高速艇螺槳發展趨勢與展望
Development of Propeller for HSC

National Kaohsiung Maritime University
31 December 2008

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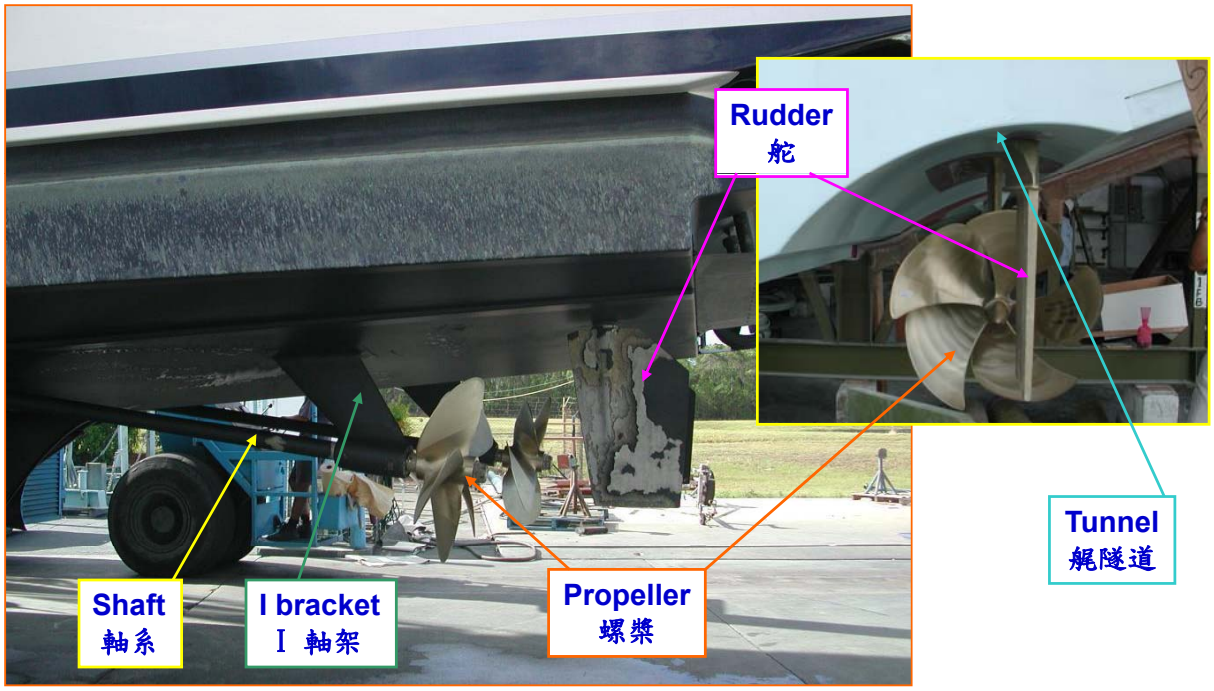
ZF Faster Propulsion System Co.,Ltd.

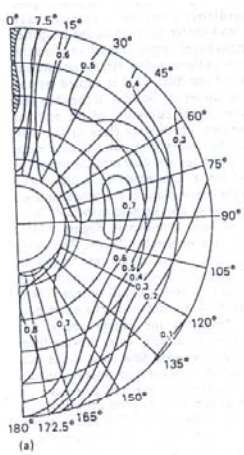
高速艇螺槳運轉環境

General Layout of Propulsion System
高速艇推進系統布置—雙俥雙舵

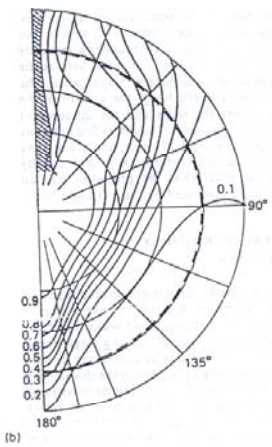


Wake Field
跡(伴)流分佈

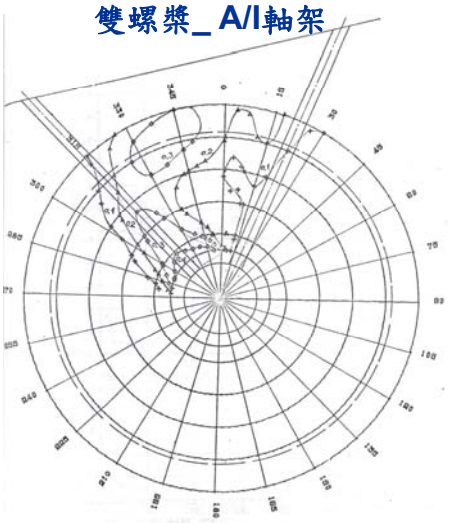
Single screw _ U form
單螺槳_U艉線形



Single screw _ V form
單螺槳_V艉線形



Twin screw _ A/I bracket
雙螺槳_ A/I軸架



Shaft Inclination for HSC

高速艇斜軸布置

Shaft inclined angle: 6 to 13 degrees (current trend) 現行趨勢

→ high risk of root cavitation erosion

高風險之根部空泡浸蝕

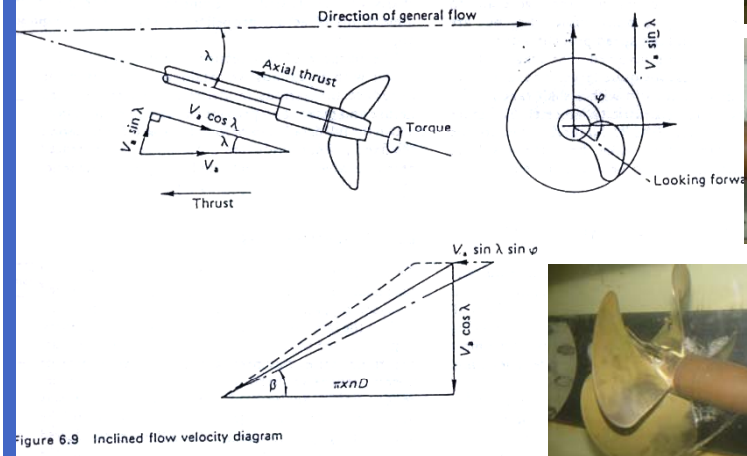


Figure 6.9 Inclined flow velocity diagram

Alpha=0, back

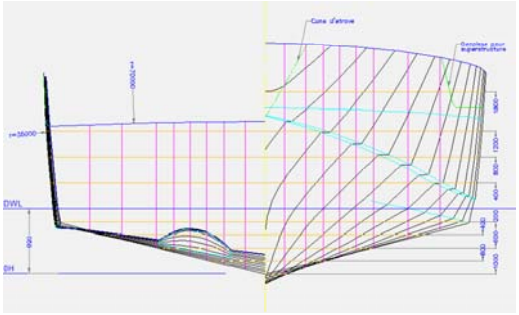
Alpha=0, face

Alpha=270, face

Alpha=90, back

Tunnel Hull Lines

艉隧道線形



. Reduce shaft inclination angle

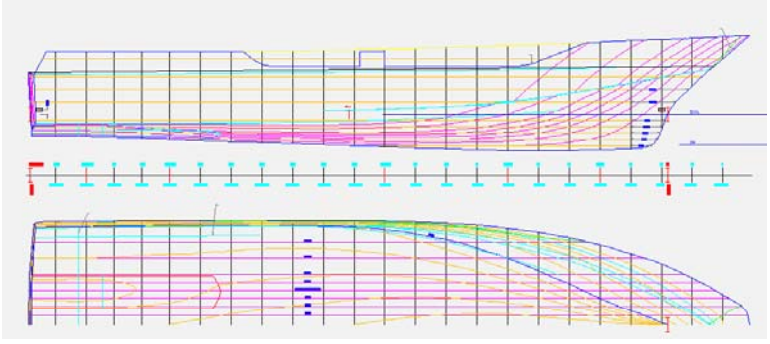
降低軸傾斜角度

. Increase tip hull clearance

增加螺槳葉尖與船底間隙

. Adjust static trim angle

調整靜止狀態之俯仰差(角度)



Propeller Characteristics in Cavitation Condition

空泡狀態下之螺槳性能_推力、扭矩與效率

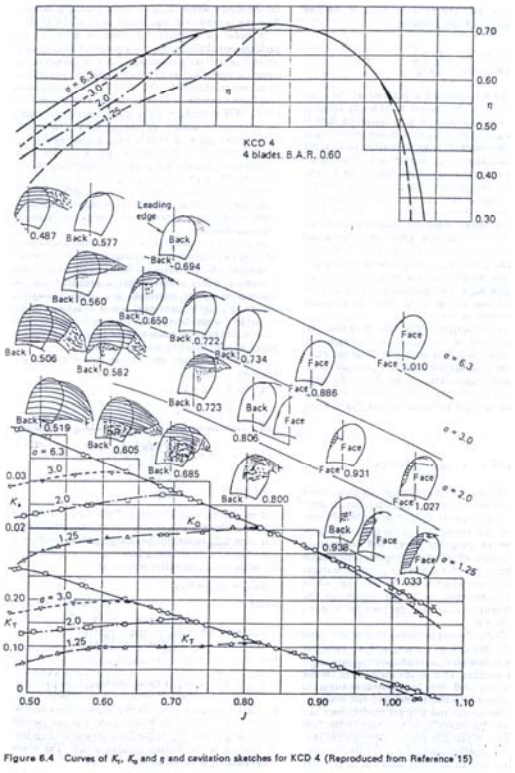
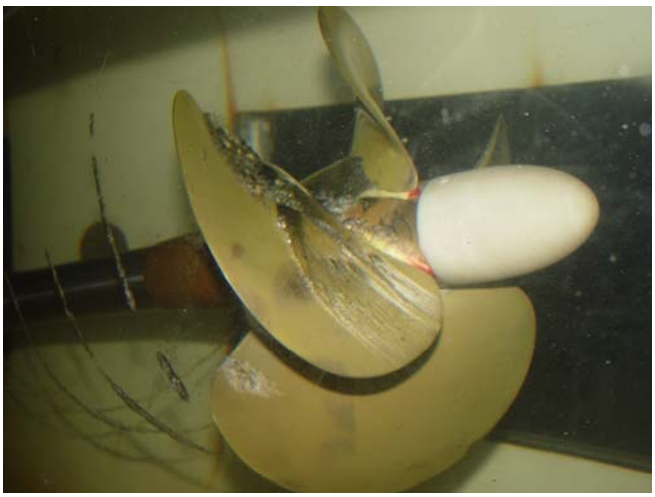


Figure 6.4 Curves of K_T, K_Q and η and cavitation sketches for KCD 4 (Reproduced from Reference 15)



Alpha=90, back

斜軸角90度，葉背面

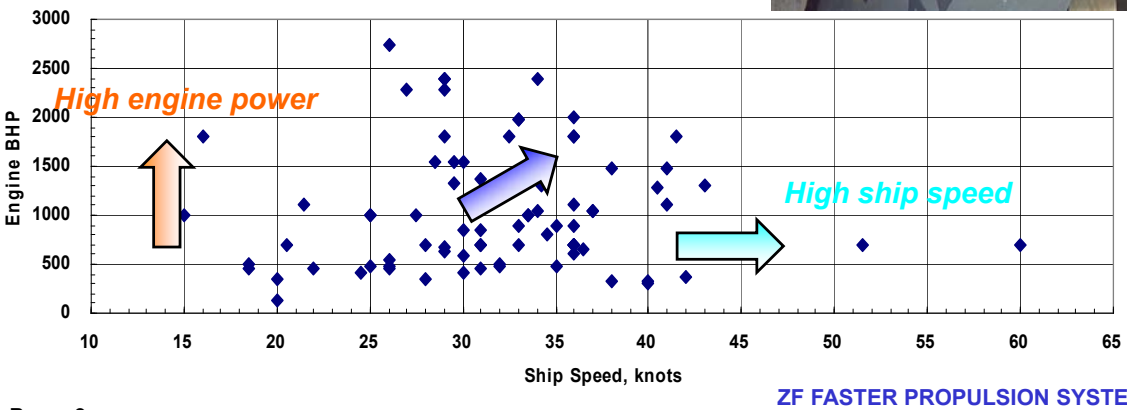
高速艇螺槳應用現況趨勢

General Trend of Propeller for High Speed Craft
高速艇螺槳之一般趨勢

◎ 引擎大馬力
◎ 船速提高
◎ 大斜軸角度
◎ 螺槳直徑限制
◎ 螺槳高推力密度
◎ 螺槳高空泡風險

Engine BHP versus Ship Speed

Root cavitation erosion



Non-dimensional Parameters
無因次參數

Froude Number, Speed Length Ratio

$$F_{nL} = \frac{V}{\sqrt{gL}} \qquad F_{n\nabla} = \frac{V}{\sqrt{g\nabla^{1/3}}} \qquad F_{nB} = \frac{V}{\sqrt{gB}}$$

$$\frac{V}{\sqrt{L}} \qquad \frac{V}{\sqrt{\nabla^{1/3}}} \qquad \frac{V}{\Delta^{1/6}}$$

Cavitation Number $\sigma = \dfrac{P_0 - P_V}{\frac{1}{2}\rho V^2}$

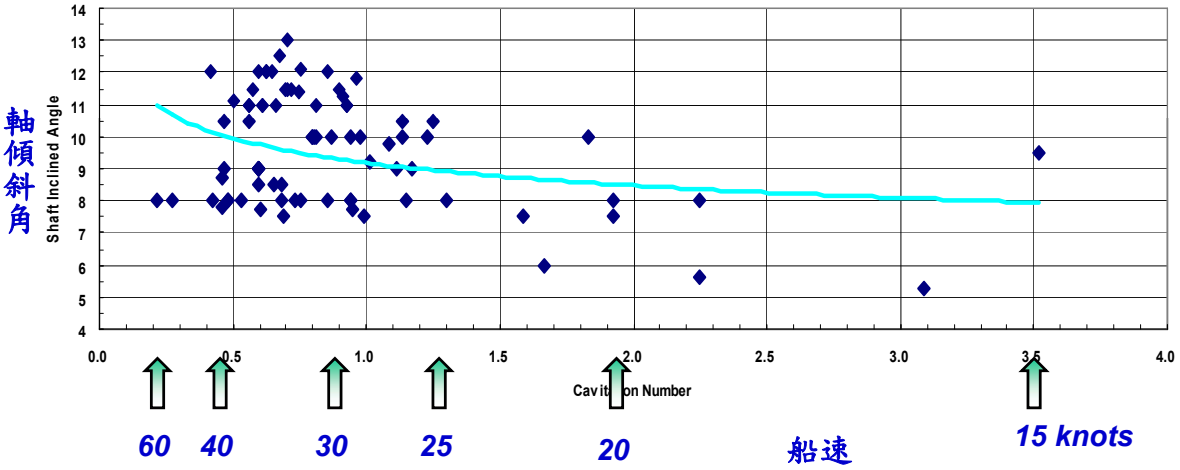
Local Cavitation Number $\sigma_{0.7R} = \dfrac{P_0 - P_V}{\frac{1}{2}\rho V_R^2}$ $\qquad V_R^2 = V_a^2 + (0.7\pi nD)^2$

Mean Thrust Loading Coefficient $\tau_c = \dfrac{T / A_p}{\frac{1}{2}\rho V_R^2}$

High Speed + High Shaft Inclined Angle
高速 + 高軸傾斜角

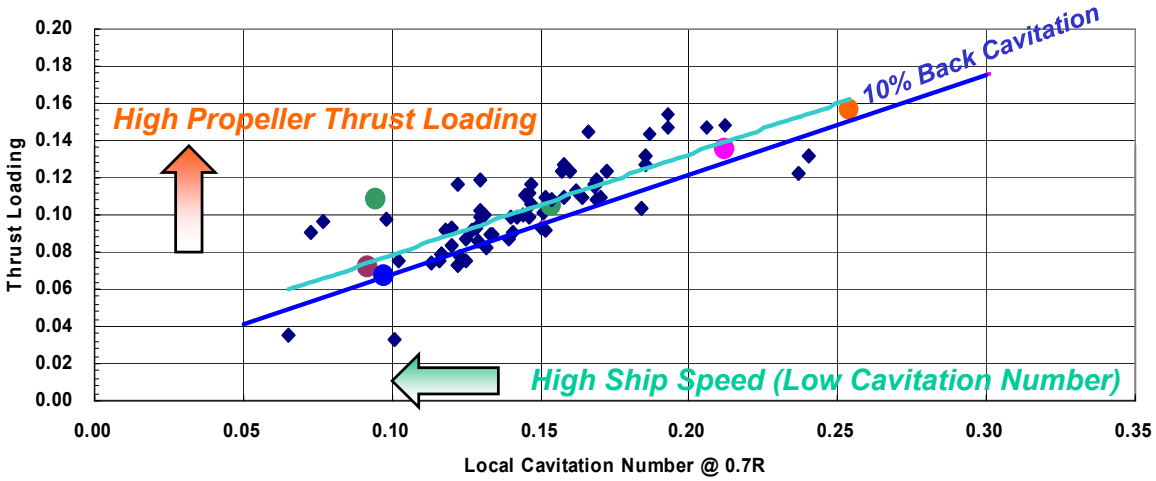
High Risk on Cavitation (efficiency reduced + cavitation erosion)
高空泡風險 (效率降低 + 空泡浸蝕)

Shaft Inclined Angle versus Cavitation Number



General Cavitation Trend Diagram
空泡趨勢_Gawn Burrill 圖表

High Ship Speed (Low Cavitation Number) 高速度(低空泡數)
High Propeller Thrust Loading（高螺槳推力負荷）
High Risk of Cavitation and Low Efficiency (高空泡浸蝕風險與低效率)



高速艇螺槳應用現況 (I)

PJ 234 _ 15 knots _ 37.68 m

巨型遊艇

Engine: 2 x 1000 ps x 2100 rpm, 3.437:1
Cavitation number = 3.517, 0.254 @ 0.7R
Propeller: 48 x 46 x 5B x 0.85 NACA
Shaft inclination = 9.5 deg

Fleming _ 15.5 m _ 18.5 knots

Engine: 2 x 500 ps x 2600 rpm, 2.53:1
Cavitation number = 2.246, 0.212 @ 0.7R
Propeller: 31 x 30 x 4B x 0.90 KCA
Shaft inclination = 8 deg

中型游艇

Carver 650 _ 16.6 m _ 31 knots

Engine: 2 x 1370 ps x 2350 rpm, 2.467:1
Cavitation number = 0.812, 0.154 @ 0.7R
Propeller: 38 x 46 x 5B x 1.05 NF
Shaft inclination = 11 deg

中型高速游艇

GC Patrol _ 13.7 m _ 41 knots

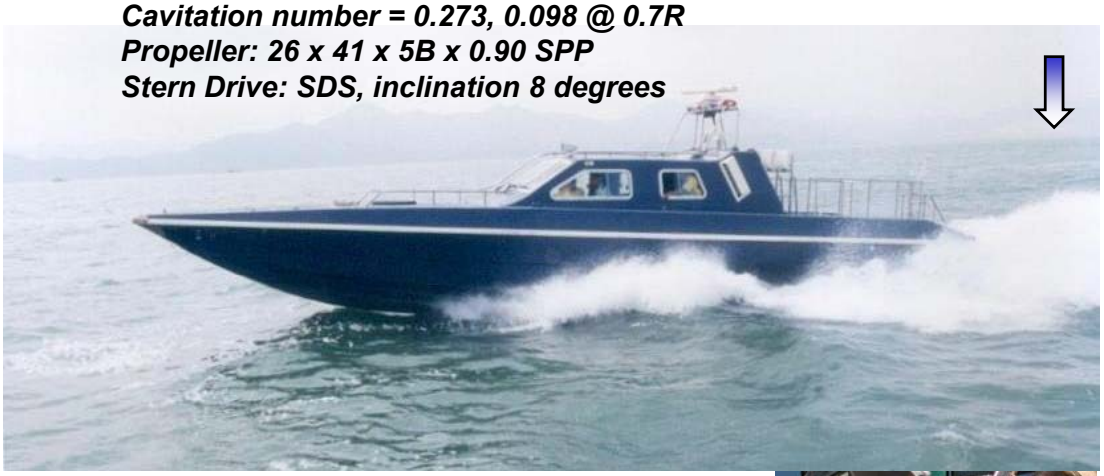
Engine: 2 x 1100 ps x 2450 rpm, 1.525:1
Cavitation number = 0.464, 0.092 @ 0.7R
Propeller: 27.5 x 36.5 x 4B x 0.90 Cupping
Shaft inclination = 10.5 degrees

高速巡邏艇

Fast Patrol _ 11.2 m _ 51 knots

Engine: 2 x 700 ps x 2300 rpm, 1.485:1
Cavitation number = 0.273, 0.098 @ 0.7R
Propeller: 26 x 41 x 5B x 0.90 SPP
Stern Drive: SDS, inclination 8 degrees

超高速巡戰艇



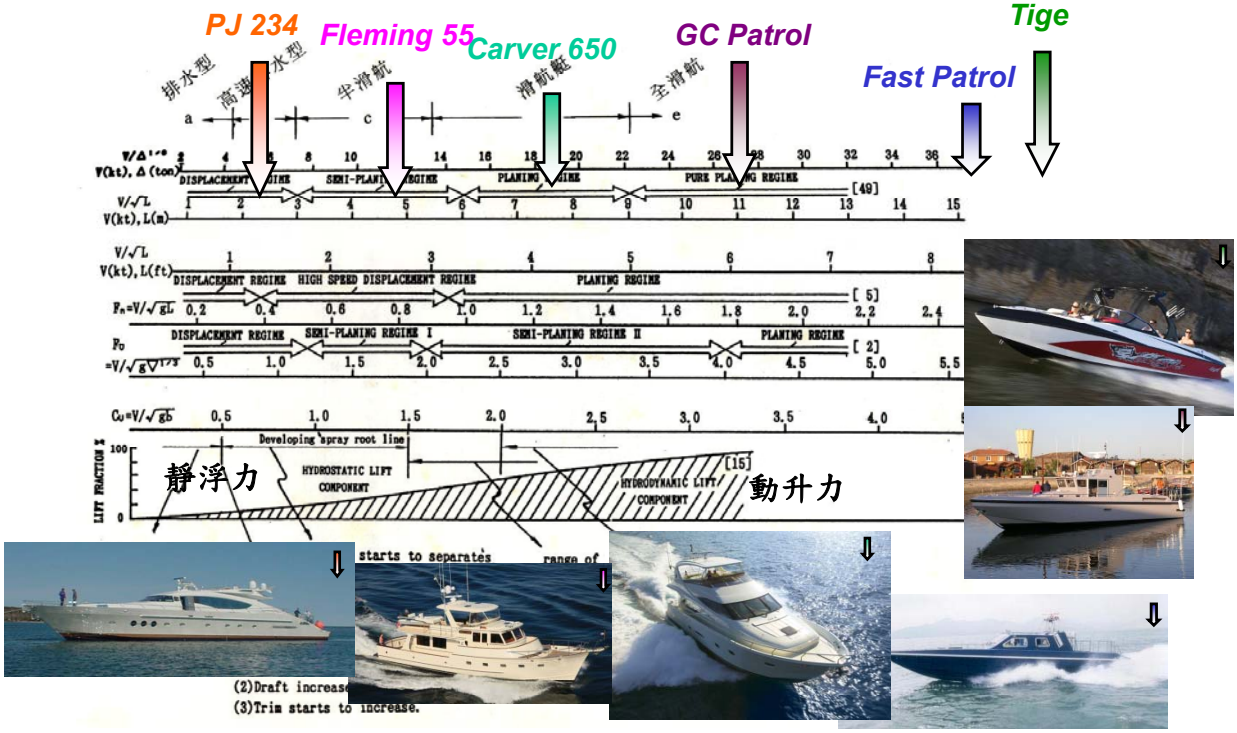
Tige _ 5.5 m _ 38 knots

Engine: 1 x 320 ps x 4600 rpm, 1.46:1
Cavitation number = 0.532, 0.095 @ 0.7R
Propeller: 13.5 x 16.5 x 4B x 0.80 Cupping

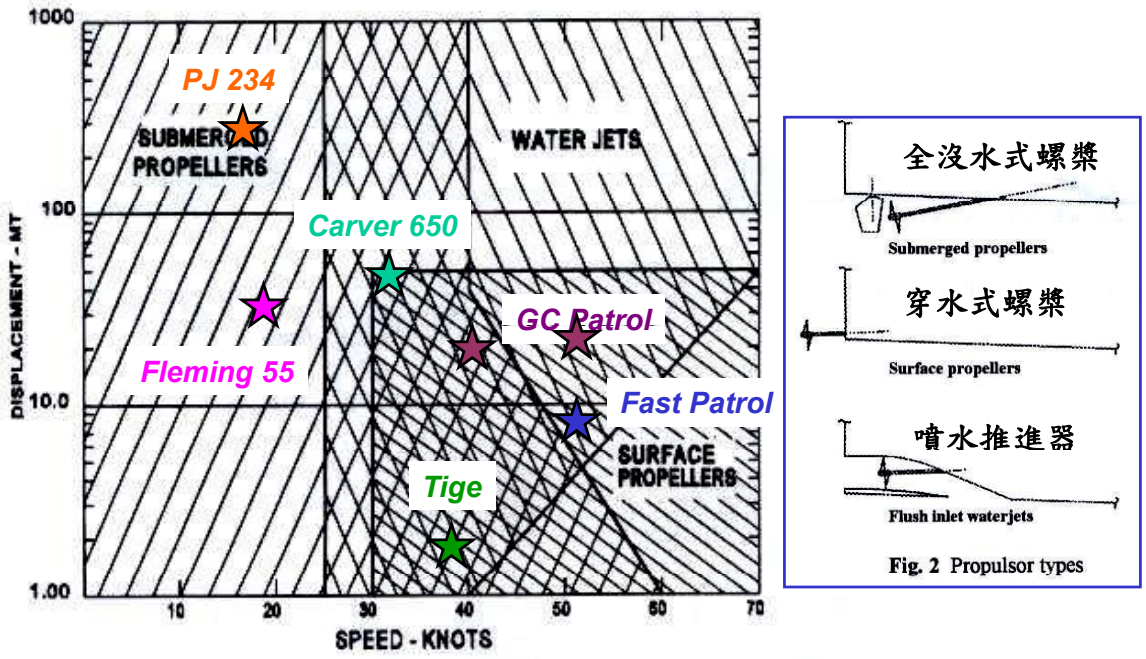
滑水艇(ski boat)

高速艇螺槳應用現況 (II)

Speed versus Length, Displacement 速長比
- Froude Number 佛勞數



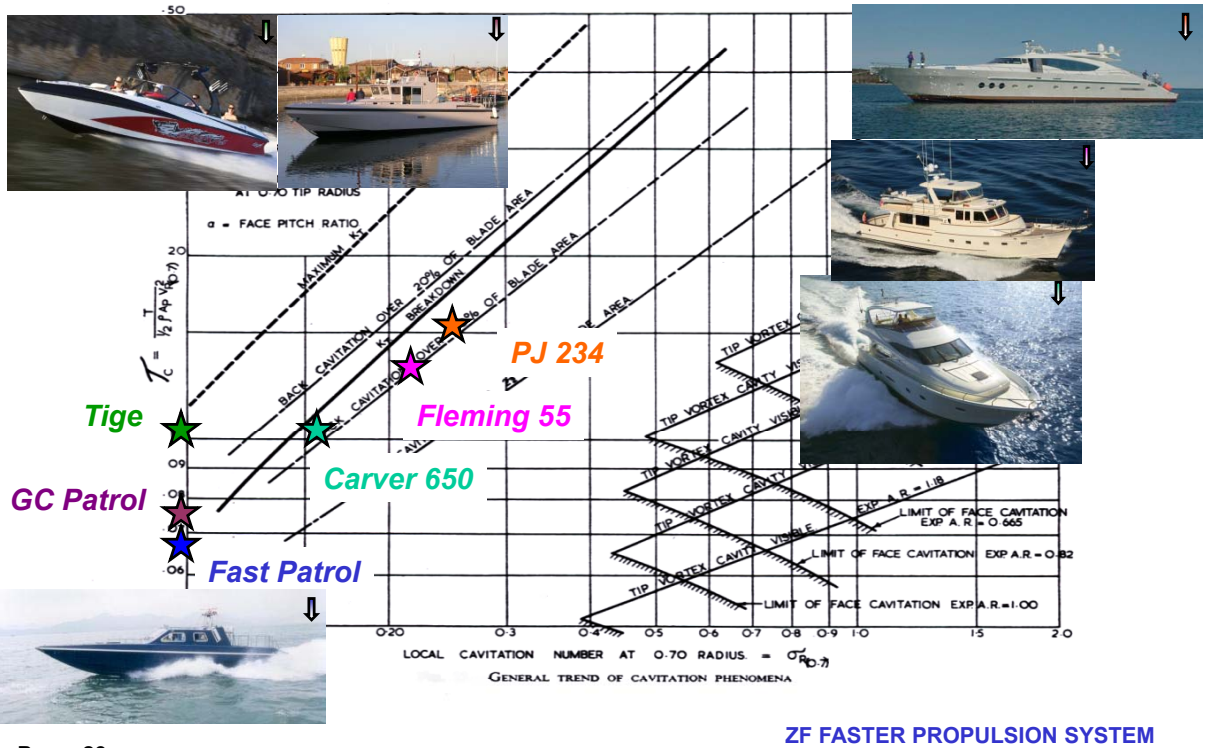
Trends for Propulsor Application
推進器應用趨勢



...nt trends for propulsor applications

Cavitation Number versus Thrust Loading

局部空泡數(0.7R)與推力負荷關係圖



高速艇螺槳系列與翼型斷面

Propeller Blade Sections (Series) for different Speed Application

不同船速狀況適用之螺槳葉片斷面型狀

SHIP SPEED (Knots)	PROPELLER BLADE SECTION	PROPELLER BLADE SECTION
<25	AEROFOIL	MAU,Wageningen-B,NACA
25-35	AEROFOIL	MAU,Wageningen-B,NACA
	OGIVAL	Gawn, Gawn-Burrill (KCA)
	CRESCENT	Newton-Rader, New-Foil
35-40	CRESCENT	Newton-Rader, New-Foil
40-50	CRESCENT	Newton-Rader, New-Foil
	SC or SPP	Rolla, SUS
>50	SC or SPP	Rolla, SUS
30-50	Cupping	Cupping KCA or NF

Propellers Series

螺槳系列

KCA – Series

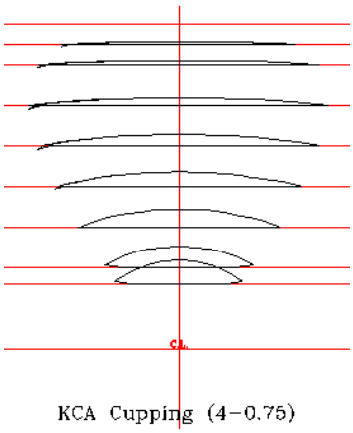
Blades : 3, 4, 5
Pitch Ratio : 0.60-2.00
Area Ratio : 0.20-1.10
Skew Angles : 0 degree
Section Type : Ogival
Remarks : Most widely use propeller series.
Suitable for most applications.
Cupped available.

Skew KCA – Series

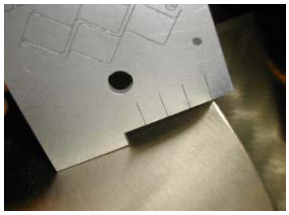
Blades : 3, 4, 5
Pitch Ratio : 0.60-2.00
Area Ratio : 0.50-1.10
Skew Angles : 25 30 35 degrees
Section Type : Ogival
Remarks : Modified from standard KCA series for smooth application.
Suitable for most applications.
Cupped available.

Propellers Series
螺槳系列

Cupping – Series



Blades : 3, 4, 5
Pitch Ratio : 0.60-2.00
Area Ratio : 0.50-1.10
Skew Angles : 0 25 30 35 degrees
Section Type : Ogival, Airfoil
Remarks : Modified from standard series.
Suitable for most applications.



NACA – Series

Blades : 3, 4, 5, 6, 7
Pitch Ratio : 0.80-1.60
Area Ratio : 0.50-1.40
Skew Angles : According to design
Section Type : Airfoil
Remarks : Theoretical design propellers series.

Propellers Series
螺槳系列

New Foil – Series

Blades : 3, 4, 5, 6, 7, 8
Pitch Ratio : 0.80-1.60
Area Ratio : 0.50-1.40
Skew Angles : According to design
Section Type : New Foil
Remarks : Theoretical design propellers series.

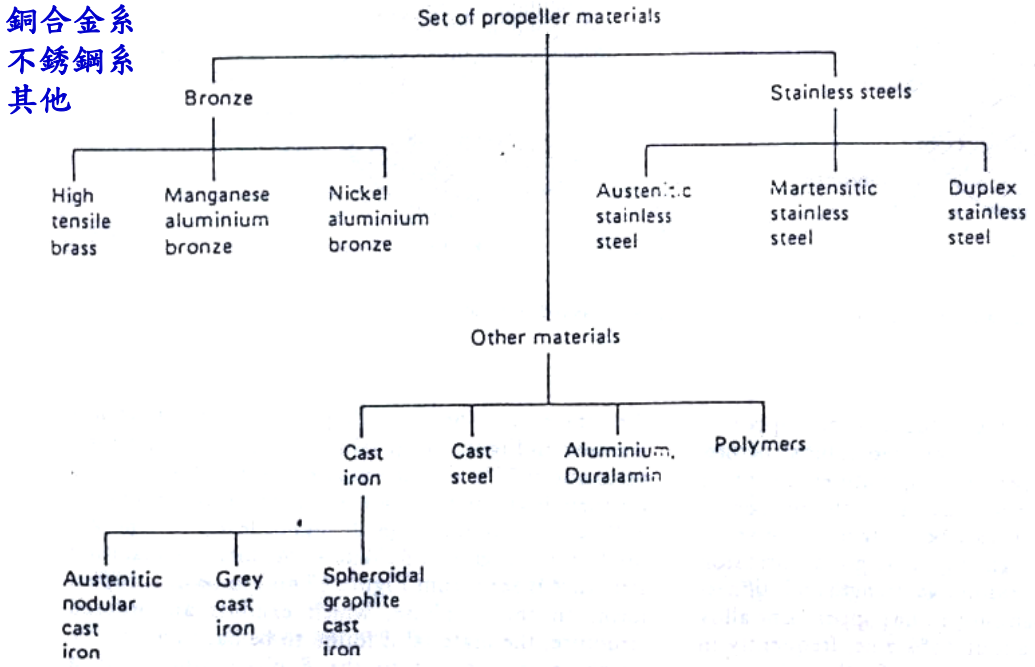
Surface Piercing Propeller

Blades : 4, 5, 6
Pitch Ratio : 0.80-1.60
Area Ratio : 0.70-1.10
Skew Angles : According to design
Section Type : SPP

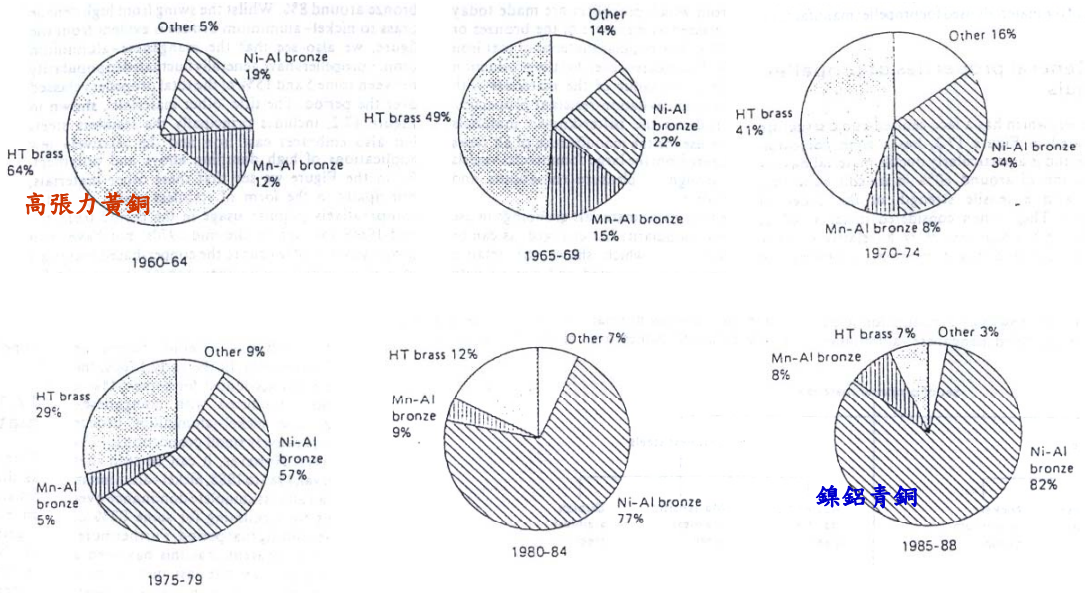
高速艇螺槳使用材料

Propeller Materials Category
螺槳用材料分類

銅合金系
不銹鋼系
其他



Popularity Progress of Propeller Materials
螺槳材料之演進 (1960-1988)



From Lloyd's Register of Shipping 英國勞氏驗船協會

Propeller Material of Lloyd's Classification

英國勞氏驗船協會規定之螺槳材料

Table 9.1.1 Chemical composition of propeller and propeller blade castings

Alloy designation	Chemical composition of ladle samples %							
	Cu	Sn	Zn	Pb	Ni	Fe	Al	Mn
Grade Cu 1 Manganese bronze (high tensile brass)	52–62	0,1–1,5	35–40	0,5 max.	1,0 max.	0,5–2,5	0,5–3,0	0,5–4,0
Grade Cu 2 Ni-manganese bronze (high tensile brass)	50–57	0,1–1,5	33–38	0,5 max.	2,5–8,0	0,5–2,5	0,5–2,0	1,0–4,0
Grade Cu 3 Ni-aluminium bronze	77–82	0,1 max.	1,0 max.	0,03 max.	3,0–6,0	2,0–6,0	7,0–11,0	0,5–4,0
Grade Cu 4 Mn-aluminium bronze	70–80	1,0 max.	6,0 max.	0,05 max.	1,5–3,0	2,0–5,0	6,5–9,0	8,0–20,0

Steel Propeller Casting

Copper Alloy Casting

Table 9.1.2 Mechanical properties for acceptance purposes: propeller and propeller blade castings

Alloy designation	0,2% proof stress N/mm² minimum	Tensile strength N/mm² minimum	Elongation on $5,65\sqrt{S_o}$ % minimum
Grade Cu 1 Manganese bronze (high tensile brass)	175	440	20
Grade Cu 2 Ni-manganese bronze (high tensile brass)	175	440	20
Grade Cu 3 Ni-aluminium bronze	245	590	16
Grade Cu 4 Mn-aluminium bronze	275	630	18

Table 4.5.1 Typical chemical composition for steel propeller castings

Alloy type	C Max. (%)	Mn Max. (%)	Cr (%)	Mo Max. (%) (see Note)	Ni (%)
Martensitic (12Cr 1Ni)	0,15	2,0	11,5–17,0	0,5	Max. 2,0
Martensitic (13Cr 4Ni)	0,06	2,0	11,5–17,0	1,0	3,5–5,0
Martensitic (16Cr 5Ni)	0,06	2,0	15,0–17,5	1,5	3,5–6,0
Austenitic (19Cr 11Ni)	0,12	1,6	16,0–21,0	4,0	8,0–13,0

NOTE
Minimum values are to be in accordance with the agreed specification or recognized National or International Standards.

Table 4.5.2 Typical mechanical properties for steel propeller castings

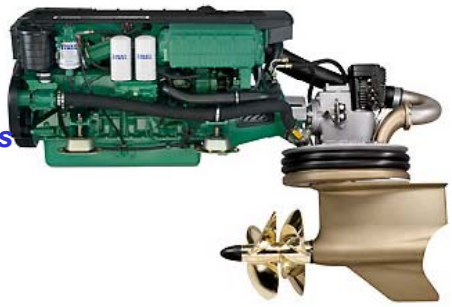
Alloy type	Yield stress or, 0,2% proof stress minimum, N/mm²	Tensile strength minimum N/mm²	Elongation on $5,65\sqrt{S_o}$ % minimum	Reduction of area % minimum	Charpy V-notch impact tests J minimum (see Notes 1 and 2)
Martensitic (12Cr 1Ni)	440	600	15	50	20
Martensitic (13Cr 4Ni)	550	750	15	35	30
Martensitic (16Cr 5Ni)	540	760	15	35	30
Austenitic (19Cr 11Ni)	190 (see Note 3)	440	30	40	–

NOTES
1. When a general service notation Ice Class 1AS, 1A, 1B or 1C is required, the tests are to be made at −10°C.
2. For general service or where the notation Ice Class 1D is required, the tests are to be made at 0°C.
3. $R_{p1,0}$ value is 205 N/mm².

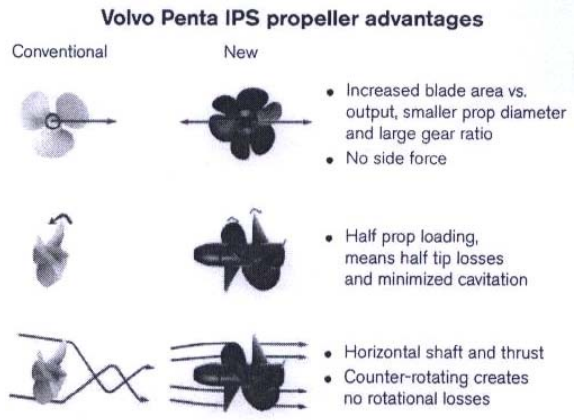
高速艇螺槳最新產品_小型英式推進器

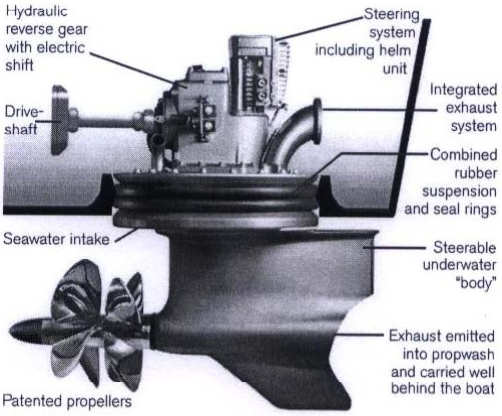
POD _ Volvo IPS 350/400/450/500/600

A revolutionary marine propulsion system



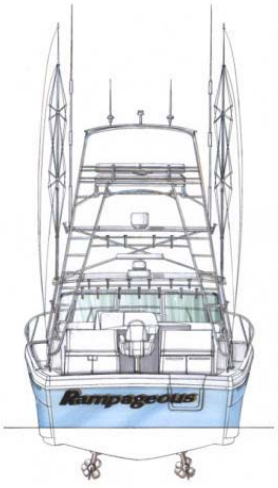
- demand for high speed, improved handling, enhanced onboard comfort and reduce emissions
- engine power ranging 350 to 600 hp
- suitable for 30 up to 50 feet planning hulls
- outstanding efficiency over 25-45 knots
- a reduced fuel consumption at 30 knots by 30%+





New Rampage 34 with IPS Pod Drives - 07/09/2008

The new Rampage 34 will be one of the first express fishboats built in the U.S. with Volvo Penta's IPS drive system



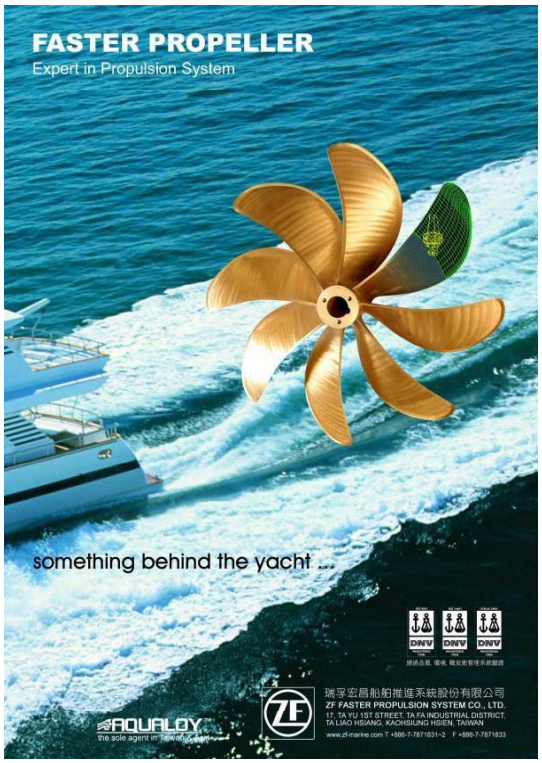
- better fuel mileage
- better performance
- better maneuverability
- run faster
- much easier to maneuver around docks with joystick technology
- 30%+ more fuel efficient than conventional inboard installations

Zeus® Pod Drive System

New ZF POD, Zeus Pod Drive
Powered by Caterpillar C9 ACERT @ 575 mhp x 2500 rpm
Into a 44' Sea Ray reaches top speed of 39 knots

FASTER CRUSING, HIGHER TOP SPEEDS,
ENHANCING MANEUVERABILITY, FUEL ECONOMY
A Clean, Quiet, and Comfortable Ride plus Precise One-Hand Docking

- *Joystick control to dock the boat with ease*
- *Reliable, smooth, hydraulic power steers the pods*
- *Actuates the integrated trim tabs*
- *Allows each pod to be steered independently, leads to much smoother and more accurate maneuverability*
- *The thrust from pod drives is horizontal compared to standard inclined shaft*
- *Minimize drag of pod shape than a shaft, strut and rudder*
- *Counter-rotating propellers eliminate rotational loss, produce no lateral forces and minimize cavitation*
- *Noise and vibration are significantly reduced, resulting in a quiet, comfortable ride*
- *A dedicated trolling valve enables lowest speeds*



Thank you

謝謝指正