

## 第十七次初階課程授課紀錄

授課時間	民國 97 年 12 月 31 日 (星期三) 下午 1:15 至 3:05		
授課地點	圖書資訊大樓四樓演講廳		
授課師資	王武雄	紀錄	林素如
出席學生	109 人		
缺席學生	7 人		
授課大綱	<ul style="list-style-type: none"> <li>一、 高速艇螺槳運轉環境 <ul style="list-style-type: none"> <li>— 高速艇推進系統布置—雙俾雙舵</li> <li>— 跡(伴)流分佈</li> <li>— 高速艇斜軸布置</li> <li>— 艙隧道線形</li> <li>— 空泡狀態下之螺槳性能_推力、扭矩與效率—</li> </ul> </li> <li>二、 高速艇螺槳應用現況趨勢 <ul style="list-style-type: none"> <li>— 高速艇螺槳之一般趨勢</li> <li>— 無因次參數</li> <li>— 高速 + 高軸傾斜角</li> <li>— 空泡趨勢_Gawn Burrill 圖表</li> </ul> </li> <li>三、 高速艇螺槳應用現況 (I) <ul style="list-style-type: none"> <li>— PJ 234 _ 15 knots _ 37.68 m (巨型遊艇)</li> <li>— Fleming _ 15.5 m _ 18.5 knots (中型遊艇)</li> <li>— Carver 650 _ 16.6 m _ 31 knots (中型高速遊艇)</li> <li>— GC Patrol _ 13.7 m _ 41 knots (高速巡邏艇)</li> <li>— Fast Patrol _ 11.2 m _ 51 knots (超高速巡邏艇)</li> <li>— Tige _ 5.5 m _ 38 knots (滑水艇(ski boat))</li> </ul> </li> <li>四、 高速艇螺槳應用現況 (II) <ul style="list-style-type: none"> <li>— Speed versus Length, Displacement 速長比- Froude Number 佛勞數</li> <li>— 推進器應用趨勢</li> <li>— 局部空泡數(0.7R)與推力負荷關係圖</li> </ul> </li> <li>五、 高速艇螺槳系列與翼型斷面 <ul style="list-style-type: none"> <li>— 不同船速狀況適用之螺槳葉片斷面型狀</li> <li>— 螺槳系列</li> </ul> </li> <li>六、 高速艇螺槳使用材料 <ul style="list-style-type: none"> <li>— 螺槳用材料分類</li> <li>— 螺槳材料之演進 (1960-1988)</li> <li>— 英國勞氏驗船協會規定之螺槳材料</li> </ul> </li> <li>七、 高速艇螺槳最新產品_小型英式推進器 <ul style="list-style-type: none"> <li>— POD _ Volvo IPS 350/400/450/500/600</li> <li>— New Rampage 34 with IPS Pod Drives - 07/09/2008</li> <li>— Zeus® Pod Drive System</li> </ul> </li> </ul>		

## 內容目錄

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一、演講海報



敬邀您參加

教育部補助大學校院培育海洋科技實務人才計畫  
初階實務課程 - 船廠經營管理

# 高速艇螺槳發展趨勢與展望

## 王武雄

瑞孚宏昌船舶推進系統股份有限公司  
總經理

97年12月31日

下午 1:15 至 3:05


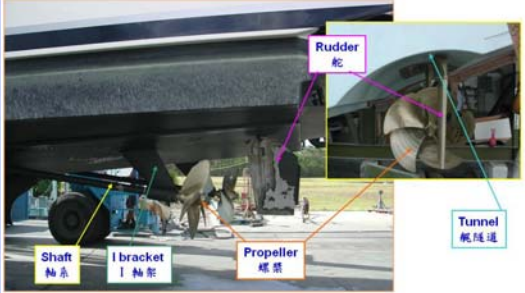
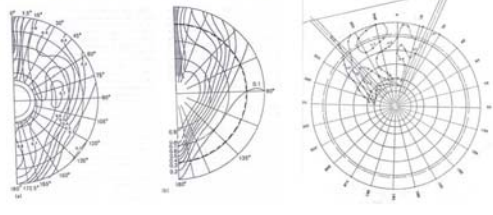
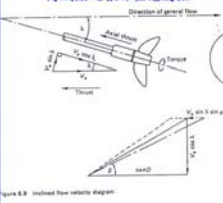

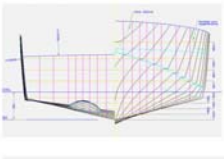
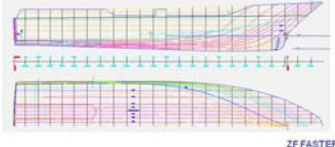
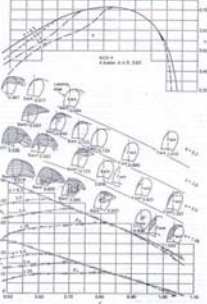


圖書資訊大樓四樓演講廳



## 二、師資簡介

中文姓名	王武雄	公司電話	07-7871831ext3 3	
E-mail	wuu.shyong.wang@zf-marine.com			
主要學歷				
畢業學校	國別	主修學門系所	學位	起迄年月
國立成功大學	中華民國	造船工程學系	學士	62.9-66.6
現職及與專長相關之經歷（由最近工作經驗依序往前追溯）				
公司名稱	部門	職稱	起迄年月	
瑞孚宏昌船舶推進系統股份有限公司		總經理	87.7 迄今	
財團法人聯合船舶設計發展中心	初步設計組 - 科技專案室	工程員-副主任	66.9-87.6	
本計畫中負責項目				
<p><b>初階實務演講課程：</b></p> <p><b>主題：高速艇螺槳發展趨勢與展望</b></p> <p><b>日期：97年12月31日</b></p> <p><b>時間：下午1：15至3：05</b></p> <p><b>地點：圖書資訊大樓四樓演講廳</b></p>				

三、授課簡報

<p><b>ZF</b></p> <p>高速艇螺槳發展趨勢與展望 Development of Propeller for HSC</p> <p>National Kaohsiung Maritime University 31 December 2008</p> <p>Wuu-Shyong Wang ZF Faster Propulsion System Co.,Ltd.</p> <p>Page 1 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b></p> <p>高速艇螺槳運轉環境</p> <p>SeaRay 60DA _ 36 knots</p>  <p>Page 2 ZF FASTER PROPULSION SYSTEM</p>
<p><b>ZF</b> General Layout of Propulsion System 高速艇推進系統佈置—雙體雙舵</p>  <p>Page 3 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b> Wake Field 跡(伴)流分佈</p> <p>Single screw _ U form 單螺槳_U 槳線形 Single screw _ V form 單螺槳_V 槳線形 Twin screw _ A/I bracket 雙螺槳_A/I 軸架</p>  <p>Page 4 ZF FASTER PROPULSION SYSTEM</p>
<p><b>ZF</b> Shaft Inclination for HSC 高速艇斜軸佈置</p> <p>Shaft inclined angle: 6 to 13 degrees (current trend) 現行趨勢 — high risk of root cavitation erosion 高風險之根部空泡侵蝕</p>   <p>Page 5 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b> Tunnel Hull Lines 艇隧道線形</p>  <ul style="list-style-type: none"> <li>Reduce shaft inclination angle 降低軸傾斜角度</li> <li>Increase tip hull clearance 增加螺槳葉尖與船底間隙</li> <li>Adjust static trim angle 調整靜止狀態之俯仰角(角度)</li> </ul>  <p>Page 6 ZF FASTER PROPULSION SYSTEM</p>
<p><b>ZF</b> Propeller Characteristics in Cavitation Condition 空泡狀態下之螺槳性能—推力、扭矩與效率</p>   <p>Alpha=90, back 斜軸角90度·葉背面</p> <p>Page 7 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b></p> <p>高速艇螺槳應用現況趨勢</p> <p>Viking 73 _ 36 knots</p>  <p>Page 8 ZF FASTER PROPULSION SYSTEM</p>



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

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

Engine IHP versus Ship Speed

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**Non-dimensional Parameters**  
 無因次參數

**Froude Number, Speed Length Ratio**

$$F_{st} = \frac{V}{\sqrt{gL}}$$

$$F_{sv} = \frac{V}{\sqrt{gV^{1/3}}}$$

$$F_{sb} = \frac{V}{\sqrt{gB}}$$

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

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

**Local Cavitation Number**  $\sigma_{0.7R} = \frac{P_0 - P_v}{\frac{1}{2}\rho V_R^2}$   $V_R^2 = V^2 + (0.7\pi nD)^2$

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

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**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 + 空泡侵蝕)

Shaft Inclined Angle versus Cavitation Number

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**General Cavitation Trend Diagram**  
 空泡趨勢\_Gawn Burrill 圖表

High Ship Speed (Low Cavitation Number) 高速(低空泡數)  
 High Propeller Thrust Loading (高螺旋槳推力負荷)  
 High Risk of Cavitation and Low Efficiency (高空泡侵蝕風險與低效率)

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**高速艇螺旋槳應用現況 (I)**

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**PJ 234 \_ 15 knots \_ 37.68 m**

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

巨型遊艇

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**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

中型遊艇

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**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

中型高速遊艇

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**GC Patrol\_ 13.7 m\_ 41 knots** ZF

Engine: 2 x 1100 ps x 2450 rpm, 1.525:1 高速巡邏艇  
 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



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**Fast Patrol\_ 11.2 m\_ 51 knots** ZF

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




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**Tige\_ 5.5 m\_ 38 knots** ZF

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



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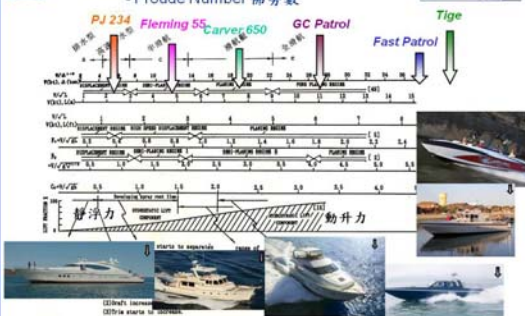
**高速艇螺槳應用現況 (II)** ZF

CNB 20 m Police Patrol\_ 25 knots



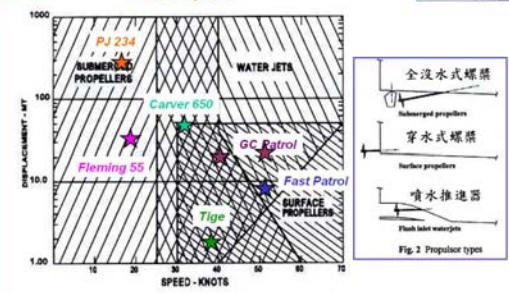
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**Speed versus Length, Displacement 速長比 - Froude Number 佛勞數** ZF



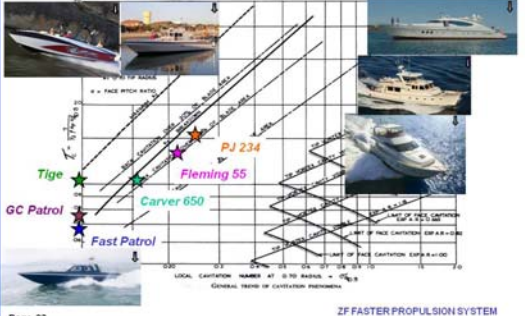
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**Trends for Propulsor Application 推進器應用趨勢** ZF



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**Cavitation Number versus Thrust Loading 局部空泡數(0.7R)與推力負荷關係圖** ZF



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**高速艇螺槳系列與異型斷面** ZF

Marlow 86\_ 29 knots



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<p><b>ZF</b> Propeller Blade Sections (Series) for different Speed Application 不同船速狀況適用之螺旋葉片斷面型狀</p> <table border="1"> <thead> <tr> <th>SHEP SPEED (Knots)</th> <th>PROPELLER BLADE SECTION</th> <th>PROPELLER BLADE SECTION</th> </tr> </thead> <tbody> <tr> <td>&lt;25</td> <td>AEROFDIL </td> <td>MAU, Vagenengen-B, NACA</td> </tr> <tr> <td rowspan="2">25-35</td> <td>AEROFDIL </td> <td>MAU, Vagenengen-B, NACA</td> </tr> <tr> <td>OGIVAL </td> <td>Gawn, Gawn-Burrill (KCA)</td> </tr> <tr> <td rowspan="2">35-40</td> <td>CRESCENT </td> <td>Newton-Roder, New-Foil</td> </tr> <tr> <td>CRESCENT </td> <td>Newton-Roder, New-Foil</td> </tr> <tr> <td rowspan="2">40-50</td> <td>CRESCENT </td> <td>Newton-Roder, New-Foil</td> </tr> <tr> <td>SC or SPP </td> <td>Rolls, SUS</td> </tr> <tr> <td>&gt;50</td> <td>SC or SPP </td> <td>Rolls, SUS</td> </tr> <tr> <td>30-50</td> <td>Cupping </td> <td>Cupping KCA or NF</td> </tr> </tbody> </table> <p>Page 25 ZF FASTER PROPULSION SYSTEM</p>	SHEP SPEED (Knots)	PROPELLER BLADE SECTION	PROPELLER BLADE SECTION	<25	AEROFDIL 	MAU, Vagenengen-B, NACA	25-35	AEROFDIL 	MAU, Vagenengen-B, NACA	OGIVAL 	Gawn, Gawn-Burrill (KCA)	35-40	CRESCENT 	Newton-Roder, New-Foil	CRESCENT 	Newton-Roder, New-Foil	40-50	CRESCENT 	Newton-Roder, New-Foil	SC or SPP 	Rolls, SUS	>50	SC or SPP 	Rolls, SUS	30-50	Cupping 	Cupping KCA or NF	<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>KCA – Series</p> <p>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.</p>  <p>Page 26 ZF FASTER PROPULSION SYSTEM</p>
SHEP SPEED (Knots)	PROPELLER BLADE SECTION	PROPELLER BLADE SECTION																										
<25	AEROFDIL 	MAU, Vagenengen-B, NACA																										
25-35	AEROFDIL 	MAU, Vagenengen-B, NACA																										
	OGIVAL 	Gawn, Gawn-Burrill (KCA)																										
35-40	CRESCENT 	Newton-Roder, New-Foil																										
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>50	SC or SPP 	Rolls, SUS																										
30-50	Cupping 	Cupping KCA or NF																										
<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>Skew KCA – Series</p> <p>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.</p>  <p>Page 27 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>Cupping – Series</p> <p>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.</p>   <p>Page 28 ZF FASTER PROPULSION SYSTEM</p>																											
<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>NACA – Series</p> <p>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.</p>  <p>Page 29 ZF FASTER PROPULSION SYSTEM</p>	<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>New Foil – Series</p> <p>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.</p>  <p>Page 30 ZF FASTER PROPULSION SYSTEM</p>																											
<p><b>ZF</b> Propellers Series 螺旋系列</p> <p>Surface Piercing Propeller</p> <p>Blades : 4, 5, 6 Pitch Ratio : 0.80-1.60 Area Ratio : 0.70-1.10 Skew Angles : According to design Section Type : SPP</p>  <p>Page 31 ZF FASTER PROPULSION SYSTEM</p>	<p>高速艇螺旋使用材料</p>  <p>Page 32 ZF FASTER PROPULSION SYSTEM</p>																											



**Propeller Materials Category**  
螺旋槳材料分類

鋼合金系  
不銹鋼系  
其他

Set of propeller materials

Steel alloys

High tensile brass  
Manganese aluminum bronze  
Nickel aluminum bronze

Stainless steels

Austenitic stainless steel  
Martensitic stainless steel  
Duplex stainless steel

Other materials

Cast iron  
Cast steel  
Aluminum  
Curalamin  
Polymers

Austenitic nodular cast iron  
Grey cast iron  
Spheroidal graphite cast iron

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**Popularity Progress of Propeller Materials**  
螺旋槳材料之演進 (1960-1988)

From Lloyd's Register of Shipping 英國勞氏船級協會

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**Propeller Material of Lloyd's Classification**  
英國勞氏船級協會規定之螺旋槳材料

**Table 9.1.1 Chemical composition of propeller and propeller blade castings**

Alloy designation	Cu	Mn	Zn	Si	Fe	Al	Ni
Grade Cu-1 High-tensile brass	52-62	0.4-0.8	0.4-0.8	0.3 max.	1.5 max.	0.0-0.1	0.0-0.05
Grade Cu-2 High-tensile brass	50-57	0.4-0.8	0.4-0.8	0.3 max.	1.5 max.	0.0-0.1	0.0-0.05
Grade Cu-3 Ni-aluminum-bronze	77-82	0.1 max.	1.0 max.	0.05 max.	0.3-0.6	0.3-0.6	7.0-10.0
Grade Cu-4 Ni-aluminum-bronze	75-80	1.0 max.	0.2 max.	0.05 max.	1.5-2.0	0.3-0.6	6.5-9.0

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

Alloy designation	0.2% proof stress, N/mm <sup>2</sup>	Tensile strength, N/mm <sup>2</sup>	Elongation at break, %
Grade Cu-1 High-tensile brass	175	440	20
Grade Cu-2 High-tensile brass	175	440	20
Grade Cu-3 Ni-aluminum-bronze	245	590	16
Grade Cu-4 Ni-aluminum-bronze	275	620	14

**Table 9.1.3 Typical chemical composition for steel propeller castings**

Alloy type	C	Mn	Si	P	S	Ni	Cr
Marine-1 (S15 Mn)	0.16	0.35	0.035	0.015	0.008	0	0
Marine-2 (S15 Mn)	0.16	0.35	0.035	0.015	0.008	0	0
Marine-3 (S15 Mn)	0.16	0.35	0.035	0.015	0.008	0	0
Marine-4 (S15 Mn)	0.16	0.35	0.035	0.015	0.008	0	0

**Table 9.1.4 Typical mechanical properties for steel propeller castings**

Alloy type	Yield strength, N/mm <sup>2</sup>	Tensile strength, N/mm <sup>2</sup>	Elongation at break, %	Impact energy, J/cm <sup>2</sup>
Marine-1 (S15 Mn)	440	590	16	30
Marine-2 (S15 Mn)	440	590	16	30
Marine-3 (S15 Mn)	440	590	16	30
Marine-4 (S15 Mn)	440	590	16	30

Steel Propeller Casting

Copper Alloy Casting

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**高遠艇螺旋槳最新產品\_小型英式推進器**

Viking 56 \_ 41 knots

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**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 planing hulls
- outstanding efficiency over 25-45 knots
- a reduced fuel consumption at 30 knots by 30%+

**Volvo Penta IPS propeller advantages**

- Increased blade area vs. output, smaller prop diameter and larger gear ratio
- No side force
- Half gear loading means half top losses and minimized cavitation
- Horizontal shaft and thrust
- Counter-rotating propellers

Page 37 ZF FASTER PROPULSION SYSTEM

**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

Page 38 ZF FASTER PROPULSION SYSTEM

**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 CRUISING, 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

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**FASTER PROPELLER**  
Something behind the yacht

Thank you  
謝謝指正

Hatteras 60 \_ 41.5 knots

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### 四、授課照片

97 年 12 月 31 日：高速艇螺槳發展趨勢與展望



主任介紹演講者－王武雄總經理



說明高速艇螺槳發展趨勢與展望



說明高速艇螺槳運轉環境



高速艇螺槳推進系統布置－雙俥雙舵

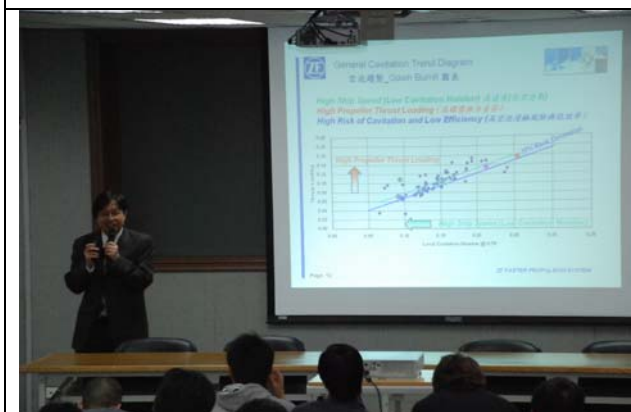






空泡狀態下螺槳性能、推力、扭力與效率

高速螺槳之一般趨勢



空泡趨勢\_Gawn Burrill 圖表

頒發遊艇設計獎學金

## 五、演講內容