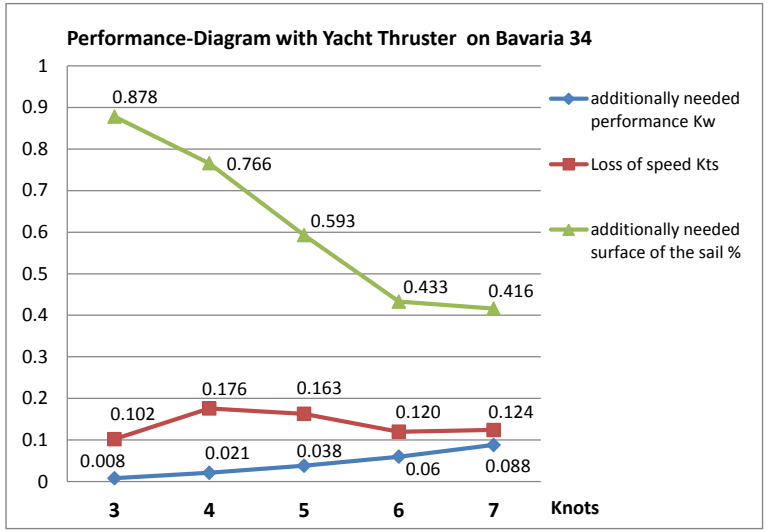
YACHT THRUSTER™

External Thrusters for Power & Sailboats by eXTURN

Simple calculations performed by Vienna Institute of Hydrodynamics

This chart clearly shows the minimal loss of performance using a Yacht Thruster



Theoretical loss of performance due to eXturn - External Mounted Thruster

Brand	BAVARIA 34		sailboat		
Length waterline	9,2m	30 ft	maximum hull speed	7,371	Knots
Overall boat length	10.71m	35 ft	Max. speed in meters per second	8.5	mph
Lightweight tonnage	5700kg	12 570 lbs	Main sail + Genoa, Standard	637	Sq ft
Engine power	13,3kw	18 hp	Motor Horsepower	18,000	HP
			Air density	0.0807	lb/ft3

Sailing course: Ahead wind –"Butterfly"

Resistance coefficient = 1,0 surface of the sail = 637 sq ft

WIND SPEED		BOAT SPEED		Apparent WIND SPEED	Apparent wind		bow thruster newton resistance (folding prop is 13.00 at 5 knots by comparison)	Additional drive required	Additional Sail area	
					Sail surface	Sail presure	resistance	Loss of Performance	Loss of sail surface	Sailing performance
knots	mph	mph	knots	Δ mph	ε Sq Ft	ε PSI	Δ Rts / N	Hp	ε %	ε Hp
9	10.3	3.4	3	9	637	0.082	5.00	0.010	0,878	0.117
14	16.1	4.6	4	12.9	637	0.189	10.00	0.028	0,766	3.605
19	21.8	5.7	5	18.1	637	0.366	15.00	0.050	0,593	9.713
25	28.7	6.9	6	23.9	637	0.637	19.00	0.080	0,433	18.136
30	34.5	8.0	7	30.0	637	1.011	29.00	0.117	0,416	33.659

Folding prop is 13.00 at 5 knots by comparison

tunnel thruster requires 10% additional by comparison

Legend:

(mph, knots) = real boat speed during testing

pparent wind = wind speed less boat speed

ıce of the sail = Complete standard surface of the sail. Course « Butterfly », direction of wind stern

ıre of the sail = Apparent pressure of wind multiplied by standard surface of the sail

Resistance = Real resistance at any speed caused by bow thruster. This figure is Difference between hull resistance including bow thruster less hull resistance without bow thruster. This figure is always constant at respective speed, no matter which boat type is taken under consideration.

performance = Performance needed to overcome resistance caused by the bow thruster

ıce of the sail = part of total standard surface of the sail to overcome resistance caused by the bow thruster

performance = sailing performance expressed as Hp

oefficient CD = common resistance coefficients to calculate pressure of wind. This figure ranges from 1,0 to 1,9 (gust of wind)

Resistance Tests with EXTURN bow and stern thruster

Vienna Model Basin Ltd performed resistance tests with the EXTURN bow and stern thruster installed on the bow of a 34 feet yacht (main dimensions comparable to a Bavaria 34). The results of the tests were compared to the same hull shape of the yacht without any bow thruster installed; see Figure 1 and Figure 2.

Figure 1: Yacht without bow thruster

Figure 2: Yacht with EXTURN bow thruster

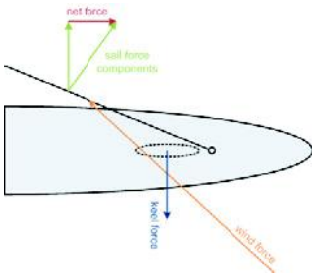


Figure 3: Forces on the yacht

Table 1 shows the results of the resistance test were $R_{TS}1$ represents the resistance of the yacht without any thruster and $R_{TS}2$ represents the yacht with EXTURN thruster.

It can be concluded that the EXTURN thruster only shows a marginally increased resistance compared to a yacht without bow thruster which hardly influences the performance of the yacht. This minor increase of total resistance can also be demonstrated by a corresponding increase of sail area, see Table 2. According to *H. Scharping, 1987, "Konstruktion und Bau von Yachten", Delius Klasing Verlag, Bielefeld, p. 163-164.* the wind speed corresponds to a certain wind pressure on the sail depending on the drag coefficient C_D. The wind pressure is calculated as follows:

$$P = C_D \cdot \frac{\rho}{2} \cdot V^2 \cdot 1{,}0$$

where P is pressure, C_D is the drag coefficient, ρ is density of air, V is wind speed and A is sail area. Figure 3 shows the forces acting on the yacht where the net force can also be substituted by the resistance R_{TS}. Therefore, the increase of the sail area can be derived by

$$\Delta A = \frac{RTS3(VS) - RTS2(VS)}{P_n}$$

where ΔA is the increase of sail area, $R_{TS}1$ is the resistance of the bare hull of the yacht without bow thrusters, $R_{TS}2$ is the yacht with the EXTURN bow thrusters and P_n are the pressures for different drag coefficients. Table 2 shows the results of the sail area increase.

V_S [Kn]	V_S [m/s]	$R_{TS}1$ [kN]	$R_{TS}2$ [kN]
3	1,543	0,142	0,147
4	2,058	0,217	0,227
5	2,572	0,444	0,459
6	3,087	0,929	0,948
7	3,601	1,613	1,637
8	4,116	2,400	2,429

Table 1: Results of the resistance tests

		Sail area increase EXTURN thruster vs. bare hull			
V_S [Kn]	V_S [m/s]	A gust [m²]	A P1 [m²]	A P2 [m²]	A P3 [m²]
3	1,543	0,00	1,00	2,00	3,00
4	2,058	1,59	1,43	1,11	0,31
5	2,572	2,38	2,14	1,67	0,47
6	3,087	3,02	2,71	2,11	0,59
7	3,601	2,33	1,33	1,00	0,28
8	4,116	2,82	1,61	1,21	0,34

Table 2: Sail area increase