applications. Mitteilungen der VWS, Heft 57, 1991.

It was one of the authors, who deliberately decided that the presentation of these advanced ideas based on a sound theory of knowledge might not be suitable for members of the Society of Naval Architects and Marine Engineers at New York in 1991. His verdict was, that the theory of knowledge might be required for the physical sciences, but not for the engineering sciences!

With best regards sincerely yours,

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Enclosure:

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