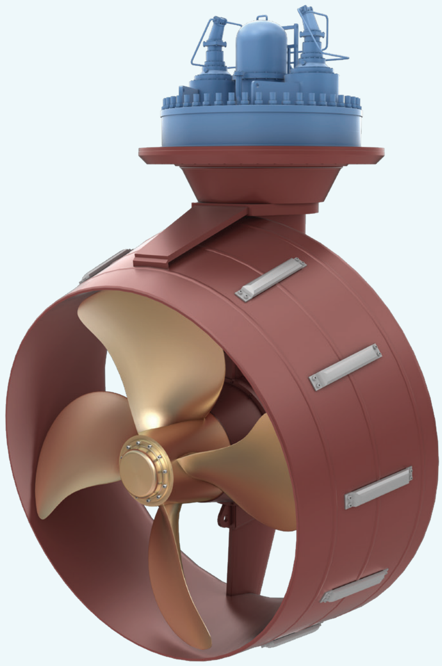
EFFECT OF TITLED NOZZLE



Example: UUC thruster with tilted nozzle

KONGSBERG AZIMUTH THRUSTERS

EFFECT OF TILTED NOZZLE

Background

The propagation direction and velocity distribution of propeller slipstreams are crucial for station keeping performance and low speed manoeuvring operations. That is because the slipstream can interfere with neighbouring thrusters and/or the hull, as sketched in Figure 1. These slipstream interactions can lead to significant reductions of the station keeping performance. Typical thrust losses are in the range 10-30%, but even 50% loss has been measured for certain hull applications.

Reduction of interaction losses

In the horizontal plane, it is possible to minimize thrust interaction loss by alterations of slipstream directions through changes in azimuth angle of adjacent thrusters.

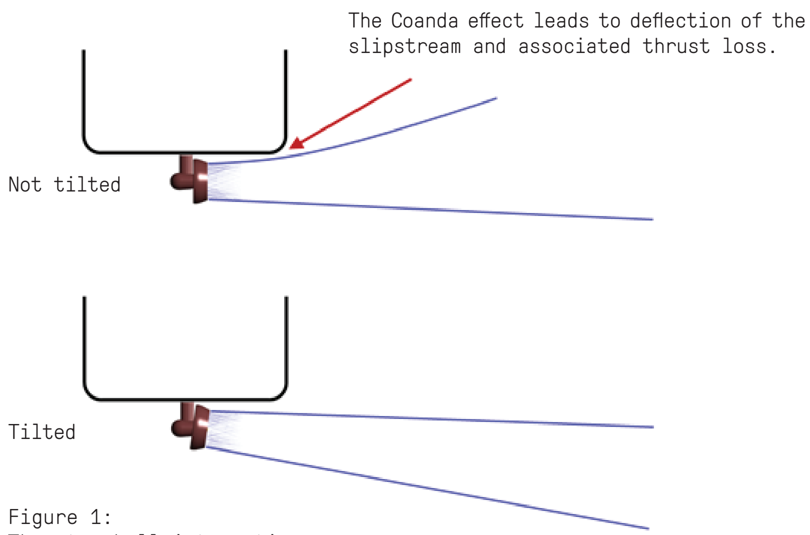


Figure 1:
Thruster-hull interaction

It is also beneficial to control the slipstream in the vertical plane. This can be done by tilting the nozzle. An alternative method is to tilt also the propeller shaft, which means that the input shaft and the propeller shaft are not perpendicular. Both alternatives turn the slipstream direction downwards, leading to a considerable reduction of the interaction losses. Advanced CFD simulations have been carried out in order to compare the performance of azimuth thrusters using different tilting options.

URANS CFD simulation

Unsteady Reynolds Averaged Navier-Stokes simulations in full scale are performed with ANSYS Fluent. Propeller is rotated using sliding mesh technology, in order to achieve the correct unsteady propeller slipstream behaviour. Such simulations are very time- and computational demanding.

Results

Figure 2 shows the simulated propeller slipstream created by the three thruster versions. It is seen that for both tilted nozzle and tilted shaft, the slipstream is directed downwards. This will significantly reduce the thrust interaction losses compared to a horizontally directed slipstream.

Results for the thruster performance are presented in Table 1 below. It is a comparison of merit coefficient or efficiency between thruster versions. Merit coefficient and efficiency are dimensionless relationships between thrust and torque. A negative difference represents reduction in performance. The results in Table 1 include an estimate of interaction losses, based on model test results. For many applications, the thruster or nozzle that has no tilt will experience much larger interaction losses than the tilted versions, hence are tilted versions highly preferable for these applications.

For manoeuvring close to zero advance speed (or bollard condition), it is no difference in merit coefficient between tilted nozzle and tilted shaft. However, at higher vessel speed, 0.5-2.5% can be gained by a tilted shaft.

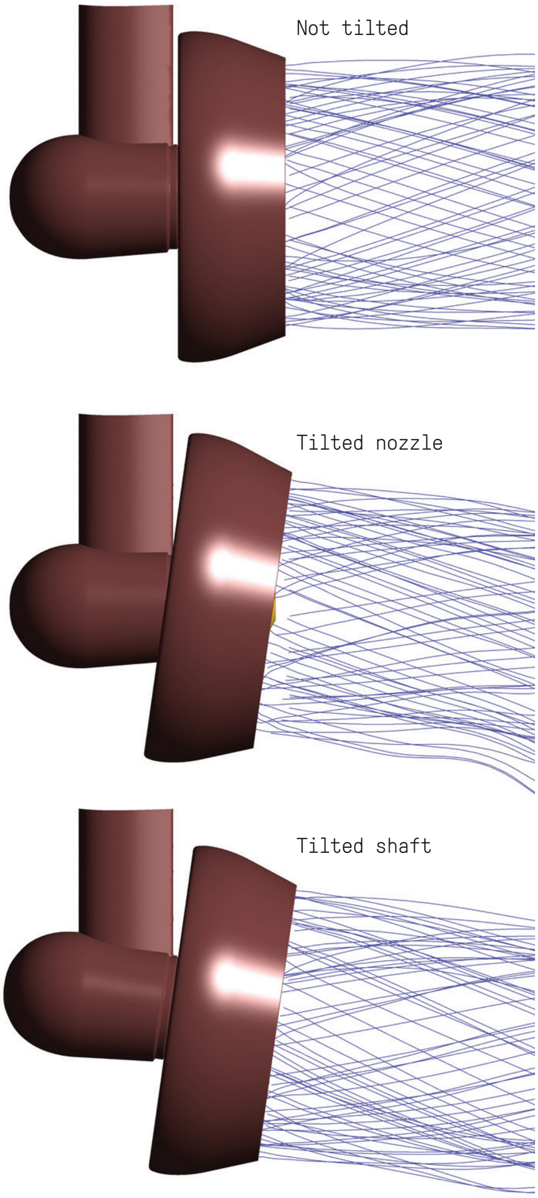


Figure 2:
Propeller slipstreams from URANS simulation.

Table 1: Results from URANS open water simulation

		Relative interaction loss (*)	Relative interaction loss (*)	SUM (*)
Merit coefficient in manoeuvring (0.2 knots)	Not tilted	-25 %	-	-25 %
	Tilted nozzle	-	-1.4 %	-1.4 %
	Tilted shaft	-	-1.4 %	-1.4 %
Efficiency in 6 knot	Not tilted	-10 %	-	-10 %
	Tilted nozzle	-	-4.8 %	-4.8 %
	Tilted shaft	-	-2.5 %	-2.5 %
Efficiency in 12 knot	Not tilted	-5.0 %	-	-5.0 %
	Tilted nozzle	-	-3.5 %	-3.5 %
	Tilted shaft	-	-3.0 %	-3.0 %

(*) The figures for relative interaction loss in Table 1 are estimated from model test results. These figures are dependent on hull application and thruster configuration.

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