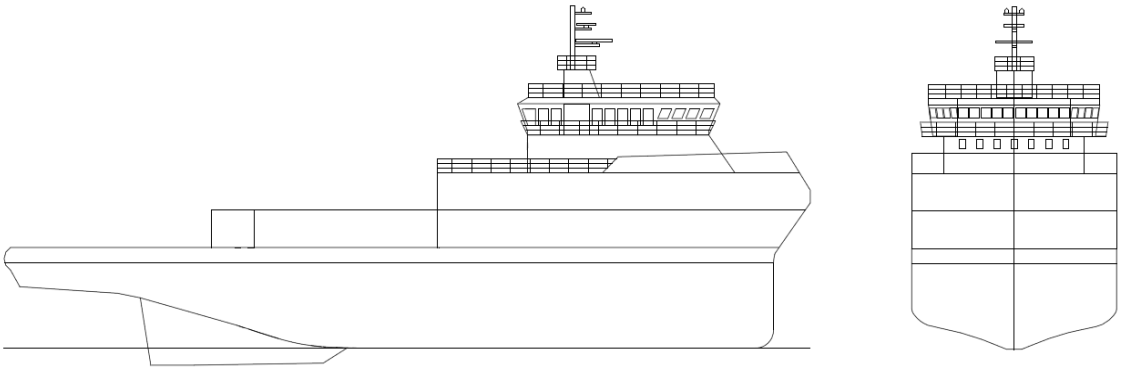
REMOLCADOR DE ALTURA POLIVALENTE

ESCUELA POLITÉCNICA SUPERIOR

UNIVERSIDAD DE A CORUÑA

PROYECTO FIN DE GRADO 2014/2015

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE



CUADERNO 6: PREDICCIÓN DE POTENCIA Y DISEÑO DE PROPULSORES

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Escola Politécnica Superior

UNIVERSIDADE DA CORUÑA

DEPARTAMENTO DE INGENIERÍA NAVAL Y OCEÁNICA

GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

CURSO 2.014-2015

PROYECTO NÚMERO

TIPO DE BUQUE: Remolcador de Altura Polivalente, escolta, lucha contra incendios y lucha contra la contaminación.

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: American Bureau of Shipping, Solas, Marpol.

CARACTERÍSTICAS DE LA CARGA: 130 toneladas de tiro a punto fijo, 700 toneladas de carga en cubierta.

VELOCIDAD Y AUTONOMÍA: 15 nudos al 85 % de la MCR, 15 % de margen de mar, autonomía de 8000 millas.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA: Maquinillas de remolque en proa y popa, gancho giratorio y articulado, los habituales en este tipo de buques.

PROPULSIÓN: Propulsión diésel-eléctrica, propulsores azimutales tipo Schottel.

TRIPULACIÓN Y PASAJE: 14 tripulantes, 60 supervivientes.

OTROS EQUIPOS E INSTALACIONES: Hélice transversal en proa,

Ferrol, 23 de Marzo de 2.015

ALUMNO: D. Mario Teijeiro Prieto.

ÍNDICE

1. INTRODUCCIÓN

En el primer cuaderno fueron realizados los cálculos para conocer la potencia total a instalar a partir de las rectas de regresión. Además, se realizó la predicción de potencia para la condición de navegación en aguas libres.

Es necesario realizar la predicción de potencia total a instalar mediante el cálculo de la potencia en la condición de remolque. Este cálculo se realizará utilizando el programa Navcad.

Con esto se determinará la potencia que tendrán que suministrar los generadores, y los motores eléctricos y el propulsor que serán necesarios para la condición de remolque cumpliendo la condición de tiro a punto fijo.

Al tener dos condiciones de navegación se asegurará que la potencia calculada es suficiente en ambas condiciones.

La propulsión será diésel-eléctrica y los propulsores azimutales tipo Schottel, tal y como se exige en los requerimientos del proyecto.

El cálculo del propulsor no está sujeto únicamente a una condición de navegación por lo que no es posible diseñar una hélice que con el mismo motor funcione en su punto óptimo en las dos condiciones. Por esto, la hélice se dimensionará para dar el tiro a punto fijo necesario que es el requerimiento más restrictivo.

Dimensionar la hélice para dar el tiro a punto fijo necesario requiere un cálculo de resistencia al avance y el cálculo del propulsor para la condición de remolque.

Los pasos a seguir serán:

1. Cálculo de resistencia al avance para la condición de remolque.
2. Cálculo del propulsor necesario para la condición de remolque.
3. Selección de la planta propulsora.

2. CÁLCULO DE LA RESISTENCIA AL AVANCE

Se calculará utilizando el programa Navcad. El cálculo será el mismo que para la condición de aguas libres y por tanto el resultado será el mismo.

2.1. Condición

En primer lugar se introducen los datos de principales del buque, la línea de fricción a utilizar, las propiedades del agua y las velocidades.

Project		
Project ID:	Proyecto	
Description:		
Summary		
Scope:	ITTC-78 (CT)	
Configuration:	Monohull	
Chine type:	Single/hard	
Length on WL:	54,170	m
Displacement:	2901,37	t
Propulsor type:	SPP	
Count:	2	
Water properties		
Water type:	Salt	
Density:	1026,00	kg/m3
Viscosity:	1,18920e-6	m2/s
Speeds		
Speed [01]	0,50	kt
Speed [02]	2,00	kt
Speed [03]	4,00	kt
Speed [04]	6,00	kt
Speed [05]	8,00	kt
Speed [06]	10,00	kt
Speed [07]	12,00	kt
Speed [08]	14,00	kt
Speed [09]	15,00	kt
Speed [10]		kt
Design condition		
Design speed:	15,00	kt

2.2. Casco

Se introducirán a continuación, los datos del casco. Las dimensiones principales introducidas son las resultantes del cálculo de la cifra de mérito.

La superficie libre calculada se aproxima mediante el método Swift ya que es el método que más se aproxima.

Los valores de los parámetros de la ITTC-78 son aproximaciones realizadas con el programa utilizando los métodos que más se aproximan.

	Aproximación
LCB fwd TR	2% aft. of mid-LWL
LCF fwd TR	Average
Max section area	Typical large ship
Waterplane area	Series 60
Half entrance angle	Holtrop
Parámetros del bulbo	Sin bulbo (Buque base Pacific Vigilance)

Hull		
Configuration:	Monohull	
Chine type:	Single/hard	
General		
Length on WL:	54,170	m
Max beam on WL:	15,580	m
Max molded draft:	6,360	m
Displacement:	2901,37	t
Wetted surface:	1039,8	m2
Demi-hull spacing:		m
ITTC-78 (CT)		
LCB fwd TR:	26,002	m
LCF fwd TR:	28,168	m
Max section area:	92,4	m2
Waterplane area:	562,0	m2
Bulb section area:	0,0	m2
Bulb ctr below WL:	0,000	m
Bulb nose fwd TR:	0,000	m
Transom area:	0,0	m2
Transom beam WL:	0,000	m
Transom immersion:	0,000	m
Half entrance angle:	21,10	deg
Bow shape factor:	0,0	[AVG flow]
Stern shape factor:	0,0	[AVG flow]

2.3. Apéndices

Se definirán los apéndices por componentes.

Al utilizar propulsores azimutales tipo Schottel no habrá un eje que genere resistencia al avance.

Los valores introducidos para el skeg y el thruster de proa son tomados del buque base Pacific Vigilance.

Appendage		
Definition:	Component	
Percent of hull drag:		%
Planing influence		
LCE fwd TR:		m
VCE below WL:		m
Shafting		
Count:	2	
Max prop diameter:	4670	mm
Shaft angle to WL:	0	deg
Exposed shaft length:	0,000	m
Shaft diameter:	0,000	m
Wetted surface:	0,0	m2
Strut bossing length:	0,000	m
Bossing diameter:	0,000	m
Wetted surface:	0,0	m2
Hull bossing length:	0,000	m
Bossing diameter:	0,000	m
Wetted surface:	0,0	m2

Skeg/Keel		
Count:	1	
Type:	Skeg	
Mean length:	11,860	m
Mean width:	1,033	m
Height aft:	1,140	m
Height mid:	1,970	m
Height fwd:	4,040	m
Root chord:		m
Tip chord:		m
Span:		m
T/C ratio:		
LE sweep:		deg
Keel bulb length:		m
Keel bulb diameter:		m
Skeg projected area:	25,8	m2
Skeg wetted surface:	63,9	m2

Tunnel thruster		
Count:	1	
Diameter:	1,580	m

2.4. Cargas ambientales

No se aplicarán cargas ambientales ya que se tendrán en cuenta con el 15% de margen de mar indicado en los requerimientos del proyecto.

2.5. Margen de mar

Se aplica un margen de diseño para tener en cuenta las cargas ambientales.

Margin		
Design margin:	15	%
Basis:	Hull + added dr...	

2.6. Cálculo

Se define que el método de predicción utilizado será el Oortmerssen que es el más adecuado para remolcadores.

La línea de fricción utilizada será la ITTC-57.

Para aproximar el factor de forma se utiliza el método Holtrop ya que es el que mejor se aproxima.

Se añadirá el cálculo por el método Holtrop de la resistencia producida por los apéndices y el margen de mar.

Vessel drag	Calc	ITTC-78 (CT)
Technique:		Prediction
Prediction:		Oortmerssen
Reference ship:		
Model LWL:	[m]	
Viscous		
Expansion:		Standard
Friction line:		ITTC-57
Hull form factor:	On	1,318
Speed corr:	Off	
Spray drag corr:	Off	
Corr allowance:		ITTC-78 (v2008)
Roughness [mm]:	Off	
Catamaran		
Interference:	Off	
Added drag		
Appendage:	Calc	Holtrop (Compone...
Wind:	Off	
Seas:	Off	
Shallow/channel:	Off	
Margin:	Calc	Hull + added drag [15...

2.6. Resultados

Los resultados son los mismos que los presentados en el cuaderno 1 ya que la resistencia al avance será la misma en las dos condiciones de navegación del buque.

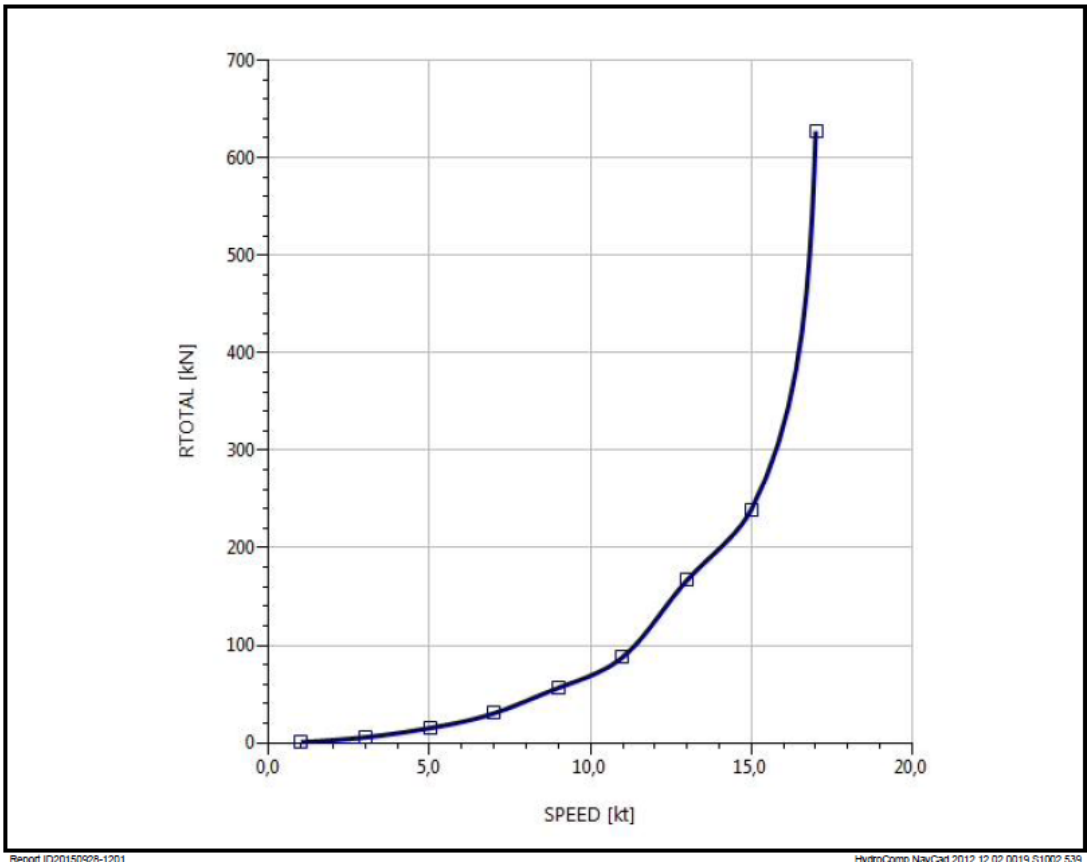
Resistance
28 sep 2015 12:01
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Vessel drag	**ITTC-78 (CT)**	**Added drag**	
Technique:	[Calc] Prediction	Appendage:	[Calc] Holtrop (Component)
Prediction:	Oortmerssen	Wind:	[Off]
Reference ship:		Seas:	[Off]
Model LWL:		Shallow/channel:	[Off]
Expansion:	Standard	Margin:	[Calc] Hull + added drag [15%]
Friction line:	ITTC-57	**Water properties**	
Hull form factor:	[On] 1,318	Water type:	Salt
Speed corr:	[Off]	Density:	1026,00 kg/m3
Spray drag corr:	[Off]	Viscosity:	1,18920e-6 m2/s
Corr allowance:	ITTC-78 (v2008)		
Roughness [mm]:	[Off]		

Predicted resistance



Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Analysis parameters

Vessel drag		ITTC-78 (CT)
Technique:	[Calc]	Prediction
Prediction:		Oortmerssen
Reference ship:		
Model LWL:		
Expansion:		Standard
Friction line:		ITTC-57
Hull form factor:	[On]	1,318
Speed corr:	[Off]	
Spray drag corr:	[Off]	
Corr allowance:		ITTC-78 (v2008)
Roughness [mm]:	[Off]	

Added drag		
Appendage:	[Calc]	Holtrop (Component)
Wind:	[Off]	
Seas:	[Off]	
Shallow/channel:	[Off]	
Margin:	[Calc]	Hull + added drag [15%]
Water properties		
Water type:		Salt
Density:		1026,00 kg/m3
Viscosity:		1,18920e-6 m2/s

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	0,33	0,56	3,48	2,45	0,480	21,1	0,93
Range	0,05··0,50	0,51··0,69	3,50··6,30	1,90··3,40	0,467··0,537	10,0··38,0	0,73··0,97

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CV/CF]	CR	dCF	CA	CT
1,00	0,022	0,044	2,34e7	0,002601	1,318	0,000001	0,000000	0,000463	0,003892
3,00	0,067	0,131	7,03e7	0,002194	1,318	0,000001	0,000000	0,000649	0,003541
5,00	0,112	0,218	1,17e8	0,002036	1,318	0,000001	0,000000	0,000682	0,003367
7,00	0,156	0,306	1,64e8	0,001942	1,318	0,000205	0,000000	0,000690	0,003454
9,00	0,201	0,393	2,11e8	0,001875	1,318	0,000770	0,000000	0,000689	0,003931
11,00	0,246	0,481	2,58e8	0,001825	1,318	0,001036	0,000000	0,000685	0,004126
13,00	0,290	0,568	3,05e8	0,001784	1,318	0,002703	0,000000	0,000679	0,005733
+ 15,00 +	0,335	0,655	3,52e8	0,001750	1,318	0,003237	0,000000	0,000672	0,006215
17,00	0,379	0,743	3,98e8	0,001722	1,318	0,010099	0,000000	0,000665	0,013032

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
1,00	0,55	0,06	0,00	0,00	0,00	0,09	0,70	0,3	0,4
3,00	4,50	0,49	0,00	0,00	0,00	0,75	5,74	6,9	8,9
5,00	11,88	1,32	0,00	0,00	0,00	1,98	15,19	30,6	39,1
7,00	23,90	2,52	0,00	0,00	0,00	3,96	30,38	86,1	109,4
9,00	44,95	4,08	0,00	0,00	0,00	7,35	56,39	208,1	261,1
11,00	70,48	6,00	0,00	0,00	0,00	11,47	87,96	398,8	497,7
13,00	136,77	8,27	0,00	0,00	0,00	21,76	166,79	914,7	1115,5
+ 15,00 +	197,42	10,88	0,00	0,00	0,00	31,25	239,55	1523,4	1848,5
17,00	531,70	13,84	0,00	0,00	0,00	81,83	627,37	4650,0	5486,7

	OTHER	
SPEED [kt]	CTLR	CTLT
1,00	0,00001	0,03877
3,00	0,00001	0,03527
5,00	0,00001	0,03354
7,00	0,00204	0,03440
9,00	0,00767	0,03915
11,00	0,01032	0,04109
13,00	0,02691	0,05709
+ 15,00 +	0,03223	0,06190
17,00	0,10057	0,12979

Report ID20150928-1201 HydroComp NavCad 2012 12.02.0019.61002.539

Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Hull data

General		
Configuration:		Monohull
Chine type:		Single/hard
Length on WL:		54,170 m
Max beam on WL:	[LWL/BWL 3,477]	15,580 m
Max molded draft:	[BWL/T 2,450]	6,360 m
Displacement:	[CB 0,527]	2901,37 t
Wetted surface:	[CWS 5,200]	1039,8 m2
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,480]	26,002 m
LCF fwd TR:	[XCF/LWL 0,520]	28,168 m
Max section area:	[CX 0,932]	92,4 m2
Waterplane area:	[CWP 0,666]	562,0 m2
Bulb section area:		0,0 m2
Bulb ctr below WL:		0,000 m
Bulb nose fwd TR:		0,000 m
Transom area:	[ATR/AX 0,000]	0,0 m2
Transom beam WL:	[BTR/BWL 0,000]	0,000 m
Transom immersion:	[TTR/T 0,000]	0,000 m
Half entrance angle:		21,10 deg
Bow shape factor:	[AVG flow]	0,0
Stern shape factor:	[AVG flow]	0,0

Planing		
Proj chine length:		*0,000 m*
Proj bottom area:		*0,0 m2*
LCG fwd TR:	*[XCG/LP 0,000]*	*0,000 m*
VCG below WL:		*0,000 m*
Aft station (fwd TR):		*0,000 m*
Chine beam:		*0,000 m*
Chine ht below WL:		*0,000 m*
Deadrise:		*0,00 deg*
Fwd station (fwd TR):		*0,000 m*
Chine beam:		*0,000 m*
Chine ht below WL:		*0,000 m*
Deadrise:		*0,00 deg*
Propulsor type:		*SPP*
Propeller diameter		*3700,0 mm*
Shaft angle to WL:		*0,00 deg*
Position fwd TR:		*0,000 m*
Position below WL:		*0,000 m*

Report ID20150928-1201 HydroComp NavCad 2012 12.02.0019.61002.539

Appendage data

General	
Definition:	Component
Percent of hull drag:	5,00 %
Planing influence	
LCE fwd TR:	0,000 m
VCE below WL:	0,000 m
Shafting	
Count:	2
Max prop diam:	3700,0 mm
Shaft angle to WL:	0,00 deg
Exposed shaft length:	0,000 m
Shaft diameter:	0,000 m
Wetted surface:	0,0 m2
Strut bossing length:	0,000 m
Bossing diameter:	0,000 m
Wetted surface:	0,0 m2
Hull bossing length:	0,000 m
Bossing diameter:	0,000 m
Wetted surface:	0,0 m2
Strut (per shaft line)	
Count:	0
Root chord:	0,000 m
Tip chord:	0,000 mm
Span:	0,000 m
T/C ratio:	0,000
Projected area:	0,0 m2
Wetted surface:	0,0 m2
Exposed palm depth:	0,000 m
Exposed palm width:	0,000 m
Rudder	
Count:	0
Rudder location:	Behind propeller
Type:	Balanced foil
Root chord:	0,000 m
Tip chord:	0,000 m
Span:	0,000 m
T/C ratio:	0,000
LE sweep:	0,00 deg
Projected area:	0,0 m2
Wetted surface:	0,0 m2

Skeg/Keel	
Count:	1
Type:	Skeg
Mean length:	11,860 m
Mean width:	1,033 m
Height aft:	1,140 m
Height mid:	1,970 m
Height fwd:	4,040 m
Projected area:	25,8 m2
Wetted surface:	63,9 m2
Stabilizer	
Count:	0
Root chord:	0,000 m
Tip chord:	0,000 m
Span:	0,000 m
T/C ratio:	0,000
LE sweep:	0,00 deg
Wetted surface:	0,0 m2
Projected area:	0,0 m2
Dynamic multiplier:	1,00
Bilge keel	
Count:	0
Mean length:	0,000 m
Mean base width:	0,000 m
Mean projection:	0,000 m
Wetted surface:	0,0 m2
Tunnel thruster	
Count:	1
Diameter:	1,580 m
Sonar dome	
Count:	0
Wetted surface:	0,0 m2
Miscellaneous	
Count:	0
Drag area:	0,0 m2
Drag coef:	0,00

Environment data

Wind		Seas	
Wind speed:	0,00 kt	Significant wave ht:	0,000 m
Angle off bow:	0,00 deg	Modal wave period:	0,0 sec
Gradient correction:	Off	**Shallow/channel**	
Exposed hull		Water depth:	0,000 m
Transverse area:	0,0 m2	Type:	Shallow water
VCE above WL:	0,000 m	Channel width:	0,000 m
Profile area:	0,0 m2	Channel side slope:	0,00 deg
Superstructure		Hull girth:	0,000 m
Superstructure shape:	Cargo ship		
Transverse area:	0,0 m2		
VCE above WL:	0,000 m		
Profile area:	0,0 m2		

Report ID20150928-1201 HydroComp NavCad 2012 12.02.0019.S1002.539

Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Symbols and values

FN = Froude number [LWL]
FV = Froude number [VOL]
RN = Reynolds number [LWL]
CF = Frictional resistance coefficient
CV/CF = Viscous/frictional resistance coefficient ratio [dynamic form factor]
CR = Residuary resistance coefficient
dCF = Added frictional resistance coefficient for roughness
CA = Correlation allowance [dynamic]
CT = Total bare-hull resistance coefficient

RBARE = Bare-hull resistance
RAPP = Additional appendage resistance
RWIND = Additional wind resistance
RSEAS = Additional sea-state resistance
RCHAN = Additional shallow/channel resistance
RMARGIN = Resistance margin
RTOTAL = Total vessel resistance

CTLR = Telfer residuary resistance coefficient
CTLT = Telfer total bare-hull resistance coefficient
PEBARE = Bare-hull effective power
PETOTAL = Total effective power

\+ = Design speed indicator
* = Exceeds parameter limit

Report ID20150928-1201 HydroComp NavCad 2012 12.02.0019.S1002.539

Navegación en aguas libres (15 nudos)		
Resistencia	239,55	kN
Potencia por propulsor	1848,5	kW

3. CÁLCULO DE LA POTENCIA

El cálculo de potencia se realizará para la condición de remolque ya que con este obtendremos una potencia necesaria mayor por lo que es el más restrictivo

3.1. Motor eléctrico

Se introducirán los siguientes datos:

Nº propulsores	2	-
Paso de la hélice	FPP	Paso fijo
Tipo de propulsor	Kaplan 19 A	El más similar a hélices azimutales
Nº palas	4	-

Se introducen los valores del propulsor del buque base y se van ajustando para dimensionar el nuevo propulsor para que este consiga aportar el tiro a punto fijo necesario.

El tiro a punto a fijo tiene que darse a una velocidad cero por lo que se definirán unas velocidades más bajas para obtener un resultado más aproximado al designar como velocidad de diseño la más baja posible.

Se introducen los datos de un motor que se aproxime a la potencia de remolque calculada en el cuaderno 1 mediante rectas de regresión.

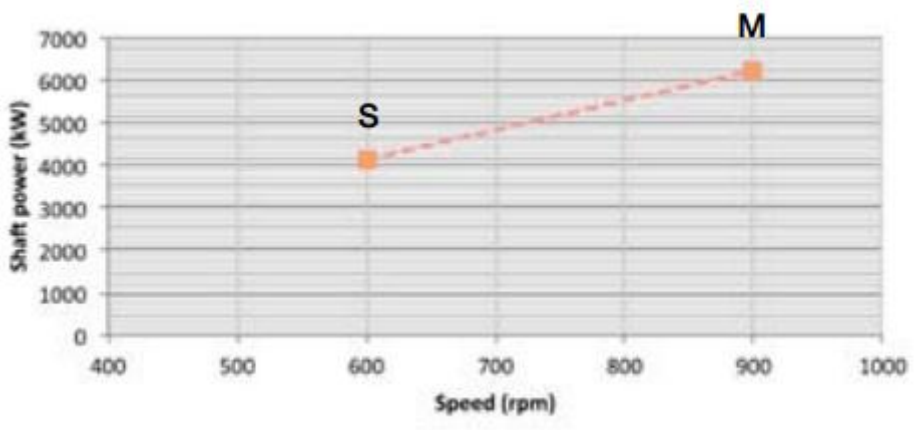
Condición	Nº generadores en funcionamiento	Potencia por generador (kW)	% Funcionamiento
Navegación en aguas libres	2	-	51%
Remolque	3	3632,83	100%

A partir de la potencia de 3632,83 kW por generador no se consigue el tiro a punto fijo deseado por lo que se decide aumentar la potencia.

El motor eléctrico elegido que proporciona las toneladas a punto fijo requeridas, a una velocidad próxima a cero nudos, es un motor ABB High speed drive 710 sd S cuyas características se adjuntan en el Anexo I. Los generadores tendrán que suministrar esta potencia más la potencia necesaria para la demanda eléctrica.

La potencia de este motor es de 4150 kW. El diámetro máximo para el que conseguimos este tiro es de 4670 mm.

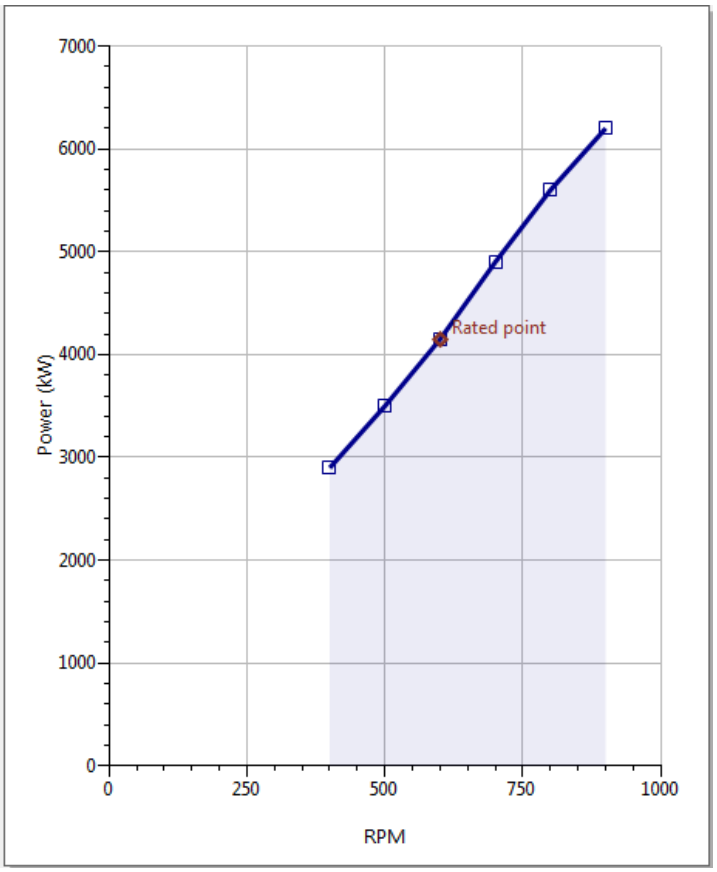
La curva del motor se introduce a partir de la curva obtenida del fabricante:



Properties			
Description:		High speed drive	
Import file:		C:\Users\Port...	
Units			
Power:		[0.0]	kW
Fuel rate:		[0.00]	L/h
Parameters			
Rated power:		4150,0	kW
Rated RPM:		600	
Parasitic load:		0,0	kW

	MAX POWER CURVE		
	RPM	Power	Fuel
1	900	6200,0	0,00
2	800	5600,0	0,00
3	700	4900,0	0,00
4	600	4150,0	0,00
5	500	3500,0	0,00
6	400	2900,0	0,00
7			
8			
9			
10			

	DEFINED LOAD CURVE		
	RPM	Power	Fuel
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



A continuación, se introduce una estimación de la eficiencia y el ratio de la reductora así como de la eficiencia del eje:

	Aproximación	
Eficiencia de la reductora	1	Direct drive
Ratio de la reductora	Valor común en este tipo de propulsores	-
Eficiencia del eje	0,97	Single-screw

Propulsor		
Count:	2	
Propulsor type:	Propeller series	
Propeller type:	FPP	
Propeller series:	Kaplan 19A	
Propeller sizing:	By power	
Reference prop:		
Blade count:	4	
Expanded area ratio:	0,6999	
Propeller diameter:	4670,0	mm
Propeller mean pitch:	5064,5	mm
Hub immersion:	5500,0	mm
Engine/gear		
Engine data:	High speed driv...	
Rated RPM:	600	RPM
Rated power:	4150,0	kW
Gear efficiency:	1,00	
Gear ratio:	5,449	
Shaft efficiency:	0,97	
Propeller options		
Oblique angle corr:	Off	
Shaft angle to WL:	0,00	deg
Added rise of run:	0,00	deg
Propeller cup:	0,0	mm
KTKQ corrections:	Standard	
Scale correction:		
KT multiplier:	1,00	
KQ multiplier:	1,00	

3.2. Cálculo

Finalmente se calcula el nuevo propulsor:

To size			
Gear ratio:	Size	**5,449**	
Expanded area ratio:	Size	**0,700**	
Propeller diameter:	Size	**4670,0**	mm
Propeller mean pitch:	Size	**5064,5**	mm
Design condition			
Max prop diam:		4670,0	mm
Design speed:		2,00	kt
Reference power:		4150,0	kW
Design point:		1,000	
Reference RPM:		600,0	
Design point:		1,000	

La velocidad de diseño para la que se puede hacer el cálculo con los parámetros introducidos es de 2 nudos. Para esta velocidad el tiro a punto fijo obtenido es de 1205 kN. El método de predicción utilizado vuelve a ser el Oortmersen y en esta ocasión el tipo de análisis será para la condición de remolque (Towing).

Hull-propulsor	Calc	
Technique:		Prediction
Prediction:		Oortmerssen
Reference ship:		
Max prop diam:	[mm]	4670,0
Corrections		
Viscous scale corr:	On	Standard
Rudder location:		Behind propeller
Friction line:		ITTC-57
Hull form factor:		1,318
Corr allowance:		ITTC-78 (v2008)
Roughness [mm]:	Off	
Ducted prop corr:	On	
Tunnel stern corr:	Off	
Effective diam:	[m]	
Recess depth:	[m]	
System analysis		
Cavitation criteria:		Keller eqn
Analysis type:		Towing
CPP method:		Fixed RPM
Engine RPM:		
Mass multiplier:		
RPM constraint:		
Limit [RPM/s]:		

Velocidad (kt)	TPF (kN)	TPF (ton)
2	1205,31	122,990816
0,5	1283,3	130,94898

El tiro a punto fijo que se obtiene para una velocidad de 0,5 nudos ya sería mayor de 130 toneladas por lo que el tiro a 0 nudos, que sería mayor, cumpliría con el requerimiento de las 130 toneladas.

3.3. Resultados

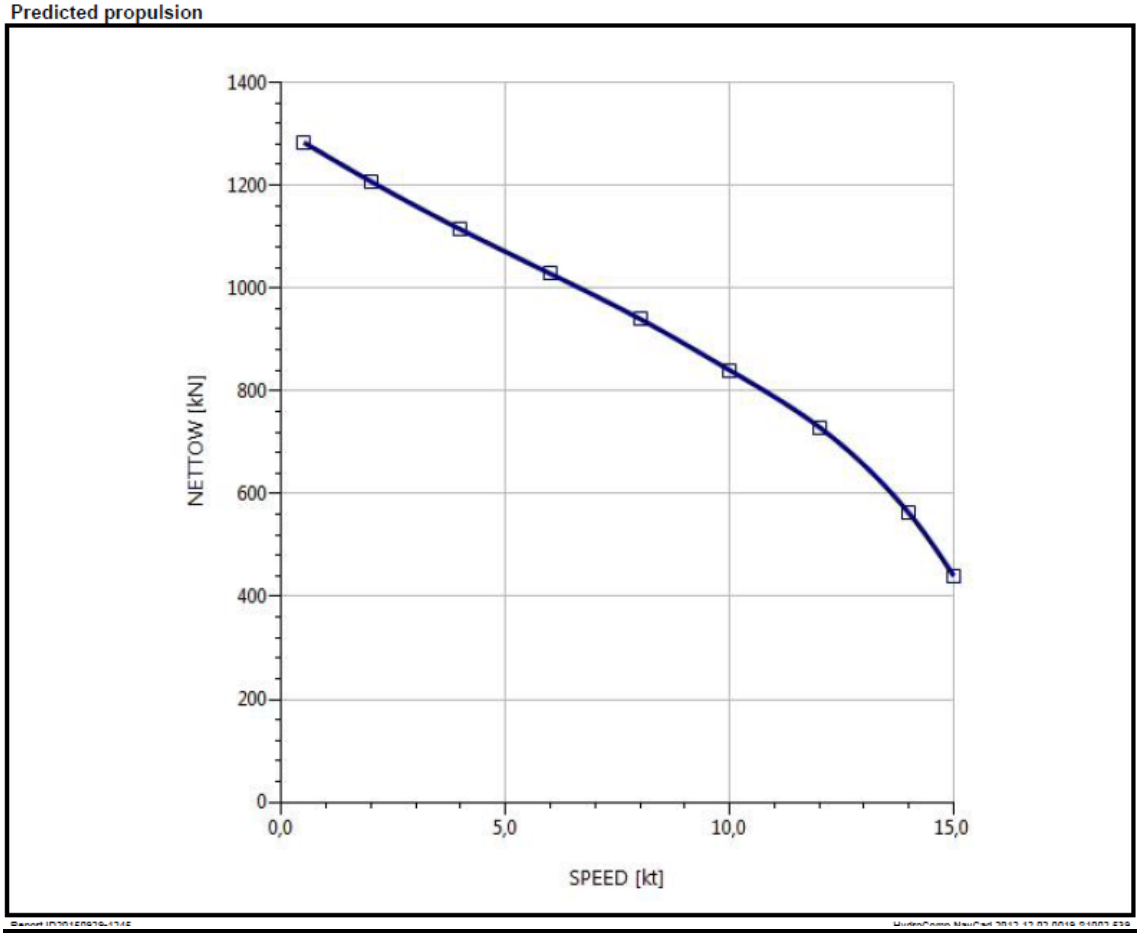
Propulsion
29 sep 2015 12:45
HydroComp NavCad 2012

Project ID	Proyecto
Description	
File name	Proyecto.hcnc

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	Prediction	Cavitation criteria:	Keller eqn
Prediction:	[Calc] Oortmerssen	Analysis type:	Towing
Reference ship:		CPP method:	
Max prop diam:	4670,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[On] Standard	RPM constraint:	
Rudder location:	Behind propeller	Limit [RPM/s]:	
Friction line:	ITTC-57	**Water properties**	
Hull form factor:	1,318	Water type:	Salt
Corr allowance:	ITTC-78 (v2008)	Density:	1026,00 kg/m3
Roughness [mm]:	[Off] 0,00	Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[On]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Predicted propulsion



Propulsion

29 sep 2015 12:45
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Analysis parameters

Hull-propulsor interaction			System analysis	
Technique:	Prediction		Cavitation criteria:	Keller eqn
Prediction:	[Calc] Oortmerssen		Analysis type:	Towing
Reference ship:			CPP method:	
Max prop diam:	4670,0 mm		Engine RPM:	
Corrections			Mass multiplier:	
Viscous scale corr:	[On] Standard		RPM constraint:	
Rudder location:	Behind propeller		Limit [RPM/s]:	
Friction line:	ITTC-57		**Water properties**	
Hull form factor:	1,318		Water type:	Salt
Corr allowance:	ITTC-78 (v2008)		Density:	1026,00 kg/m3
Roughness [mm]:	[Off] 0,00		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[On]			
Tunnel stern corr:	[Off]			
Effective diam:				
Recess depth:				

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	0,04*	0,56	3,48	2,45	0,480	21,1	0,93
Range	0,05··0,50	0,51··0,69	3,50··6,30	1,90··3,40	0,467··0,537	10,0··38,0	0,73··0,97

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	0,0	0,0917	0,3231	1,1657	599	4143,1	---	99,8
+ 2,00 +	0,4	0,0946	0,3052	1,1585	600	4150,0	---	100,0
4,00	8,9	0,0982	0,2834	1,1473	604	4180,5	---	100,7
6,00	39,1	0,1015	0,2640	1,1345	614	4250,1	---	102,4
8,00	109,4	0,1045	0,2471	1,1200	627	4349,4	---	104,8
10,00	261,1	0,1072	0,2327	1,1039	644	4481,6	---	108,0
12,00	497,7	0,1096	0,2207	1,0861	666	4645,1	---	111,9
14,00	1115,5	0,1117	0,2112	1,0666	692	4835,9	---	116,5
15,00	1848,5	0,1126	0,2074	1,0562	705	4934,2	---	118,9

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	110	406,79	4018,8	4143,1	8286,1	8286,1	0,0
+ 2,00 +	110	404,45	4025,5	4150,0	8300,0	8300,0	0,0
4,00	111	400,55	4055,1	4180,5	8361,0	8361,0	0,0
6,00	113	396,70	4122,6	4250,1	8500,2	8500,2	0,0
8,00	115	392,29	4218,9	4349,4	8698,8	8698,8	0,0
10,00	118	387,51	4347,2	4481,6	8963,2	8963,2	0,0
12,00	122	382,31	4505,8	4645,1	9290,3	9290,3	0,0
14,00	127	376,48	4690,9	4835,9	9671,9	9671,9	0,0
15,00	129	372,95	4786,1	4934,2	9868,3	9868,3	0,0

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	0,0473	0,0398	948,12	1283,48	1283,30
+ 2,00 +	0,1736	0,1497	869,25	1207,95	1207,25
4,00	0,3116	0,2756	781,26	1119,74	1114,00
6,00	0,4202	0,3788	708,71	1043,18	1027,99
8,00	0,5026	0,4591	644,47	970,39	940,01
10,00	0,5592	0,5146	584,32	896,68	840,30
12,00	0,5892	0,5432	524,53	817,48	729,53
14,00	0,5909	0,5429	462,13	729,03	562,24
15,00	0,5807	0,5314	428,68	679,54	439,99

Report ID20150929-1245 HydroComp NavCad 2012.12.02.0019.81002.539

Propulsion

29 sep 2015 12:45
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	0,0273	0,5783	0,05313	776,19	2612,5	1976,6	35858	2,97e7	0,2906
+ 2,00 +	0,1087	0,5290	0,05270	44,764	41,029	113,99	566,67	2,97e7	0,2435
4,00	0,2150	0,4685	0,05143	10,139	5,1785	25,82	72,219	3,00e7	0,1890
6,00	0,3165	0,4125	0,04944	4,1181	1,5597	10,487	21,996	3,06e7	0,1436
8,00	0,4116	0,3593	0,04684	2,1206	0,67148	5,4002	9,5924	3,15e7	0,1060
10,00	0,4990	0,3083	0,04378	1,238	0,35232	3,1525	5,1066	3,26e7	0,0744
12,00	0,5778	0,2590	0,04042	0,77588	0,20959	1,9758	3,0878	3,39e7	0,0472
14,00	0,6477	0,2117	0,03693	0,50458	0,1359	1,2849	2,0386	3,55e7	0,0230
15,00	0,6797	0,1887	0,03516	0,40857	0,11199	1,0404	1,6964	3,63e7	0,0117

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	5533,66	4,12	0,85	26,89	0,447	39,35	4,9	4,9	2898,1
+ 2,00 +	348,09	4,11	0,85	26,92	0,440	39,12	4,8	4,8	2975,7
4,00	87,72	4,05	0,83	27,12	0,430	38,88	4,6	4,6	3101,2
6,00	39,28	3,93	0,80	27,53	0,421	38,54	4,2	4,2	3243,5
8,00	22,24	3,77	0,75	28,13	0,409	37,90	3,6	3,6	3392,8
10,00	14,32	3,57	0,70	28,91	0,395	36,97	3,1	3,1	3539,5
12,00	10,00	3,34	0,65	29,89	0,379	35,78	2,5	2,5	3676,3
14,00	7,38	3,10	0,59	31,03 !	0,362	34,36	2,0	2,0	3798,6
15,00	6,44	2,98	0,56	31,65 !	0,352	33,54	2,0	2,0	3854,0

Report ID20150929-1245 HydroComp NavCad 2012 12.02.0019.01002.539

Propulsion

29 sep 2015 12:45
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Hull data

General		
Configuration:		Monohull
Chine type:		Single/hard
Length on WL:		54,170 m
Max beam on WL:	[LWL/BWL 3,477]	15,580 m
Max molded draft:	[BWL/T 2,450]	6,360 m
Displacement:	[CB 0,527]	2901,37 t
Wetted surface:	[CWS 5,200]	1039,8 m2
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,480]	26,002 m
LCF fwd TR:	[XCF/LWL 0,520]	28,168 m
Max section area:	[CX 0,932]	92,4 m2
Waterplane area:	[CWP 0,666]	562,0 m2
Bulb section area:		0,0 m2
Bulb ctr below WL:		0,000 m
Bulb nose fwd TR:		0,000 m
Transom area:	[ATR/AX 0,000]	0,0 m2
Transom beam WL:	[BTR/BWL 0,000]	0,000 m
Transom immersion:	[TTR/T 0,000]	0,000 m
Half entrance angle:		21,10 deg
Bow shape factor:	[AVG flow]	0,0
Stern shape factor:	[AVG flow]	0,0

Planing		
Proj chine length:		*0,000 m*
Proj bottom area:		*0,0 m2*
LCG fwd TR:	*[XCG/LP 0,000]*	*0,000 m*
VCG below WL:		*0,000 m*
Aft station (fwd TR):		*0,000 m*
Chine beam:		*0,000 m*
Chine ht below WL:		*0,000 m*
Deadrise:		*0,00 deg*
Fwd station (fwd TR):		*0,000 m*
Chine beam:		*0,000 m*
Chine ht below WL:		*0,000 m*
Deadrise:		*0,00 deg*
Propulsor type:		*SPP*
Propeller diameter		*4670,0 mm*
Shaft angle to WL:		*0,00 deg*
Position fwd TR:		*0,000 m*
Position below WL:		*0,000 m*

Propulsor data

Propulsor			Propeller options	
Count:	2		Oblique angle corr:	Off
Propulsor type:	Propeller series		Shaft angle to WL:	0,00 deg
Propeller type:	FPP		Added rise of run:	0,00 deg
Propeller series:	Kaplan 19A		Propeller cup:	0,0 mm
Propeller sizing:	By power		KTKQ corrections:	Standard
KTKQ file:			Scale correction:	Full ITTC
Blade count:	4		KT multiplier:	1,00
Expanded area ratio:	0,6999	[Size]	KQ multiplier:	1,00
Propeller diameter:	4670,0 mm	[Size]	Blade T/C [0.7R]:	Standard
Propeller mean pitch: [P/D 1,0845]	5064,5 mm	[Size]	Roughness:	Standard
Hub immersion:	5500,0 mm		Cav breakdown:	Off
Engine/gear			Nozzle L/D:	Standard
Engine data:	Untitled Engine Obje...		**Design condition**	
Rated RPM:	600 RPM		Max prop diam:	4670,0 mm
Rated power:	4150,0 kW		Design speed:	2,00 kt
Gear efficiency:	1,00		Reference power:	4150,0 kW
Gear ratio:	5,449	[Size]	Design point:	1,000
Shaft efficiency:	0,97		Reference RPM:	600,0
			Design point:	1,000

Propulsion
29 sep 2015 12:45
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Symbols and values

SPEED =	Vessel speed
FN =	Froude number [LWL]
FV =	Froude number [VOL]
PETOTAL =	Total vessel effective power
WFT =	Taylor wake fraction coefficient
THD =	Thrust deduction coefficient
EFFR =	Relative-rotative efficiency
RPMENG =	Engine RPM
PBPROP =	Brake power per propulsor
QPROP =	Propulsor open water torque
PDPROP =	Delivered power per propulsor
PSPROP =	Shaft power per propulsor
PSTOTAL =	Total vessel shaft power
PBTOTAL =	Total vessel brake power
TRANSP =	Transport factor
FUEL =	Fuel rate per engine
LOADENG =	Percentage of engine max available power at given RPM
RPMPROP =	Propulsor RPM
EFFO =	Propulsor open-water efficiency
EFFOA =	Overall propulsion efficiency [=PETOTAL/PSTOTAL]
THRPROP =	Open-water thrust per propulsor
DELTHR =	Total vessel delivered thrust
NETTOW =	Total vessel net tow pull
CPPITCH =	Operational pitch of CPP
J =	Propulsor advance coefficient
KT =	Propulsor thrust coefficient [horizontal, if in oblique flow]
KQ =	Propulsor torque coefficient
KTJ2 =	Propulsor thrust loading ratio
KQJ3 =	Propulsor torque loading ratio
CTH =	Horizontal component of bare-hull resistance coefficient
CP =	Propulsor thrust loading coefficient
RNPROP =	Propeller Reynolds number at 0.7R
KTN =	Nozzle thrust coefficient

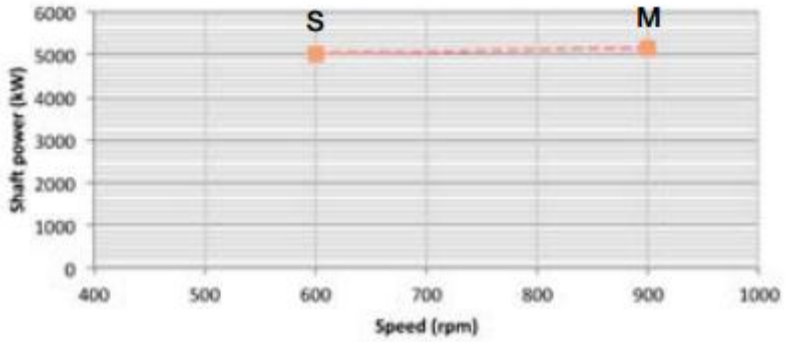
SIGMAV =	Cavitation number of propeller by vessel speed
SIGMAN =	Cavitation number of propeller by RPM
SIGMA07R =	Cavitation number of blade section at 0.7R
TIPSPEED =	Propeller circumferential tip speed
MINBAR =	Minimum expanded blade area ratio recommended by selected cavitation criteria
PRESS =	Average propeller loading pressure
CAVAVG =	Average predicted back cavitation percentage
CAVMAX =	Peak predicted back cavitation percentage [if in oblique flow]
PITCHFC =	Minimum recommended pitch to avoid face cavitation
+ =	Design speed indicator
* =	Exceeds recommended parameter limit
! =	Exceeds recommended cavitation criteria [warning]
!! =	Substantially exceeds recommended cavitation criteria [critical]
!!! =	Thrust breakdown is indicated [severe]
--- =	Insignificant or not applicable

Report ID20150929-1245 HydroComp NavCad 2012 12.02.0019.01002.539

Con esta potencia aunque se obtiene el tiro a punto fijo necesario, se obtiene un diámetro para el propulsor de 4670 mm, el cual, es demasiado grande para las dimensiones del buque calculadas en comparación con el tamaño del propulsor del buque base.

Para reducir este diámetro se calculará un propulsor con un motor de más potencia que proporcione las mismas toneladas a punto fijo:

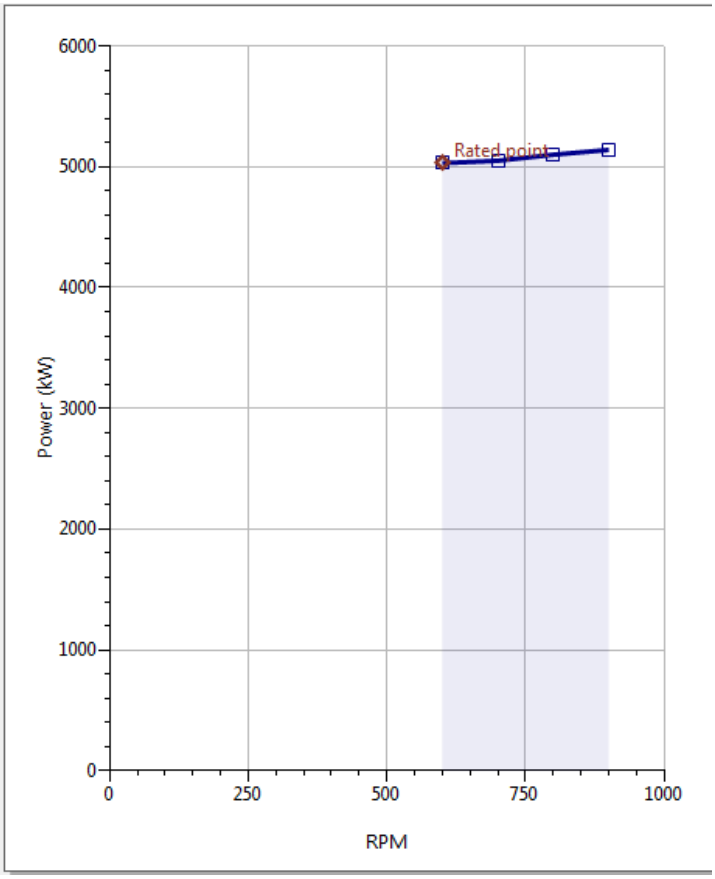
Se elige el motor eléctrico ABB High Speed Drive 710 – single drive S de 5030 kW cuyas características se encuentran en el Anexo I. A continuación se introduce en el Navcad la curva del motor:



Properties			
Description:	Untitled Engin...		
Import file:	C:\Users\Port...		
Units			
Power:	[0.0]	kW	
Fuel rate:	[0.00]	L/h	
Parameters			
Rated power:	5030,0	kW	
Rated RPM:	600		
Parasitic load:	0,0	kW	

	MAX POWER CURVE		
	RPM	Power	Fuel
1	900	5140,0	0,00
2	800	5100,0	0,00
3	700	5050,0	0,00
4	600	5030,0	0,00
5			
6			
7			
8			
9			
10			

	DEFINED LOAD CURVE		
	RPM	Power	Fuel
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



Con este nuevo motor eléctrico el diámetro máximo con el que se obtiene el tiro a punto fijo es de 3900 mm. Este dato se ha obtenido realizando varias pruebas de cálculo variando el diámetro máximo del propulsor hasta conseguir el tiro a punto a fijo deseado.

Velocidad (kt)	TPF (kN)	TPF (ton)
2	1224,33	124,931633
0,5	1285,63	131,186735

Propulsion

8 oct 2015 06:25
HydroComp NavCad 2012

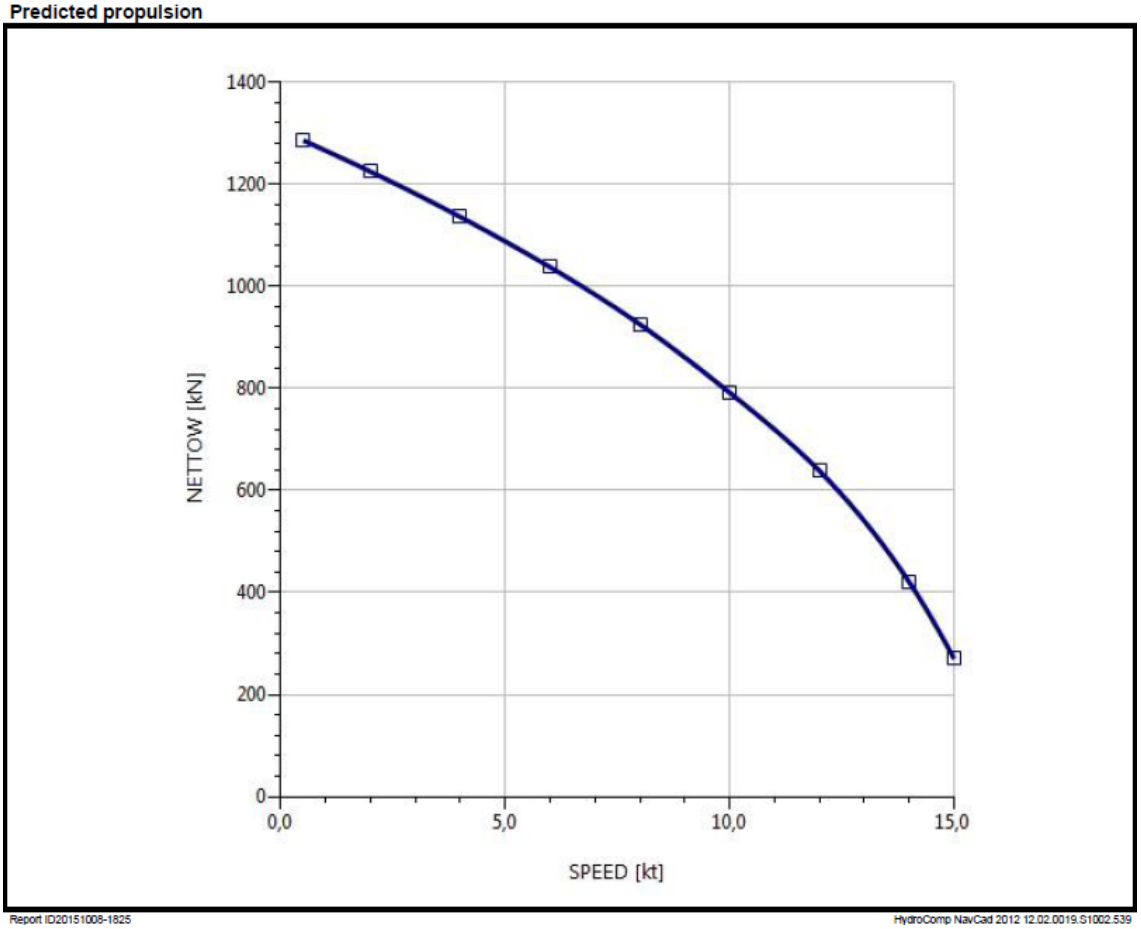
Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		
Technique:		Prediction
Prediction:	[Calc]	Oortmerssen
Reference ship:		
Max prop diam:		3900,0 mm
Corrections		
Viscous scale corr:	[On]	Standard
Rudder location:		Behind propeller
Friction line:		ITTC-57
Hull form factor:		1,318
Corr allowance:		ITTC-78 (v2008)
Roughness [mm]:	[Off]	0,00
Ducted prop corr:	[On]	
Tunnel stern corr:	[Off]	
Effective diam:		
Recess depth:		

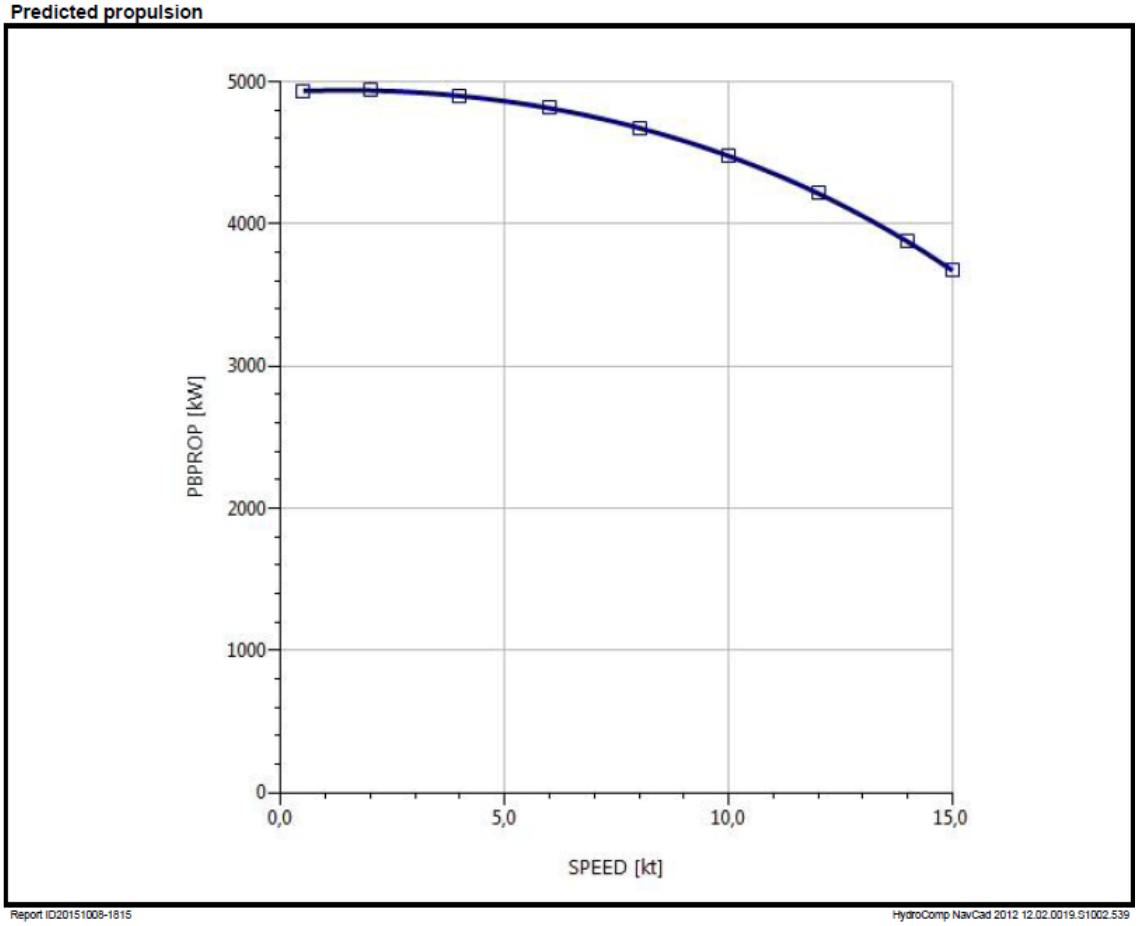
System analysis	
Cavitation criteria:	Keller eqn
Analysis type:	Towing
CPP method:	
Engine RPM:	
Mass multiplier:	
RPM constraint:	
Limit [RPM/s]:	
Water properties	
Water type:	Salt
Density:	1026,00 kg/m3
Viscosity:	1,18920e-6 m2/s

Predicted propulsion



Report ID20151008-1825 HydroComp NavCad 2012 12.02.0019.S1002.539

Predicted propulsion



Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		
Technique:		**Prediction**
Prediction:	**[Calc]**	**Oortmerssen**
Reference ship:		
Max prop diam:		**3900,0 mm**
Corrections		
Viscous scale corr:	**[On]**	**Standard**
Rudder location:		**Behind propeller**
Friction line:		**ITTC-57**
Hull form factor:		**1,318**
Corr allowance:		**ITTC-78 (v2008)**
Roughness [mm]:	**[Off]**	**0,00**
Ducted prop corr:	**[On]**	
Tunnel stern corr:	**[Off]**	
Effective diam:		
Recess depth:		

System analysis	
Cavitation criteria:	**Keller eqn**
Analysis type:	**Towing**
CPP method:	
Engine RPM:	
Mass multiplier:	
RPM constraint:	
Limit [RPM/s]:	
Water properties	
Water type:	**Salt**
Density:	**1026,00 kg/m3**
Viscosity:	**1,18920e-6 m2/s**

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,09**	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	0,0	0,0946	0,3197	1,1579	900	4935,4	---	98,1
2,00	0,4	0,0975	0,3018	1,1506	900	4937,8	---	98,2
+ 4,00 +	8,9	0,1011	0,2800	1,1394	900	4900,0	---	97,4
6,00	39,1	0,1044	0,2606	1,1266	900	4813,5	---	95,7
8,00	109,4	0,1074	0,2437	1,1122	900	4674,4	---	92,9
10,00	261,1	0,1101	0,2293	1,0960	900	4477,0	---	89,0
12,00	497,7	0,1125	0,2173	1,0782	900	4213,6	---	83,8
14,00	1115,5	0,1146	0,2078	1,0587	900	3873,8	---	77,0
15,00	1848,5	0,1155	0,2040	1,0484	900	3671,4	---	73,0

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	157	337,34	4787,3	4935,4	9870,7	9870,7	0,0
2,00	157	335,38	4789,6	4937,8	9875,5	9875,5	0,0
+ 4,00 +	157	329,60	4753,0	4900,0	9800,0	9800,0	0,0
6,00	157	320,13	4669,1	4813,5	9627,0	9627,0	0,0
8,00	157	306,89	4534,2	4674,4	9348,8	9348,8	0,0
10,00	157	289,66	4342,7	4477,0	8954,1	8954,1	0,0
12,00	157	268,19	4087,1	4213,6	8427,1	8427,1	0,0
14,00	157	242,11	3757,6	3873,8	7747,6	7747,6	0,0
15,00	157	227,21	3561,2	3671,4	7342,8	7342,8	0,0

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	0,0397	0,0335	945,08	1285,81	1285,63
2,00	0,1478	0,1276	877,24	1225,03	1224,33
+ 4,00 +	0,2707	0,2396	792,54	1141,31	1135,57
6,00	0,3740	0,3374	711,67	1052,39	1037,21
8,00	0,4602	0,4207	631,77	955,57	925,19
10,00	0,5290	0,4871	550,05	847,85	791,47
12,00	0,5767	0,5319	463,84	726,07	638,11
14,00	0,5938	0,5456	370,46	586,95	420,16
15,00	0,5855	0,5358	320,27	509,87	270,32

Report ID20151008-1816 HydroComp NavCad 2012 12.02.0019.S1002.539

Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	0,0228	0,5822	0,05328	1116,5	4475,1	2843,2	61839	2,95e7	0,2939
2,00	0,0910	0,5404	0,05297	65,193	70,196	166,01	976,13	2,95e7	0,2539
+ 4,00 +	0,1814	0,4882	0,05206	14,844	8,7278	37,799	122,56	2,96e7	0,2059
6,00	0,2710	0,4384	0,05057	5,968	2,5398	15,197	36,069	2,97e7	0,1636
8,00	0,3602	0,3892	0,04847	3,0002	1,0376	7,64	14,927	2,99e7	0,1262
10,00	0,4488	0,3388	0,04575	1,6819	0,50599	4,283	7,3866	3,00e7	0,0926
12,00	0,5372	0,2857	0,04236	0,99025	0,2733	2,5216	4,0557	3,03e7	0,0615
14,00	0,6252	0,2282	0,03824	0,5838	0,15647	1,4866	2,3646	3,05e7	0,0311
15,00	0,6692	0,1973	0,03589	0,44056	0,11976	1,1219	1,8278	3,07e7	0,0157

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	5569,27	2,90	0,60	32,04 !	0,595	55,97	8,5	8,5	2419,2
2,00	350,34	2,90	0,60	32,04 !	0,587	55,63	8,4	8,4	2471,9
+ 4,00 +	88,29	2,90	0,60	32,04 !	0,574	54,81	8,0	8,0	2556,5
6,00	39,53	2,90	0,59	32,04 !	0,555	53,36	7,3	7,3	2655,6
8,00	22,39	2,90	0,58	32,04 !	0,529	51,06	6,3	6,3	2766,7
10,00	14,41	2,90	0,58	32,04 !	0,494	47,80	5,1	5,1	2887,0
12,00	10,06	2,90	0,57	32,04 !	0,450	43,54	3,8	3,8	3013,2
14,00	7,43	2,90	0,56	32,04 !	0,398	38,26	2,5	2,5	3141,7
15,00	6,48	2,90	0,55	32,04 !	0,368	35,25	2,0	2,0	3205,7

Report ID20151008-1816 HydroComp NavCad 2012 12.02.0019.S1002.539

Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Hull data

General			Planing		
Configuration:		Monohull	*Proj chine length:*		*0,000 m*
Chine type:		Single/hard	*Proj bottom area:*		*0,0 m2*
Length on WL:		54,170 m	*LCG fwd TR:*	*[XCG/LP 0,000]*	*0,000 m*
Max beam on WL:	[LWL/BWL 3,477]	15,580 m	*VCG below WL:*		*0,000 m*
Max molded draft:	[BWL/T 2,450]	6,360 m	*Aft station (fwd TR):*		*0,000 m*
Displacement:	[CB 0,527]	2901,37 t	*Chine beam:*		*0,000 m*
Wetted surface:	[CWS 5,200]	1039,8 m2	*Chine ht below WL:*		*0,000 m*
ITTC-78 (CT)			*Deadrise:*		*0,00 deg*
LCB fwd TR:	[XCB/LWL 0,480]	26,002 m	*Fwd station (fwd TR):*		*0,000 m*
LCF fwd TR:	[XCF/LWL 0,520]	28,168 m	*Chine beam:*		*0,000 m*
Max section area:	[CX 0,932]	92,4 m2	*Chine ht below WL:*		*0,000 m*
Waterplane area:	[CWP 0,666]	562,0 m2	*Deadrise:*		*0,00 deg*
Bulb section area:		0,0 m2	*Propulsor type:*		*SPP*
Bulb ctr below WL:		0,000 m	*Propeller diameter*		*3900,0 mm*
Bulb nose fwd TR:		0,000 m	*Shaft angle to WL:*		*0,00 deg*
Transom area:	[ATR/AX 0,000]	0,0 m2	*Position fwd TR:*		*0,000 m*
Transom beam WL:	[BTR/BWL 0,000]	0,000 m	*Position below WL:*		*0,000 m*
Transom immersion:	[TTR/T 0,000]	0,000 m			
Half entrance angle:		21,10 deg			
Bow shape factor:	[AVG flow]	0,0			
Stern shape factor:	[AVG flow]	0,0			

Propulsor data

Propulsor				Propeller options	
Count:		2		Oblique angle corr:	Off
Propulsor type:		Propeller series		Shaft angle to WL:	0,00 deg
Propeller type:		FPP		Added rise of run:	0,00 deg
Propeller series:		Kaplan 19A		Propeller cup:	0,0 mm
Propeller sizing:		By power		KTKQ corrections:	Standard
KTKQ file:				Scale correction:	Full ITTC
Blade count:		4		KT multiplier:	1,00
Expanded area ratio:		0,6999	[Size]	KQ multiplier:	1,00
Propeller diameter:		3900,0 mm	[Size]	Blade T/C [0.7R]:	Standard
Propeller mean pitch:	[P/D 1,0857]	4234,4 mm	[Size]	Roughness:	Standard
Hub immersion:		5500,0 mm		Cav breakdown:	Off
Engine/gear				Nozzle L/D:	Standard
Engine data:		Untitled Engine Obje...		**Design condition**	
Rated RPM:		600 RPM		Max prop diam:	3900,0 mm
Rated power:		5030,0 kW		Design speed:	4,00 kt
Gear efficiency:		1,00		Reference power:	4900,0 kW
Gear ratio:		5,736	[Size]	Design point:	1,000
Shaft efficiency:		0,97		Reference RPM:	900,0
				Design point:	1,000

Report ID20151008-1816
HydroComp NavCad 2012 12.02.0019.S1002.539

Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID Proyecto
Description
File name Proyecto.hcnc

Symbols and values

SPEED =	Vessel speed
FN =	Froude number [LWL]
FV =	Froude number [VOL]
PETOTAL =	Total vessel effective power
WFT =	Taylor wake fraction coefficient
THD =	Thrust deduction coefficient
EFFR =	Relative-rotative efficiency
RPMENG =	Engine RPM
PBPROP =	Brake power per propulsor
QPROP =	Propulsor open water torque
PDPROP =	Delivered power per propulsor
PSPROP =	Shaft power per propulsor
PSTOTAL =	Total vessel shaft power
PBTOTAL =	Total vessel brake power
TRANSP =	Transport factor
FUEL =	Fuel rate per engine
LOADENG =	Percentage of engine max available power at given RPM
RPMPROP =	Propulsor RPM
EFFO =	Propulsor open-water efficiency
EFFOA =	Overall propulsion efficiency [=PETOTAL/PSTOTAL]
THRPROP =	Open-water thrust per propulsor
DELTHR =	Total vessel delivered thrust
NETTOW =	Total vessel net tow pull
CPPITCH =	Operational pitch of CPP
J =	Propulsor advance coefficient
KT =	Propulsor thrust coefficient [horizontal, if in oblique flow]
KQ =	Propulsor torque coefficient
KTJ2 =	Propulsor thrust loading ratio
KQJ3 =	Propulsor torque loading ratio
CTH =	Horizontal component of bare-hull resistance coefficient
CP =	Propulsor thrust loading coefficient
RNPROP =	Propeller Reynolds number at 0.7R
KTN =	Nozzle thrust coefficient
SIGMAV =	Cavitation number of propeller by vessel speed
SIGMAN =	Cavitation number of propeller by RPM
SIGMA07R =	Cavitation number of blade section at 0.7R
TIPSPEED =	Propeller circumferential tip speed
MINBAR =	Minimum expanded blade area ratio recommended by selected cavitation criteria
PRESS =	Average propeller loading pressure
CAVAVG =	Average predicted back cavitation percentage
CAVMAX =	Peak predicted back cavitation percentage [if in oblique flow]
PITCHFC =	Minimum recommended pitch to avoid face cavitation
+ =	Design speed indicator
* =	Exceeds recommended parameter limit
! =	Exceeds recommended cavitation criteria [warning]
!! =	Substantially exceeds recommended cavitation criteria [critical]
!!! =	Thrust breakdown is indicated [severe]
--- =	Insignificant or not applicable

4. SELECCIÓN DE LA PLANTA PROPULSORA

A partir de los cálculos realizados se definirá la planta propulsora.

4.1. Motores diésel generadores

La potencia que tendrán que tener los generadores será la necesaria para alimentar a los motores eléctricos y cubrir la demanda eléctrica.

El valor de la demanda eléctrica que se ha calculado en el cuaderno 1 es sólo una estimación. Por esto, los generadores se definirán en el cuaderno 10 cuando se tengan datos fiables sobre el consumo de los equipos que afectarán a esta.

4.2. Motores eléctricos

Los resultados del cálculo del propulsor indican que con dos motores eléctricos de 5030 kW y 600 rpm se llegaría al requerimiento de 130 toneladas de tiro a punto fijo.

El motor eléctrico elegido que cuenta con estas características es el motor ABB High speed Drive 710 sd S. Los datos del motor están definidos en el Anexo I.

4.3. Propulsor

Una vez conocidos los datos de los motores eléctricos y las características que tendrán que tener los propulsores, se elige el propulsor azimutal Rolls-Royce US60 cuyas características se encuentran en el Anexo I.

Se ha elegido este propulsor ya que cumple con el diámetro máximo calculado, al poder tener un diámetro de entre 3800 y 4000 mm, y con la potencia ya que funciona con una potencia de 5000 kW.

5. HÉLICE TRANSVERSAL DE PROA

Se definirá una hélice transversal en proa para cumplir con los requerimientos de la RPA.

Según el libro Proyecto Básico del Buque Mercante, el empuje requerido para estas hélices en el caso de un remolcador se calcula en función de la obra viva y la obra muerta:

$$Empuje\ obra\ viva = 6 - 9\ kg/m2$$

$$Empuje\ obra\ muerta = 4 - 8\ kg/m2$$

A continuación se muestran las áreas de la obra viva y la obra muerta tomadas de la disposición general del buque:

	Área (m2)	Empuje (kg)
Obra viva	300,91	2256,825
Obra muerta	67,22	403,32

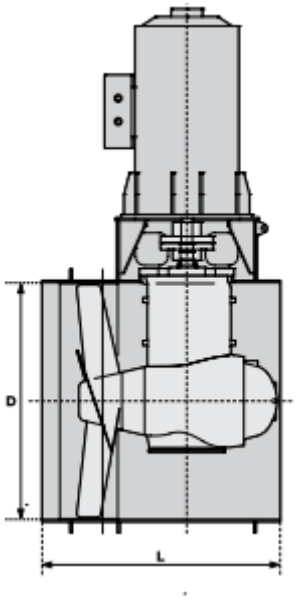
Se utilizará el mayor de los dos valores, es decir, el de la obra viva. Para calcular la potencia del motor de accionamiento de la hélice transversal se considerará según el libro de referencia, una relación entre el empuje y la potencia del motor de accionamiento de 11 kg/CV.

La potencia requerida será:

Empuje (kg)	2256,825
Empuje/Potencia (kg/CV)	11
Potencia (kW)	153

Se ha elegido una hélice transversal de proa de la marca comercial Wärtsilä de 516 kW a 50 Hz. La potencia del thruster elegido es mayor a la calculada, sin embargo se acerca más al rango de potencias de los thruster de los buques de referencia.

Modelo	CT/FT 125 H
Frecuencia (Hz)	50
Input rpm	1465
Output rpm	433
Potencia (kW)	516
D (mm)	1250
L (mm)	1550
Peso (kg)	2800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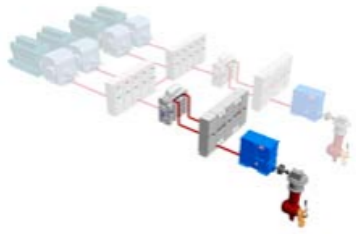
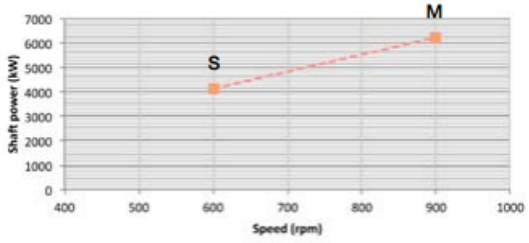
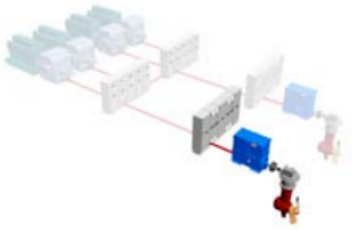
ANEXO I

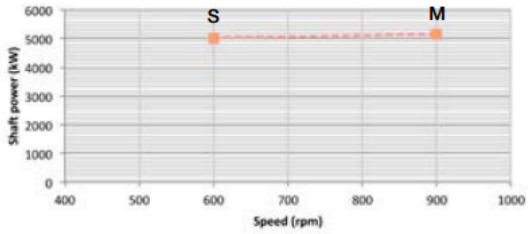
CARACTERÍSTICAS TÉCNICAS DE LOS MOTORES ELÉCTRICOS





High Speed Drive 710 - Single Drive (with Transformer)						
	Drive Step	S	M	L	X	Y
	Motor Speed (rpm)	≥600	≥900	-	-	-
	Maximum Power (kW)	4150	6200	-	-	-
	Maximum Torque (kNm)	66,0	65,8	-	-	-
	Drive (kVA)	5960	9000	-	-	-
	Transformer (kVA)	4800	7000	-	-	-
	Braking Capacity (MJ)	-	-	-	-	-
Drivetrain Efficiency (%)	Motor	96,9	96,7	-	-	-
	Frequency Converter	98	98	-	-	-
	Transformer	99	99	-	-	-
	Total Electrical Efficiency	95,0	94,8	-	-	-
Main Connection	Input Voltage (VAC)	690 / 3300 / 6600 / 11000	6600 / 11000	-	-	-
	Frequency (Hz)	50/60	50/60	-	-	-
	Power factor	0,95	0,95	-	-	-
	Input power (kVA)	4600	6887	-	-	-
	Input Current (A)	3850 / 805 / 403 / 242	603 / 362	-	-	-
Footprint (m²)	Motor	9,5	9,5	-	-	-
	Frequency Converter	4,1	7,7	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	8,6	10,5	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	22,2	27,6	-	-	-
Dimensions (L x W xH)	Motor	3550 x 2665 x 2650	3550 x 2665 x 2650	-	-	-
	Frequency Converter	5730 x 718 x 2088	6530 x 1176 x 2475	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	3600 x 2400 x 2650	4200 x 2500 x 2800	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
Weight (kg)	Motor	12210	12210	-	-	-
	Frequency Converter	4370	5500	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	8250	11500	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	24830	29210	-	-	-
LT-water flow (m³/h)	Motor	23	23	-	-	-
	Frequency Converter	10,4	10,3	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	13	12	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
Losses to water (kW)	Motor	117	190	-	-	-
	Frequency Converter	99	85,7	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	100	123	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	315,8	398,9	-	-	-
Losses to ambient (kW)	Motor	11,0	21,2	-	-	-
	Frequency Converter	8,3	7,2	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	7,3	8,9	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	26,6	37,2	-	-	-





High Speed Drive 710 - Single Drive (AFE)						
	Drive Step	S	M	L	X	Y
	Motor Speed (rpm)	≥600	≥900	-	-	-
	Maximum Power (kW)	5030	5140	-	-	-
	Maximum Torque (kNm)	80,1	54,5	-	-	-
	Drive (kVA)	6620	6620	-	-	-
	Transformer (kVA)	-	-	-	-	-
	Networking Braking	Limited	Limited	-	-	-
Drivetrain Efficiency (%)	Motor	97	97,2	-	-	-
	Frequency Converter	97	97	-	-	-
	Transformer	-	-	-	-	-
	Total Electrical Efficiency	94,1	94,3	-	-	-
Main Connection	Input Voltage (VAC)	690	690	-	-	-
	Frequency (Hz)	50/60	50/60	-	-	-
	Power factor	0,99	0,99	-	-	-
	Input power (kVA)	5400	5507	-	-	-
	Input Current (A)	4518	4608	-	-	-
Footprint (m²)	Motor	9,5	9,5	-	-	-
	Frequency Converter	8,4	8,4	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	17,9	17,9	-	-	-
Dimensions (L x W x H)	Motor	3550 x 2665 x 2650	3550 x 2665 x 2650	-	-	-
	Frequency Converter	11730 x 718 x 2088	11730 x 718 x 2088	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
Weight (kg)	Motor	20500	13500	-	-	-
	Frequency Converter	9885	9885	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	30385	23385	-	-	-
LT-water flow (m³/h)	Motor	23	23	-	-	-
	Frequency Converter	24,7	24,7	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
Losses to water (kW)	Motor	137	130	-	-	-
	Frequency Converter	215	215	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-
	Total	352	345	-	-	-
osses to ambient (kW)	Motor	16	14	-	-	-
	Frequency Converter	10,1	10,3	-	-	-
	Braking Resistor	-	-	-	-	-
	Transformer	-	-	-	-	-
	Excitation Transformer	-	-	-	-	-
	Harmonic Filter	-	-	-	-	-

ANEXO II

RESULTADOS DEL CÁLCULO DE RESISTENCIA AL AVANCE

Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID	**Proyecto**
Description	
File name	**Proyecto.hcnc**

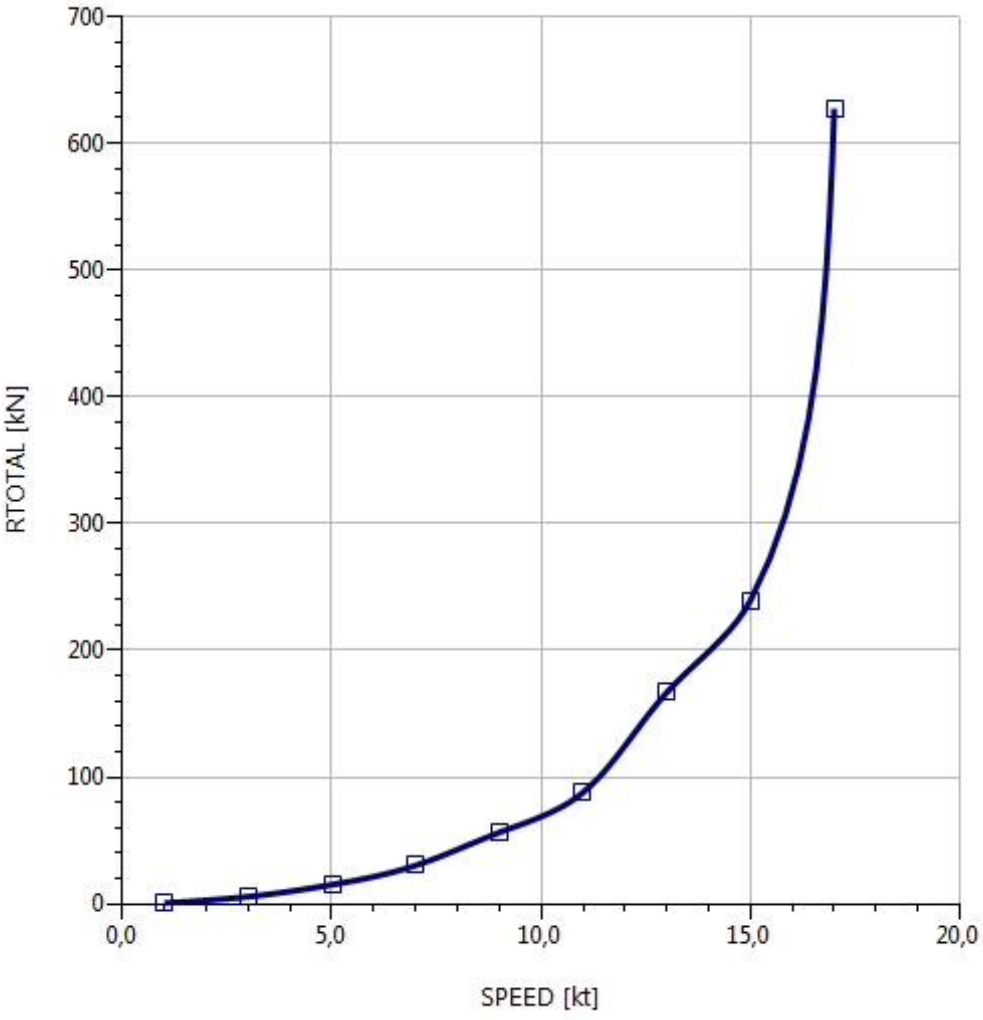
Analysis parameters

Vessel drag		**ITTC-78 (CT)**
Technique:	**[Calc]**	**Prediction**
Prediction:		**Oortmerssen**
Reference ship:		
Model LWL:		
Expansion:		**Standard**
Friction line:		**ITTC-57**
Hull form factor:	**[On]**	**1,318**
Speed corr:	**[Off]**	
Spray drag corr:	**[Off]**	
Corr allowance:		**ITTC-78 (v2008)**
Roughness [mm]:	**[Off]**	

Added drag		
Appendage:	**[Calc]**	**Holtrop (Component)**
Wind:	**[Off]**	
Seas:	**[Off]**	
Shallow/channel:	**[Off]**	
Margin:	**[Calc]**	**Hull + added drag [15%]**

Water properties	
Water type:	**Salt**
Density:	**1026,00 kg/m3**
Viscosity:	**1,18920e-6 m2/s**

Predicted resistance



Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Vessel drag		**ITTC-78 (CT)**
Technique:	**[Calc]**	**Prediction**
Prediction:		**Oortmerssen**
Reference ship:		
Model LWL:		
Expansion:		**Standard**
Friction line:		**ITTC-57**
Hull form factor:	**[On]**	**1,318**
Speed corr:	**[Off]**	
Spray drag corr:	**[Off]**	
Corr allowance:		**ITTC-78 (v2008)**
Roughness [mm]:	**[Off]**	

Added drag		
Appendage:	**[Calc]**	**Holtrop (Component)**
Wind:	**[Off]**	
Seas:	**[Off]**	
Shallow/channel:	**[Off]**	
Margin:	**[Calc]**	**Hull + added drag [15%]**

Water properties	
Water type:	**Salt**
Density:	**1026,00 kg/m3**
Viscosity:	**1,18920e-6 m2/s**

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,33**	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CV/CF]	CR	dCF	CA	CT
1,00	**0,022**	**0,044**	**2,34e7**	**0,002601**	**1,318**	**0,000001**	**0,000000**	**0,000463**	**0,003892**
3,00	**0,067**	**0,131**	**7,03e7**	**0,002194**	**1,318**	**0,000001**	**0,000000**	**0,000649**	**0,003541**
5,00	**0,112**	**0,218**	**1,17e8**	**0,002036**	**1,318**	**0,000001**	**0,000000**	**0,000682**	**0,003367**
7,00	**0,156**	**0,306**	**1,64e8**	**0,001942**	**1,318**	**0,000205**	**0,000000**	**0,000690**	**0,003454**
9,00	**0,201**	**0,393**	**2,11e8**	**0,001875**	**1,318**	**0,000770**	**0,000000**	**0,000689**	**0,003931**
11,00	**0,246**	**0,481**	**2,58e8**	**0,001825**	**1,318**	**0,001036**	**0,000000**	**0,000685**	**0,004126**
13,00	**0,290**	**0,568**	**3,05e8**	**0,001784**	**1,318**	**0,002703**	**0,000000**	**0,000679**	**0,005733**
+ 15,00 +	**0,335**	**0,655**	**3,52e8**	**0,001750**	**1,318**	**0,003237**	**0,000000**	**0,000672**	**0,006215**
17,00	**0,379**	**0,743**	**3,98e8**	**0,001722**	**1,318**	**0,010099**	**0,000000**	**0,000665**	**0,013032**

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
1,00	**0,55**	**0,06**	**0,00**	**0,00**	**0,00**	**0,09**	**0,70**	**0,3**	**0,4**
3,00	**4,50**	**0,49**	**0,00**	**0,00**	**0,00**	**0,75**	**5,74**	**6,9**	**8,9**
5,00	**11,88**	**1,32**	**0,00**	**0,00**	**0,00**	**1,98**	**15,19**	**30,6**	**39,1**
7,00	**23,90**	**2,52**	**0,00**	**0,00**	**0,00**	**3,96**	**30,38**	**86,1**	**109,4**
9,00	**44,95**	**4,08**	**0,00**	**0,00**	**0,00**	**7,35**	**56,39**	**208,1**	**261,1**
11,00	**70,48**	**6,00**	**0,00**	**0,00**	**0,00**	**11,47**	**87,96**	**398,8**	**497,7**
13,00	**136,77**	**8,27**	**0,00**	**0,00**	**0,00**	**21,76**	**166,79**	**914,7**	**1115,5**
+ 15,00 +	**197,42**	**10,88**	**0,00**	**0,00**	**0,00**	**31,25**	**239,55**	**1523,4**	**1848,5**
17,00	**531,70**	**13,84**	**0,00**	**0,00**	**0,00**	**81,83**	**627,37**	**4650,0**	**5486,7**

	OTHER	
SPEED [kt]	CTLR	CTLT
1,00	**0,00001**	**0,03877**
3,00	**0,00001**	**0,03527**
5,00	**0,00001**	**0,03354**
7,00	**0,00204**	**0,03440**
9,00	**0,00767**	**0,03915**
11,00	**0,01032**	**0,04109**
13,00	**0,02691**	**0,05709**
+ 15,00 +	**0,03223**	**0,06190**
17,00	**0,10057**	**0,12979**

Resistance

28 sep 2015 12:01

HydroComp NavCad 2012

Project ID **Proyecto**

Description

File name **Proyecto.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Single/hard**
Length on WL:		**54,170 m**
Max beam on WL:	[LWL/BWL 3,477]	**15,580 m**
Max molded draft:	[BWL/T 2,450]	**6,360 m**
Displacement:	[CB 0,527]	**2901,37 t**
Wetted surface:	[CWS 5,200]	**1039,8 m2**

ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,480]	**26,002 m**
LCF fwd TR:	[XCF/LWL 0,520]	**28,168 m**
Max section area:	[CX 0,932]	**92,4 m2**
Waterplane area:	[CWP 0,666]	**562,0 m2**
Bulb section area:		**0,0 m2**
Bulb ctr below WL:		**0,000 m**
Bulb nose fwd TR:		**0,000 m**
Transom area:	[ATR/AX 0,000]	**0,0 m2**
Transom beam WL:	[BTR/BWL 0,000]	**0,000 m**
Transom immersion:	[TTR/T 0,000]	**0,000 m**
Half entrance angle:		**21,10 deg**
Bow shape factor:	[AVG flow]	**0,0**
Stern shape factor:	[AVG flow]	**0,0**

Planing		
Proj chine length:		***0,000 m***
Proj bottom area:		***0,0 m2***
LCG fwd TR:	*[XCG/LP 0,000]*	***0,000 m***
VCG below WL:		***0,000 m***
Aft station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Fwd station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Propulsor type:		***SPP***
Propeller diameter		***3700,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***

Resistance

28 sep 2015 12:01
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Appendage data

General	
Definition:	**Component**
Percent of hull drag:	**5,00 %**
Planing influence	
LCE fwd TR:	**0,000 m**
VCE below WL:	**0,000 m**
Shafting	
Count:	**2**
Max prop diam:	**3700,0 mm**
Shaft angle to WL:	**0,00 deg**
Exposed shaft length:	**0,000 m**
Shaft diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Strut bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Hull bossing length:	**0,000 m**
Bossing diameter:	**0,000 m**
Wetted surface:	**0,0 m2**
Strut (per shaft line)	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 mm**
Span:	**0,000 m**
T/C ratio:	**0,000**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**
Exposed palm depth:	**0,000 m**
Exposed palm width:	**0,000 m**
Rudder	
Count:	**0**
Rudder location:	**Behind propeller**
Type:	**Balanced foil**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 m2**

Skeg/Keel	
Count:	**1**
Type:	**Skeg**
Mean length:	**11,860 m**
Mean width:	**1,033 m**
Height aft:	**1,140 m**
Height mid:	**1,970 m**
Height fwd:	**4,040 m**
Projected area:	**25,8 m2**
Wetted surface:	**63,9 m2**
Stabilizer	
Count:	**0**
Root chord:	**0,000 m**
Tip chord:	**0,000 m**
Span:	**0,000 m**
T/C ratio:	**0,000**
LE sweep:	**0,00 deg**
Wetted surface:	**0,0 m2**
Projected area:	**0,0 m2**
Dynamic multiplier:	**1,00**
Bilge keel	
Count:	**0**
Mean length:	**0,000 m**
Mean base width:	**0,000 m**
Mean projection:	**0,000 m**
Wetted surface:	**0,0 m2**
Tunnel thruster	
Count:	**1**
Diameter:	**1,580 m**
Sonar dome	
Count:	**0**
Wetted surface:	**0,0 m2**
Miscellaneous	
Count:	**0**
Drag area:	**0,0 m2**
Drag coef:	**0,00**

Environment data

Wind	
Wind speed:	**0,00 kt**
Angle off bow:	**0,00 deg**
Gradient correction:	**Off**
Exposed hull	
Transverse area:	**0,0 m2**
VCE above WL:	**0,000 m**
Profile area:	**0,0 m2**
Superstructure	
Superstructure shape:	**Cargo ship**
Transverse area:	**0,0 m2**
VCE above WL:	**0,000 m**
Profile area:	**0,0 m2**

Seas	
Significant wave ht:	**0,000 m**
Modal wave period:	**0,0 sec**
Shallow/channel	
Water depth:	**0,000 m**
Type:	**Shallow water**
Channel width:	**0,000 m**
Channel side slope:	**0,00 deg**
Hull girth:	**0,000 m**

Resistance

28 sep 2015 12:01

HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Symbols and values

FN	=	Froude number [LWL]
FV	=	Froude number [VOL]
RN	=	Reynolds number [LWL]
CF	=	Frictional resistance coefficient
CV/CF	=	Viscous/frictional resistance coefficient ratio [dynamic form factor]
CR	=	Residuary resistance coefficient
dCF	=	Added frictional resistance coefficient for roughness
CA	=	Correlation allowance [dynamic]
CT	=	Total bare-hull resistance coefficient
RBARE	=	Bare-hull resistance
RAPP	=	Additional appendage resistance
RWIND	=	Additional wind resistance
RSEAS	=	Additional sea-state resistance
RCHAN	=	Additional shallow/channel resistance
RMARGIN	=	Resistance margin
RTOTAL	=	Total vessel resistance
CTLR	=	Telfer residuary resistance coefficient
CTLT	=	Telfer total bare-hull resistance coefficient
PEBARE	=	Bare-hull effective power
PETOTAL	=	Total effective power
+	=	Design speed indicator
*	=	Exceeds parameter limit

Resistance

28 sep 2015 12:00
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Vessel drag		**ITTC-78 (CT)**
Technique:	**[Calc]**	**Prediction**
Prediction:		**Oortmerssen**
Reference ship:		
Model LWL:		
Expansion:		**Standard**
Friction line:		**ITTC-57**
Hull form factor:	**[On]**	**1,318**
Speed corr:	**[Off]**	
Spray drag corr:	**[Off]**	
Corr allowance:		**ITTC-78 (v2008)**
Roughness [mm]:	**[Off]**	

Added drag		
Appendage:	**[Calc]**	**Holtrop (Component)**
Wind:	**[Off]**	
Seas:	**[Off]**	
Shallow/channel:	**[Off]**	
Margin:	**[Calc]**	**Hull + added drag [15%]**

Water properties	
Water type:	**Salt**
Density:	**1026,00 kg/m3**
Viscosity:	**1,18920e-6 m2/s**

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,33**	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CV/CF]	CR	dCF	CA	CT
1,00	**0,022**	**0,044**	**2,34e7**	**0,002601**	**1,318**	**0,000001**	**0,000000**	**0,000463**	**0,003892**
3,00	**0,067**	**0,131**	**7,03e7**	**0,002194**	**1,318**	**0,000001**	**0,000000**	**0,000649**	**0,003541**
5,00	**0,112**	**0,218**	**1,17e8**	**0,002036**	**1,318**	**0,000001**	**0,000000**	**0,000682**	**0,003367**
7,00	**0,156**	**0,306**	**1,64e8**	**0,001942**	**1,318**	**0,000205**	**0,000000**	**0,000690**	**0,003454**
9,00	**0,201**	**0,393**	**2,11e8**	**0,001875**	**1,318**	**0,000770**	**0,000000**	**0,000689**	**0,003931**
11,00	**0,246**	**0,481**	**2,58e8**	**0,001825**	**1,318**	**0,001036**	**0,000000**	**0,000685**	**0,004126**
13,00	**0,290**	**0,568**	**3,05e8**	**0,001784**	**1,318**	**0,002703**	**0,000000**	**0,000679**	**0,005733**
+ 15,00 +	**0,335**	**0,655**	**3,52e8**	**0,001750**	**1,318**	**0,003237**	**0,000000**	**0,000672**	**0,006215**
17,00	**0,379**	**0,743**	**3,98e8**	**0,001722**	**1,318**	**0,010099**	**0,000000**	**0,000665**	**0,013032**

	RESISTANCE AND EFFECTIVE POWER								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RMARGIN [kN]	RTOTAL [kN]	PEBARE [kW]	PETOTAL [kW]
1,00	**0,55**	**0,06**	**0,00**	**0,00**	**0,00**	**0,09**	**0,70**	**0,3**	**0,4**
3,00	**4,50**	**0,49**	**0,00**	**0,00**	**0,00**	**0,75**	**5,74**	**6,9**	**8,9**
5,00	**11,88**	**1,32**	**0,00**	**0,00**	**0,00**	**1,98**	**15,19**	**30,6**	**39,1**
7,00	**23,90**	**2,52**	**0,00**	**0,00**	**0,00**	**3,96**	**30,38**	**86,1**	**109,4**
9,00	**44,95**	**4,08**	**0,00**	**0,00**	**0,00**	**7,35**	**56,39**	**208,1**	**261,1**
11,00	**70,48**	**6,00**	**0,00**	**0,00**	**0,00**	**11,47**	**87,96**	**398,8**	**497,7**
13,00	**136,77**	**8,27**	**0,00**	**0,00**	**0,00**	**21,76**	**166,79**	**914,7**	**1115,5**
+ 15,00 +	**197,42**	**10,88**	**0,00**	**0,00**	**0,00**	**31,25**	**239,55**	**1523,4**	**1848,5**
17,00	**531,70**	**13,84**	**0,00**	**0,00**	**0,00**	**81,83**	**627,37**	**4650,0**	**5486,7**

	OTHER	
SPEED [kt]	CTLR	CTLT
1,00	**0,00001**	**0,03877**
3,00	**0,00001**	**0,03527**
5,00	**0,00001**	**0,03354**
7,00	**0,00204**	**0,03440**
9,00	**0,00767**	**0,03915**
11,00	**0,01032**	**0,04109**
13,00	**0,02691**	**0,05709**
+ 15,00 +	**0,03223**	**0,06190**
17,00	**0,10057**	**0,12979**

ANEXO III

RESULTADOS DEL CÁLCULO DE POTENCIA OPCIÓN 1

Propulsion

29 sep 2015 12:45

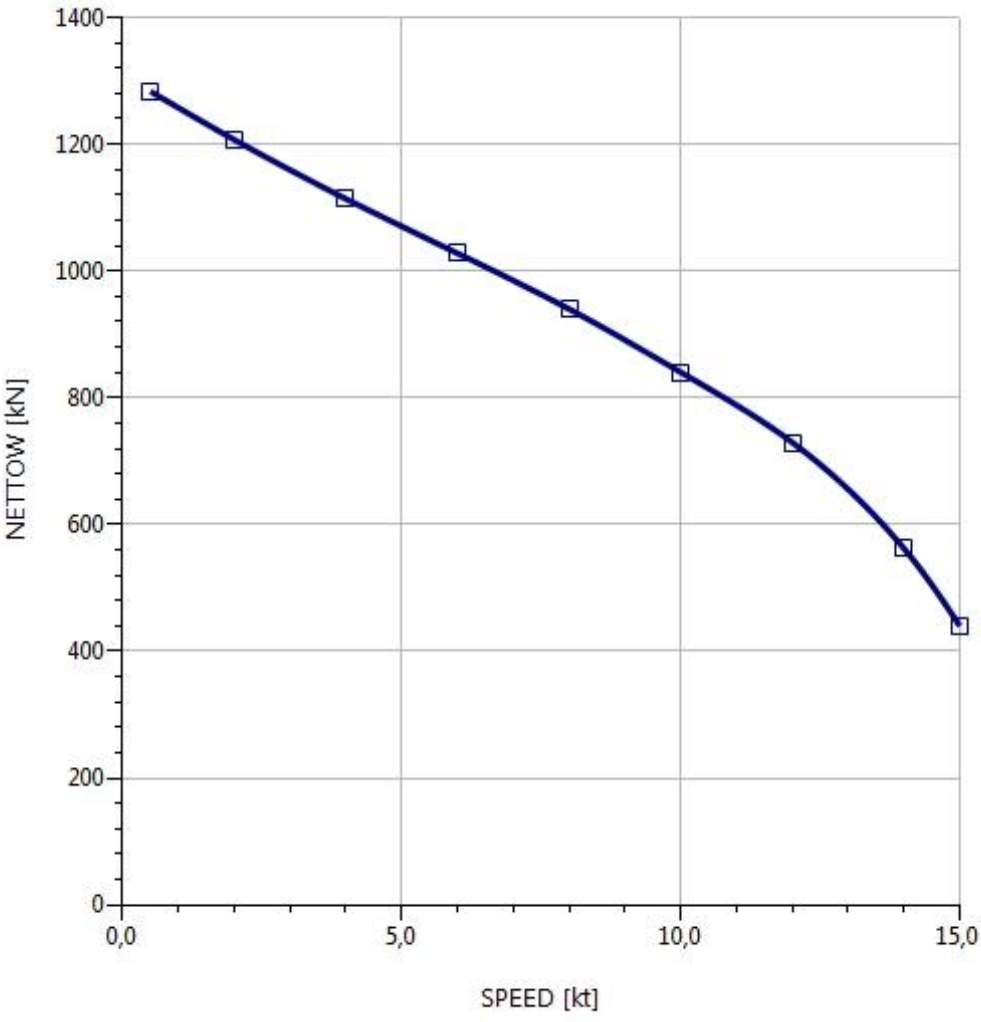
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**4670,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Predicted propulsion



Propulsion

29 sep 2015 12:45
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**4670,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,04***	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	**0,0**	**0,0917**	**0,3231**	**1,1657**	**599**	**4143,1**	**---**	**99,8**
+ 2,00 +	**0,4**	**0,0946**	**0,3052**	**1,1585**	**600**	**4150,0**	**---**	**100,0**
4,00	**8,9**	**0,0982**	**0,2834**	**1,1473**	**604**	**4180,5**	**---**	**100,7**
6,00	**39,1**	**0,1015**	**0,2640**	**1,1345**	**614**	**4250,1**	**---**	**102,4**
8,00	**109,4**	**0,1045**	**0,2471**	**1,1200**	**627**	**4349,4**	**---**	**104,8**
10,00	**261,1**	**0,1072**	**0,2327**	**1,1039**	**644**	**4481,6**	**---**	**108,0**
12,00	**497,7**	**0,1096**	**0,2207**	**1,0861**	**666**	**4645,1**	**---**	**111,9**
14,00	**1115,5**	**0,1117**	**0,2112**	**1,0666**	**692**	**4835,9**	**---**	**116,5**
15,00	**1848,5**	**0,1126**	**0,2074**	**1,0562**	**705**	**4934,2**	**---**	**118,9**

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	**110**	**406,79**	**4018,8**	**4143,1**	**8286,1**	**8286,1**	**0,0**
+ 2,00 +	**110**	**404,45**	**4025,5**	**4150,0**	**8300,0**	**8300,0**	**0,0**
4,00	**111**	**400,55**	**4055,1**	**4180,5**	**8361,0**	**8361,0**	**0,0**
6,00	**113**	**396,70**	**4122,6**	**4250,1**	**8500,2**	**8500,2**	**0,0**
8,00	**115**	**392,29**	**4218,9**	**4349,4**	**8698,8**	**8698,8**	**0,0**
10,00	**118**	**387,51**	**4347,2**	**4481,6**	**8963,2**	**8963,2**	**0,0**
12,00	**122**	**382,31**	**4505,8**	**4645,1**	**9290,3**	**9290,3**	**0,0**
14,00	**127**	**376,48**	**4690,9**	**4835,9**	**9671,9**	**9671,9**	**0,0**
15,00	**129**	**372,95**	**4786,1**	**4934,2**	**9868,3**	**9868,3**	**0,0**

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	**0,0473**	**0,0398**	**948,12**	**1283,48**	**1283,30**
+ 2,00 +	**0,1736**	**0,1497**	**869,25**	**1207,95**	**1207,25**
4,00	**0,3116**	**0,2756**	**781,26**	**1119,74**	**1114,00**
6,00	**0,4202**	**0,3788**	**708,71**	**1043,18**	**1027,99**
8,00	**0,5026**	**0,4591**	**644,47**	**970,39**	**940,01**
10,00	**0,5592**	**0,5146**	**584,32**	**896,68**	**840,30**
12,00	**0,5892**	**0,5432**	**524,53**	**817,48**	**729,53**
14,00	**0,5909**	**0,5429**	**462,13**	**729,03**	**562,24**
15,00	**0,5807**	**0,5314**	**428,68**	**679,54**	**439,99**

Propulsion

29 sep 2015 12:45

HydroComp NavCad 2012

Project ID **Proyecto**

Description

File name **Proyecto.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	**0,0273**	**0,5783**	**0,05313**	**776,19**	**2612,5**	**1976,6**	**35858**	**2,97e7**	**0,2906**
+ 2,00 +	**0,1087**	**0,5290**	**0,05270**	**44,764**	**41,029**	**113,99**	**566,67**	**2,97e7**	**0,2435**
4,00	**0,2150**	**0,4685**	**0,05143**	**10,139**	**5,1785**	**25,82**	**72,219**	**3,00e7**	**0,1890**
6,00	**0,3165**	**0,4125**	**0,04944**	**4,1181**	**1,5597**	**10,487**	**21,996**	**3,06e7**	**0,1436**
8,00	**0,4116**	**0,3593**	**0,04684**	**2,1206**	**0,67148**	**5,4002**	**9,5924**	**3,15e7**	**0,1060**
10,00	**0,4990**	**0,3083**	**0,04378**	**1,238**	**0,35232**	**3,1525**	**5,1066**	**3,26e7**	**0,0744**
12,00	**0,5778**	**0,2590**	**0,04042**	**0,77588**	**0,20959**	**1,9758**	**3,0878**	**3,39e7**	**0,0472**
14,00	**0,6477**	**0,2117**	**0,03693**	**0,50458**	**0,1359**	**1,2849**	**2,0386**	**3,55e7**	**0,0230**
15,00	**0,6797**	**0,1887**	**0,03516**	**0,40857**	**0,11199**	**1,0404**	**1,6964**	**3,63e7**	**0,0117**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	**5533,66**	**4,12**	**0,85**	**26,89**	**0,447**	**39,35**	**4,9**	**4,9**	**2898,1**
+ 2,00 +	**348,09**	**4,11**	**0,85**	**26,92**	**0,440**	**39,12**	**4,8**	**4,8**	**2975,7**
4,00	**87,72**	**4,05**	**0,83**	**27,12**	**0,430**	**38,88**	**4,6**	**4,6**	**3101,2**
6,00	**39,28**	**3,93**	**0,80**	**27,53**	**0,421**	**38,54**	**4,2**	**4,2**	**3243,5**
8,00	**22,24**	**3,77**	**0,75**	**28,13**	**0,409**	**37,90**	**3,6**	**3,6**	**3392,8**
10,00	**14,32**	**3,57**	**0,70**	**28,91**	**0,395**	**36,97**	**3,1**	**3,1**	**3539,5**
12,00	**10,00**	**3,34**	**0,65**	**29,89**	**0,379**	**35,78**	**2,5**	**2,5**	**3676,3**
14,00	**7,38**	**3,10**	**0,59**	**31,03 !**	**0,362**	**34,36**	**2,0**	**2,0**	**3798,6**
15,00	**6,44**	**2,98**	**0,56**	**31,65 !**	**0,352**	**33,54**	**2,0**	**2,0**	**3854,0**

Propulsion

29 sep 2015 12:45

HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Single/hard**
Length on WL:		**54,170 m**
Max beam on WL:	[LWL/BWL 3,477]	**15,580 m**
Max molded draft:	[BWL/T 2,450]	**6,360 m**
Displacement:	[CB 0,527]	**2901,37 t**
Wetted surface:	[CWS 5,200]	**1039,8 m2**

ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,480]	**26,002 m**
LCF fwd TR:	[XCF/LWL 0,520]	**28,168 m**
Max section area:	[CX 0,932]	**92,4 m2**
Waterplane area:	[CWP 0,666]	**562,0 m2**
Bulb section area:		**0,0 m2**
Bulb ctr below WL:		**0,000 m**
Bulb nose fwd TR:		**0,000 m**
Transom area:	[ATR/AX 0,000]	**0,0 m2**
Transom beam WL:	[BTR/BWL 0,000]	**0,000 m**
Transom immersion:	[TTR/T 0,000]	**0,000 m**
Half entrance angle:		**21,10 deg**
Bow shape factor:	[AVG flow]	**0,0**
Stern shape factor:	[AVG flow]	**0,0**

Planing		
Proj chine length:		***0,000 m***
Proj bottom area:		***0,0 m2***
LCG fwd TR:	*[XCG/LP 0,000]*	***0,000 m***
VCG below WL:		***0,000 m***
Aft station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Fwd station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Propulsor type:		***SPP***
Propeller diameter		***4670,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***

Propulsor data

Propulsor			
Count:		**2**	
Propulsor type:		**Propeller series**	
Propeller type:		**FPP**	
Propeller series:		**Kaplan 19A**	
Propeller sizing:		**By power**	
KTKQ file:			
Blade count:		**4**	
Expanded area ratio:		**0,6999**	**[Size]**
Propeller diameter:		**4670,0 mm**	**[Size]**
Propeller mean pitch:	[P/D 1,0845]	**5064,5 mm**	**[Size]**
Hub immersion:		**5500,0 mm**	

Engine/gear			
Engine data:		**Untitled Engine Obje...**	
Rated RPM:		**600 RPM**	
Rated power:		**4150,0 kW**	
Gear efficiency:		**1,00**	
Gear ratio:		**5,449**	**[Size]**
Shaft efficiency:		**0,97**	

Propeller options	
Oblique angle corr:	**Off**
Shaft angle to WL:	**0,00 deg**
Added rise of run:	**0,00 deg**
Propeller cup:	**0,0 mm**
KTKQ corrections:	**Standard**
Scale correction:	**Full ITTC**
KT multiplier:	**1,00**
KQ multiplier:	**1,00**
Blade T/C [0.7R]:	**Standard**
Roughness:	**Standard**
Cav breakdown:	**Off**
Nozzle L/D:	**Standard**

Design condition	
Max prop diam:	**4670,0 mm**
Design speed:	**2,00 kt**
Reference power:	**4150,0 kW**
Design point:	**1,000**
Reference RPM:	**600,0**
Design point:	**1,000**

Propulsion

29 sep 2015 12:45

HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Symbols and values

SPEED =	Vessel speed
FN =	Froude number [LWL]
FV =	Froude number [VOL]
PETOTAL =	Total vessel effective power
WFT =	Taylor wake fraction coefficient
THD =	Thrust deduction coefficient
EFFR =	Relative-rotative efficiency
RPMENG =	Engine RPM
PBPROP =	Brake power per propulsor
QPROP =	Propulsor open water torque
PDPROP =	Delivered power per propulsor
PSPROP =	Shaft power per propulsor
PSTOTAL =	Total vessel shaft power
PBTOTAL =	Total vessel brake power
TRANSP =	Transport factor
FUEL =	Fuel rate per engine
LOADENG =	Percentage of engine max available power at given RPM
RPMPROP =	Propulsor RPM
EFFO =	Propulsor open-water efficiency
EFFOA =	Overall propulsion efficiency [=PETOTAL/PSTOTAL]
THRPROP =	Open-water thrust per propulsor
DELTHR =	Total vessel delivered thrust
NETTOW =	Total vessel net tow pull
CPPITCH =	Operational pitch of CPP
J =	Propulsor advance coefficient
KT =	Propulsor thrust coefficient [horizontal, if in oblique flow]
KQ =	Propulsor torque coefficient
KTJ2 =	Propulsor thrust loading ratio
KQJ3 =	Propulsor torque loading ratio
CTH =	Horizontal component of bare-hull resistance coefficient
CP =	Propulsor thrust loading coefficient
RNPROP =	Propeller Reynolds number at 0.7R
KTN =	Nozzle thrust coefficient
SIGMAV =	Cavitation number of propeller by vessel speed
SIGMAN =	Cavitation number of propeller by RPM
SIGMA07R =	Cavitation number of blade section at 0.7R
TIPSPEED =	Propeller circumferential tip speed
MINBAR =	Minimum expanded blade area ratio recommended by selected cavitation criteria
PRESS =	Average propeller loading pressure
CAVAVG =	Average predicted back cavitation percentage
CAVMAX =	Peak predicted back cavitation percentage [if in oblique flow]
PITCHFC =	Minimum recommended pitch to avoid face cavitation
+ =	Design speed indicator
* =	Exceeds recommended parameter limit
! =	Exceeds recommended cavitation criteria [warning]
!! =	Substantially exceeds recommended cavitation criteria [critical]
!!! =	Thrust breakdown is indicated [severe]
--- =	Insignificant or not applicable

Propulsion

29 sep 2015 12:45
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**4670,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,04***	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	**0,0**	**0,0917**	**0,3231**	**1,1657**	**599**	**4143,1**	**---**	**99,8**
+ 2,00 +	**0,4**	**0,0946**	**0,3052**	**1,1585**	**600**	**4150,0**	**---**	**100,0**
4,00	**8,9**	**0,0982**	**0,2834**	**1,1473**	**604**	**4180,5**	**---**	**100,7**
6,00	**39,1**	**0,1015**	**0,2640**	**1,1345**	**614**	**4250,1**	**---**	**102,4**
8,00	**109,4**	**0,1045**	**0,2471**	**1,1200**	**627**	**4349,4**	**---**	**104,8**
10,00	**261,1**	**0,1072**	**0,2327**	**1,1039**	**644**	**4481,6**	**---**	**108,0**
12,00	**497,7**	**0,1096**	**0,2207**	**1,0861**	**666**	**4645,1**	**---**	**111,9**
14,00	**1115,5**	**0,1117**	**0,2112**	**1,0666**	**692**	**4835,9**	**---**	**116,5**
15,00	**1848,5**	**0,1126**	**0,2074**	**1,0562**	**705**	**4934,2**	**---**	**118,9**

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	**110**	**406,79**	**4018,8**	**4143,1**	**8286,1**	**8286,1**	**0,0**
+ 2,00 +	**110**	**404,45**	**4025,5**	**4150,0**	**8300,0**	**8300,0**	**0,0**
4,00	**111**	**400,55**	**4055,1**	**4180,5**	**8361,0**	**8361,0**	**0,0**
6,00	**113**	**396,70**	**4122,6**	**4250,1**	**8500,2**	**8500,2**	**0,0**
8,00	**115**	**392,29**	**4218,9**	**4349,4**	**8698,8**	**8698,8**	**0,0**
10,00	**118**	**387,51**	**4347,2**	**4481,6**	**8963,2**	**8963,2**	**0,0**
12,00	**122**	**382,31**	**4505,8**	**4645,1**	**9290,3**	**9290,3**	**0,0**
14,00	**127**	**376,48**	**4690,9**	**4835,9**	**9671,9**	**9671,9**	**0,0**
15,00	**129**	**372,95**	**4786,1**	**4934,2**	**9868,3**	**9868,3**	**0,0**

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	**0,0473**	**0,0398**	**948,12**	**1283,48**	**1283,30**
+ 2,00 +	**0,1736**	**0,1497**	**869,25**	**1207,95**	**1207,25**
4,00	**0,3116**	**0,2756**	**781,26**	**1119,74**	**1114,00**
6,00	**0,4202**	**0,3788**	**708,71**	**1043,18**	**1027,99**
8,00	**0,5026**	**0,4591**	**644,47**	**970,39**	**940,01**
10,00	**0,5592**	**0,5146**	**584,32**	**896,68**	**840,30**
12,00	**0,5892**	**0,5432**	**524,53**	**817,48**	**729,53**
14,00	**0,5909**	**0,5429**	**462,13**	**729,03**	**562,24**
15,00	**0,5807**	**0,5314**	**428,68**	**679,54**	**439,99**

Propulsion

29 sep 2015 12:45

HydroComp NavCad 2012

Project ID **Proyecto**

Description

File name **Proyecto.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	**0,0273**	**0,5783**	**0,05313**	**776,19**	**2612,5**	**1976,6**	**35858**	**2,97e7**	**0,2906**
+ 2,00 +	**0,1087**	**0,5290**	**0,05270**	**44,764**	**41,029**	**113,99**	**566,67**	**2,97e7**	**0,2435**
4,00	**0,2150**	**0,4685**	**0,05143**	**10,139**	**5,1785**	**25,82**	**72,219**	**3,00e7**	**0,1890**
6,00	**0,3165**	**0,4125**	**0,04944**	**4,1181**	**1,5597**	**10,487**	**21,996**	**3,06e7**	**0,1436**
8,00	**0,4116**	**0,3593**	**0,04684**	**2,1206**	**0,67148**	**5,4002**	**9,5924**	**3,15e7**	**0,1060**
10,00	**0,4990**	**0,3083**	**0,04378**	**1,238**	**0,35232**	**3,1525**	**5,1066**	**3,26e7**	**0,0744**
12,00	**0,5778**	**0,2590**	**0,04042**	**0,77588**	**0,20959**	**1,9758**	**3,0878**	**3,39e7**	**0,0472**
14,00	**0,6477**	**0,2117**	**0,03693**	**0,50458**	**0,1359**	**1,2849**	**2,0386**	**3,55e7**	**0,0230**
15,00	**0,6797**	**0,1887**	**0,03516**	**0,40857**	**0,11199**	**1,0404**	**1,6964**	**3,63e7**	**0,0117**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	**5533,66**	**4,12**	**0,85**	**26,89**	**0,447**	**39,35**	**4,9**	**4,9**	**2898,1**
+ 2,00 +	**348,09**	**4,11**	**0,85**	**26,92**	**0,440**	**39,12**	**4,8**	**4,8**	**2975,7**
4,00	**87,72**	**4,05**	**0,83**	**27,12**	**0,430**	**38,88**	**4,6**	**4,6**	**3101,2**
6,00	**39,28**	**3,93**	**0,80**	**27,53**	**0,421**	**38,54**	**4,2**	**4,2**	**3243,5**
8,00	**22,24**	**3,77**	**0,75**	**28,13**	**0,409**	**37,90**	**3,6**	**3,6**	**3392,8**
10,00	**14,32**	**3,57**	**0,70**	**28,91**	**0,395**	**36,97**	**3,1**	**3,1**	**3539,5**
12,00	**10,00**	**3,34**	**0,65**	**29,89**	**0,379**	**35,78**	**2,5**	**2,5**	**3676,3**
14,00	**7,38**	**3,10**	**0,59**	**31,03 !**	**0,362**	**34,36**	**2,0**	**2,0**	**3798,6**
15,00	**6,44**	**2,98**	**0,56**	**31,65 !**	**0,352**	**33,54**	**2,0**	**2,0**	**3854,0**

ANEXO IV

RESULTADOS DEL CÁLCULO DE POTENCIA OPCIÓN 2

Propulsion

8 oct 2015 06:15

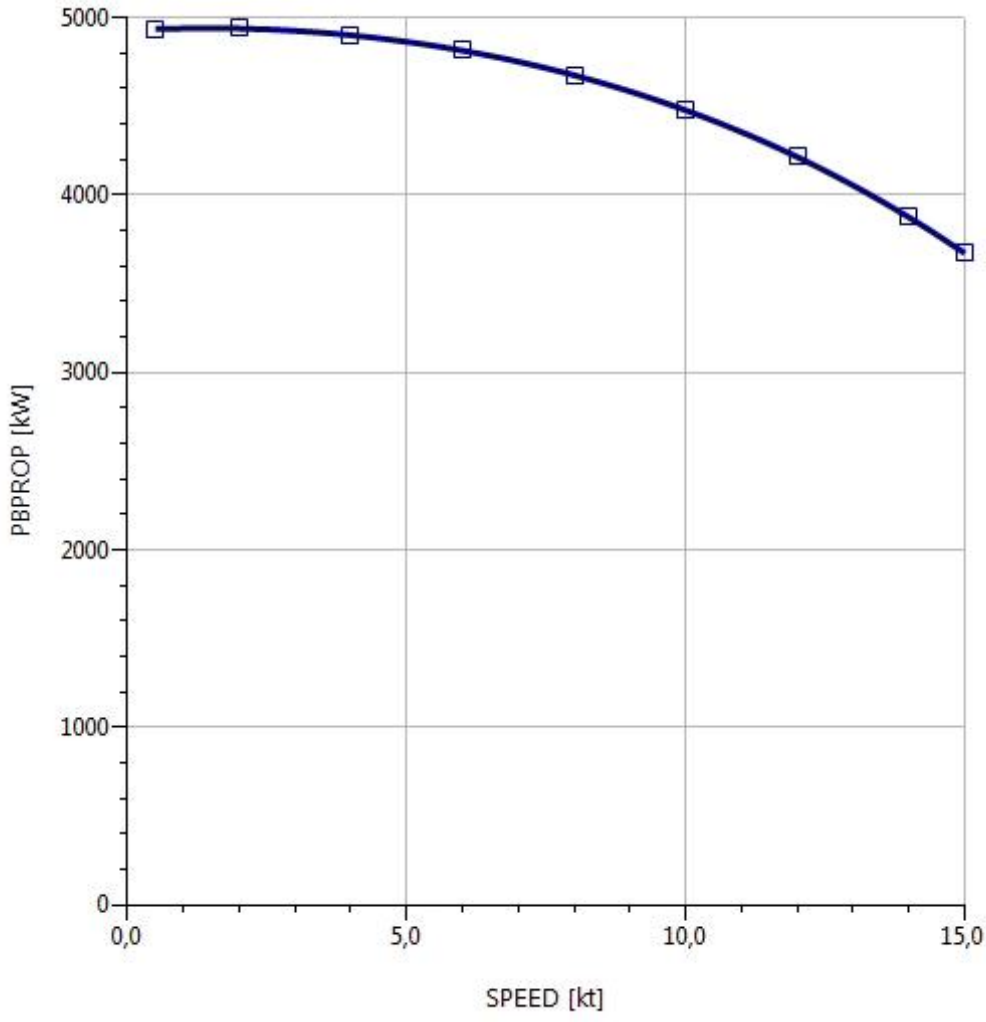
HydroComp NavCad 2012

Project ID	**Proyecto**
Description	
File name	**Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**3900,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Predicted propulsion



Propulsion

8 oct 2015 06:25

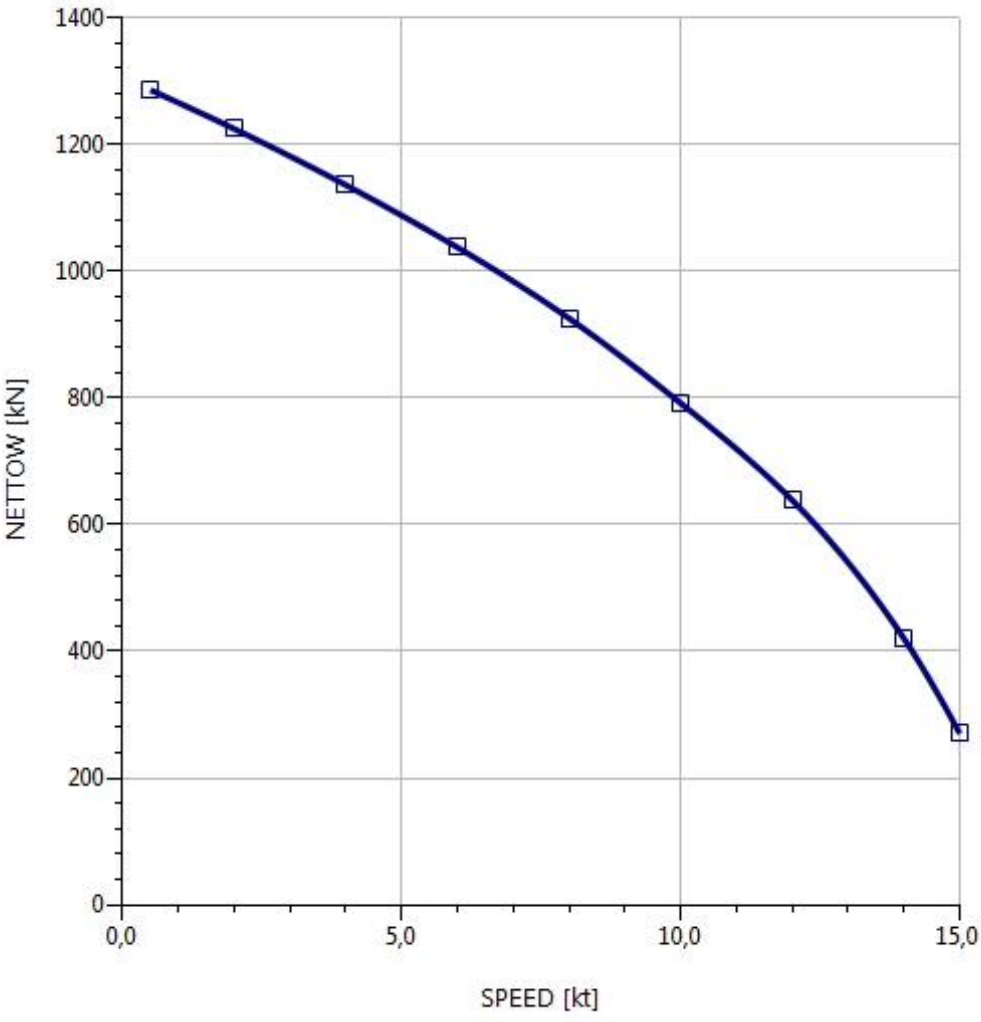
HydroComp NavCad 2012

Project ID	**Proyecto**
Description	
File name	**Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**3900,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Predicted propulsion



Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**3900,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,09**	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	**0,0**	**0,0946**	**0,3197**	**1,1579**	**900**	**4935,4**	**---**	**98,1**
2,00	**0,4**	**0,0975**	**0,3018**	**1,1506**	**900**	**4937,8**	**---**	**98,2**
+ 4,00 +	**8,9**	**0,1011**	**0,2800**	**1,1394**	**900**	**4900,0**	**---**	**97,4**
6,00	**39,1**	**0,1044**	**0,2606**	**1,1266**	**900**	**4813,5**	**---**	**95,7**
8,00	**109,4**	**0,1074**	**0,2437**	**1,1122**	**900**	**4674,4**	**---**	**92,9**
10,00	**261,1**	**0,1101**	**0,2293**	**1,0960**	**900**	**4477,0**	**---**	**89,0**
12,00	**497,7**	**0,1125**	**0,2173**	**1,0782**	**900**	**4213,6**	**---**	**83,8**
14,00	**1115,5**	**0,1146**	**0,2078**	**1,0587**	**900**	**3873,8**	**---**	**77,0**
15,00	**1848,5**	**0,1155**	**0,2040**	**1,0484**	**900**	**3671,4**	**---**	**73,0**

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	**157**	**337,34**	**4787,3**	**4935,4**	**9870,7**	**9870,7**	**0,0**
2,00	**157**	**335,38**	**4789,6**	**4937,8**	**9875,5**	**9875,5**	**0,0**
+ 4,00 +	**157**	**329,60**	**4753,0**	**4900,0**	**9800,0**	**9800,0**	**0,0**
6,00	**157**	**320,13**	**4669,1**	**4813,5**	**9627,0**	**9627,0**	**0,0**
8,00	**157**	**306,89**	**4534,2**	**4674,4**	**9348,8**	**9348,8**	**0,0**
10,00	**157**	**289,66**	**4342,7**	**4477,0**	**8954,1**	**8954,1**	**0,0**
12,00	**157**	**268,19**	**4087,1**	**4213,6**	**8427,1**	**8427,1**	**0,0**
14,00	**157**	**242,11**	**3757,6**	**3873,8**	**7747,6**	**7747,6**	**0,0**
15,00	**157**	**227,21**	**3561,2**	**3671,4**	**7342,8**	**7342,8**	**0,0**

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	**0,0397**	**0,0335**	**945,08**	**1285,81**	**1285,63**
2,00	**0,1478**	**0,1276**	**877,24**	**1225,03**	**1224,33**
+ 4,00 +	**0,2707**	**0,2396**	**792,54**	**1141,31**	**1135,57**
6,00	**0,3740**	**0,3374**	**711,67**	**1052,39**	**1037,21**
8,00	**0,4602**	**0,4207**	**631,77**	**955,57**	**925,19**
10,00	**0,5290**	**0,4871**	**550,05**	**847,85**	**791,47**
12,00	**0,5767**	**0,5319**	**463,84**	**726,07**	**638,11**
14,00	**0,5938**	**0,5456**	**370,46**	**586,95**	**420,16**
15,00	**0,5855**	**0,5358**	**320,27**	**509,87**	**270,32**

Propulsion

8 oct 2015 06:16

HydroComp NavCad 2012

Project ID **Proyecto**

Description

File name **Proyecto.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	**0,0228**	**0,5822**	**0,05328**	**1116,5**	**4475,1**	**2843,2**	**61839**	**2,95e7**	**0,2939**
2,00	**0,0910**	**0,5404**	**0,05297**	**65,193**	**70,196**	**166,01**	**976,13**	**2,95e7**	**0,2539**
+ 4,00 +	**0,1814**	**0,4882**	**0,05206**	**14,844**	**8,7278**	**37,799**	**122,56**	**2,96e7**	**0,2059**
6,00	**0,2710**	**0,4384**	**0,05057**	**5,968**	**2,5398**	**15,197**	**36,069**	**2,97e7**	**0,1636**
8,00	**0,3602**	**0,3892**	**0,04847**	**3,0002**	**1,0376**	**7,64**	**14,927**	**2,99e7**	**0,1262**
10,00	**0,4488**	**0,3388**	**0,04575**	**1,6819**	**0,50599**	**4,283**	**7,3866**	**3,00e7**	**0,0926**
12,00	**0,5372**	**0,2857**	**0,04236**	**0,99025**	**0,2733**	**2,5216**	**4,0557**	**3,03e7**	**0,0615**
14,00	**0,6252**	**0,2282**	**0,03824**	**0,5838**	**0,15647**	**1,4866**	**2,3646**	**3,05e7**	**0,0311**
15,00	**0,6692**	**0,1973**	**0,03589**	**0,44056**	**0,11976**	**1,1219**	**1,8278**	**3,07e7**	**0,0157**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	**5569,27**	**2,90**	**0,60**	**32,04 !**	**0,595**	**55,97**	**8,5**	**8,5**	**2419,2**
2,00	**350,34**	**2,90**	**0,60**	**32,04 !**	**0,587**	**55,63**	**8,4**	**8,4**	**2471,9**
+ 4,00 +	**88,29**	**2,90**	**0,60**	**32,04 !**	**0,574**	**54,81**	**8,0**	**8,0**	**2556,5**
6,00	**39,53**	**2,90**	**0,59**	**32,04 !**	**0,555**	**53,36**	**7,3**	**7,3**	**2655,6**
8,00	**22,39**	**2,90**	**0,58**	**32,04 !**	**0,529**	**51,06**	**6,3**	**6,3**	**2766,7**
10,00	**14,41**	**2,90**	**0,58**	**32,04 !**	**0,494**	**47,80**	**5,1**	**5,1**	**2887,0**
12,00	**10,06**	**2,90**	**0,57**	**32,04 !**	**0,450**	**43,54**	**3,8**	**3,8**	**3013,2**
14,00	**7,43**	**2,90**	**0,56**	**32,04 !**	**0,398**	**38,26**	**2,5**	**2,5**	**3141,7**
15,00	**6,48**	**2,90**	**0,55**	**32,04 !**	**0,368**	**35,25**	**2,0**	**2,0**	**3205,7**

Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Single/hard**
Length on WL:		**54,170 m**
Max beam on WL:	[LWL/BWL 3,477]	**15,580 m**
Max molded draft:	[BWL/T 2,450]	**6,360 m**
Displacement:	[CB 0,527]	**2901,37 t**
Wetted surface:	[CWS 5,200]	**1039,8 m2**
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,480]	**26,002 m**
LCF fwd TR:	[XCF/LWL 0,520]	**28,168 m**
Max section area:	[CX 0,932]	**92,4 m2**
Waterplane area:	[CWP 0,666]	**562,0 m2**
Bulb section area:		**0,0 m2**
Bulb ctr below WL:		**0,000 m**
Bulb nose fwd TR:		**0,000 m**
Transom area:	[ATR/AX 0,000]	**0,0 m2**
Transom beam WL:	[BTR/BWL 0,000]	**0,000 m**
Transom immersion:	[TTR/T 0,000]	**0,000 m**
Half entrance angle:		**21,10 deg**
Bow shape factor:	[AVG flow]	**0,0**
Stern shape factor:	[AVG flow]	**0,0**

Planing		
Proj chine length:		***0,000 m***
Proj bottom area:		***0,0 m2***
LCG fwd TR:	*[XCG/LP 0,000]*	***0,000 m***
VCG below WL:		***0,000 m***
Aft station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Fwd station (fwd TR):		***0,000 m***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Deadrise:		***0,00 deg***
Propulsor type:		***SPP***
Propeller diameter		***3900,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***

Propulsor data

Propulsor			
Count:		**2**	
Propulsor type:		**Propeller series**	
Propeller type:		**FPP**	
Propeller series:		**Kaplan 19A**	
Propeller sizing:		**By power**	
KTKQ file:			
Blade count:		**4**	
Expanded area ratio:		**0,6999**	**[Size]**
Propeller diameter:		**3900,0 mm**	**[Size]**
Propeller mean pitch:	[P/D 1,0857]	**4234,4 mm**	**[Size]**
Hub immersion:		**5500,0 mm**	
Engine/gear			
Engine data:		**Untitled Engine Obje...**	
Rated RPM:		**600 RPM**	
Rated power:		**5030,0 kW**	
Gear efficiency:		**1,00**	
Gear ratio:		**5,736**	**[Size]**
Shaft efficiency:		**0,97**	

Propeller options	
Oblique angle corr:	**Off**
Shaft angle to WL:	**0,00 deg**
Added rise of run:	**0,00 deg**
Propeller cup:	**0,0 mm**
KTKQ corrections:	**Standard**
Scale correction:	**Full ITTC**
KT multiplier:	**1,00**
KQ multiplier:	**1,00**
Blade T/C [0.7R]:	**Standard**
Roughness:	**Standard**
Cav breakdown:	**Off**
Nozzle L/D:	**Standard**
Design condition	
Max prop diam:	**3900,0 mm**
Design speed:	**4,00 kt**
Reference power:	**4900,0 kW**
Design point:	**1,000**
Reference RPM:	**900,0**
Design point:	**1,000**

Propulsion

8 oct 2015 06:16

HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Symbols and values

SPEED =	Vessel speed
FN =	Froude number [LWL]
FV =	Froude number [VOL]
PETOTAL =	Total vessel effective power
WFT =	Taylor wake fraction coefficient
THD =	Thrust deduction coefficient
EFFR =	Relative-rotative efficiency
RPMENG =	Engine RPM
PBPROP =	Brake power per propulsor
QPROP =	Propulsor open water torque
PDPROP =	Delivered power per propulsor
PSPROP =	Shaft power per propulsor
PSTOTAL =	Total vessel shaft power
PBTOTAL =	Total vessel brake power
TRANSP =	Transport factor
FUEL =	Fuel rate per engine
LOADENG =	Percentage of engine max available power at given RPM
RPMPROP =	Propulsor RPM
EFFO =	Propulsor open-water efficiency
EFFOA =	Overall propulsion efficiency [=PETOTAL/PSTOTAL]
THRPROP =	Open-water thrust per propulsor
DELTHR =	Total vessel delivered thrust
NETTOW =	Total vessel net tow pull
CPPITCH =	Operational pitch of CPP
J =	Propulsor advance coefficient
KT =	Propulsor thrust coefficient [horizontal, if in oblique flow]
KQ =	Propulsor torque coefficient
KTJ2 =	Propulsor thrust loading ratio
KQJ3 =	Propulsor torque loading ratio
CTH =	Horizontal component of bare-hull resistance coefficient
CP =	Propulsor thrust loading coefficient
RNPROP =	Propeller Reynolds number at 0.7R
KTN =	Nozzle thrust coefficient
SIGMAV =	Cavitation number of propeller by vessel speed
SIGMAN =	Cavitation number of propeller by RPM
SIGMA07R =	Cavitation number of blade section at 0.7R
TIPSPEED =	Propeller circumferential tip speed
MINBAR =	Minimum expanded blade area ratio recommended by selected cavitation criteria
PRESS =	Average propeller loading pressure
CAVAVG =	Average predicted back cavitation percentage
CAVMAX =	Peak predicted back cavitation percentage [if in oblique flow]
PITCHFC =	Minimum recommended pitch to avoid face cavitation
+ =	Design speed indicator
* =	Exceeds recommended parameter limit
! =	Exceeds recommended cavitation criteria [warning]
!! =	Substantially exceeds recommended cavitation criteria [critical]
!!! =	Thrust breakdown is indicated [severe]
--- =	Insignificant or not applicable

Propulsion

8 oct 2015 06:16
HydroComp NavCad 2012

Project ID **Proyecto**
Description
File name **Proyecto.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**[Calc] Oortmerssen**	Analysis type:	**Towing**
Reference ship:		CPP method:	
Max prop diam:	**3900,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[On] Standard**	RPM constraint:	
Rudder location:	**Behind propeller**	Limit [RPM/s]:	
Friction line:	**ITTC-57**	**Water properties**	
Hull form factor:	**1,318**	Water type:	**Salt**
Corr allowance:	**ITTC-78 (v2008)**	Density:	**1026,00 kg/m3**
Roughness [mm]:	**[Off] 0,00**	Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[On]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Prediction method check [Oortmerssen]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	XCB/LWL	IE	CX
Value	**0,09**	**0,56**	**3,48**	**2,45**	**0,480**	**21,1**	**0,93**
Range	**0,05··0,50**	**0,51··0,69**	**3,50··6,30**	**1,90··3,40**	**0,467··0,537**	**10,0··38,0**	**0,73··0,97**

Prediction results [System]

	HULL-PROPULSOR				ENGINE			
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]
0,50	**0,0**	**0,0946**	**0,3197**	**1,1579**	**900**	**4935,4**	**---**	**98,1**
2,00	**0,4**	**0,0975**	**0,3018**	**1,1506**	**900**	**4937,8**	**---**	**98,2**
+ 4,00 +	**8,9**	**0,1011**	**0,2800**	**1,1394**	**900**	**4900,0**	**---**	**97,4**
6,00	**39,1**	**0,1044**	**0,2606**	**1,1266**	**900**	**4813,5**	**---**	**95,7**
8,00	**109,4**	**0,1074**	**0,2437**	**1,1122**	**900**	**4674,4**	**---**	**92,9**
10,00	**261,1**	**0,1101**	**0,2293**	**1,0960**	**900**	**4477,0**	**---**	**89,0**
12,00	**497,7**	**0,1125**	**0,2173**	**1,0782**	**900**	**4213,6**	**---**	**83,8**
14,00	**1115,5**	**0,1146**	**0,2078**	**1,0587**	**900**	**3873,8**	**---**	**77,0**
15,00	**1848,5**	**0,1155**	**0,2040**	**1,0484**	**900**	**3671,4**	**---**	**73,0**

	POWER DELIVERY						
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP
0,50	**157**	**337,34**	**4787,3**	**4935,4**	**9870,7**	**9870,7**	**0,0**
2,00	**157**	**335,38**	**4789,6**	**4937,8**	**9875,5**	**9875,5**	**0,0**
+ 4,00 +	**157**	**329,60**	**4753,0**	**4900,0**	**9800,0**	**9800,0**	**0,0**
6,00	**157**	**320,13**	**4669,1**	**4813,5**	**9627,0**	**9627,0**	**0,0**
8,00	**157**	**306,89**	**4534,2**	**4674,4**	**9348,8**	**9348,8**	**0,0**
10,00	**157**	**289,66**	**4342,7**	**4477,0**	**8954,1**	**8954,1**	**0,0**
12,00	**157**	**268,19**	**4087,1**	**4213,6**	**8427,1**	**8427,1**	**0,0**
14,00	**157**	**242,11**	**3757,6**	**3873,8**	**7747,6**	**7747,6**	**0,0**
15,00	**157**	**227,21**	**3561,2**	**3671,4**	**7342,8**	**7342,8**	**0,0**

	EFFICIENCY		THRUST		
SPEED [kt]	EFFO	EFFOA	THRPROP [kN]	DELTHR [kN]	NETTOW [kN]
0,50	**0,0397**	**0,0335**	**945,08**	**1285,81**	**1285,63**
2,00	**0,1478**	**0,1276**	**877,24**	**1225,03**	**1224,33**
+ 4,00 +	**0,2707**	**0,2396**	**792,54**	**1141,31**	**1135,57**
6,00	**0,3740**	**0,3374**	**711,67**	**1052,39**	**1037,21**
8,00	**0,4602**	**0,4207**	**631,77**	**955,57**	**925,19**
10,00	**0,5290**	**0,4871**	**550,05**	**847,85**	**791,47**
12,00	**0,5767**	**0,5319**	**463,84**	**726,07**	**638,11**
14,00	**0,5938**	**0,5456**	**370,46**	**586,95**	**420,16**
15,00	**0,5855**	**0,5358**	**320,27**	**509,87**	**270,32**

Propulsion

8 oct 2015 06:16

HydroComp NavCad 2012

Project ID **Proyecto**

Description

File name **Proyecto.hcnc**

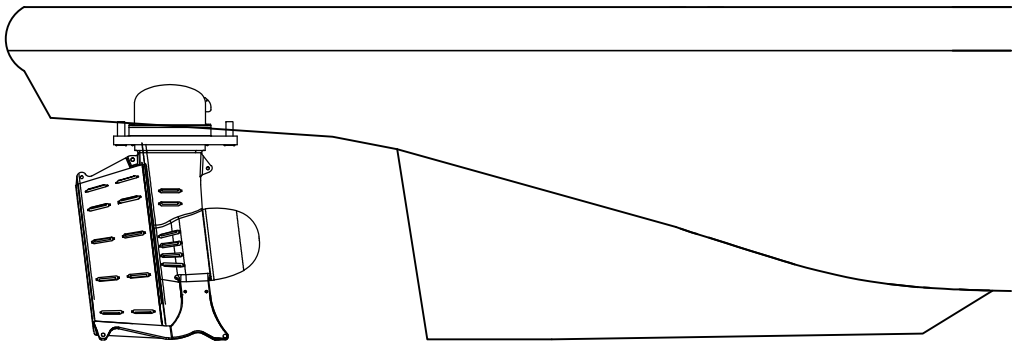
Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	KTN
0,50	**0,0228**	**0,5822**	**0,05328**	**1116,5**	**4475,1**	**2843,2**	**61839**	**2,95e7**	**0,2939**
2,00	**0,0910**	**0,5404**	**0,05297**	**65,193**	**70,196**	**166,01**	**976,13**	**2,95e7**	**0,2539**
+ 4,00 +	**0,1814**	**0,4882**	**0,05206**	**14,844**	**8,7278**	**37,799**	**122,56**	**2,96e7**	**0,2059**
6,00	**0,2710**	**0,4384**	**0,05057**	**5,968**	**2,5398**	**15,197**	**36,069**	**2,97e7**	**0,1636**
8,00	**0,3602**	**0,3892**	**0,04847**	**3,0002**	**1,0376**	**7,64**	**14,927**	**2,99e7**	**0,1262**
10,00	**0,4488**	**0,3388**	**0,04575**	**1,6819**	**0,50599**	**4,283**	**7,3866**	**3,00e7**	**0,0926**
12,00	**0,5372**	**0,2857**	**0,04236**	**0,99025**	**0,2733**	**2,5216**	**4,0557**	**3,03e7**	**0,0615**
14,00	**0,6252**	**0,2282**	**0,03824**	**0,5838**	**0,15647**	**1,4866**	**2,3646**	**3,05e7**	**0,0311**
15,00	**0,6692**	**0,1973**	**0,03589**	**0,44056**	**0,11976**	**1,1219**	**1,8278**	**3,07e7**	**0,0157**

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
0,50	**5569,27**	**2,90**	**0,60**	**32,04 !**	**0,595**	**55,97**	**8,5**	**8,5**	**2419,2**
2,00	**350,34**	**2,90**	**0,60**	**32,04 !**	**0,587**	**55,63**	**8,4**	**8,4**	**2471,9**
+ 4,00 +	**88,29**	**2,90**	**0,60**	**32,04 !**	**0,574**	**54,81**	**8,0**	**8,0**	**2556,5**
6,00	**39,53**	**2,90**	**0,59**	**32,04 !**	**0,555**	**53,36**	**7,3**	**7,3**	**2655,6**
8,00	**22,39**	**2,90**	**0,58**	**32,04 !**	**0,529**	**51,06**	**6,3**	**6,3**	**2766,7**
10,00	**14,41**	**2,90**	**0,58**	**32,04 !**	**0,494**	**47,80**	**5,1**	**5,1**	**2887,0**
12,00	**10,06**	**2,90**	**0,57**	**32,04 !**	**0,450**	**43,54**	**3,8**	**3,8**	**3013,2**
14,00	**7,43**	**2,90**	**0,56**	**32,04 !**	**0,398**	**38,26**	**2,5**	**2,5**	**3141,7**
15,00	**6,48**	**2,90**	**0,55**	**32,04 !**	**0,368**	**35,25**	**2,0**	**2,0**	**3205,7**

ANEXO V

CROQUIS DE LA SITUACIÓN DEL PROPULSOR



ESCALA	SISTEMA	FORMATO
1 : 200		UNE A-4

UNIVERSIDADE DA CORUÑA
ESCOLA POLITÉCNICA SUPERIOR DE FERROL
GRADO EN INGENIERÍA DE PROPULSIÓN Y SERVICIOS DEL BUQUE

	AUTOR	FECHA	FIRMA
DIBUJADO	Mario Teijeiro Prieto	12/2015	
COMPROBADO			
Vº Bº NORMAS			
TUROR DEL PROYECTO	Don Raul Villa Caro		

PROYECTO

Remolcador de altura polivalente

PLANO

Croquis propulsor

REV.	HOJA
	1 DE 1

ARCHIVO	SUSTITUIDO POR	SUSTITUYE A

ANEXO VI

CARACTERÍSTICAS TÉCNICAS DE LA HÉLICE TRANSVERSAL DE PROA

WÄRTSILÄ

WÄRTSILÄ Thrusters

Wärtsilä specializes in complete ship propulsion systems. Besides our marine engines, we are also well known worldwide as a designer and manufacturer of WÄRTSILÄ® fixed pitch and controllable pitch propellers, waterjets, gearboxes, transverse tunnel thrusters and steerable thrusters.

Several thousand transverse thrusters are in operation today, the first of which were delivered back in 1964. Since 1996 Wärtsilä has produced a standard family of transverse thrusters (controllable, CT, and fixed pitch, FT) in the power range up to 3300 kW.

Many operators rely on the performance of the Wärtsilä transverse thruster while manoeuvring in harbour or for maintaining dynamic positioning all over the globe.

DESIGN PHILOSOPHY

Wärtsilä has given top priority to reliability and durability when designing the current range of thrusters.

The transverse thruster offers considerable savings in operational costs due to:

- Reliable and durable components
- Long lifetime of the bearings and gears
- High efficiency
- Maintenance-friendly design.

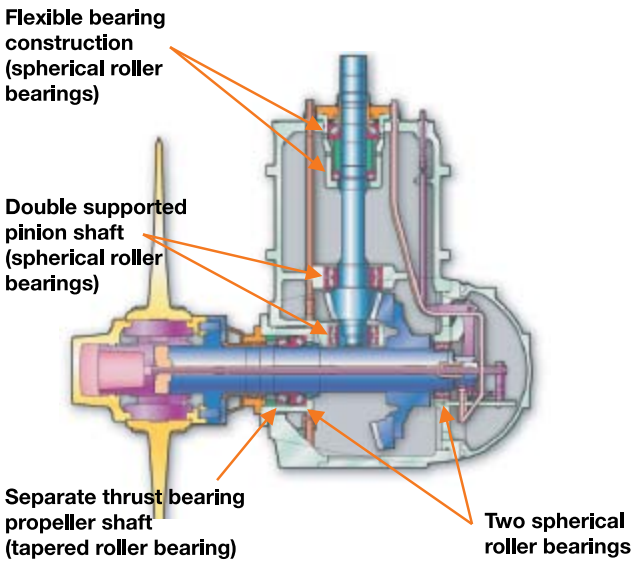
The Wärtsilä transverse thruster design is highly standardized and optimized for use in:

- All sea-going vessels
- Special ships with high demands for dynamic positioning (DP).

Although our transverse thruster is a standard design, developed to cover the practical range of applications, special designs may be required in certain cases.

Barge carrier Smit Pioneer is equipped with three LIPS CT250 transverse thrusters.

The passenger RoRo vessel Seafrance Rodin is equipped with four LIPS CT225 transverse thrusters.



We have the know-how and skills to help our customers solve such problems and construct a system tailored to their needs.
The Wärtsilä transverse thruster offers major technical benefits:

- Designed with the smallest possible tunnel diameter, which minimizes the mounting space in the vessel and increases hull efficiency
- Designed for maximum thrust (within class requirements)
- High efficiency obtained by adapting the propeller design to the tunnel diameter and to optimize the flow towards the propeller
- Standard blades of backward skewed design with rounded tips, resulting in optimum thrust efficiency while obtaining a more gradual change in the cavitation volume
- A large blade area to keep cavitation volume as low as possible. This results in maximum thrust output at minimum noise and vibration levels, giving optimum comfort in the accommodation.

MARKET REQUIREMENTS

The market requires transverse thrusters with full performance capabilities in both normal conditions and during continuous running for dynamic positioning. High-quality materials and well-proven designs are a must.

We believe that flexibility and creativity in all projects is the best way to support owners, operators, consultants and yards. The design of the Wärtsilä transverse thruster enables us to provide flexible and dedicated solutions for any requirement.

The concept further offers reduced lead times and easy availability of spare parts. Long design experience, use of the highest quality materials, and special solutions like double support for the pinion wheels, sealing solutions and the proven long lifetime of our gears and bearings, make us a unique Ship Power partner in all markets.

Whatever the market requires, we can deliver standard, can-mounted transverse thrusters. We also give top priority to providing service and spare parts worldwide, anywhere and at any time.

FEATURES AND BENEFITS

BEARING ARRANGEMENT

Wärtsilä transverse thrusters make exclusive use of anti-friction spherical roller or tapered roller bearings, which run completely immersed in ISO 150 gear type lubricating oil.

A split axial and radial bearing layout is applied: each bearing has a specific function and therefore performs optimally. Bearing lifetime is in the order of 60,000 hours based on an average operating profile.

SEALS

High-quality seals are fitted on the propeller shaft and pinion shaft to prevent water ingress or oil leakage.
PINION SHAFT
Standard viton lip seal combined with a nitride hardened liner.
PROPELLER SHAFT
Standard NBR lip seals combined with a stainless steel liner and a rope guard (split steel cover).
OPTIONAL:

- Viton lip seals with ceramic coated corrosion resistant liner
- Specific customer requirements.

GEAR SET / CONTACT PATTERN

The bevel gears (pinion and crown wheel) are of the Cyclo-palloid HPG type. The teeth are fine-machined when the hardening process is completed successfully.

When finished, the gearwheels comply with Class 6 or better under DIN 3965. Optimal tooth contact is achieved by precise adjustment of the gear wheels. Deflection of the gear mesh under variable load is prevented because the pinion is supported by radial roller bearings at both sides (lower bearing in cast-in straddle).

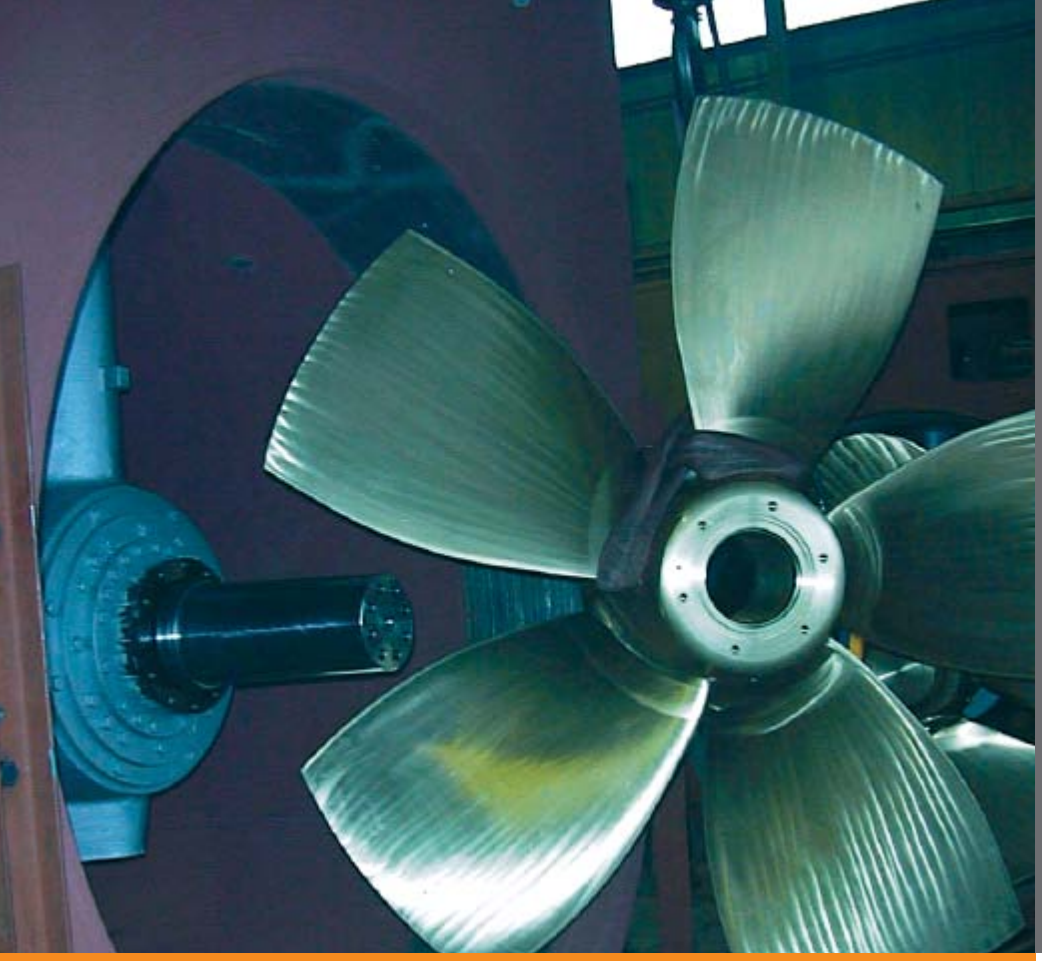
All in all, gearwheel lifetime is infinite.

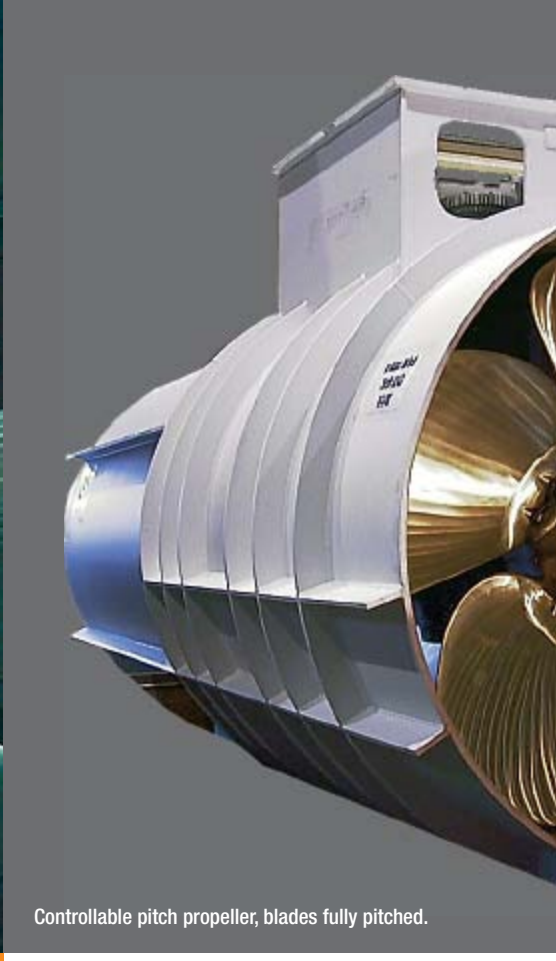
PROPELLER DESIGN

Hub and blades are cast of patented Cunial® bronze. The propeller diameter ranges from 1.25 m to 3 m.

A large blade area is chosen to keep the cavitation volume as low as possible. This design results in maximum thrust output with minimum noise and vibration to achieve optimum comfort in the accommodation. The thrust achieved is approximately 0.15 kN/KW based on our standard tunnel configuration.

The well-balanced combination of materials minimizes electrochemical corrosion.





Controllable pitch propeller, blades fully pitched.

SELECTION OF TRANSVERSE THRUSTERS

CT TRANSVERSE THRUSTER DESIGN OFFERS:

- Controllable pitch propeller blades actuated by a hydraulic cylinder yoke. Together with the mechanically linked feedback system, this creates a smooth, fast, reliable and accurate pitch control system
- Blades of skew back design
- Compact hub design which is also applied for controllable pitch propellers and steerable thrusters
- Pitch-to-zero-system to minimize trailing under sailing conditions

FT TRANSVERSE THRUSTER DESIGN OFFERS:

- Propeller hydro dynamically designed for every specific order (4 or 5 blades)
- Hydraulic shrink-fitted propeller to the propeller shaft
- Optional: electric motor with 3-step and stepless speed control

Selection criteria for applying CT versus FT

		FT 3-step (AUX)[1]	FT stepless (DP)[2]	CT
Drive E-motor		slip-ring	squirrel cage	squirrel cage
Speed control		3 steps	frequency	constant
Thrust control		fixed steps less fast	smooth and fast	smooth and fast
Joystick/DP		not fit	fit	fit
Maintenance		more	less	most
Power efficiency		fair	good	fair
Noise and vibrations	Standby Full power	good fair	good fair	fair good
Dimensions		less compact	extensive	compact

1) AUX: Auxiliairy for manoeuvring purposes. 2) DP: Dynamic positioning.

TUNNELS

Our standard tunnel section is made of rolled mild steel, the thickness and length of which depend on the propeller diameter. The tunnel is reinforced by three rings that can be welded directly into the ship's structure.

The tunnel arrangement can be manufactured for both vertical or horizontal installation.

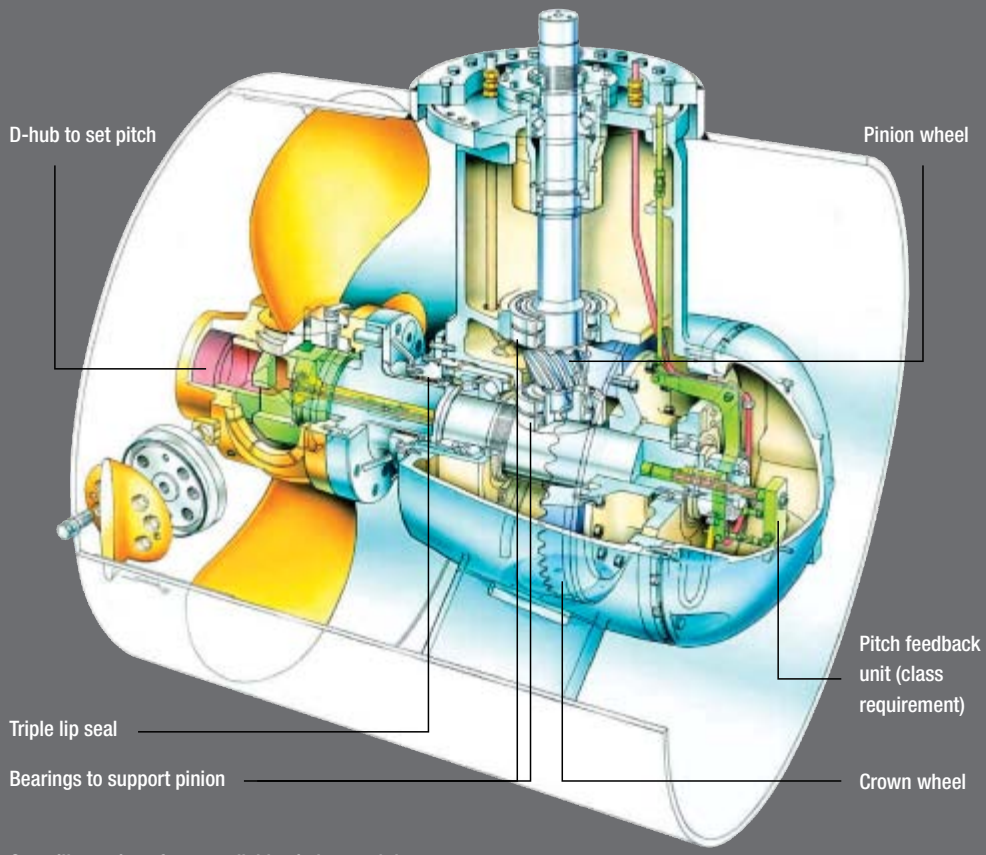
Special arrangements are possible:

- (Dis-) mountable tunnel
- Split delivery (tunnel in advance).

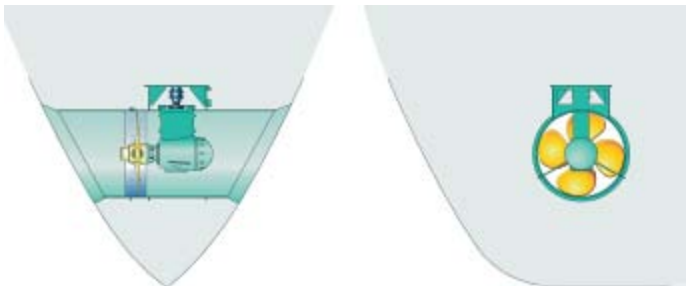
OPTIONS

- With or without motor support
- Extra tunnel length
- Extra reinforcement rings
- Longitudinal stiffeners
- Stainless steel liner
- Cladded stainless steel liner
- Tunnel ends cut according to hull form
- Special customer demands fulfilled

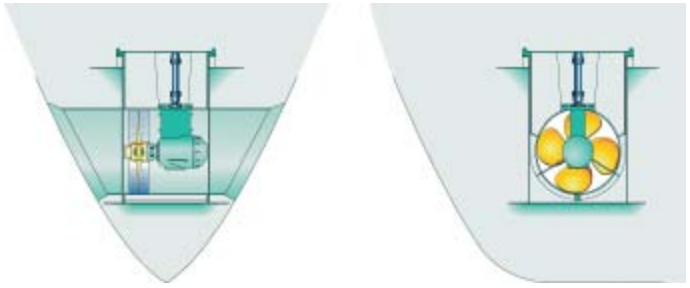
Our specialists can advise you about the optimum tunnel location, the best configuration for the entrance and the geometry of the grids to ensure maximum efficiency.



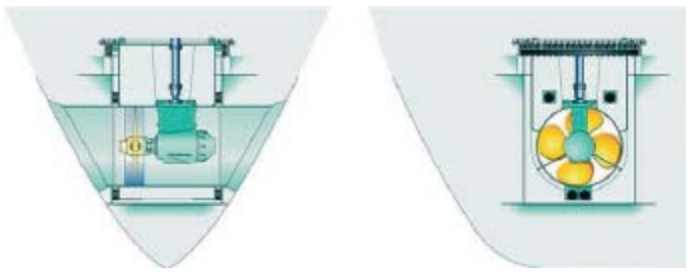
Open illustration of a controllable pitch tunnel thruster.



Weld-in tunnel.



(Dis-) Mountable construction.



Low noise (dis-) mountable construction.

AUXILIARY SYSTEMS

Each transverse thruster has its own independent auxiliary system consisting of:

- Hydraulic/lubrication systems
- Remote control system
- Optional: electric motor.

HYDRAULIC/LUBRICATION SYSTEMS

LUBRICATING SYSTEM:

- Header tank is loose supplied and mounted on a certain level above the thruster, to obtain over-pressure in the submerged part of the thruster
- No extra pump is needed
- Oil type: mineral ISO 150/100.

HYDRAULIC PITCH ACTUATING SYSTEM (CT ONLY):

- Power pack tank (located near thruster)
  - Pump E-motor driven
  - Control valve
  - Level switch
  - Filter mounted on top of tank
- Oil type: mineral ISO 150/100.

OPTIONS:

- Two pumps (each 50% or 100%, DP class requirement),
- Oil cooler
- Oil heater
- Temperature switch
- Power pack air pressurized

REMOTE CONTROL SYSTEM(S)

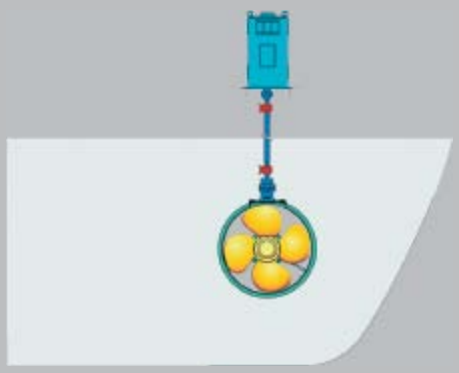
Wärtsilä can supply various types of remote starting equipment and remote controls.

Controllable pitch transverse thrusters have an electrically operated pitch control system. The control panels, normally located on the bridge wheelhouse and wings, can be situated at various locations depending on the type and function of the vessel.

OPTIONS:

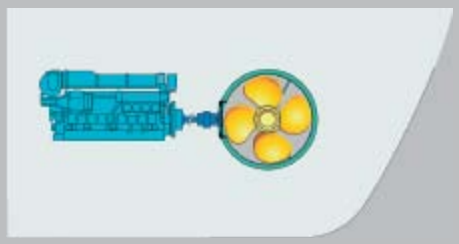
- Portable control panel
- VDR interface.

Vertical prime mover directly coupled to the input.

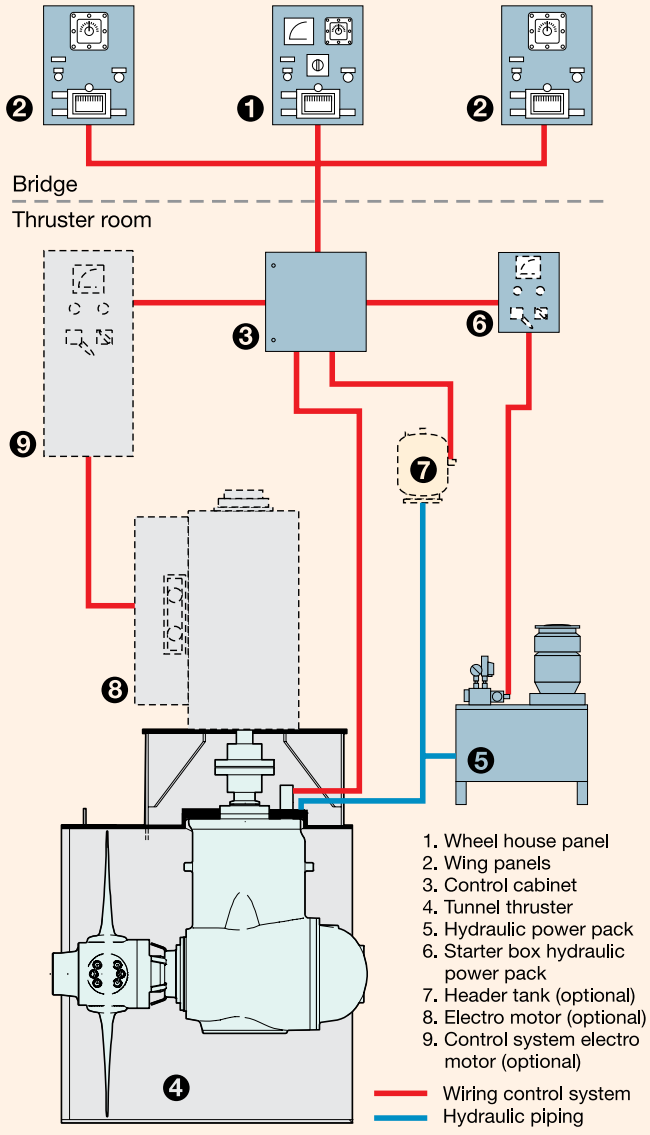


Vertical prime mover coupled by an extended shafting arrangement.

Indirect horizontal prime mover by means of a right angle gearbox.



Direct horizontal prime mover.



The Wärtsilä Plant in Wuxi, PR China, has produced transverse thrusters since end 2004.

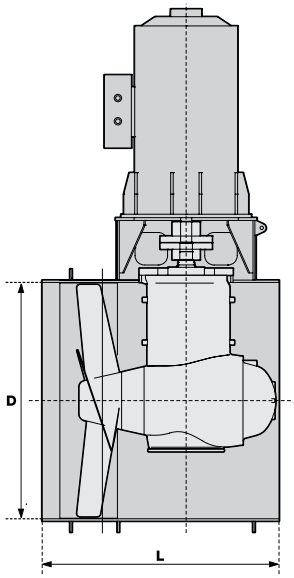
WORLDWIDE SERVICE AND MAINTENANCE

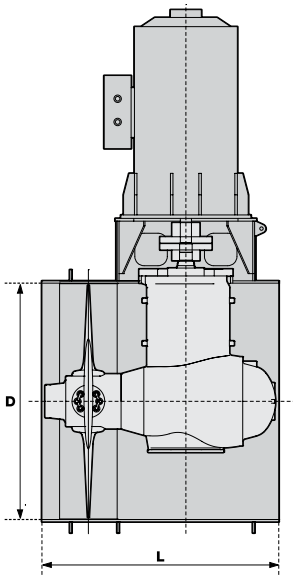
Worldwide service stations are available to provide you with spare parts and support by professional service engineers. Well equipped workshops contribute to our ability to give you high-quality local service.

When necessary the service stations can count on dedicated support from our thruster engineering team. Professional and quick support at low cost is near to your place of operation.

Type	Electr. freq.	Rational frequency		Max. power (kW) [1]		D	L	Mass[2]
	(Hz)	Input (rpm)	Output (rpm)	Manoeuv-ring	Dynamic positioning	(mm)	(mm)	(kg)
CT/FT125 H	60	1755	519	614	404	1250	1550	2800
	50	1465	433	516	341			
CT/FT150 H	60	1755	430	880	589	1500	1800	4200
	50	1465	359	735	492			
CT/FT175 H	60	1755	379	1025	713	1750	2000	5900
	50	1465	316	900	595			
CT/FT175 M	60	1170	371	995	995	1750	2000	5900
	50	975	309	829	829			
CT/FT200 H	60	1170	263	1115	742	2000	2250	8100
	50	1465	329	1394	928			
CT/FT200 M	60	1170	324	1515	1227	2000	2250	8100
	50	975	270	1262	1022			
CT/FT225 H	60	1170	287	1785	1201	2250	2350	11500
	50	975	239	1487	1001			
CT/FT225 M	60	880	266	1649	1478	2250	2350	11500
	50	975	295	1827	1502			
CT/FT250 H	60	1170	265	2175	1458	2500	2550	13800
	50	975	221	1813	1215			
CT/FT250 M	60	880	233	1998	1599	2500	2550	13800
	50	975	259	2213	1754			
CT/FT275 H	60	880	216	2532	1735	2750	2800	17800
	50	975	239	2805	1923			
CT/FT275 M	60	880	238	2569	2241	2750	2800	17800
	50	735	199	2145	1858			
CT/FT300 H	60	880	216	3145	2454	3000	3000	22700
	50	735	180	2625	2035			
CT/FT300 M	60	705	210	3405	2657	3000	3000	22700
	50	735	219	3550	2771			

1) Max. power is dependent on sailing profile and classification society requirements.
2) Includes a standard tunnel with e-motor support.





WÄRTSILÄ

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

07.2009 / Bock's Office / Arkmedia