Escola Politécnica Superior

Trabajo Fin de Grado
CURSO 2.017/18

BUQUE ATUNERO CONGELADOR DE 3.700 m³

Grado en Ingeniería Naval y Oceánica

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FECHA:

JUNIO 2.018

1. RPA

GRADO EN INGENIERÍA NAVAL Y OCEÁNICA

TRABAJO FIN DE GRADO

PROYECTO NÚMERO: 18-05

TIPO DE BUQUE: Buque atunero congelador de 3.700 m^3 con bandera española destinado a la pesca de cerco en el Océano Pacífico Oriental.

CLASIFICACIÓN, COTA Y REGLAMENTOS DE APLICACIÓN: El buque ha de cumplir las reglas establecidas por la Sociedad de Clasificación BUREAU VERITAS para alcanzar la cota:

I ✠ HULL ✠ MACH, Fishing vessel, Unrestricted navigation, REF-CARGO-QUICKFREEZE, INWATERSURVEY

Además, el buque deberá ajustarse a los siguientes reglamentos:

Protocolo de Torremolinos 1.993 con sus enmiendas en vigor.

Reglamentos de los Canales de Suez y Panamá.

Reglamento MARPOL 73/78.

CARACTERÍSTICAS DE LA CARGA: Atún que se distribuirá y congelará en cubas por el sistema de inmersión en salmuera.

VELOCIDAD Y AUTONOMÍA: El buque alcanzará una velocidad en pruebas de 19 nudos con el motor desarrollando su potencia máxima continua (100% MCR) y cuya autonomía será de 60-70 días operacionales.

SISTEMAS Y EQUIPOS DE CARGA / DESCARGA: Los equipos de carga y descarga serán la pluma de panga y plumas auxiliares (Br y Er) para carga y descarga de la pesca y en general los habituales para este tipo de buque.

PROPULSIÓN: Motor propulsor diésel 4 tiempos no reversible.

TRIPULACIÓN Y PASAJE: El buque estará operado por 30 tripulantes con camarotes y aseos individuales.

OTROS EQUIPOS E INSTALACIONES: Los habituales en este tipo de barcos.

Ferrol, 18 Septiembre 2.017

ALUMNO/A: **Dª EVA LUZ VILLAR CHOUCIÑO**

UNIVERSIDADE DA CORUÑA

Escola Politécnica Superior

TRABAJO FIN DE GRADO

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BUQUE ATUNERO CONGELADOR DE 3.700 m³

Grado en Ingeniería Naval y Oceánica

CUADERNO 6

"PREDICCIÓN DE POTENCIA PROPULSORA Y DISEÑO DE PROPULSOR Y TIMÓN"

ÍNDICE

2. INTRODUCCIÓN

El Buque correspondiente al proyecto número 18-05 es un pesquero Purse Seiner con capacidad de cubas de 3.700 m^3, a motor, con casco de acero, proyectado para la pesca del atún con arte de cerco en el Océano Pacífico Oriental.

El buque con todo su equipo y maquinaria, se construirá de acuerdo con las reglas, y bajo la inspección de la Sociedad de Clasificación Bureau Veritas, para alcanzar la cota:

I ✠ HULL ✠ MACH, Fishing vessel, Unrestricted navigation, REF-CARGO-QUICKFREEZE, INWATERSURVEY

Donde:

- REF-CARGO-QUICKFREEZE: notación de clase adicional asignada a buques diseñados con plantas de congelación, con la condición de que el número y la energía de las unidades de refrigeración son tales que la temperatura específica puede ser mantenida con una unidad en standby.

- INWATERSURVEY: notación de clase adicional asignada a buques con los arreglos necesarios para facilitar la inspección bajo agua.

Las dimensiones principales de dicho Buque Proyecto calculadas en el Cuaderno 1, *"Dimensionamiento Preliminar y Elección de la Cifra de Mérito"* y los coeficientes ajustados en el Cuaderno 3 *"Coeficientes y Plano de Formas",* son los que se muestran a continuación:

ESLORA ENTRE PERPENDICULARES……………………………	96,70 m
ESLORA TOTAL………………………………………………………	112,40 m
MANGA…………………………………………………………………	18,00 m
PUNTAL A LA CUBIERTA PRINCIPAL…………………………	8,20 m
PUNTAL A LA CUBIERTA SUPERIOR…………………………	11,00 m
CALADO………………………………………………………………	7,50 m
Velocidad (100% MCR)……………………………………………	19 nudos
Número de Froude…………………………………………………	0,318
COEFICIENTE DE BLOQUE………………………………………	0,592
COEFICIENTE DE LA MAESTRA…………………………………	0,937
COEFICIENTE PRISMÁTICO………………………………………	0,631
COEFICIENTE DE LA FLOTACIÓN………………………………	0,841
DESPLAZAMIENTO……………………………………………………	7.917 Tn
VOLUMEN DE CUBAS………………………………………………	3.700 m^3
TRIPULACIÓN………………………………………………………	30
POTENCIA ……………………………………………………………	7.200 kW

En el presente Cuaderno 6 *"Predicción de Potencia Propulsora y Diseño de Propulsor y Timón"* se procederá al desarrollo de los siguientes puntos:

- Estimación de la potencia propulsora del Buque Proyecto para alcanzar una velocidad de 19 nudos al 100% de la MCR.
- Método y resultados del cálculo del propulsor.
- Cálculo del timón.
- Croquis del propulsor, codaste y timón.

En el Cuaderno 1 se ha realizado una estimación previa de potencia en base a las dimensiones y características adimensionales obtenidas en el mismo.

En este cuaderno se van a desarrollar con mayor detalle y precisión los cálculos de potencia propulsora necesaria para el cumplimiento de los requerimientos de velocidad en pruebas fijados en los RPA.

A partir de los resultados obtenidos, se verifica la elección del motor que se va a instalar en el Buque Proyecto y, a partir de los valores de potencia en el eje y revoluciones, se procede a realizar el diseño de la hélice.

Cabe decir que el buque estará provisto de un motor diésel mecánico, instalado en la sala de máquinas a popa de las bodegas de carga. La razón por la que se toma dicha decisión es para conseguir un mejor aprovechamiento del espacio al disminuir la línea de ejes, además de que, de este modo, los esfuerzos sobre la misma serán menores y el rendimiento del sistema propulsivo mayor.

Por último, se estudiarán las dimensiones y características del timón adecuado a las características del buque apoyándose en el reglamento ofrecido por la Sociedad de Clasificación Bureau Veritas.

3. CÁLCULO DE RESISTENCIA AL AVANCE

La resistencia al avance del buque es la fuerza que se opone al movimiento del mismo en el agua a una determinada velocidad, y estará íntimamente ligada a las dimensiones y formas del buque. De este modo, se estimará la potencia que es necesaria proporcionar al buque para conseguir una velocidad en pruebas de 19 nudos.

Para dicho cálculo, el software que se utilizará será el Navcad, el cual incluye diferentes métodos de cálculo; se justificará la aplicación del que se adecúe más al Buque Proyecto.

3.1. DATOS DE ENTRADA

Para la realización de los cálculos se toman los valores necesarios del Cuaderno 3 *"Coeficientes y Plano de Formas"*. Se establece un desplazamiento de cálculo correspondiente al calado medio de proyecto, por tratarse del caso más desfavorable.

De este modo, se introducen las características principales del buque, así como los coeficientes de forma, extraídos ambos de la tabla de hidrostáticas del mismo, y los correspondientes datos requeridos para el cálculo como se muestra a continuación:

Características Principales (valores obtenidos de tabla de hidrostáticas)

Eslora Total…………………………	112,40 m
Eslora en la Flotación…………………………	103,818 m
Eslora entre perpendiculares …………………………	96,70 m
Manga máxima en la Flotación…………………………	18,00 m
Puntal a cubierta principal …………………………	8,20 m
Puntal a cubierta superior…………………………	11,00 m
Calado máximo de diseño…………………………	7,50 m
Coeficiente de la Maestra…………………………	0,937
Coeficiente Prismático…………………………	0,631
Coeficiente de Bloque…………………………	0,592
Coeficiente de la Flotación…………………………	0,840
Superficie Mojada …………………………	2.452,0 m^2
Superficie Línea de Agua …………………………	1.462,7 m^2
LCB…………………………	44,997 m
LCF…………………………	38,277 m
Desplazamiento…………………………	7.917,0 Tn
Velocidad en pruebas…………………………	19 kn

Bulbo (valores extraídos de la disposición general)

Área transversal (curva de áreas seccionales)…………………………	12,90 m^2
Nariz longitudinal (desde espejo de popa) …………………………	108,93 m
Altura del centro desde línea de flotación …………………………	2,25 m
Semiángulo de entrada …………………………	22,0°
Forma de proa …………………………	V
Forma de popa …………………………	U

Espejo de Popa (valores tomados del Software Maxsurf)

Área sumergida .... 1,02 m^2

Manga en la flotación.. 5,55 m

Inmersión.. 0,315 m

Márgenes

Rugosidad.. 15 %

Margen de Mar.. 0 %

Apéndices (porcentaje).. 2 %*

**Para el cálculo de los apéndices (timón, hélices transversales y quillas de balance), por falta de precisión de ciertos datos requeridos, se aplica para los cálculos un porcentaje del 2%.*

Hydrostatics at DWL

	Measurement	Value	Units
1	Displacement	7917	t
2	Volume (displaced)	7723,803	m^3
3	Draft Amidships	7,500	m
4	Immersed depth	8,203	m
5	WL Length	103,818	m
6	Beam max extents on	17,999	m
7	Wetted Area	2452,002	m^2
8	Max sect. area	126,506	m^2
9	Waterpl. Area	1462,705	m^2
10	Prismatic coeff. (Cp)	0,631	
11	Block coeff. (Cb)	0,592	
12	Max Sect. area coeff.	0,937	
13	Waterpl. area coeff. (	0,840	
14	LCB length	44,997	from ze
15	LCF length	38,277	from ze
16	LCB %	46,533	from ze
17	LCF %	39,584	from ze
18	KB	4,271	m
19	KG fluid	0,000	m
20	BMt	4,124	m
21	BML	120,852	m
22	GMt corrected	8,395	m
23	GML	125,123	m
24	KMt	8,395	m
25	KML	125,123	m
26	Immersion (TPc)	14,993	tonne/c
27	MTc	102,439	tonne.m
28	RM at 1deg = GMt.Dis	1159,868	tonne.m
29	Length:Beam ratio	5,373	
30	Beam:Draft ratio	2,400	
31	Length:Vol^0.333 rati	4,892	
32	Precision	High	115 stat

Density (water): 1,025 tonne/m^3

Std. densities: 1,025 tonne/m^3 - Std. Metric sea water (1025.0 kg/m^3)

Imagen 1. Tabla hidrostáticas

El método de predicción aplicado es “Holtrop”. Éste parte de una base de datos muy amplia constituida por diversos tipos de buque (petroleros, bulkcarriers, pesqueros…).

Se considera un método de gran precisión en la predicción de potencia para buques de formas finas, con altas velocidades y para buques llenos y lentos, de manera que se puede considerar adecuado para el Buque Proyecto, a pesar de ser un buque pesquero, por las siguientes razones:

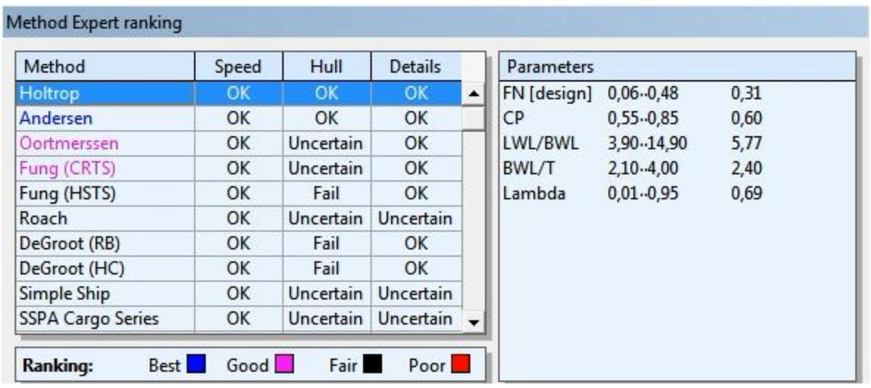
- Los buques atuneros se asemejan más a mercantes que a buques pesqueros comunes, lo que hace que sea más factible aplicar dicho método de predicción de potencia.

- El método de predicción de potencia “Holtrop” está basado en un mayor tipo de buques que otros métodos, por lo que será más adecuado para un mayor rango de buques.

- Es el método que actualmente se emplea para buques atuneros, prediciéndose la velocidad en pruebas con una gran exactitud.

De este modo, se comprueba su aplicabilidad en los siguientes datos extraídos del programa:

PARÁMETRO	RANGO APLICABLE	VALOR B.P.
Fn	0,06 - 0,48	0,31
CP	0,55 - 0,85	0,6
LWL/BWL	3,90 - 14,90	5,77
BWL/T	2,10 - 4,00	2,4
Lambda	0,01 - 0,95	0,69



3.2. RESULTADOS

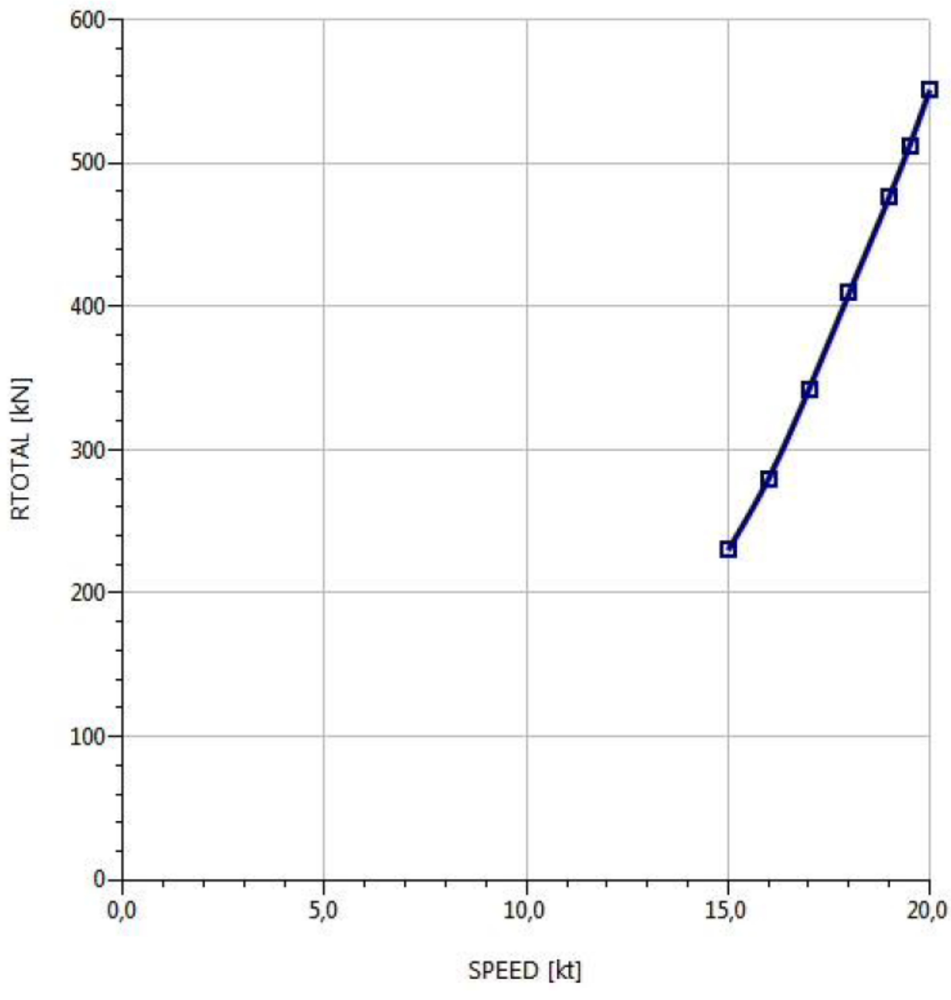
Para obtener el valor preliminar de resistencia al avance, se ha empleado, además del método Holtrop, la línea de fricción ITTC 57.

Como se muestra en los datos empleados para el cálculo, no se aplica margen de mar ya que la velocidad que debe alcanzar el Buque Proyecto es la velocidad al 100% de la MCR.

Para dicha velocidad en pruebas de 19 nudos, la resistencia total obtenida es de 476,64 kN y la potencia efectiva (E.H.P) (cara posterior de la hélice) es igual a 4.658,9 kW.

VELOCIDAD (kN)	RESISTENCIA (kN)	POTENCIA EFECTIVA (kW)
19,0	476,64	4.658,9

Los resultados de **resistencia** para las diferentes **velocidades** de trabajo del Buque Proyecto se muestran en la siguiente gráfica:



Los resultados obtenidos se adjuntan en el ANEXO I.

4. CÁLCULO DEL SISTEMA DE PROPULSIÓN

Para la predicción de potencia propulsora, el estudio se realiza basándose en la estimación de la potencia que es necesaria proporcionar para vencer la resistencia al avance hallada en el apartado anterior y conseguir la velocidad en pruebas de 19 nudos.

El proceso de cálculo consiste en dos etapas:

- Diseño preliminar del propulsor a partir de la resistencia al avance obtenida.
- Cálculo en el que se tendrán en cuenta valores de potencia del motor que se instalará definitivamente en el Buque Proyecto.

4.1. DATOS DE ENTRADA

Una vez calculada la resistencia al avance, y haciendo uso de las características principales del buque aplicadas al apartado de cálculo de resistencia al avance, se introducen los parámetros del propulsor, de manera que se aseguren los siguientes aspectos:

- Máximo rendimiento y por tanto potencia absorbida mínima.
- Buenas condiciones de iteración hélice-carena.
- Disminución del coeficiente rotativo-relativo.
- Consecuente aumento del coeficiente propulsivo.

Se busca el **punto de diseño óptimo**; los datos que se utilizan para ello son los que se muestran a continuación:

Empuje en Aguas Libres (THRPROP).. 602,91 kN
Velocidad de Diseño.. 19,0 Kn
Punto de Diseño... 1,00
RPM de Referencia.. 750 r.p.m.
Relación de Transmisión (no reversible)... 0,98
Eficiencia del Eje (1 eje)... 0,97

4.1.1. Elección del tipo de Propulsor

A la hora de diseñar el propulsor, se han de tener en cuenta diversos aspectos como los que se muestran a continuación:

- La hélice ha de proporcionar al buque el empuje necesario para que éste pueda navegar a la velocidad fijada en los RPA con un rendimiento máximo.

En el caso del Buque Proyecto, este ha de alcanzar 19 nudos al 100% de la MCR del motor principal en pruebas.

- Se han de reducir a límites admisibles los fenómenos de cavitación, por lo que es fundamental elegir una relación área desarrollada/área de disco lo suficientemente grande. Para conseguir una buena relación sin que disminuya de manera considerable el rendimiento del propulsor, se aplica el criterio de Keller que proporciona la relación área desarrollada/área disco mínima necesaria para evitar dicho fenómeno.

El Buque Proyecto dispondrá de una hélice de paso controlable, esto es, con palas orientables que mantienen el ángulo de ataque constante.

Por otro lado, a la hora de seleccionar el tipo de propulsor de un buque atunero, se han de considerar varios factores que nos decantarán por la elección de este tipo de hélice:

- En los buques atuneros se busca tanto la velocidad para llegar en menos tiempo al caladero como un empuje adecuado para la maniobra de pesca, en ambos casos con un rendimiento óptimo. Este tipo de propulsor permite un buen comportamiento del buque en las distintas situaciones de navegación.

- La velocidad en las operaciones de la maniobra es fundamental para garantizar una mayor cantidad de pescado en la red. Es en esta situación donde se realizan la mayor parte de los cambios de velocidad y donde es más vital la actuación de este tipo de propulsores debido a los bruscos cambios de régimen sobre el motor principal. De nuevo, la instalación de este tipo de propulsor beneficia esta situación.

Las hélices de paso controlable permiten adecuar en todo momento el paso de la hélice y consecuentemente la potencia absorbida a las revoluciones del motor. Así, se garantiza que el motor está funcionando en su punto óptimo, con independencia de la velocidad a la que gira, siendo la disponibilidad de par la adecuada en cada momento.

En consecuencia, el motor no sufre bruscas aplicaciones de carga a regímenes de giro que no son las adecuadas, por lo que se reduce considerablemente el número de problemas previstos a lo largo de la vida operativa.

Por otro lado, al funcionar el motor en su punto óptimo, el consumo de combustible es mínimo para una determinada potencia, con el consiguiente ahorro que esto supone. Además, este tipo de hélices, al ofrecer la posibilidad de modificar el paso se pueden adaptar a los requisitos de las distintas condiciones de navegación sin necesidad de modificar las revoluciones del motor principal.

Dichas situaciones de navegación pueden producirse por:

- Distintos calados o desplazamientos en función de las condiciones de carga, como se observa en los resultados recogidos en el Cuaderno 5 *"Condiciones de Carga y Estabilidad"*.

- Distintos grados de suciedad de la obra viva.
- Distintos estados de la mar.

Por tanto, a partir de la resistencia al avance y su potencia, se busca el punto de diseño óptimo de la hélice. Para ello se utilizan, además de los datos indicados al principio de este apartado, las siguientes características del propulsor:

Propulsión:

Paso Controlable…………………………………………………………………………………… CPP
Número de palas…………………………………………………………………………………… 4, 5 y 6
Diámetro máximo del propulsor………………………………………………………………… 4.800 mm
Inmersión del eje (dato extraído de la disposición general)………………………………… 5.400 mm

Como ya se ha citado, los valores de paso y diámetro del propulsor son variables ya que son estimados por el propio programa (Keller) en base al resto de datos. Para determinar el número de palas se han realizado los cálculos para hélices de cuatro, cinco y seis palas, eligiendo en una primera fase la que mayor rendimiento (EFFOA) ofrece.

4.2. RESULTADOS EN NAVEGACIÓN LIBRE

Los resultados obtenidos son los valores de dimensionamiento del propulsor, así como la potencia al freno (BHP) necesaria para propulsar el buque a la velocidad en pruebas.

En la siguiente tabla se muestran los resultados de dimensionamiento del propulsor y la potencia al freno necesaria para el rango de velocidades para una hélice de 6, 5 y 4 palas respectivamente.

Nº PALAS	GEAR RATIO	EXPANDED AREA RATIO	PROPELLER DIAMETER (mm)	PROPELLER MEAN PITCH (mm)	REFERENCE THRUST (kN)	EFFO	EFFOA	MERIT	RPMPROP	POTENCIA MOTOR DISPONIBLE	BHP (kW)
6	5,859	0,727	4.800	5.065,7	602,91	0,633	0,687	0,518	128	96,0 %	6.915,6
5	5,460	0,676	4.800	4.680,5	602,91	0,623	0,676	0,511	137	97,5 %	7.023 ,5
4	5,061	0,625	4.800	4.314,2	602,91	0,616	0,666	0,504	148	99,1 %	7.138,1

Los resultados obtenidos se adjuntan en los ANEXOS II (4 palas), III (5 palas) y ANEXO IV (6 palas).

Como se puede comprobar, el propulsor que ofrece un mejor rendimiento a priori (EFFOA) es la hélice de 6 palas.

Sin embargo, el hecho de instalar una hélice cuyo número de palas coincide con el número de cilindros del motor seleccionado, supone un alto riesgo de que se produzcan vibraciones en el sistema propulsor, llegando incluso a generar fenómenos de resonancia entre la hélice y el motor.

Como es de saber, estos efectos son indeseables en cualquier máquina o estructura, ya que:

- Aumentan los esfuerzos y las tensiones.
- Producen pérdidas de energía.
- Son fuentes de desgaste de materiales.
- Son fuentes de daños por fatiga.
- Son fuentes de movimientos y ruidos molestos.

Es por todo ello que, en una aplicación real, se optaría por seleccionar la hélice de 5 o 4 palas para evitar los efectos de las vibraciones.

La práctica habitual en buques atuneros es elegir una hélice de 4 palas, por lo que será la que se instale en el Buque Proyecto. Se llevará a cabo igualmente un estudio comparativo de resultados para las hélices de 4, 5 y 6 palas.

4.2.1. Motor

A la hora de seleccionar el motor propulsor para en el Buque Proyecto, la potencia calculada para la propulsión no se sobredimensiona ni con el régimen de servicio ni con la potencia del alternador de cola.

Como se ve en el Cuaderno 11 *"Planta Eléctrica",* una de las características del Buque Proyecto es la utilización de un alternador de cola de 2.500 kW (3.125 kVA) que cubrirá la demanda eléctrica en cualquier condición de navegación del buque:

- No utilizará el alternador de cola en situaciones especiales en las que los requerimientos de velocidad exijan la máxima potencia del motor (100% MCR).

- Se encenderán los generadores auxiliares en esta situación, cuando el alternador de cola se avería o en puerto.

- Los alternadores son muy sensibles a las perturbaciones que se producen, por lo que se instala un regulador de voltaje para determinados equipos a bordo del buque.

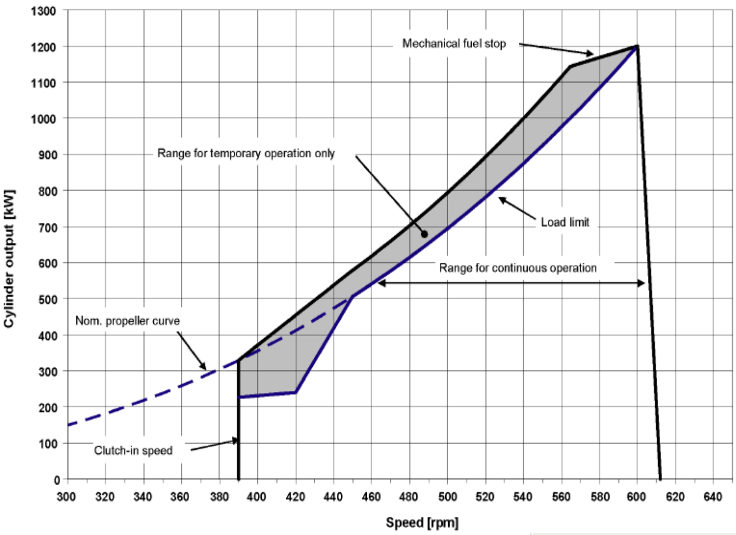
De esta manera, la potencia mínima requerida para alcanzar la velocidad de pruebas es:

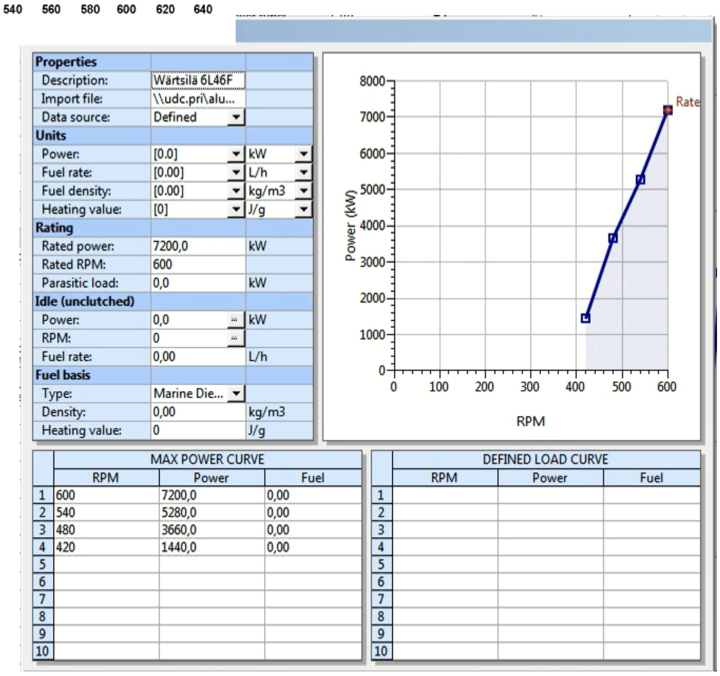
$$\boldsymbol{BHP = 7.138,1\ kW}$$

En base a este resultado, se decide instalar un motor **WÄRTSILA 6L46F de 7.200 kW** de potencia (9.790 BHP), 6 cilindros y 600 r.p.m; cuyas características técnicas se muestran en el ANEXO V.

Marca……………………………………………………	WÄRTSILA
Modelo……………………………………………………	6L46F
Potencia de Servicio…………………………………	7.200 kW (9.790 BHP)
Velocidad Nominal……………………………………	600 r.p.m.
Velocidad Media del Pistón……………………………	11,6 m/s
Ciclo………………………………………………………	4 tiempos
Número de Cilindros…………………………………	6 en línea
Peso………………………………………………………	97 Tn
Cilindrada………………………………………………	96,4 l/cyl
Diámetro del Cilindro…………………………………	460 mm (*)
Carrera del Pistón……………………………………	580 mm
Número de Válvulas…………………………………	2 admisión 2 exhaustación

Partiendo de su curva de potencia propulsiva y manteniendo los parámetros de punto de diseño y propulsor seleccionado, se determina la carga a la que se somete el motor.

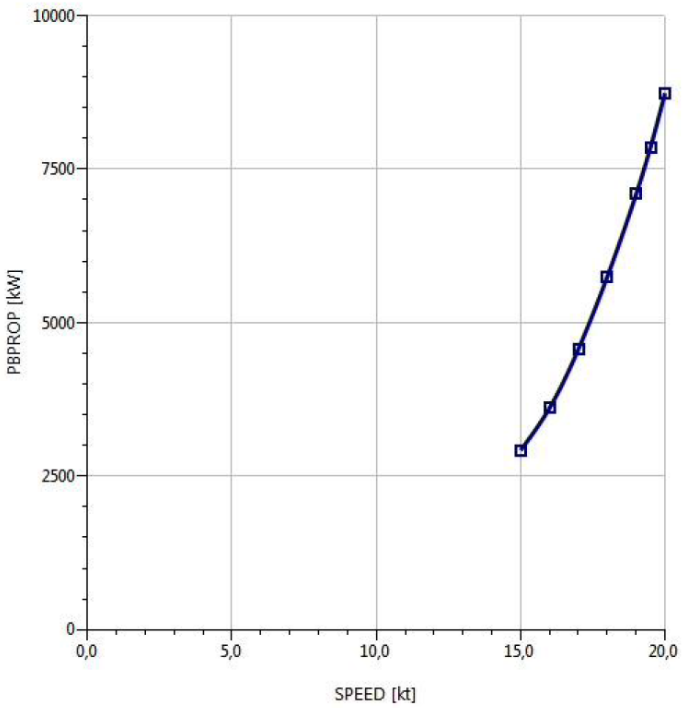




De este modo se obtiene un nuevo dimensionamiento de la hélice para propulsión (by power) ajustándose a los parámetros del motor. Los resultados obtenidos y la gráfica resistencia-velocidad se muestran a continuación (Resultados adjuntos en el ANEXO VI).

Nº PALAS	GEAR RATIO	EXPANDED AREA RATIO	PROPELLER DIAMETER (mm)	PROPELLER MEAN PITCH (mm)	REF. THRUST (kN)	EFFO	EFFOA	MERIT	RPM	BHP (kW)	CARGA (%)
6_6L46F	4,634	0,743	4.800	5.049	7.200	0,631	0,685	0,517	129	6.936,7	96,3
5_6L46F	4,328	0,686	4.800	4.663	7.200	0,623	0,677	0,510	139	7.014,4	97,4
4_6L46F	4,028	0,630	4.800	4.305	7.200	0,616	0,670	0,504	149	7.092,6	98,5

La gráfica obtenida para la hélice de 4 palas instalada se muestra a continuación:



Analizando los resultados obtenidos, se observa lo siguiente:

- Para la velocidad de 19 nudos el motor está trabajando al 98,5% de su MCR alcanzando una potencia total al freno (PBTOTAL) de 7.093,6 kW, lo que verifica el cumplimiento los RPA requeridos.

- Se obtienen los siguientes resultados de cavitación, coeficiente de estela y coeficientes del propulsor:

WFT	THD	J	KT	KQ	CTH	CP	CAVAVG
0,2884	0,2094	0,5837	0,1796	0,02708	1,3423	2,158	4,0

WFT = coeficiente de estela de Taylor, determinado por la diferencia entre la velocidad del buque y la del fluido perturbado producida por la interacción de la carena sobre la hélice. Se debe considerar aquí el efecto que tiene el bulbo en popa sobre este fenómeno; este permite que la velocidad de entrada del agua al propulsor sea más eficaz, manteniendo las curvas isoestela constantes y por tanto disminuyendo el efecto de estela.

CAVAVG = porcentaje medio de cavitación (aceptable hasta un 5%); en determinados puntos se alcanzan altas velocidades que dan origen a bajas presiones, de manera que, si la presión local en esos puntos llega a hacerse igual a la presión de vapor, ésta se vaporiza (hierve) formándose burbujas de vapor. Estas burbujas son arrastradas por el flujo y, al llegar a zonas de presiones más altas, vuelve a presentarse el cambio de fase, esta vez en sentido inverso, lo que origina el fenómeno de cavitación (colapso de las burbujas).

Se observa que los valores obtenidos se encuentran dentro de un rango aceptable.

4.2.2. Diseño del tipo de Propulsor (Hélice)

A continuación, se muestran las imágenes del diseño del propulsor que se instalará en el Buque Proyecto:

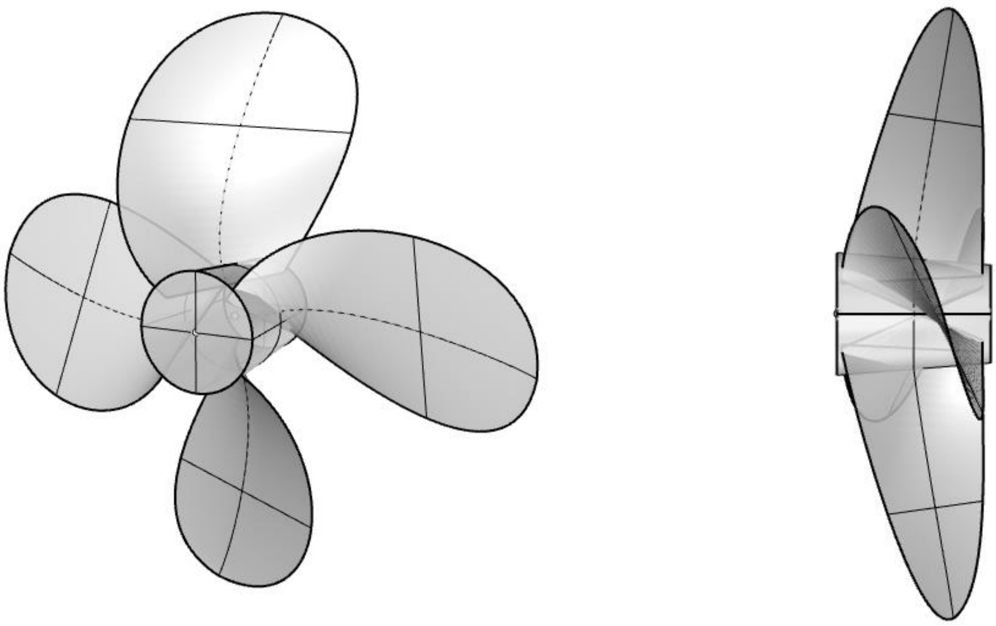


Imagen 2. Hélice Buque Proyecto

4.3. CLARAS ENTRE EL PROPULSOR Y EL CODASTE

En este apartado se comprueban los huelgos iniciales supuestos en el Cuaderno 3 *"Coeficientes y Plano de Formas"* para la hélice final en el vano del codaste, de tal manera que se asegure el espacio suficiente para alojarla y así evitar problemas debido a la interacción de la hélice con el casco y el timón.

Las formas de popa se suelen definir con el apoyo de los reglamentos de las Sociedades de Clasificación, sin embargo, la aplicable al Buque Proyecto no incluye el cálculo de los vanos del codaste, por lo que se utilizará de nuevo el reglamento del DNV-GL. Ambas utilizan expresiones que dependen del tanto de las características del buque como del diámetro del propulsor y del número de palas del mismo.

- **DNV-GL:**

$$clara\ a = (0{,}24 - 0{,}01 \cdot Z) \cdot D = 960{,}0\ mm$$

$$clara\ b = (0{,}35 - 0{,}02 \cdot Z) \cdot D = 1.296{,}0\ mm$$

$$clara\ c = 0{,}10 \cdot D = 480{,}0\ mm$$

$$clara\ d = 0{,}035 \cdot D = 168{,}0\ mm$$

donde:

Z = número de palas que es 4.

D = diámetro de la hélice. Se toman los **4.800 mm**.

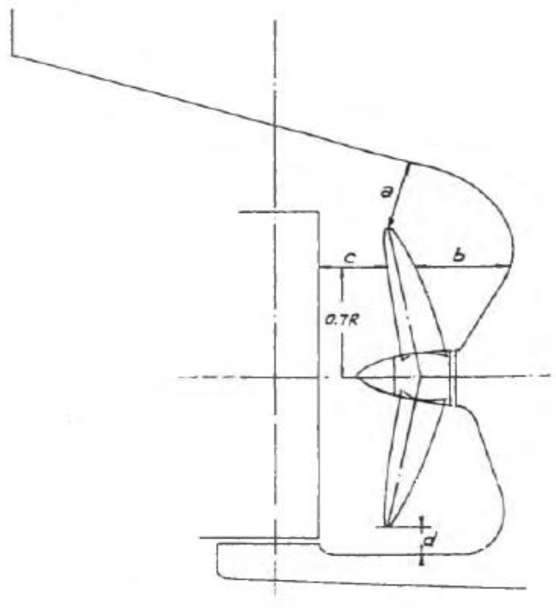


Imagen 3. Claras de codaste

Los resultados obtenidos para el Buque Proyecto una vez instalado el propulsor definitivo son los que se muestran en la disposición general:

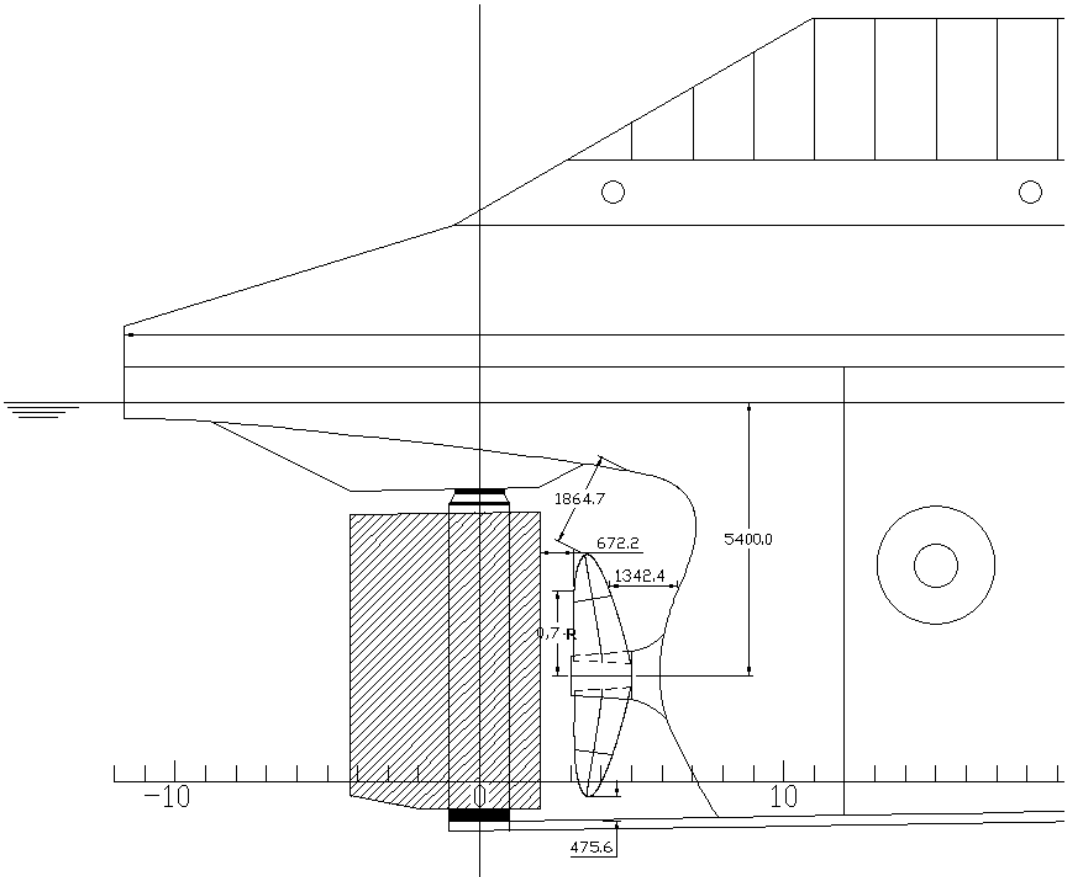


Imagen 4. Claras Buque Proyecto

Como se adelantaba en el Cuaderno 3 *"Coeficientes y Plano de Formas",* la disposición planteada cumple con las claras de codaste mínimas exigidas por el Reglamento.

CLARA	REGLAMENTO	BUQUE PROYECTO
Clara a (mm)	960,0	1.864,7
Clara b (mm)	1.296,0	1.342,4
Clara c (mm)	480,0	672,2
Clara d (mm)	168,0	475,6

5. CÁLCULO DEL TIMÓN

En este apartado se calcularán las características principales del timón que se instalará en el Buque Proyecto.

A la hora de diseñar un timón se han de tener en cuenta una serie de aspectos como se muestra a continuación:

- Ha de ser capaz de dar fuerzas iguales en ambas direcciones, lo que implica que la sección o perfil del timón ha de ser simétrica respecto al plano longitudinal del buque.
- Ha de suministrar momento de giro lo mayor posible con una fuerza dada, por lo que su localización más adecuada será en el extremo del buque.
- Para obtener una elevada fuerza con una determinada geometría, es conveniente situarlo en la zona de mayores velocidades locales del agua, es decir, e el chorro de la hélice.
- El efecto de estela producido por el casco es negativo, así que buques de dimensiones similares y estelas más altas necesitan timones más grandes que otros con estelas más bajas.
- La relación de alargamiento (h/c) tiene una gran influencia en la fuerza del timón.
- Para un área dada, un timón alto y estrecho genera una fuerza mayor que uno de poca altura y mucha cuerda.
- La relación de espesor del timón tiene poca influencia en el valor de la fuerza. Son preferibles los timones esbeltos.
- Cuando el perfil del timón está muy cargado (mucha fuerza por unidad de cuerda) se produce un ángulo determinado y de forma brusca el desprendimiento de la capa límite, lo cual da lugar a una disminución de la fuerza, un aumento de par en la mecha y vibraciones; este fenómeno debe evitarse al menos para ángulos menores a 35º.

5.1. CARACTERÍSTICAS GEOMÉTRICAS DEL TIMÓN

Para el diseño del timón se han aplicado los requerimientos expuestos por la Sociedad de Clasificación del Buque Proyecto, Bureau Veritas, empleando la *Parte B, Capítulo 9, Sección 1 "Timones".*

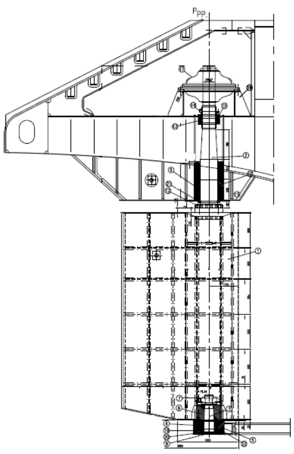


Imagen 5. Timón currenciforme

22	RESINA PINZOTE	RESINA	S/PLANO Nº 296.300.352
21	BRIDA DE SUJECCIÓN LIMERA	AISI 316L	S/PLANO Nº 296.300.351
20	ANILLO DE SUJECCIÓN PINZOTE	AC. NAVAL	S/PLANO Nº 296.300.352
19	PORTA CASQUILLOS PINZOTE	AC. NAVAL	S/PLANO Nº 296.300.352
18	LLANTAS DE SEGURIDAD	AC. NAVAL	
17	SERVOMOTOR	——	
16	POLIN DEL SERVOMOTOR	AC. LAMINADO	
15	ESTOPADA	TEFLON	COMERCIAL
14	PRENSA ESTOPAS	BRONCE CAÑON PB 85/5/5/5	S/PLANO Nº 296.300.354
13	SOPORTE DEL PRENSA ESTOPAS	AC. MOLDEADO	S/PLANO Nº 296.300.354
12	BULONES DE ACOPLAMIENTO MECHA–PALA TIMON	F–125	S/PLANO Nº 296.300.353
11	ANILLO DE TOPE INFERIOR DE LA MECHA	AC. LAMINADO	S/PLANO Nº 296.300.353
10	CASQUILLO DE LA LIMERA	BRONCE CAÑON PB 85/5/5/5	S/PLANO Nº 296.300.351
9	LIMERA	AC. MOLDEADO	S/PLANO Nº 296.300.351
8	CHAPA DE CIERRE	AC. LAMINADO	S/PLANO Nº 296.300.352
7	SEGURO CONTRA GIRO TUERCA PINZOTE	AC. LAMINADO	S/PLANO Nº 296.300.352
6	PIEZA FUNDIDA EN PALA TIMON	AC. MOLDEADO	S/PLANOS Nº 296.300.352 Nº 296.300.355
5	PIEZA FUNDIDA EN ZAPATA CODASTE	AC. MOLDEADO	S/PLANOS Nº 296.300.352 Nº 296.300.355
4	CASQUILLO DEL PINZOTE	BRONCE CAÑON PB 85/5/5/5	S/PLANO Nº 296.300.352
3	PINZOTE	AC. INOXIDAB. (AISI 316)	S/PLANO Nº 296.300.352
2	MECHA	AC. FORJADO F–112	S/PLANO Nº 296.300.353
1	PALA DEL TIMON	AC. LAMINADO	S/PLANO Nº 296.21.406.01.00
MARCA	DENOMINACION	MATERIAL	OBSERVACIONES

5.1.1. Tipo de Timón

Para el Buque Proyecto se ha escogido el habitual en este tipo de buques, un timón de acero soldado, con piezas fundidas, currentiforme de tipo colgado, soportado por la mecha, y servomotor y guiado por un pinzote cónico de acero inoxidable apoyado en un casquillo embutido en la zapata del codaste, evitando así que la red se enrede entre el timón y la hélice durante las maniobras de pesca.

El timón se dispondrá de forma que pueda girar a 35º a cada banda a máxima velocidad. A su vez, el aparato de gobierno será de funcionamiento electro-hidráulico y su potencia será tal que será capaz de llevar el timón de banda a banda un ángulo total de 65 grados en 28 segundos con una sola bomba.

5.1.2. Superficie de la Pala de Timón

La superficie del timón guarda relación con el área de deriva del buque, de manera que se obtenga una maniobrabilidad adecuada.

En este tipo de buques, el área lateral del timón oscila entre un 2,90% y un 3,00% del área de deriva del buque.

El área de deriva al calado de trazado es de aproximadamente 740,00 m^2. Para el cálculo de la superficie lateral del timón se ha empleado un valor medio de 2,95%; así:

$$A = 0{,}0295 \cdot A_{deriva} = 0{,}0295 \cdot 740{,}00 = \mathbf{21{,}80\ m^2}$$

Comprobando el área del timón del buque referencia nº11 de la base de datos “Jocay”, se verifica la proporcionalidad con el Buque Proyecto.

$$A_{T_{Jocay}} = 5{,}4 \cdot 3{,}05 = 16{,}50\ m^2$$

5.1.3. Contorno del Timón

El contorno del timón es de tipo trapezoidal. A continuación, se obtienen las dimensiones del mismo.

- **Altura:** la altura del timón está condicionada por la disposición del codaste y por la instalación de una aleta fija en su parte superior que permite una mejor maniobrabilidad al impedir la formación de torbellinos en la estela a la salida de la hélice. El espacio disponible permite una altura de 6,75 m. Aplicando el reglamento Bureau Veritas, dicha altura será igual a un 115% del diámetro de la hélice (4.800 mm):

$$h = 1{,}15 \cdot X = 1{,}15 \cdot 4.800 = \mathbf{5{,}60\ m}$$

El propulsor del Buque Proyecto es de 5,061 m de diámetro, por lo que el timón tendrá una altura de 5,825 m. De este modo se comprueba que el codaste cuenta con espacio suficiente para un timón de dicho tamaño.

- **Cuerda:** el valor de la cuerda está relacionado con la altura y el área de la pala, de manera que:

$$c = l_{med} = \frac{A_T}{h} = \frac{21,80}{5,60} = \mathbf{3,90\ m}$$

- **Relación de Compensación:** la relación de compensación es el área de la pala a popa de la mecha del timón en relación con el área de la pala a proa de la mecha. Según las SSCC, esta relación no deberá superar el 33%. En este caso se utilizará una relación de compensación igual a 33 % que se corresponde a la relación de compensación del buque nº11 de la base de datos “Jocay”.
Teniendo en cuenta la forma trapezoidal, la altura total del timón y el área de compensación, se obtiene una longitud media de compensación máxima por proa de la mecha:

$$R_{comp} = \frac{A_{pr}}{A_T} \cdot 100$$

$$A_{pr} = R_{comp} \cdot \frac{A_T}{100} = \frac{33}{100} \cdot 21,80 = \mathbf{7,20\ m^2}$$

- Teniendo en cuenta la forma trapezoidal, la altura total del timón y el área de compensación máxima, se obtiene una **longitud media de compensación** máxima por proa de la mecha:

$$L_{mc} = \frac{A_{pr}}{h} = \frac{7,20}{5,60} = \mathbf{1,30\ m}$$

- La **relación de aspecto** (cociente entre la altura y la longitud media del timón) suele ser cercana a 1,5, de manera que:

$$R_{asp} = 1,5 = \frac{h}{l_{mt}} = \frac{5,60}{l_{mt}}\ ; l_{mt} = \frac{5,60}{1,5} = \mathbf{3,75\ m}$$

5.1.4. ***Sección o Perfil del Timón***

El perfil empleado debe tener una geometría que conduzca a un reparto de presiones de tal forma que el centro de las mismas no se mueva excesivamente con el aumento del ángulo del timón.

Además, debe tener una buena resistencia al desplazamiento del flujo, así como una buena respuesta en cuanto a coeficiente de sustentación.

Se utiliza un perfil currentiforme. En este caso se usará un perfil tipo *NACA*. Esta familia de perfiles se caracteriza por tener el máximo espesor a una distancia del 70% de la línea de cuerda, medido desde el borde de salida, y son simétricos respecto a su eje longitudinal.

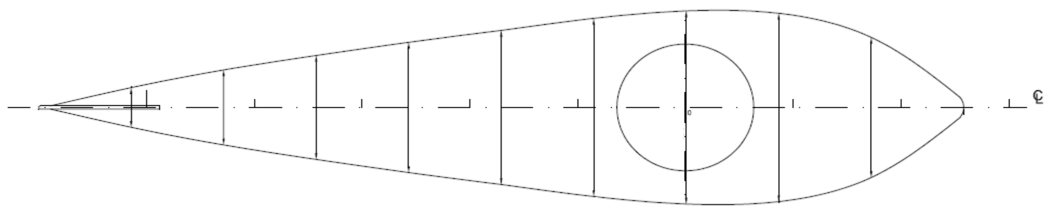


Imagen 6. Perfil del timón

Estos perfiles suministran un mayor valor de sustentación y además penaliza la resistencia al avance del buque de forma más reducida que otros perfiles. Otra de sus características es que conduce a un reparto de presiones de tal forma que el centro de las mismas no se mueve excesivamente con el aumento del ángulo del timón.

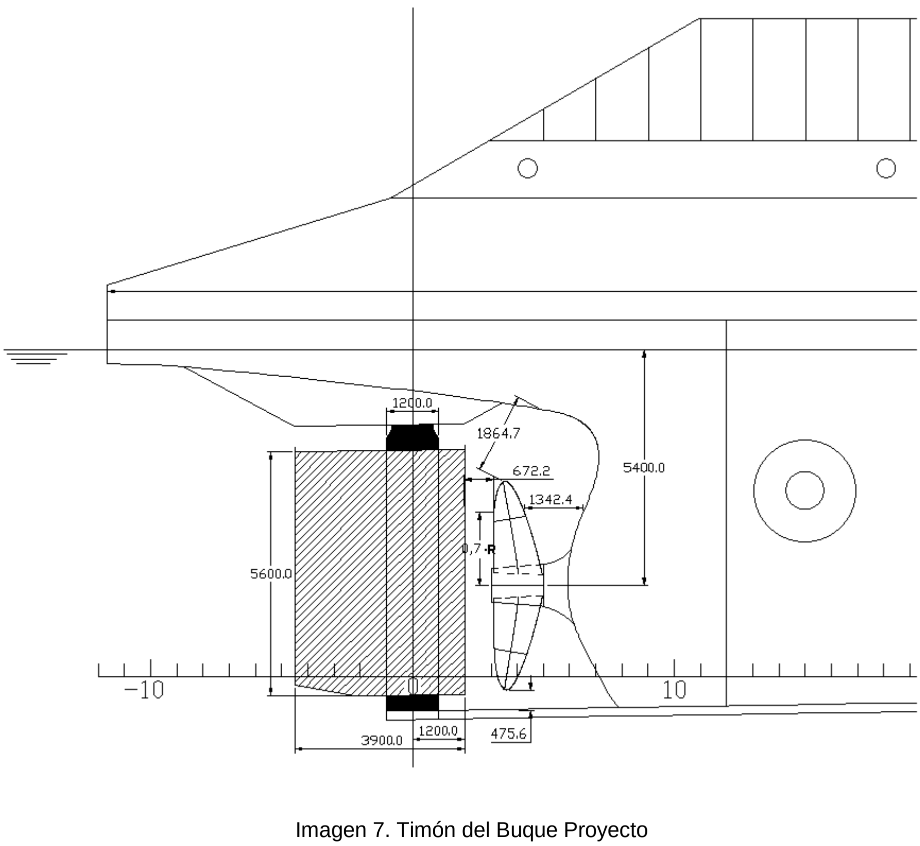


Imagen 7. Timón del Buque Proyecto

5.2. CÁLCULO DEL PAR TORSOR Y FUERZA SOBRE LA PALA

En función de las características geométricas, se procede al cálculo de las fuerzas y momentos que actúan sobre la pala y la mecha del timón por la acción del agua sobre ellos cuando se mete el timón a una banda, requeridos para el cálculo del escantillonado de la estructura del timón, mechas y apoyos.

La Sociedad de Clasificación Bureau Veritas establece una serie de fórmulas para dicho cálculo.

- La **Fuerza sobre el Timón, C_R**: la fuerza sobre el timón, en N, se obtiene a partir de la siguiente fórmula:

$$C_R = 132 \cdot n_R \cdot A \cdot V^2 \cdot r_1 \cdot r_2 \cdot r_3$$

donde:

n_r = coeficiente de navegación, que para la notación *"unrestricted navigation"* se toma **1**.

A = área del timón en m^2. Se toman **21,80 m^2**.

V = velocidad de avance o velocidad de ciar (no menor de $0{,}5 \cdot V_{AV}$; se toman **2/3 de V_{AV}**) en m/s.

r_1 = factor de forma que se deduce de:

$$r_1 = \frac{\lambda + 2}{3}$$

λ = coeficiente que se deduce de:

$$\lambda = \frac{h^2}{A_T} \quad (no\ mayor\ de\ 2)$$

h = altura en metros del área del timón que se obtiene de la siguiente expresión:

$$h = \frac{z_3 + z_4 - z_2}{2} = \mathbf{5,600\ m}$$

A_T = área total de la pala timón A en m^2, añadiendo el área de la mecha del timón o el área del soporte si alguno es mayor que la altura h. Se toma de la disposición general **0,70 m^2** de esta última.

$$A_T = 21{,}80 + 0{,}70 = \mathbf{22,50\ m^2}$$

Así, se obtiene:

$$r_1 = \frac{\left(\frac{h^2}{A_T} + 2\right)}{3} = \frac{\left(\frac{5{,}600^2}{22{,}50} + 2\right)}{3} = \frac{3{,}40}{3} = \mathbf{1{,}13}$$

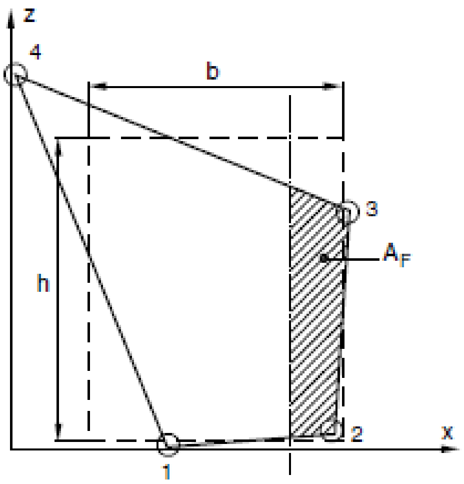
r_2 = coeficiente. para el perfil empleado para el buque proyecto se toma **1,10** para la condición de avance y **0,80** para la condición de ciar.

r_3 = coeficiente. se toma **1**.

Table 2 : Values of coefficient r_2

Rudder profile type	r_2 for ahead condition	r_2 for astern condition
NACA 00 - Goettingen	1,10	0,80
Hollow	1,35	0,90
Flat side	1,10	0,90
High lift	1,70	1,30
Fish tail	1,40	0,80
Single plate	1,00	1,00
Mixed profiles (e.g. HSVA)	1,21	0,90

Figure 1 : Geometry of rudder blade without cut-outs



de este modo, sustituyendo valores se tiene:

$$C_{R_{avante}} = 132 \cdot 1 \cdot 21{,}80 \cdot (19 \cdot 0{,}51447)^2 \cdot 1{,}13 \cdot 1{,}10 \cdot 1 = \mathbf{342.146{,}8\ N} = \mathbf{342{,}146\ kN}$$

$$C_{R_{ciando}} = 132 \cdot 1 \cdot 21{,}80 \cdot \left(\frac{2}{3} \cdot 19 \cdot 0{,}51447\right)^2 \cdot 1{,}13 \cdot 0{,}80 \cdot 1 = \mathbf{110.592{,}9\ N} = \mathbf{110{,}59\ kN}$$

- El **par torsor, m_{tr},** para ambas condiciones, se obtiene, en n·m, a partir de la siguiente fórmula:

$$M_{TR} = C_R \cdot r$$

donde:

r = palanca de fuerza C_R, en metros que equivale a:

$$r = b \cdot \left(\alpha - \frac{A_F}{A}\right) \ \ (no\ menor\ de\ 0{,}1 \cdot b\ en\ condición\ de\ avance)$$

b = manga media, en metros, del área de la pala, la cual se obtiene a partir de la siguiente expresión:

$$b = \frac{x_2 + x_3 - x_1}{2} = \mathbf{3,90\ m}$$

α = coeficiente. Se toma 0,33 para condición avance y 0,66 para condición ciar.

A_F = área, en m^2, de la parte de la pala del timón a proa de la línea media de la mecha del timón. Se toman **7,00 m^2**.

A = área total, en m^2 de la pala del timón. Se toman **21,80 m^2**.

Así, se obtiene:

$$r_{avante} = 3{,}90 \cdot \left(0{,}33 - \frac{7{,}00}{21{,}80}\right) = 0{,}035\ m < 0{,}1 \cdot b\ ;\ \boldsymbol{se\ toma\ 0,1 \cdot b = 0,390\ m}$$

$$r_{ciando} = 3{,}90 \cdot \left(0{,}66 - \frac{7{,}00}{21{,}80}\right) = \mathbf{1,32\ m}$$

De manera que:

$$M_{TR_{avante}} = 341.766{,}0\ \cdot 0{,}390 = \mathbf{133.437,2\ N \cdot m}$$

$$M_{TR_{ciando}} = 110.469{,}8 \cdot 1{,}32 = \mathbf{146.171,3\ N \cdot m}$$

- El **Par Torsor para el diseño del servo** se obtiene multiplicando el mayor valor obtenido del cálculo del par torsor por un factor de seguridad de 1,3;

$$Q_{torsor} = 146.171{,}3 \cdot 1{,}3 = 1\mathbf{90.022,8\ N \cdot m}$$

ANEXO I_RESISTENCIA

Resistance

5 jun 2018 09:18
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Vessel drag		ITTC-78 (CT)	Added drag		
Technique:	[Calc]	Prediction	Appendage:	[Calc]	Percentage
Prediction:		Holtrop	Wind:	[Off]	
Reference ship:			Seas:	[Off]	
Model LWL:			Shallow/channel:	[Off]	
Expansion:		Standard	Towed:	[Off]	
Friction line:		ITTC-57	Margin:	[Calc]	Hull + added drag [0%]
Hull form factor:	[On]	1,244	**Water properties**		
Speed corr:	[Off]		Water type:		Salt
Spray drag corr:	[Off]		Density:		1026,00 kg/m3
Corr allowance:		ITTC-78 (v2008)	Viscosity:		1,18920e-6 m2/s
Roughness [mm]:	[On]	0,15			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T	Lambda
Value	0,31	0,59	5,77	2,40	0,68
Range	0,06··0,48	0,55··0,85	3,90··14,90	2,10··4,00	0,01··0,95

Prediction results

	SPEED COEFS		ITTC-78 COEFS						
SPEED [kt]	FN	FV	RN	CF	[CTLT/CF]	CR	dCF	CA	CT
15,00	0,242	0,554	6,74e8	0,001608	1,244	0,000535	0,000000	0,000503	0,003039
16,00	0,258	0,591	7,19e8	0,001595	1,244	0,000769	0,000000	0,000497	0,003251
17,00	0,274	0,628	7,63e8	0,001583	1,244	0,001058	0,000000	0,000491	0,003519
18,00	0,290	0,665	8,08e8	0,001572	1,244	0,001315	0,000000	0,000486	0,003756
+ 19,00 +	0,306	0,702	8,53e8	0,001561	1,244	0,001505	0,000000	0,000480	0,003927
19,50	0,314	0,721	8,76e8	0,001556	1,244	0,001593	0,000000	0,000477	0,004006
20,00	0,322	0,739	8,98e8	0,001551	1,244	0,001693	0,000000	0,000474	0,004097

	RESISTANCE								
SPEED [kt]	RBARE [kN]	RAPP [kN]	RWIND [kN]	RSEAS [kN]	RCHAN [kN]	RTOWED [kN]	RMARGIN [kN]	RTOTAL [kN]	
15,00	225,41	4,51	0,00	0,00	0,00	0,00	0,00	229,92	
16,00	274,32	5,49	0,00	0,00	0,00	0,00	0,00	279,81	
17,00	335,19	6,70	0,00	0,00	0,00	0,00	0,00	341,89	
18,00	401,14	8,02	0,00	0,00	0,00	0,00	0,00	409,16	
+ 19,00 +	467,29	9,35	0,00	0,00	0,00	0,00	0,00	476,64	
19,50	502,11	10,04	0,00	0,00	0,00	0,00	0,00	512,15	
20,00	540,13	10,80	0,00	0,00	0,00	0,00	0,00	550,94	

	EFFECTIVE POWER		OTHER		
SPEED [kt]	PEBARE [kW]	PETOTAL [kW]	CTLR	CTLT	RBARE/W
15,00	1739,4	1774,2	0,00874	0,04964	0,00290
16,00	2258,0	2303,1	0,01256	0,05309	0,00353
17,00	2931,4	2990,0	0,01728	0,05747	0,00432
18,00	3714,5	3788,8	0,02148	0,06135	0,00517
+ 19,00 +	4567,5	4658,9	0,02458	0,06414	0,00602
19,50	5037,0	5137,7	0,02602	0,06543	0,00647
20,00	5557,4	5668,5	0,02765	0,06691	0,00696

Resistance

5 jun 2018 09:18
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.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:		**103,818 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,400]	**7,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,551]	**7917,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,712]	**2427,7 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,937]	**126,5 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,783]	**1462,7 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**12,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**2,250 m**	*Max prop diameter:*		***4800,0 mm***
Bulb nose fwd TR:		**108,930 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,042]	**0,315 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**22,00 deg**	*Device count:*		***0***
Bow shape factor:	[BTK flow]	**-1,0**	*Span:*		***0,000 m***
Stern shape factor:	[WL flow]	**1,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Resistance

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Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.hcnc**

Appendage data

General	
Definition:	**Percentage**
Percent of hull drag:	**2,00 %**
Planing influence	
LCE fwd TR:	**0,000 m**
VCE below WL:	**0,000 m**
Shafting	
Count:	**1**
Max prop diameter:	**4800,0 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:	**1**
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:	**0**
Type:	**Skeg**
Mean length:	**0,000 m**
Mean width:	**0,000 m**
Height aft:	**0,000 m**
Height mid:	**0,000 m**
Height fwd:	**0,000 m**
Projected area:	**0,0 m2**
Wetted surface:	**0,0 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:	**2**
Mean length:	**0,000 m**
Mean base width:	**0,000 m**
Mean projection:	**0,000 m**
Wetted surface:	**0,0 m2**
Tunnel thruster	
Count:	**3**
Diameter:	**0,000 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

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Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Symbols and values

SPEED = Vessel speed
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
RTOWED = Additional towed object resistance
RMARGIN = Resistance margin
RTOTAL = Total vessel resistance

PEBARE = Bare-hull effective power
PETOTAL = Total effective power

CTLR = Telfer residuary resistance coefficient
CTLT = Telfer total bare-hull resistance coefficient
RBARE/W = Bare-hull resistance to weight ratio

+ = Design speed indicator
* = Exceeds parameter limit

Resistance

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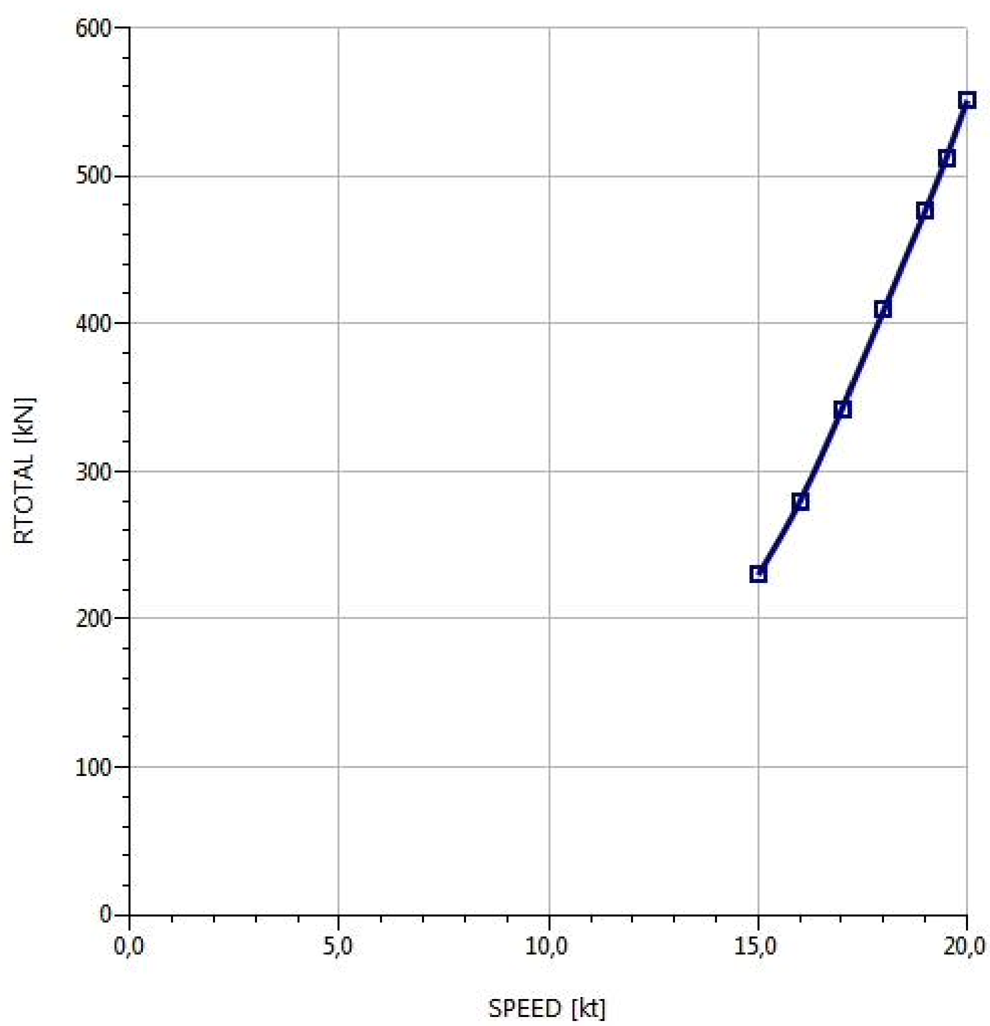
Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.hcnc**

Analysis parameters

Vessel drag		ITTC-78 (CT)	Added drag		
Technique:	[Calc]	Prediction	Appendage:	[Calc]	Percentage
Prediction:		Holtrop	Wind:	[Off]	
Reference ship:			Seas:	[Off]	
Model LWL:			Shallow/channel:	[Off]	
Expansion:		Standard	Towed:	[Off]	
Friction line:		ITTC-57	Margin:	[Calc]	Hull + added drag [0%]
Hull form factor:	[On]	1,244	**Water properties**		
Speed corr:	[Off]		Water type:		Salt
Spray drag corr:	[Off]		Density:		1026,00 kg/m3
Corr allowance:		ITTC-78 (v2008)	Viscosity:		1,18920e-6 m2/s
Roughness [mm]:	[On]	0,15			

Predicted resistance



ANEXO II_PROPULSIÓN 4 PALAS

Propulsion

5 jun 2018 09:28
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0032	750	2928,0	---	40,7	
16,00	2303,1	0,2889	0,2094	1,0032	750	3622,9	---	50,3	
17,00	2990,0	0,2887	0,2094	1,0032	750	4589,8	---	63,7	
18,00	3788,8	0,2885	0,2094	1,0032	750	5780,7	---	80,3	
+ 19,00 +	4658,9	0,2884	0,2094	1,0032	750	7138,1	---	99,1	
19,50	5137,7	0,2883	0,2094	1,0032	750	7913,1	---	109,9	
20,00	5668,5	0,2882	0,2094	1,0032	750	8800,0	---	122,2	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	148	179,93	35,55	2783,4	2869,5	2869,5	2928,0	204,6	2873,0
16,00	148	222,63	43,99	3443,9	3550,4	3550,4	3622,9	176,4	3191,3
17,00	148	282,05	55,73	4363,0	4498,0	4498,0	4589,8	147,9	3552,7
18,00	148	355,24	70,19	5495,2	5665,1	5665,1	5780,7	124,4	3932,4
+ 19,00 +	148	438,65	86,67	6785,5	6995,3	6995,3	7138,1	106,3	4314,2
19,50	148	486,28	96,08	7522,2	7754,8	7754,8	7913,1	98,4	4512,8
20,00	148	540,78	106,85	8365,3	8624,0	8624,0	8800,0	90,8	4724,7

	EFFICIENCY				THRUST	
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]
15,00	0,5713	0,9800	0,6183	0,41224	290,83	229,92
16,00	0,5996	0,9800	0,6487	0,4473	353,93	279,81
17,00	0,6146	0,9800	0,6647	0,47688	432,47	341,89
18,00	0,6185	0,9800	0,6688	0,49571	517,56	409,16
+ 19,00 +	0,6161	0,9800	0,6660	0,50474	602,91	476,64
19,50	0,6130	0,9800	0,6625	0,50713	647,83	512,15
20,00	0,6082	0,9800	0,6573	0,50879	696,90	550,94

Propulsion

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Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	0,4627	0,0875	0,01128	0,40889	0,1139	1,0412	1,8167	3,88e7	
16,00	0,4937	0,1065	0,01396	0,43708	0,11602	1,113	1,8504	3,89e7	
17,00	0,5247	0,1302	0,01769	0,47281	0,12243	1,204	1,9527	3,90e7	
18,00	0,5557	0,1558	0,02228	0,50444	0,1298	1,2845	2,0702	3,91e7	
+ 19,00 +	0,5868	0,1815	0,02751	0,52713	0,13617	1,3423	2,1719	3,92e7	
19,50	0,6023	0,1950	0,03049	0,5376	0,13959	1,369	2,2264	3,93e7	
20,00	0,6178	0,2098	0,03391	0,54964	0,14383	1,3996	2,294	3,93e7	
	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	9,97	2,14	0,42	37,24	0,405	25,72	2,0	2,0	2697,1
16,00	8,76	2,14	0,42	37,24	0,449	31,30	2,0	2,0	2907,3
17,00	7,76	2,14	0,42	37,24	0,505	38,24	2,0	2,0	3128,9
18,00	6,91	2,14	0,42	37,24	0,565	45,77	2,5	2,5	3349,7
+ 19,00 +	6,20	2,14	0,41	37,24	0,625	53,32	4,2	4,2	3563,4
19,50	5,89	2,14	0,41	37,24	0,657	57,29	5,3	5,3	3670,2
20,00	5,60	2,14	0,41	37,24	0,691	61,63	6,8	6,8	3779,5

Propulsion

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HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.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:		**103,818 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,400]	**7,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,551]	**7917,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,712]	**2427,7 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,937]	**126,5 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,783]	**1462,7 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**12,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**2,250 m**	*Max prop diameter:*		***4800,0 mm***
Bulb nose fwd TR:		**108,930 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,042]	**0,315 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**22,00 deg**	*Device count:*		***0***
Bow shape factor:	[BTK flow]	**-1,0**	*Span:*		***0,000 m***
Stern shape factor:	[WL flow]	**1,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Propulsor data

Propulsor				Propeller options	
Count:		**1**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**B Series**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Standard**
Reference prop:				Scale correction:	**Full ITTC**
Blade count:		**4**		KT multiplier:	**1,000**
Expanded area ratio:		**0,6249**	**[Size]**	KQ multiplier:	**1,000**
Propeller diameter:		**4800,0 mm**	**[Size]**	Blade T/C [0.7R]:	**Standard**
Propeller mean pitch:	[P/D 0,8988]	**4314,2 mm**	**[Size]**	Roughness:	**Standard**
Hub immersion:		**5400,0 mm**		Cav breakdown:	**Off**
Engine/gear				**Design condition**	
Engine data:		**Cuaderno_6**		Max prop diam:	**4800,0 mm**
Rated RPM:		**600 RPM**		Design speed:	**19,00 kt**
Rated power:		**7200,0 kW**		Reference power:	**7200,0 kW**
Gear efficiency:		**0,980**		Design point:	**1,000**
Load correction:		**Off**		Reference RPM:	**750,0**
Gear ratio:		**5,061**	**[Size]**	Design point:	**1,000**
Shaft efficiency:		**0,970**			

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

5 jun 2018 09:30
HydroComp NavCad 2014

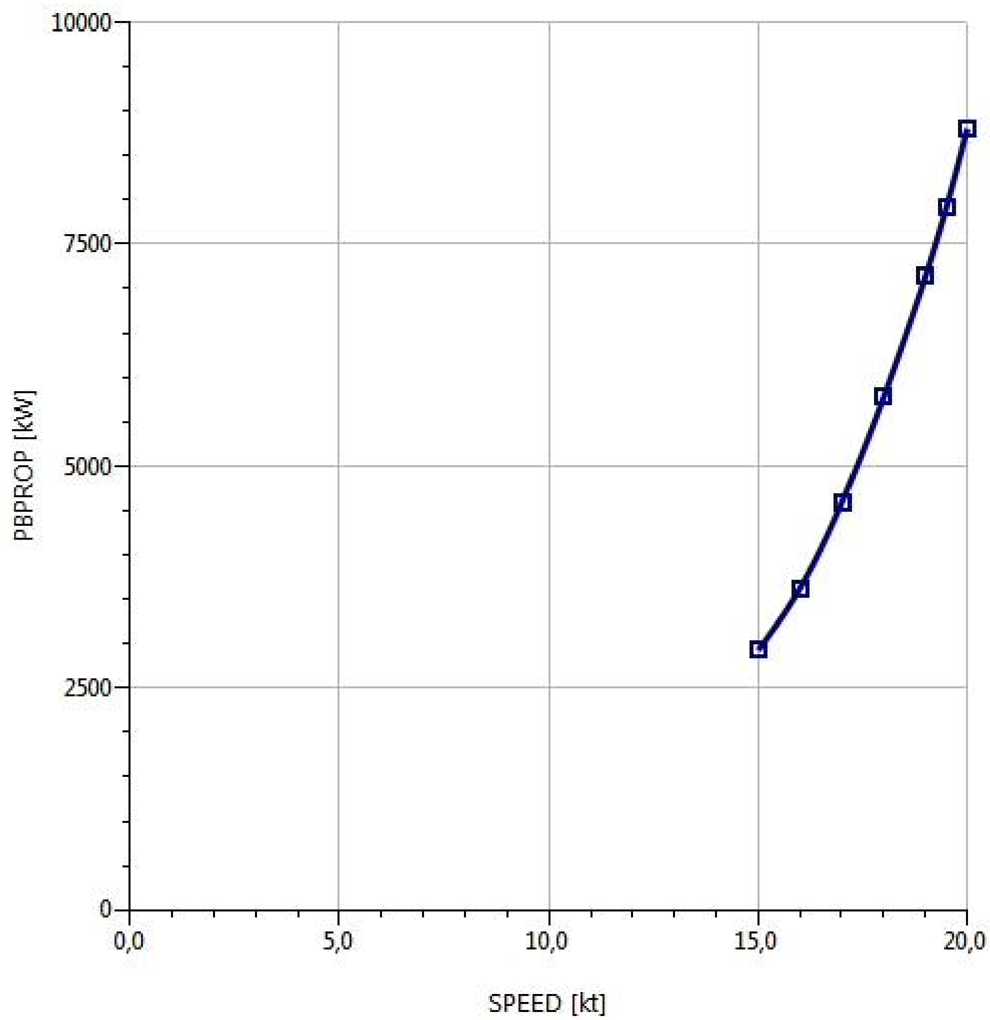
Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction	
Technique:	[Calc] Prediction
Prediction:	Holtrop
Reference ship:	
Max prop diam:	4800,0 mm
Corrections	
Viscous scale corr:	[Off]
Rudder location:	
Friction line:	
Hull form factor:	
Corr allowance:	
Roughness [mm]:	
Ducted prop corr:	[Off]
Tunnel stern corr:	[Off]
Effective diam:	
Recess depth:	

System analysis	
Cavitation criteria:	Keller eqn
Analysis type:	Free run
CPP method:	Fixed RPM
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



ANEXO III_PROPULSIÓN 5 PALAS

Propulsion

5 jun 2018 10:42
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0070	750	2842,5	---	39,5	
16,00	2303,1	0,2889	0,2094	1,0070	750	3544,9	---	49,2	
17,00	2990,0	0,2887	0,2094	1,0070	750	4509,2	---	62,6	
18,00	3788,8	0,2885	0,2094	1,0070	750	5686,9	---	79,0	
+ 19,00 +	4658,9	0,2884	0,2094	1,0070	750	7023,5	---	97,5	
19,50	5137,7	0,2883	0,2094	1,0070	750	7786,0	---	108,1	
20,00	5668,5	0,2882	0,2094	1,0070	750	8659,5	---	120,3	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	137	189,15	34,65	2702,1	2785,7	2785,7	2842,5	210,8	3124,3
16,00	137	235,89	43,21	3369,8	3474,0	3474,0	3544,9	180,3	3466,2
17,00	137	300,06	54,96	4286,4	4419,0	4419,0	4509,2	150,6	3855,5
18,00	137	378,42	69,31	5405,9	5573,1	5573,1	5686,9	126,4	4266,0
+ 19,00 +	137	467,37	85,60	6676,5	6883,0	6883,0	7023,5	108,0	4680,5
19,50	137	518,11	94,90	7401,4	7630,3	7630,3	7786,0	100,0	4896,9
20,00	137	576,24	105,54	8231,7	8486,3	8486,3	8659,5	92,2	5128,5

	EFFICIENCY				THRUST	
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]
15,00	0,5863	0,9800	0,6369	0,42302	290,83	229,92
16,00	0,6105	0,9800	0,6630	0,4554	353,93	279,81
17,00	0,6232	0,9800	0,6766	0,48355	432,47	341,89
18,00	0,6264	0,9800	0,6798	0,50197	517,56	409,16
+ 19,00 +	0,6238	0,9800	0,6769	0,51102	602,91	476,64
19,50	0,6206	0,9800	0,6733	0,51343	647,83	512,15
20,00	0,6157	0,9800	0,6680	0,51507	696,90	550,94

Propulsion

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HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	**0,4991**	**0,1019**	**0,01380**	**0,40889**	**0,111**	**1,0412**	**1,7637**	**3,12e7**	
16,00	**0,5326**	**0,1240**	**0,01721**	**0,43708**	**0,11395**	**1,113**	**1,8106**	**3,13e7**	
17,00	**0,5660**	**0,1515**	**0,02190**	**0,47281**	**0,12074**	**1,204**	**1,9184**	**3,14e7**	
18,00	**0,5995**	**0,1813**	**0,02761**	**0,50444**	**0,12818**	**1,2845**	**2,0366**	**3,15e7**	
+ 19,00 +	**0,6329**	**0,2112**	**0,03410**	**0,52713**	**0,1345**	**1,3423**	**2,137**	**3,16e7**	
19,50	**0,6497**	**0,2269**	**0,03781**	**0,5376**	**0,13787**	**1,369**	**2,1906**	**3,17e7**	
20,00	**0,6664**	**0,2441**	**0,04205**	**0,54964**	**0,14208**	**1,3996**	**2,2574**	**3,17e7**	
	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	**9,97**	**2,48**	**0,49**	**34,53**	**0,430**	**23,78**	**2,0**	**2,0**	**2909,4**
16,00	**8,76**	**2,48**	**0,49**	**34,53**	**0,479**	**28,94**	**2,0**	**2,0**	**3136,2**
17,00	**7,76**	**2,48**	**0,48**	**34,53**	**0,541**	**35,36**	**2,0**	**2,0**	**3375,2**
18,00	**6,91**	**2,48**	**0,48**	**34,53**	**0,609**	**42,32**	**2,4**	**2,4**	**3613,4**
+ 19,00 +	**6,20**	**2,48**	**0,47**	**34,53**	**0,676**	**49,29**	**4,0**	**4,0**	**3843,9**
19,50	**5,89**	**2,48**	**0,47**	**34,53**	**0,711**	**52,97**	**5,1**	**5,1**	**3959,1**
20,00	**5,60**	**2,48**	**0,47**	**34,53**	**0,750**	**56,98**	**6,5**	**6,5**	**4077,0**

Propulsion

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HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.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:		**103,818 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,400]	**7,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,551]	**7917,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,712]	**2427,7 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,937]	**126,5 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,783]	**1462,7 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**12,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**2,250 m**	*Max prop diameter:*		***4800,0 mm***
Bulb nose fwd TR:		**108,930 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,042]	**0,315 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**22,00 deg**	*Device count:*		***0***
Bow shape factor:	[BTK flow]	**-1,0**	*Span:*		***0,000 m***
Stern shape factor:	[WL flow]	**1,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Propulsor data

Propulsor				Propeller options	
Count:		**1**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**B Series**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Standard**
Reference prop:				Scale correction:	**Full ITTC**
Blade count:		**5**		KT multiplier:	**1,000**
Expanded area ratio:		**0,6759**	**[Size]**	KQ multiplier:	**1,000**
Propeller diameter:		**4800,0 mm**	**[Size]**	Blade T/C [0.7R]:	**Standard**
Propeller mean pitch:	[P/D 0,9751]	**4680,5 mm**	**[Size]**	Roughness:	**Standard**
Hub immersion:		**5400,0 mm**		Cav breakdown:	**Off**
Engine/gear				**Design condition**	
Engine data:		**Cuaderno_6**		Max prop diam:	**4800,0 mm**
Rated RPM:		**600 RPM**		Design speed:	**19,00 kt**
Rated power:		**7200,0 kW**		Reference power:	**7200,0 kW**
Gear efficiency:		**0,980**		Design point:	**1,000**
Load correction:		**Off**		Reference RPM:	**750,0**
Gear ratio:		**5,460**	**[Size]**	Design point:	**1,000**
Shaft efficiency:		**0,970**			

Propulsion

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Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

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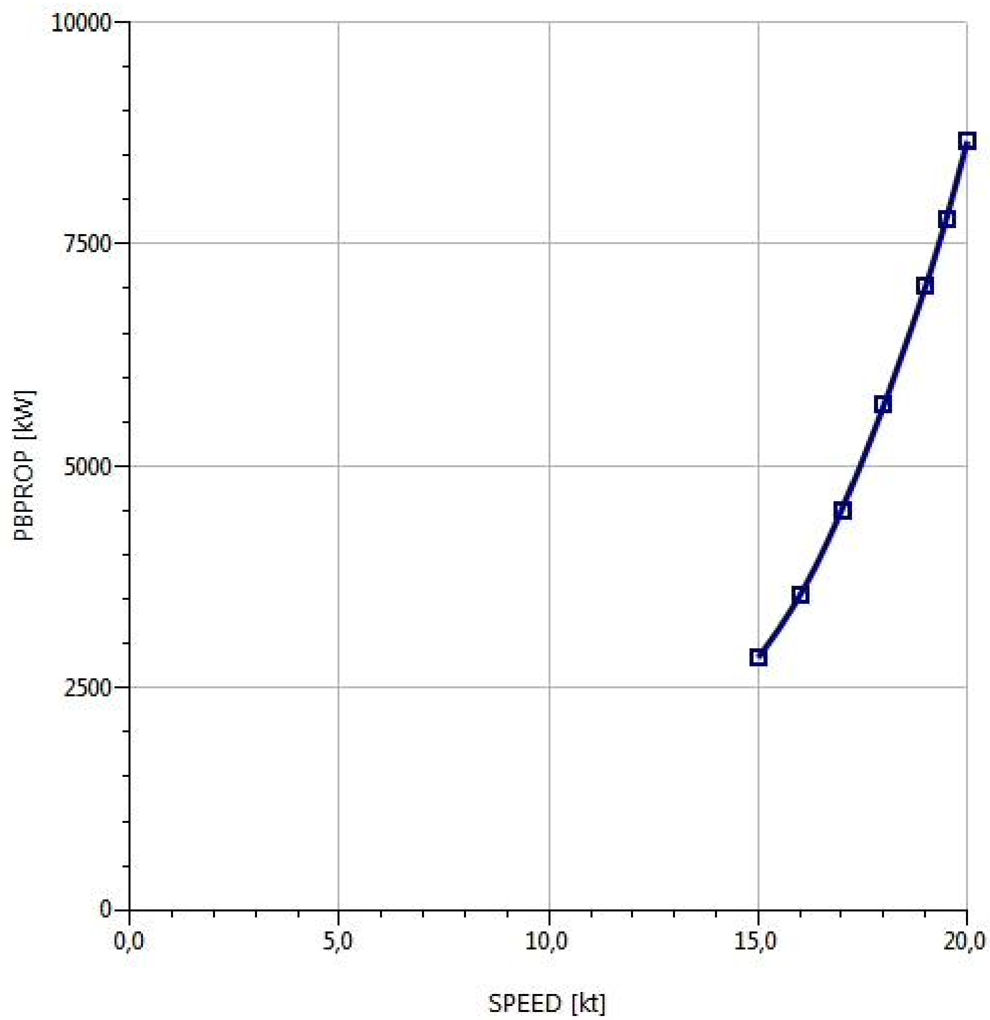
Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**[Calc] Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**Holtrop**	Analysis type:	**Free run**
Reference ship:		CPP method:	**Fixed RPM**
Max prop diam:	**4800,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[Off]**	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	**Salt**
Corr allowance:		Density:	**1026,00 kg/m3**
Roughness [mm]:		Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[Off]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Predicted propulsion



ANEXO IV_ PROPULSIÓN 6 PALAS

Propulsion

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HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0070	750	2776,0	---	38,6	
16,00	2303,1	0,2889	0,2094	1,0070	750	3482,0	---	48,4	
17,00	2990,0	0,2887	0,2094	1,0070	750	4439,4	---	61,7	
18,00	3788,8	0,2885	0,2094	1,0070	750	5600,3	---	77,8	
+ 19,00 +	4658,9	0,2884	0,2094	1,0070	750	6915,6	---	96,0	
19,50	5137,7	0,2883	0,2094	1,0070	750	7668,0	---	106,5	
20,00	5668,5	0,2882	0,2094	1,0070	750	8533,6	---	118,5	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	128	198,25	33,83	2638,9	2720,5	2720,5	2776,0	215,8	3394,5
16,00	128	248,66	42,44	3310,0	3412,3	3412,3	3482,0	183,5	3759,9
17,00	128	317,04	54,11	4220,1	4350,6	4350,6	4439,4	152,9	4176,7
18,00	128	399,94	68,26	5323,6	5488,3	5488,3	5600,3	128,4	4617,9
+ 19,00 +	128	493,88	84,29	6574,0	6777,3	6777,3	6915,6	109,7	5065,7
19,50	128	547,61	93,46	7289,2	7514,6	7514,6	7668,0	101,6	5300,6
20,00	128	609,42	104,01	8112,0	8362,9	8362,9	8533,6	93,6	5553,1

	EFFICIENCY				THRUST		
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]	
15,00	0,6003	0,9800	0,6522	0,43316	290,83	229,92	
16,00	0,6215	0,9800	0,6749	0,46362	353,93	279,81	
17,00	0,6330	0,9800	0,6873	0,49115	432,47	341,89	
18,00	0,6360	0,9800	0,6903	0,50973	517,56	409,16	
+ 19,00 +	0,6335	0,9800	0,6874	0,51899	602,91	476,64	
19,50	0,6301	0,9800	0,6837	0,52134	647,83	512,15	
20,00	0,6248	0,9800	0,6778	0,52267	696,90	550,94	

Propulsion

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Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	0,5357	0,1173	0,01666	0,40889	0,1084	1,0412	1,7224	2,61e7	
16,00	0,5716	0,1428	0,02090	0,43708	0,11193	1,113	1,7784	2,62e7	
17,00	0,6075	0,1745	0,02665	0,47281	0,11887	1,204	1,8887	2,63e7	
18,00	0,6434	0,2088	0,03361	0,50444	0,12623	1,2845	2,0056	2,64e7	
+ 19,00 +	0,6793	0,2432	0,04151	0,52713	0,13243	1,3423	2,1042	2,65e7	
19,50	0,6972	0,2613	0,04602	0,5376	0,13578	1,369	2,1574	2,66e7	
20,00	0,7152	0,2811	0,05122	0,54964	0,14001	1,3996	2,2246	2,66e7	

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	9,97	2,86	0,56	32,17	0,454	22,11	2,0	2,0	3122,4
16,00	8,76	2,86	0,55	32,17	0,509	26,91	2,0	2,0	3365,7
17,00	7,76	2,86	0,55	32,17	0,578	32,88	2,0	2,0	3622,3
18,00	6,91	2,86	0,55	32,17	0,652	39,35	2,3	2,3	3877,9
+ 19,00 +	6,20	2,86	0,54	32,17	0,727	45,84	3,9	3,9	4125,3
19,50	5,89	2,86	0,54	32,17	0,766	49,25	5,0	5,0	4248,9
20,00	5,60	2,86	0,54	32,17	0,809	52,98	6,5	6,5	4375,4

Propulsion

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HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.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:		**103,818 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,400]	**7,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,551]	**7917,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,712]	**2427,7 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,937]	**126,5 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,783]	**1462,7 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**12,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**2,250 m**	*Max prop diameter:*		***4800,0 mm***
Bulb nose fwd TR:		**108,930 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,042]	**0,315 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**22,00 deg**	*Device count:*		***0***
Bow shape factor:	[BTK flow]	**-1,0**	*Span:*		***0,000 m***
Stern shape factor:	[WL flow]	**1,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Propulsor data

Propulsor				Propeller options	
Count:		**1**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**B Series**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By thrust**		KTKQ corrections:	**Standard**
Reference prop:				Scale correction:	**Full ITTC**
Blade count:		**6**		KT multiplier:	**1,000**
Expanded area ratio:		**0,7269**	**[Size]**	KQ multiplier:	**1,000**
Propeller diameter:		**4800,0 mm**	**[Size]**	Blade T/C [0.7R]:	**Standard**
Propeller mean pitch:	[P/D 1,0553]	**5065,7 mm**	**[Size]**	Roughness:	**Standard**
Hub immersion:		**5400,0 mm**		Cav breakdown:	**Off**
Engine/gear				**Design condition**	
Engine data:		**Cuaderno_6**		Max prop diam:	**4800,0 mm**
Rated RPM:		**600 RPM**		Design speed:	**19,00 kt**
Rated power:		**7200,0 kW**		Reference power:	**7200,0 kW**
Gear efficiency:		**0,980**		Design point:	**1,000**
Load correction:		**Off**		Reference RPM:	**750,0**
Gear ratio:		**5,859**	**[Size]**	Design point:	**1,000**
Shaft efficiency:		**0,970**			

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

5 jun 2018 09:40
HydroComp NavCad 2014

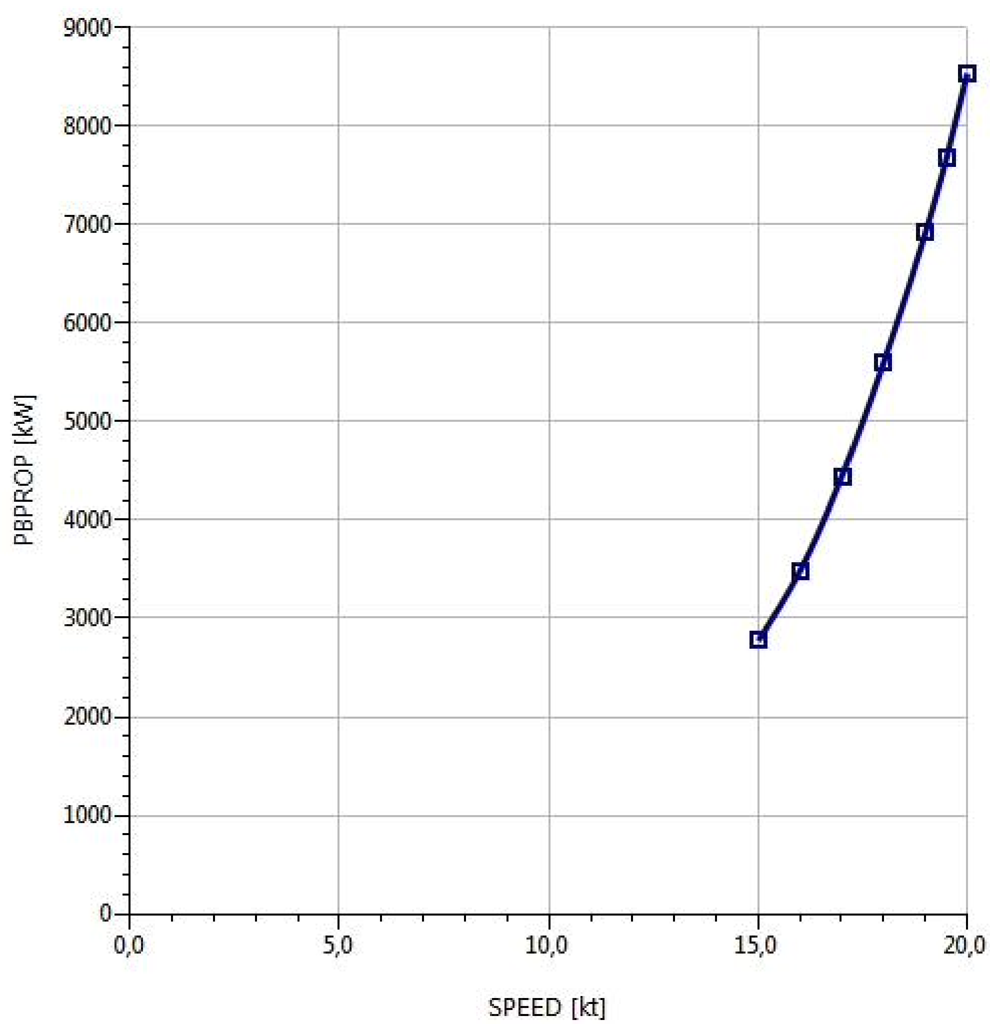
Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction	
Technique:	**[Calc] Prediction**
Prediction:	**Holtrop**
Reference ship:	
Max prop diam:	**4800,0 mm**
Corrections	
Viscous scale corr:	**[Off]**
Rudder location:	
Friction line:	
Hull form factor:	
Corr allowance:	
Roughness [mm]:	
Ducted prop corr:	**[Off]**
Tunnel stern corr:	**[Off]**
Effective diam:	
Recess depth:	

System analysis	
Cavitation criteria:	**Keller eqn**
Analysis type:	**Free run**
CPP method:	**Fixed RPM**
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



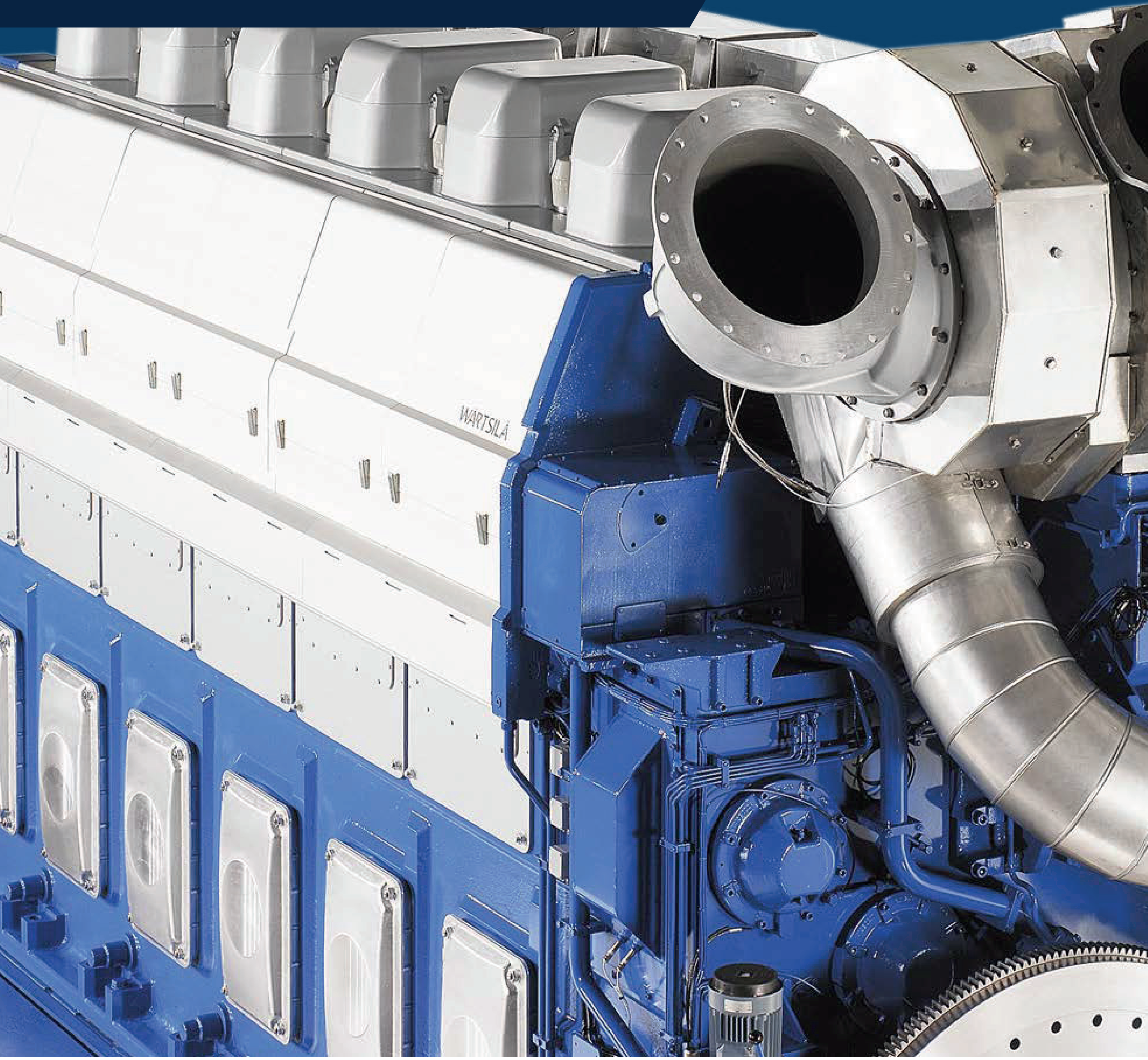
ANEXO V_MOTOR PRINCIPAL (WÄRTSILA 6L46F)

WÄRTSILÄ

WÄRTSILÄ Engines

Wärtsilä 46F

PRODUCT GUIDE



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1. Main Data and Outputs

The Wärtsilä 46F is a 4-stroke, non-reversible, turbocharged and intercooled diesel engine with direct fuel injection (twin pump).

Cylinder bore	460 mm
Stroke	580 mm
Piston displacement	96.4 l/cyl
Number of valves	2 inlet valves and 2 exhaust valves
Cylinder configuration	6, 7, 8 and 9 in-line; 12, 14 and 16 in V-form
Direction of rotation	clockwise, counter-clockwise on request
Speed	600 rpm
Mean piston speed	11.6 m/s

1.1 Maximum continuous output

Table 1-1 Maximum continuos output

Cylinder configuration	IMO Tier 2	
	kW	bhp
W 6L46F	7200	9790
W 7L46F	8400	11420
W 8L46F	9600	13050
W 9L46F	10800	14680
W 12V46F	14400	19580
W 14V46F	16800	22840
W 16V46F	19200	26110

The mean effective pressure P_e can be calculated using the following formula:

$$P_e = \frac{P \times c \times 1.2 \times 10^9}{D^2 \times L \times n \times \pi}$$

where:

P_e = mean effective pressure [bar]

P = output per cylinder [kW]

n = engine speed [r/min]

D = cylinder diameter [mm]

L = length of piston stroke [mm]

c = operating cycle (4)

1.2 Reference conditions

The output is available up to a charge air coolant temperature of max. 38°C and an air temperature of max. 45°C. For higher temperatures, the output has to be reduced according to the formula stated in ISO 3046-1:2002 (E).

The specific fuel oil consumption is stated in the chapter *Technical data*. The stated specific fuel oil consumption applies to engines with engine driven pumps, operating in ambient conditions according to ISO 15550:2002 (E). The ISO standard reference conditions are:

total barometric pressure	100 kPa
air temperature	25°C
relative humidity	30%
charge air coolant temperature	25°C

Correction factors for the fuel oil consumption in other ambient conditions are given in standard ISO 3046-1:2002.

1.3 Operation in inclined position

Max. inclination angles at which the engine will operate satisfactorily.

- Permanent athwart ship inclinations 15°
- Temporary athwart ship inclinations 22.5°
- Permanent fore-and-aft inclinations 10°

1.4 Dimensions and weights

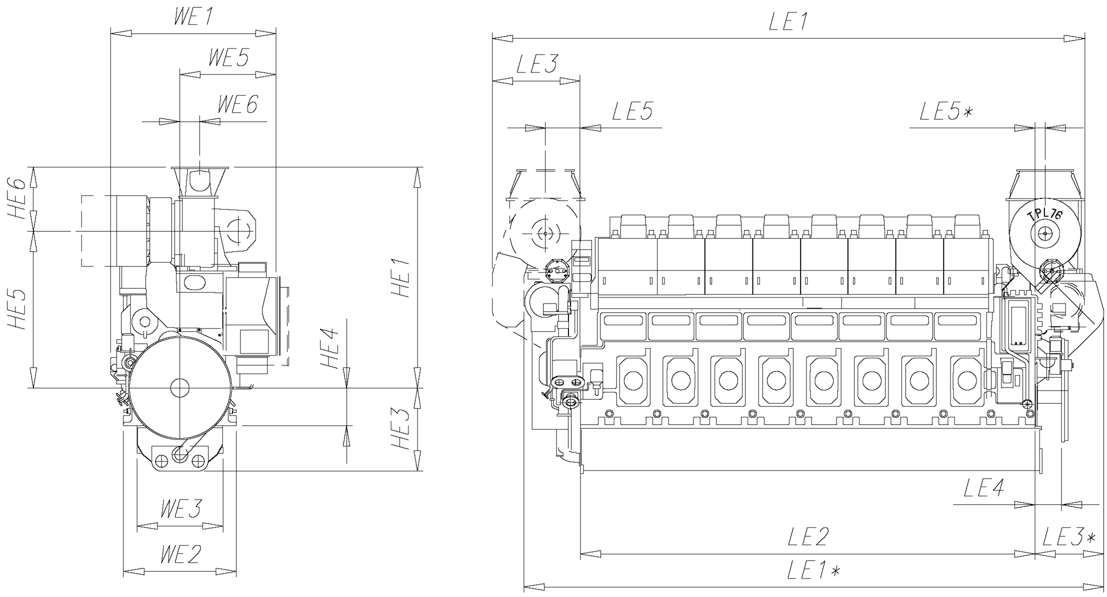


Fig 1-1 In-line engines (DAAE012051c)

Engine	LE1*	LE1	LE2	LE3*	LE3	LE4	LE5*	LE5	HE1	HE3
6L46F	8470	8620	6170	1320	1550	460	180	690	3500	1430
7L46F	9435	9440	6990	1465	1550	460	180	800	3800	1430
8L46F	10255	10260	7810	1465	1550	460	180	800	3800	1430
9L46F	11075	11080	8630	1465	1550	460	180	800	3800	1430

Engine	HE4	HE5	HE6	WE1	WE2	WE3	WE5	WE6	Weight [ton]
6L46F	650	2710	790	2905	1940	1480	1535	385	97
7L46F	650	2700	1100	3130	1940	1480	1760	340	113
8L46F	650	2700	1100	3130	1940	1480	1760	340	124
9L46F	650	2700	1100	3130	1940	1480	1760	340	140

* Turbocharger at flywheel end

All dimensions in mm. The weights are dry weights of rigidly mounted engines without flywheel.

Table 1-2 Additional weights [ton]:

Item	6L46F	7L46F	8L46F	9L46F
Flywheel	1...2	1...2	1...2	1...2
Flexible mounting (without limiters)	3	3	3	3

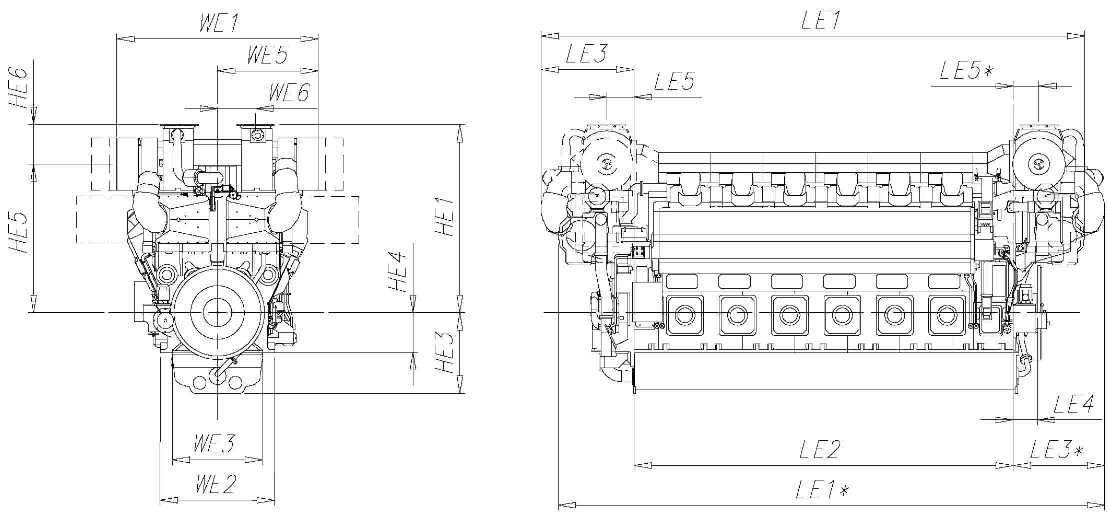


Fig 1-2 V-engines (DAAE075826B)

Engine	LE1*	LE1	LE2	LE3*	LE3	LE4	LE5*	LE5	HE1	HE3
12V46F	10945	10284	7600	1830	1952	460	520	774	3765* / 3770	1620
14V46F	-	11728	8650	-	2347	485	-	872	4234	1620
16V46F	-	12871	9700	-	2347	485	-	872	4234	1620

Engine	HE4	HE5	HE6	WE1	WE2	WE3	WE5	WE6	Weight [ton]
12V46F	800	2975* / 2980	790	4040* / 4026	2290	1820	2825* / 3150	760	177
14V46F	800	3134	1100	4678	2290	1820	3150	892	216
16V46F	800	3134	1100	4678	2290	1820	3150	892	233

* Turbocharger in flywheel end

All dimensions in mm. The weights are dry weights of rigidly mounted engines without flywheel.

Table 1-3 Additional weights [ton]:

Item	12V46F	14V46F	16V46F
Flywheel	1...2	1...2	1...2
Flexible mounting (without limiters)	3	3	3

2. Operating Ranges

2.1 Engine operating range

Below nominal speed the load must be limited according to the diagrams in this chapter in order to maintain engine operating parameters within acceptable limits. Operation in the shaded area is permitted only temporarily during transients. Minimum speed is indicated in the diagram, but project specific limitations may apply.

2.1.1 Controllable pitch propellers

An automatic load control system is required to protect the engine from overload. The load control reduces the propeller pitch automatically, when a pre-programmed load versus speed curve (“engine limit curve”) is exceeded, overriding the combinator curve if necessary. The engine load is derived from fuel rack position and actual engine speed (not speed demand).

The propulsion control must also include automatic limitation of the load increase rate. Maximum loading rates can be found later in this chapter.

The propeller efficiency is highest at design pitch. It is common practice to dimension the propeller so that the specified ship speed is attained with design pitch, nominal engine speed and 85% output in the specified loading condition. The power demand from a possible shaft generator or PTO must be taken into account. The 15% margin is a provision for weather conditions and fouling of hull and propeller. An additional engine margin can be applied for most economical operation of the engine, or to have reserve power.

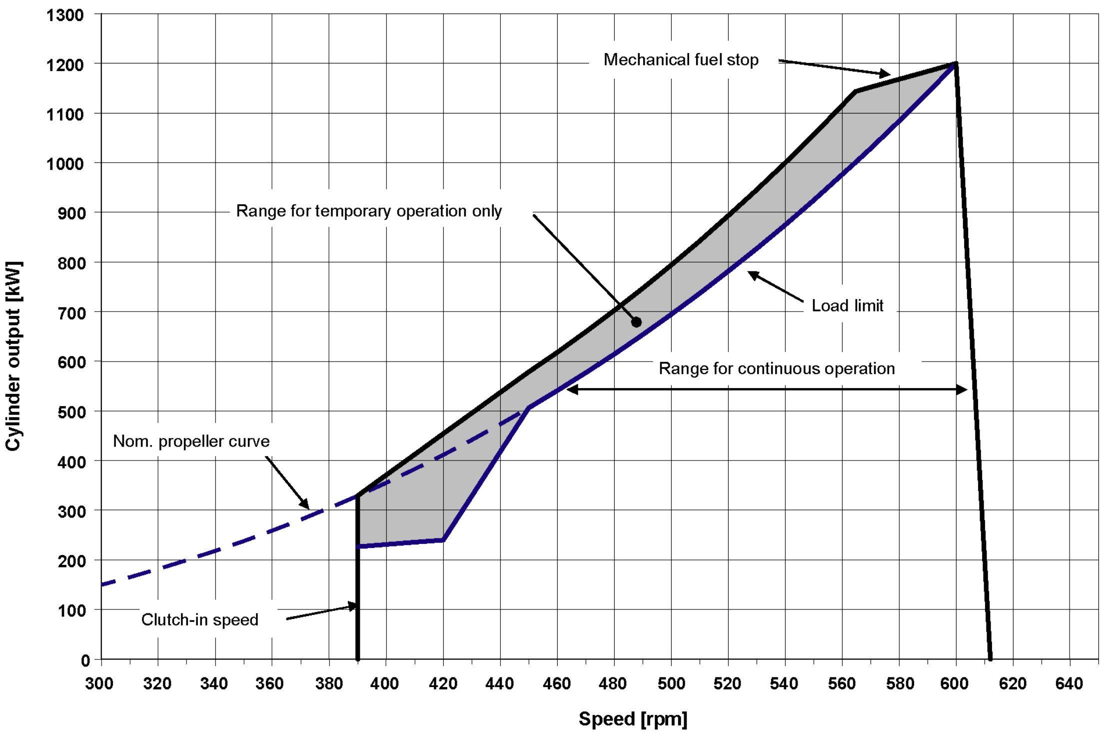


Fig 2-1 Operating field for CP Propeller, IMO Tier 2, 1200 kW/cyl, 600 rpm

2.2 Loading capacity

Controlled load increase is essential for highly supercharged diesel engines, because the turbocharger needs time to accelerate before it can deliver the required amount of air. Sufficient time to achieve even temperature distribution in engine components must also be ensured. This is especially important for larger engines.

If the control system has only one load increase ramp, then the ramp for a preheated engine should be used. The HT-water temperature in a preheated engine must be at least 60 °C, preferably 70 °C, and the lubricating oil temperature must be at least 40 °C.

The ramp for normal loading applies to engines that have reached normal operating temperature.

Emergency loading may only be possible by activating an emergency function, which generates visual and audible alarms in the control room and on the bridge.

The load should always be applied gradually in normal operation. Class rules regarding load acceptance capability of diesel generators should not be interpreted as guidelines on how to apply load in normal operation. The class rules define what the engine must be capable of, if an unexpected event causes a sudden load step.

2.2.1 Mechanical propulsion, controllable pitch propeller (CPP)

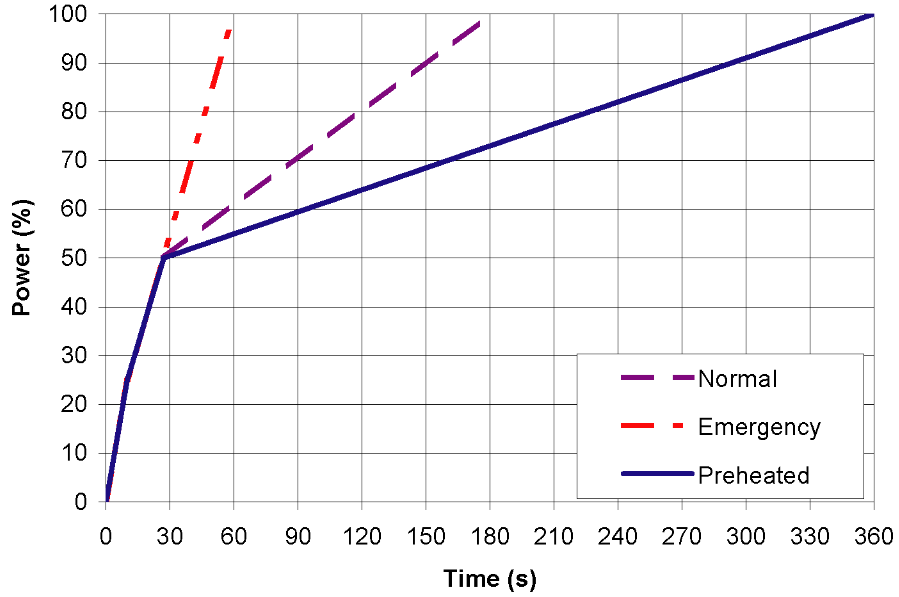


Fig 2-2 Maximum load increase rates for variable speed engines

If minimum smoke during load increase is a major priority, slower loading rate than in the diagram can be necessary below 50% load.

In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. When absolutely necessary, the load can be reduced as fast as the pitch setting system can react (overspeed due to windmilling must be considered for high speed ships).

2.2.2 Diesel electric propulsion

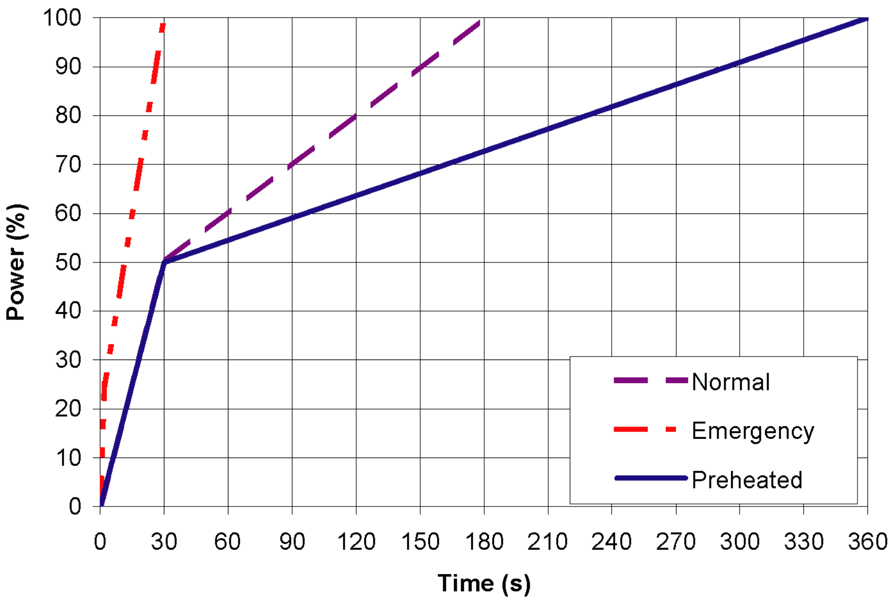


Fig 2-3 Maximum load increase rates for engines operating at nominal speed

In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. In an emergency situation the full load can be thrown off instantly.

The maximum deviation from steady state speed is less than 10%, when applying load according to the emergency loading ramp. Load increase according to the normal ramp correspondingly results in less than 3% speed deviation.

2.2.2.1 Maximum instant load steps

The electrical system must be designed so that tripping of breakers can be safely handled. This requires that the engines are protected from load steps exceeding their maximum load acceptance capability. The maximum permissible load step for an engine that has attained normal operating temperature is 33% MCR. The resulting speed drop is less than 10% and the recovery time to within 1% of the steady state speed at the new load level is max. 5 seconds.

When electrical power is restored after a black-out, consumers are reconnected in groups, which may cause significant load steps. The engine must be allowed to recover for at least 10 seconds before applying the following load step, if the load is applied in maximum steps.

2.2.2.2 Start-up time

A diesel generator typically reaches nominal speed in about 25 seconds after the start signal. The acceleration is limited by the speed control to minimise smoke during start-up.

2.3 Operation at low load and idling

The engine can be started, stopped and operated on heavy fuel under all operating conditions. Continuous operation on heavy fuel is preferred rather than changing over to diesel fuel at low load operation and manoeuvring. The following recommendations apply:

Absolute idling (declutched main engine, disconnected generator)

- Maximum 10 minutes if the engine is to be stopped after the idling. 3 minutes idling before stop is recommended.

- Maximum 6 hours if the engine is to be loaded after the idling.

Operation below 20 % load

- Maximum 100 hours continuous operation. At intervals of 100 operating hours the engine must be loaded to minimum 70 % of the rated output.

Operation above 20 % load

- No restrictions.

2.4 Low air temperature

In cold conditions the following minimum inlet air temperatures apply:

- Starting + 5°C
- Idling - 5°C
- High load - 10°C

The two-stage charge air cooler is useful for heating of the charge air during prolonged low load operation in cold conditions. Sustained operation between 0 and 40% load can however require special provisions in cold conditions to prevent too low HT-water temperature. If necessary, the preheating arrangement can be designed to heat the running engine (capacity to be checked).

For further guidelines, see chapter *Combustion air system design*.

3. Technical Data

3.1 Introduction

This chapter contains technical data of the engine (heat balance, flows, pressures etc.) for design of auxiliary systems. Further design criteria for external equipment and system layouts are presented in the respective chapter.

3.1.1 Engine driven pumps

The fuel consumption stated in the technical data tables is with engine driven pumps. The increase in fuel consumption with engine driven pumps is given in the table below; correction in g/kWh.

Table 3-1 Constant speed engines

Application	Engine driven pumps	Engine load [%]			
		100	85	75	50
Inline	Lube oil	-1.1	-1.3	-1.5	-2.4
	LT Water	-0.3	-0.4	-0.4	-0.7
	HT Water	-0.3	-0.4	-0.4	-0.7
V-engine	Lube oil	-1.0	-1.0	-1.2	-1.6
	LT Water	-0.3	-0.3	-0.3	-0.3
	HT Water	-0.3	-0.3	-0.3	-0.3

Table 3-2 Variable speed engines

Application	Engine driven pumps	Engine load [%]			
		100	85	75	50
Inline	Lube oil	-1.2	-1.3	-1.4	-1.9
	LT Water	-0.3	-0.3	-0.3	-0.3
	HT Water	-0.3	-0.3	-0.3	-0.3
V-engine	Lube oil	-1.0	-1.0	-1.2	-1.6
	LT Water	-0.3	-0.3	-0.3	-0.3
	HT Water	-0.3	-0.3	-0.3	-0.3

3.2 Wärtsilä 6L46F

Wärtsilä 6L46F		ME	DE
Cylinder output	**kW**	**1200**	**1200**
Engine speed	**rpm**	**600**	**600**
Engine output	kW	7200	7200
Mean effective pressure	MPa	2.49	2.49
Combustion air system (Note 1)			
Flow at 100% load	kg/s	12.4	12.4
Temperature at turbocharger intake, max. (TE 600)	°C	45	45
Temperature after air cooler, nom. (TE 601)	°C	50	50
Exhaust gas system (Note 2)			
Flow at 100% load	kg/s	13.08	13.08
Flow at 85% load	kg/s	11.4	11.7
Flow at 75% load	kg/s	10.8	11.7
Flow at 50% load	kg/s	7.44	9.42
Temp. after turbo, 100% load (TE 517)	°C	368	368
Temp. after turbo, 85% load (TE 517)	°C	322	318
Temp. after turbo, 75% load (TE 517)	°C	323	310
Temp. after turbo, 50% load (TE 517)	°C	327	275
Backpressure, max.	kPa	3	3
Calculated pipe diameter for 35 m/s	mm	927	927
Heat balance at 100% load (Note 3)			
Jacket water, HT-circuit	kW	846	846
Charge air, HT-circuit	kW	1488	1488
Charge air, LT-circuit	kW	762	762
Lubricating oil, LT-circuit	kW	756	756
Radiation	kW	210	210
Fuel system (Note 4)			
Pressure before injection pumps, nom. (PT 101)	kPa	0 ± 40	0 ± 40
Flow to engine, approx.	m^3/h	5.7	5.7
HFO viscosity before engine	cSt	16...24	16...24
Max. HFO temperature before engine (TE 101)	°C	140	140
MDF viscosity, min.	cSt	2.0	2.0
Max. MDF temperature before engine (TE 101)	°C	45	45
Leak fuel quantity (HFO), clean fuel at 100% load	kg/h	4.5	4.5
Leak fuel quantity (MDF), clean fuel at 100% load	kg/h	22.5	22.5
Fuel consumption at 100% load	g/kWh	179.6	179.6
Fuel consumption at 85% load	g/kWh	173.4	174.7
Fuel consumption at 75% load	g/kWh	177.9	183.6
Fuel consumption at 50% load	g/kWh	181.0	191.5
Lubricating oil system			
Pressure before bearings, nom. (PT 201)	kPa	500	500
Pressure after pump, max.	kPa	800	800

Wärtsilä 6L46F		ME	DE
Cylinder output	**kW**	**1200**	**1200**
Engine speed	**rpm**	**600**	**600**
Suction ability main pump, including pipe loss, max.	kPa	40	40
Priming pressure, nom. (PT 201)	kPa	80	80
Temperature before bearings, nom. (TE 201)	°C	56	56
Temperature after engine, approx.	°C	75	75
Pump capacity (main), engine driven	m^3/h	191	175
Pump capacity (main), electrically driven	m^3/h	191	158
Oil flow through engine	m^3/h	130	130
Priming pump capacity	m^3/h	35	35
Oil tank volume in separate system, min	m^3	13.0	13.0
Oil consumption at 100% load, approx.	g/kWh	0.7	0.7
Crankcase ventilation flow rate at full load	l/min	1350	1350
Crankcase ventilation backpressure, max.	kPa	0.4	0.4
Oil volume in turning device	l	9.5	9.5
Oil volume in speed governor	l	1.7	1.7
High temperature cooling water system			
Pressure at engine, after pump, nom. (PT 401)	kPa	250 + static	250 + static
Pressure at engine, after pump, max. (PT 401)	kPa	530	530
Temperature before cylinders, approx. (TE 401)	°C	74	74
Temperature after charge air cooler, nom.	°C	91...95	91...95
Capacity of engine driven pump, nom.	m^3/h	115	115
Pressure drop over engine, total	kPa	150	150
Pressure drop in external system, max.	kPa	100	100
Pressure from expansion tank	kPa	70...150	70...150
Water volume in engine	m^3	1.0	1.0
Low temperature cooling water system			
Pressure at engine, after pump, nom. (PT 451)	kPa	250 + static	250 + static
Pressure at engine, after pump, max. (PT 451)	kPa	530	530
Temperature before engine, max. (TE 451)	°C	38	38
Temperature before engine, min. (TE 451)	°C	25	25
Capacity of engine driven pump, nom.	m^3/h	115	115
Pressure drop over charge air cooler	kPa	50	50
Pressure drop over built-on lube oil cooler	kPa	20	20
Pressure drop over built-on temp. control valve	kPa	30	30
Pressure drop in external system, max.	kPa	150	150
Pressure from expansion tank	kPa	70 ... 150	70 ... 150
Water volume in engine	m^3	0.3	0.3
Starting air system (Note 5)			
Pressure, nom. (PT 301)	kPa	3000	3000
Pressure at engine during start, min. (20°C)	kPa	1500	1500
Pressure, max. (PT 301)	kPa	3000	3000
Low pressure limit in air vessels	kPa	1800	1800
Consumption per start at 20°C (successful start)	Nm^3	6.0	6.0
Consumption per start at 20°C, (with slowturn)	Nm^3	7.0	7.0

Notes:

Note 1	At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.
Note 2	At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 15°C.
Note 3	At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance for cooling water heat 10%, tolerance for radiation heat 30%. Fouling factors and a margin to be taken into account when dimensioning heat exchangers.
Note 4	According to ISO 15550, lower calorific value 42700 kJ/kg, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%. The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.
Note 5	At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

DE = Engine driving generator

Subject to revision without notice.

4. Description of the Engine

4.1 Definitions

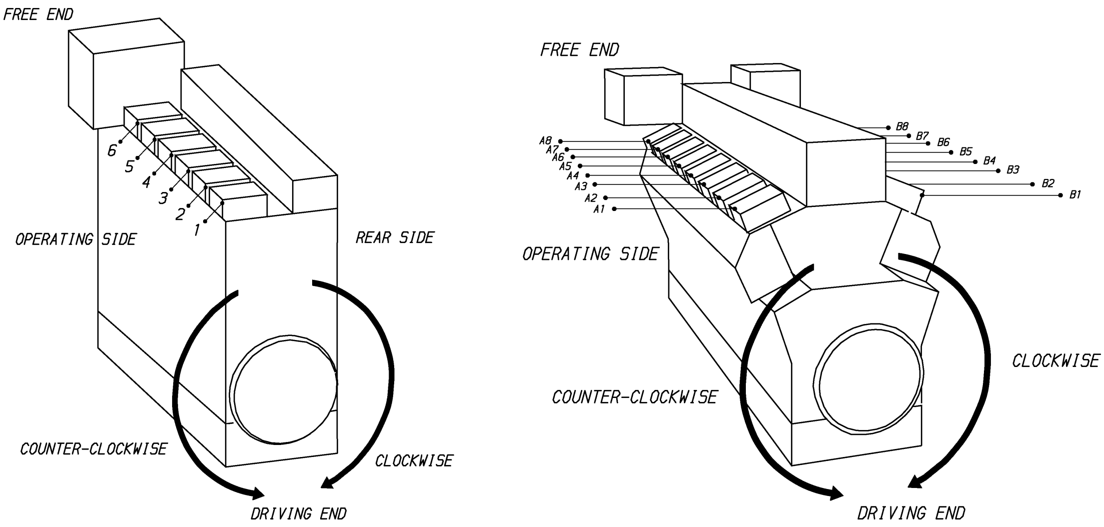


Fig 4-1 In-line engine and V-engine definitions (1V93C0029 / 1V93C0028)

4.2 Main components and systems

Main dimensions and weights are presented in the chapter *Main Data and Outputs*.

4.2.1 Engine block

The engine block is made of nodular cast iron and it is cast in one piece.

The block has a stiff and durable design, which makes it suitable for resilient mounting without intermediate foundations.

The engine has an underslung crankshaft supported by main bearing caps made of nodular cast iron. The bearing caps are guided sideways by the engine block, both at the top and at the bottom. Hydraulically tensioned bearing cap screws and horizontal side screws secure the main bearing caps.

At the driving end there is a combined thrust bearing and radial bearing for the camshaft drive and flywheel. The bearing housing of the intermediate gear is integrated in the engine block.

The cooling water is distributed around the cylinder liners with water distribution rings at the lower end of the cylinder collar. There is no wet space in the engine block around the cylinder liner, which eliminates the risk of water leakage into the crankcase.

4.2.2 Crankshaft

Low bearing loads, robust design and a crank gear capable of high cylinder pressures were set out to be the main design criteria for the crankshaft. The moderate bore to stroke ratio is a key element to achieve high rigidity.

The crankshaft line is built up from three-pieces: crankshaft, gear and end piece. The crankshaft itself is forged in one piece. Each crankthrow is individually fully balanced for safe bearing function. Clean steel technology minimizes the amount of slag forming elements and guarantees superior material properties.

All crankshafts can be equipped with a torsional vibration damper at the free end of the engine, if required by the application. Full output is available also from the free end of the engine through a power-take-off (PTO).

The main bearing and crankpin bearing temperatures are continuously monitored.

4.2.3 Connecting rod

The connecting rods are of three-piece design, which makes it possible to pull a piston without opening the big end bearing. Extensive research and development has been made to develop a connecting rod in which the combustion forces are distributed to a maximum area of the big end bearing.

The connecting rod of alloy steel is forged and has a fully machined shank. The lower end is split horizontally to allow removal of piston and connecting rod through the cylinder liner. All connecting rod bolts are hydraulically tightened. The gudgeon pin bearing is solid aluminium bronze.

Oil is led to the gudgeon pin bearing and piston through a bore in the connecting rod.

4.2.4 Main bearings and big end bearings

The main bearings and the big end bearings have steel backs and thin layers for good resistance against fatigue and corrosion. Both tri-metal and bi-metal bearings are used.

4.2.5 Cylinder liner

The centrifugally cast cylinder liner has a high and rigid collar preventing deformations due to the cylinder pressure and pretension forces. A distortion-free liner bore in combination with wear resistant materials and good lubrication provide optimum running conditions for the piston and piston rings. The liner material is a special grey cast iron alloy developed for excellent wear resistance and high strength.

Accurate temperature control is achieved with precisely positioned longitudinal cooling water bores.

An anti-polishing ring removes deposits from piston top land, which eliminates increased lubricating oil consumption due to bore polishing and liner wear.

4.2.6 Piston

The piston is of two-piece design with nodular cast iron skirt and steel crown. Wärtsilä patented skirt lubrication minimizes frictional losses and ensure appropriate lubrication of both the piston skirt and piston rings under all operating conditions.

4.2.7 Piston rings

The piston ring set consists of two compression rings and one spring-loaded conformable oil scraper ring. All piston rings have a wear resistant coating.Two compression rings and one oil scraper ring in combination with pressure lubricated piston skirt give low friction and high seizure resistance. Both compression ring grooves are hardened for good wear resistance.

4.2.8 Cylinder head

A rigid box/cone-like design ensures even circumferential contact pressure and permits high cylinder pressure. Only four hydraulically tightened cylinder head studs simplify the maintenance and leaves more room for optimisation of the inlet and outlet port flow characteristics.

The exhaust valve seats are water cooled. Closed seat rings without water pocket between the seat and the cylinder head ensure long lifetime for valves and seats. Both inlet and exhaust valves are equipped with valve rotators.

4.2.9 Camshaft and valve mechanism

The camshaft is built of forged pieces with integrated cams, one section per cylinder. The camshaft sections are connected through separate bearing journals, which makes it possible to remove single camshaft sections sideways. The bearing housings are integrated in the engine block casting and thus completely closed.

4.2.10 Camshaft drive

The camshaft is driven by the crankshaft through a gear train. The gear wheel on the crankshaft is clamped between the crankshaft and the end piece with expansion bolts.

4.2.11 Fuel injection equipment

The low pressure fuel lines consist of drilled channels in cast parts that are firmly clamped to the engine block. The entire fuel system is enclosed in a fully covered compartment for maximum safety. All leakages from injection valves, pumps and pipes are collected in a closed system. The pumps are completely sealed off from the camshaft compartment and provided with drain for leakage oil.

The injection nozzles are cooled by lubricating oil.

Wärtsilä 46F engines are equipped with twin plunger pumps that enable control of the injection timing. In addition to the timing control, the twin plunger solution also combines high mechanical strength with cost efficient design.

One plunger controls the start of injection, i.e. the timing, while the other plunger controls when the injection ends, thus the quantity of injected fuel. Timing is controlled according to engine revolution speed and load level (also other options), while the quantity is controlled as normally by the speed control.

4.2.12 Lubricating oil system

The engine is equipped with a dry oil sump.

In the standard configuration the engine is also equipped with an engine driven lubricating oil pump, located in free end, and a lubricating oil module located in the opposite end to the turbocharger. The lubricating oil module consists of an oil cooler with temperature control valves and an automatic filter. A centrifugal filter on the engine serves as an indication filter.

The pre-lubricating oil pump is to be installed in the external system.

4.2.13 Cooling water system

The fresh water cooling system is divided into a high temperature (HT) and a low temperature (LT) circuit. The HT-water cools cylinder liners, cylinder heads and the first stage of the charge air cooler. The LT-water cools the second stage of the charge air cooler and the lubricating oil.

In the most complete configuration the HT and LT cooling water pumps are both engine driven, and the electrically actuated temperature control valves are built on the engine. When desired, it is however possible to configure the engine without engine driven LT-pump, or even without both cooling water pumps.

The temperature control valves are equipped with a hand wheel for emergency operation.

4.2.14 Turbocharging and charge air cooling

The SPEX (Single Pipe Exhaust) turbocharging system is designed to combine the good part load performance of a pulse charging system with the simplicity and good high load efficiency of a constant pressure system. In order to further enhance part load performance and prevent excessive charge air pressure at high load, all engines are equipped with a wastegate on the exhaust side. The wastegate arrangement permits a part of the exhaust gas to bypass the turbine in the turbocharger at high engine load.

Variable speed engines are additionally equipped with a by-pass valve to increase the flow through the turbocharger at low engine speed and low engine load. Part of the charge air is conducted directly into the exhaust gas manifold (without passing through the engine), which increases the speed of the turbocharger. The net effect is increased charge air pressure at low engine speed and low engine load, despite the apparent waste of air.

All engines are provided with devices for water cleaning of the turbine and the compressor. The cleaning is performed during operation of the engine.

The engines have a transversely installed turbocharger. The turbocharger can be located at either end of the engine and the exhaust gas outlet can be vertical, or inclined 45 degrees in the longitudinal direction of the engine.

A two-stage charge air cooler is standard. Heat is absorbed with high temperature (HT) cooling water in the first stage, while low temperature (LT) cooling water is used for the final air cooling in the second stage. The engine has two separate cooling water circuits. The flow of LT cooling water through the charge air cooler is controlled to maintain a constant charge air temperature.

4.2.15 Automation system

Wärtsilä 46F is equipped with a modular embedded automation system, Wärtsilä Unified Controls - UNIC.

The system version UNIC C2 has a hardwired interface for control functions and a bus communication interface for alarm and monitoring.

An engine safety module and a local control panel mounted on the engine. The engine safety module handles fundamental safety, for example overspeed and low lubricating oil pressure shutdown. The safety module also performs fault detection on critical signals and alerts the alarm system about detected failures. The local control panel has push buttons for local start/stop and shutdown reset, as well as a display showing the most important operating parameters. Speed control is included in the automation system on the engine.

All necessary engine control functions are handled by the equipment on the engine, bus communication to external systems and a more comprehensive local display unit.

Conventional heavy duty cables are used on the engine and the number of connectors are minimized. Power supply, bus communication and safety-critical functions are doubled on the engine. All cables to/from external systems are connected to terminals in the main cabinet on the engine.

4.2.16 Variable Inlet valve Closure, optional

Variable Inlet valve Closure (VIC), which is available as an option, offers flexibility to apply early inlet valve closure at high load for lowest NOx levels, while good part-load performance is ensured by adjusting the advance to zero at low load. The inlet valve closure can be adjusted up to 30° crank angle.

4.3 Cross section of the engine

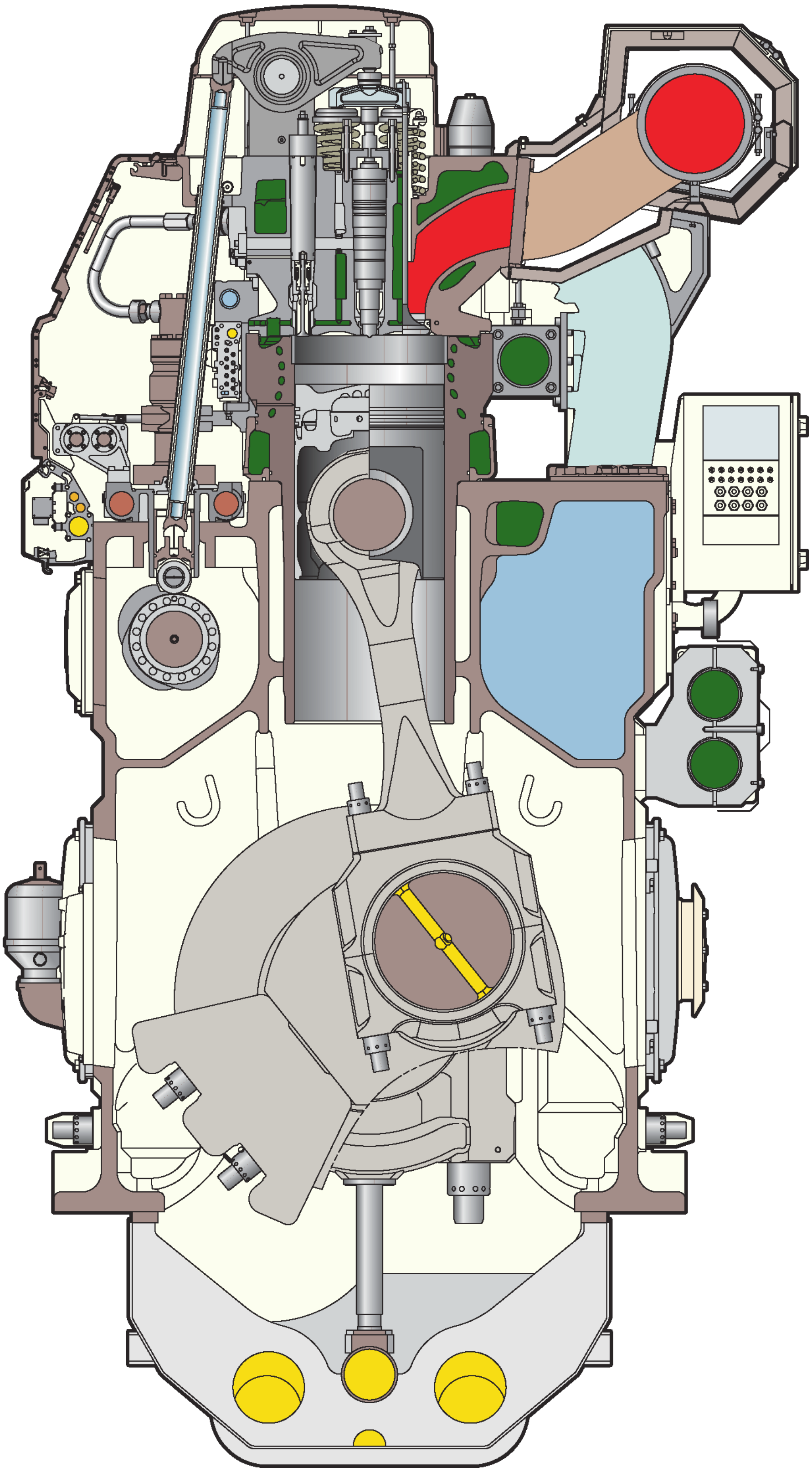


Fig 4-2 Cross section of the in-line engine

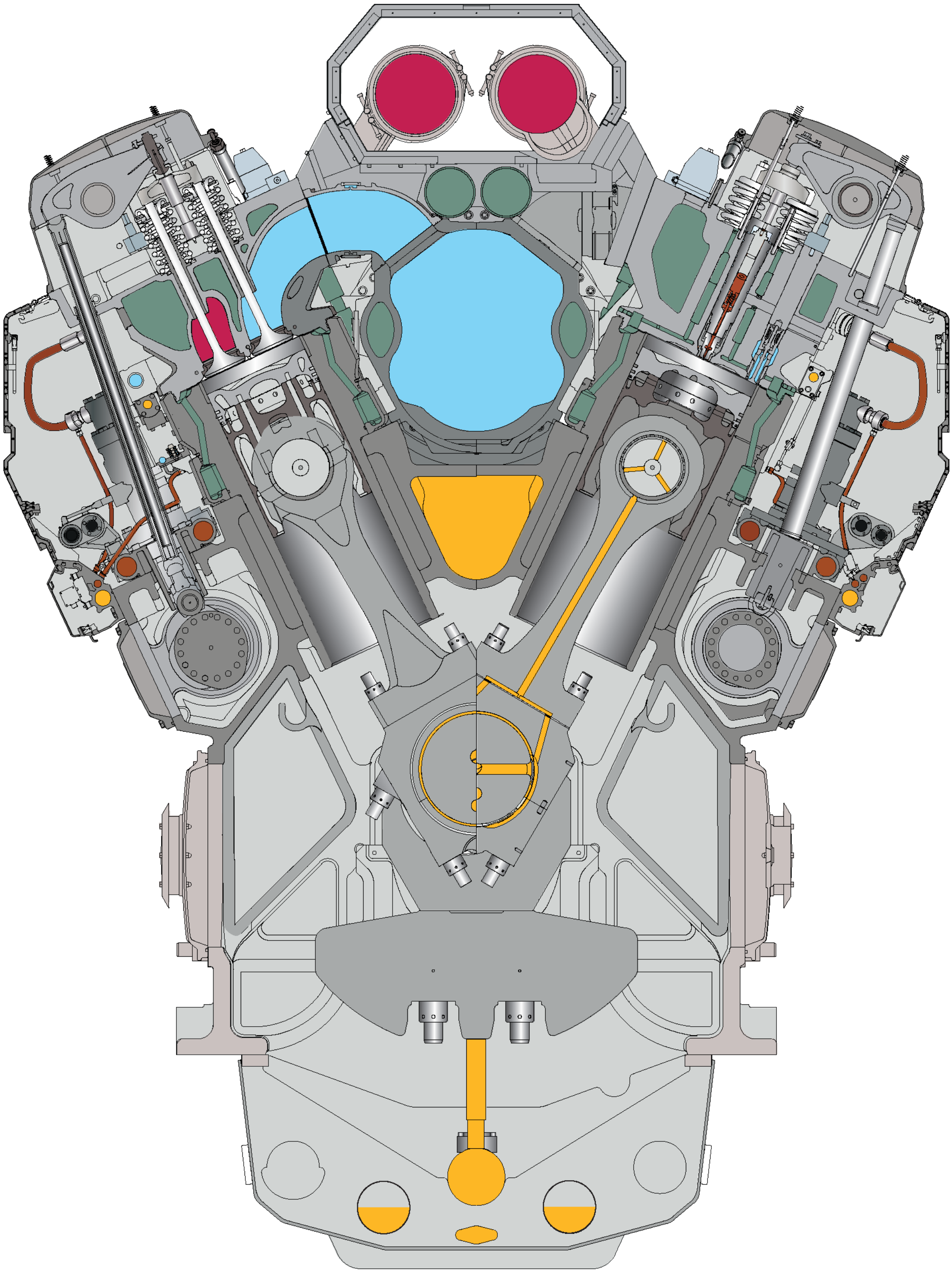


Fig 4-3 **Cross section of the V-engine**

4.4 Overhaul intervals and expected life times

The following overhaul intervals and lifetimes are for guidance only. Achievable lifetimes depend on operating conditions, average loading of the engine, fuel quality used, fuel handling system, performance of maintenance etc.

Table 4-1 Time between inspection or overhaul and expected lifetime [h] (DAAE009253B)

Component	Maintenance interval (h)	Expected lifetime (h)
Twin pump fuel injection		
- Injection nozzle	6 000	6 000
- Injection pump element	12 000	24 000
Cylinder head	12 000	60 000
- Inlet valve seat	-	36 000
- Inlet valve, guide and rotator	-	24 000
- Exhaust valve seat	-	36 000
- Exhaust valve, guide and rotator	-	24 000
Piston crown, including one reconditioning	-	48 000
Piston skirt	-	60 000
- Piston skirt/crown dismantling one	12 000	-
- Piston skirt/crown dismantling all	24 000	-
Piston rings	12 000	12 000
Cylinder liner	12 000	60 000
Anti-polishing ring	-	12 000
Gudgeon pin (inspection)	12 000	60 000
Gudgeon pin bearing (inspection)	12 000	36 000
Big end bearing	-	36 000
- Big end bearing, inspection of one	12 000	-
- Big end bearing, replacement of all	36 000	-
Main bearing	-	36 000
- Main bearing, inspection of one	18 000	-
- Main bearing, replacement of all	36 000	-
Camshaft bearing	-	60 000
- Camshaft bearing, inspection of one	36 000	-
- Camshaft bearing, replacement of all	60 000	-
Turbocharger, inspection and cleaning	12 000	-
Charger air cooler	6 000	36 000
Resilient mounting, rubber element	-	60 000

4.5 Engine storage

At delivery the engine is provided with VCI coating and a tarpaulin. For storage longer than 3 months please contact Wärtsilä Finland Oy.

ANEXO VI_PROPULSIÓN BY POWER 4, 5 Y 6 PALAS

Propulsion

5 jun 2018 09:53
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0098	600	2922,4	---	40,6	
16,00	2303,1	0,2889	0,2094	1,0098	600	3610,6	---	50,1	
17,00	2990,0	0,2887	0,2094	1,0098	600	4568,4	---	63,5	
18,00	3788,8	0,2885	0,2094	1,0098	600	5748,2	---	79,8	
+ 19,00 +	4658,9	0,2884	0,2094	1,0098	600	7092,6	---	98,5	
19,50	5137,7	0,2883	0,2094	1,0098	600	7860,0	---	109,2	
20,00	5668,5	0,2882	0,2094	1,0098	600	8738,1	---	121,4	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	149	179,84	44,65	2778,1	2864,0	2864,0	2922,4	205,0	2856,3
16,00	149	222,18	55,16	3432,2	3538,3	3538,3	3610,6	177,0	3171,7
17,00	149	281,13	69,80	4342,8	4477,1	4477,1	4568,4	148,6	3529,6
18,00	149	353,73	87,82	5464,2	5633,2	5633,2	5748,2	125,1	3905,4
+ 19,00 +	149	436,45	108,36	6742,2	6950,7	6950,7	7092,6	107,0	4283,2
19,50	149	483,68	120,08	7471,7	7702,8	7702,8	7860,0	99,1	4479,6
20,00	149	537,72	133,50	8306,5	8563,4	8563,4	8738,1	91,4	4689,1

	EFFICIENCY				THRUST		
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]	
15,00	0,5687	0,9800	0,6195	0,41031	290,83	229,92	
16,00	0,5977	0,9800	0,6509	0,44587	353,93	279,81	
17,00	0,6134	0,9800	0,6679	0,47595	432,47	341,89	
18,00	0,6179	0,9800	0,6726	0,49523	517,56	409,16	
+ 19,00 +	0,6160	0,9800	0,6703	0,50463	602,91	476,64	
19,50	0,6130	0,9800	0,6670	0,50719	647,83	512,15	
20,00	0,6085	0,9800	0,6619	0,50901	696,90	550,94	

Propulsion

5 jun 2018 09:53
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	0,4603	0,0866	0,01116	0,40889	0,11444	1,0412	1,8132	3,93e7	
16,00	0,4911	0,1054	0,01379	0,43708	0,11639	1,113	1,8441	3,94e7	
17,00	0,5220	0,1288	0,01745	0,47281	0,12267	1,204	1,9436	3,95e7	
18,00	0,5528	0,1542	0,02195	0,50444	0,12992	1,2845	2,0585	3,96e7	
+ 19,00 +	0,5837	0,1796	0,02708	0,52713	0,1362	1,3423	2,158	3,97e7	
19,50	0,5991	0,1930	0,03002	0,5376	0,13957	1,369	2,2114	3,98e7	
20,00	0,6146	0,2076	0,03337	0,54964	0,14377	1,3996	2,2779	3,99e7	

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	9,97	2,11	0,42	37,44	0,405	25,50	2,0	2,0	2683,0
16,00	8,76	2,11	0,42	37,44	0,449	31,03	2,0	2,0	2892,1
17,00	7,76	2,11	0,41	37,44	0,505	37,92	2,0	2,0	3112,5
18,00	6,91	2,11	0,41	37,44	0,565	45,38	2,4	2,4	3332,2
+ 19,00 +	6,20	2,11	0,41	37,44	0,625	52,86	4,0	4,0	3544,8
19,50	5,89	2,11	0,41	37,44	0,657	56,80	5,1	5,1	3651,0
20,00	5,60	2,11	0,41	37,44	0,691	61,10	6,5	6,5	3759,7

Propulsion

5 jun 2018 09:53
HydroComp NavCad 2014

Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Single/hard**
Length on WL:		**103,818 m**
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**
Max molded draft:	[BWL/T 2,400]	**7,500 m**
Displacement:	[CB 0,551]	**7917,00 t**
Wetted surface:	[CS 2,712]	**2427,7 m2**
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**
Max section area:	[CX 0,937]	**126,5 m2**
Waterplane area:	[CWP 0,783]	**1462,7 m2**
Bulb section area:		**12,9 m2**
Bulb ctr below WL:		**2,250 m**
Bulb nose fwd TR:		**108,930 m**
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**
Transom immersion:	[TTR/T 0,042]	**0,315 m**
Half entrance angle:		**22,00 deg**
Bow shape factor:	[BTK flow]	**-1,0**
Stern shape factor:	[WL flow]	**1,0**

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***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Fwd station (fwd TR):		***0,000 m***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Propulsor type:		***Propeller***
Max prop diameter:		***4800,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***
Transom lift device:		***Flap***
Device count:		***0***
Span:		***0,000 m***
Chord length:		***0,000 m***
Deflection angle:		***0,00 deg***
Tow point fwd TR:		***0,000 m***
Tow point below WL:		***0,000 m***

Propulsor data

Propulsor			
Count:		**1**	
Propulsor type:		**Propeller series**	
Propeller type:		**CPP**	
Propeller series:		**B Series**	
Propeller sizing:		**By power**	
Reference prop:			
Blade count:		**4**	
Expanded area ratio:		**0,6303**	**[Size]**
Propeller diameter:		**4800,0 mm**	**[Size]**
Propeller mean pitch:	[P/D 0,8969]	**4305,0 mm**	**[Size]**
Hub immersion:		**5400,0 mm**	
Engine/gear			
Engine data:		**Cuaderno_6**	
Rated RPM:		**600 RPM**	
Rated power:		**7200,0 kW**	
Gear efficiency:		**0,980**	
Load correction:		**Off**	
Gear ratio:		**4,028**	**[Size]**
Shaft efficiency:		**0,970**	

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:	**1,000**
KQ multiplier:	**1,000**
Blade T/C [0.7R]:	**Standard**
Roughness:	**Standard**
Cav breakdown:	**Off**
Design condition	
Max prop diam:	**4800,0 mm**
Design speed:	**19,00 kt**
Reference power:	**7200,0 kW**
Design point:	**1,000**
Reference RPM:	**600,0**
Design point:	**1,000**

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

5 jun 2018 09:54
HydroComp NavCad 2014

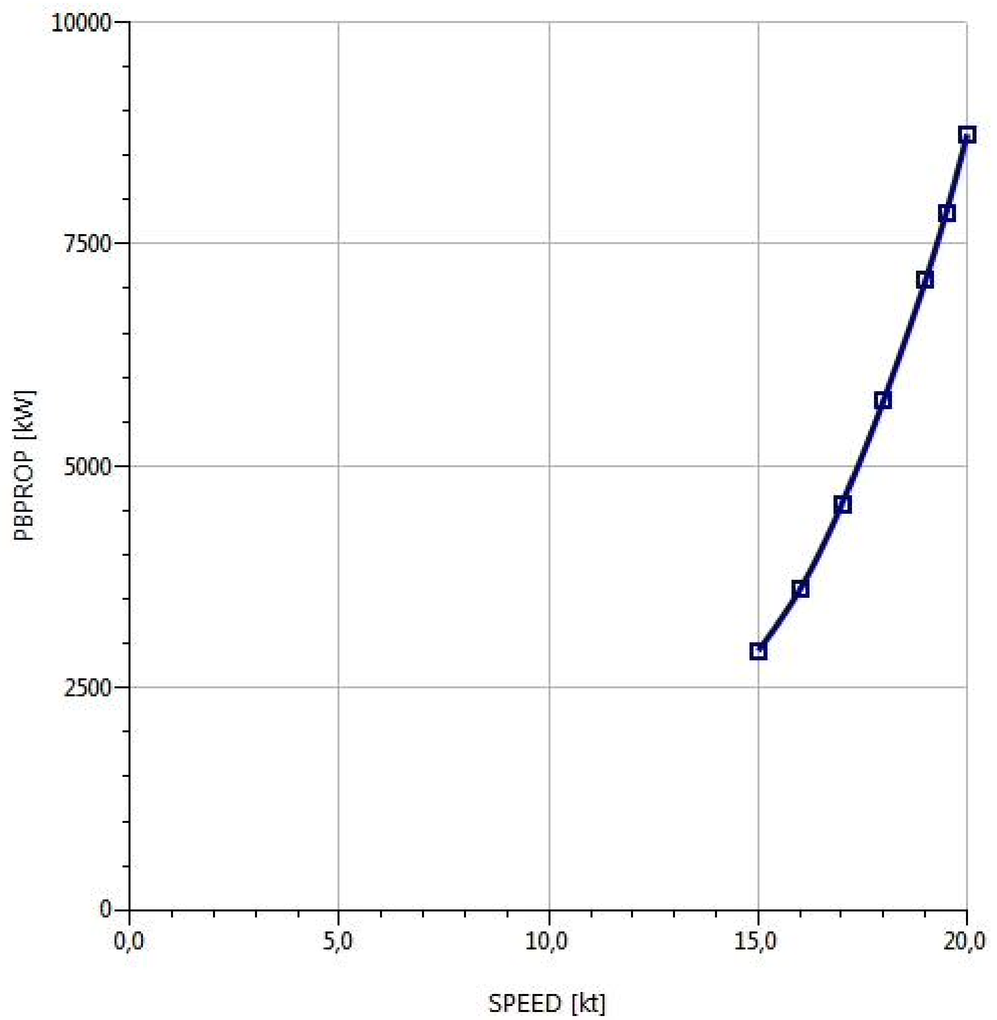
Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction	
Technique:	[Calc] Prediction
Prediction:	Holtrop
Reference ship:	
Max prop diam:	4800,0 mm
Corrections	
Viscous scale corr:	[Off]
Rudder location:	
Friction line:	
Hull form factor:	
Corr allowance:	
Roughness [mm]:	
Ducted prop corr:	[Off]
Tunnel stern corr:	[Off]
Effective diam:	
Recess depth:	

System analysis	
Cavitation criteria:	Keller eqn
Analysis type:	Free run
CPP method:	Fixed RPM
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



Propulsion

5 jun 2018 10:00
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0097	600	2860,0	---	39,7	
16,00	2303,1	0,2889	0,2094	1,0097	600	3558,3	---	49,4	
17,00	2990,0	0,2887	0,2094	1,0097	600	4517,0	---	62,7	
18,00	3788,8	0,2885	0,2094	1,0097	600	5687,2	---	79,0	
+ 19,00 +	4658,9	0,2884	0,2094	1,0097	600	7014,4	---	97,4	
19,50	5137,7	0,2883	0,2094	1,0097	600	7771,2	---	107,9	
20,00	5668,5	0,2882	0,2094	1,0097	600	8637,6	---	120,0	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	139	189,10	43,69	2718,7	2802,8	2802,8	2860,0	209,5	3092,6
16,00	139	235,28	54,36	3382,5	3487,1	3487,1	3558,3	179,6	3429,2
17,00	139	298,67	69,00	4293,8	4426,6	4426,6	4517,0	150,3	3812,0
18,00	139	376,04	86,88	5406,3	5573,5	5573,5	5687,2	126,4	4215,4
+ 19,00 +	139	463,80	107,15	6667,9	6874,2	6874,2	7014,4	108,2	4622,5
19,50	139	513,84	118,71	7387,3	7615,8	7615,8	7771,2	100,2	4834,8
20,00	139	571,13	131,95	8210,9	8464,8	8464,8	8637,6	92,5	5061,8

	EFFICIENCY				THRUST	
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]
15,00	0,5811	0,9800	0,6330	0,41932	290,83	229,92
16,00	0,6065	0,9800	0,6605	0,45247	353,93	279,81
17,00	0,6205	0,9800	0,6755	0,48143	432,47	341,89
18,00	0,6246	0,9800	0,6798	0,5006	517,56	409,16
+ 19,00 +	0,6229	0,9800	0,6777	0,51031	602,91	476,64
19,50	0,6201	0,9800	0,6746	0,51304	647,83	512,15
20,00	0,6156	0,9800	0,6697	0,515	696,90	550,94

Propulsion

5 jun 2018 10:00
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	**0,4946**	**0,1000**	**0,01355**	**0,40889**	**0,11198**	**1,0412**	**1,7745**	**3,19e7**	
16,00	**0,5278**	**0,1217**	**0,01686**	**0,43708**	**0,11469**	**1,113**	**1,8174**	**3,20e7**	
17,00	**0,5609**	**0,1488**	**0,02140**	**0,47281**	**0,12127**	**1,204**	**1,9217**	**3,21e7**	
18,00	**0,5941**	**0,1780**	**0,02695**	**0,50444**	**0,12853**	**1,2845**	**2,0367**	**3,22e7**	
+ 19,00 +	**0,6272**	**0,2074**	**0,03324**	**0,52713**	**0,13469**	**1,3423**	**2,1342**	**3,24e7**	
19,50	**0,6438**	**0,2228**	**0,03682**	**0,5376**	**0,13798**	**1,369**	**2,1864**	**3,24e7**	
20,00	**0,6604**	**0,2397**	**0,04093**	**0,54964**	**0,1421**	**1,3996**	**2,2517**	**3,25e7**	

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	**9,97**	**2,44**	**0,48**	**34,84**	**0,430**	**23,42**	**2,0**	**2,0**	**2883,2**
16,00	**8,76**	**2,44**	**0,48**	**34,84**	**0,479**	**28,50**	**2,0**	**2,0**	**3107,9**
17,00	**7,76**	**2,44**	**0,47**	**34,84**	**0,541**	**34,83**	**2,0**	**2,0**	**3344,8**
18,00	**6,91**	**2,44**	**0,47**	**34,84**	**0,609**	**41,68**	**2,2**	**2,2**	**3580,9**
+ 19,00 +	**6,20**	**2,44**	**0,47**	**34,84**	**0,676**	**48,55**	**3,7**	**3,7**	**3809,3**
19,50	**5,89**	**2,44**	**0,46**	**34,84**	**0,711**	**52,17**	**4,7**	**4,7**	**3923,5**
20,00	**5,60**	**2,44**	**0,46**	**34,84**	**0,750**	**56,12**	**6,1**	**6,1**	**4040,3**

Propulsion

5 jun 2018 10:00
HydroComp NavCad 2014

Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.hcnc**

Hull data

General		
Configuration:		**Monohull**
Chine type:		**Single/hard**
Length on WL:		**103,818 m**
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**
Max molded draft:	[BWL/T 2,400]	**7,500 m**
Displacement:	[CB 0,551]	**7917,00 t**
Wetted surface:	[CS 2,712]	**2427,7 m2**
ITTC-78 (CT)		
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**
Max section area:	[CX 0,937]	**126,5 m2**
Waterplane area:	[CWP 0,783]	**1462,7 m2**
Bulb section area:		**12,9 m2**
Bulb ctr below WL:		**2,250 m**
Bulb nose fwd TR:		**108,930 m**
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**
Transom immersion:	[TTR/T 0,042]	**0,315 m**
Half entrance angle:		**22,00 deg**
Bow shape factor:	[BTK flow]	**-1,0**
Stern shape factor:	[WL flow]	**1,0**

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***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Fwd station (fwd TR):		***0,000 m***
Deadrise:		***0,00 deg***
Chine beam:		***0,000 m***
Chine ht below WL:		***0,000 m***
Propulsor type:		***Propeller***
Max prop diameter:		***4800,0 mm***
Shaft angle to WL:		***0,00 deg***
Position fwd TR:		***0,000 m***
Position below WL:		***0,000 m***
Transom lift device:		***Flap***
Device count:		***0***
Span:		***0,000 m***
Chord length:		***0,000 m***
Deflection angle:		***0,00 deg***
Tow point fwd TR:		***0,000 m***
Tow point below WL:		***0,000 m***

Propulsor data

Propulsor			
Count:		**1**	
Propulsor type:		**Propeller series**	
Propeller type:		**CPP**	
Propeller series:		**B Series**	
Propeller sizing:		**By power**	
Reference prop:			
Blade count:		**5**	
Expanded area ratio:		**0,6863**	**[Size]**
Propeller diameter:		**4800,0 mm**	**[Size]**
Propeller mean pitch:	[P/D 0,9716]	**4663,6 mm**	**[Size]**
Hub immersion:		**5400,0 mm**	
Engine/gear			
Engine data:		**Cuaderno_6**	
Rated RPM:		**600 RPM**	
Rated power:		**7200,0 kW**	
Gear efficiency:		**0,980**	
Load correction:		**Off**	
Gear ratio:		**4,328**	**[Size]**
Shaft efficiency:		**0,970**	

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:	**1,000**
KQ multiplier:	**1,000**
Blade T/C [0.7R]:	**Standard**
Roughness:	**Standard**
Cav breakdown:	**Off**
Design condition	
Max prop diam:	**4800,0 mm**
Design speed:	**19,00 kt**
Reference power:	**7200,0 kW**
Design point:	**1,000**
Reference RPM:	**600,0**
Design point:	**1,000**

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

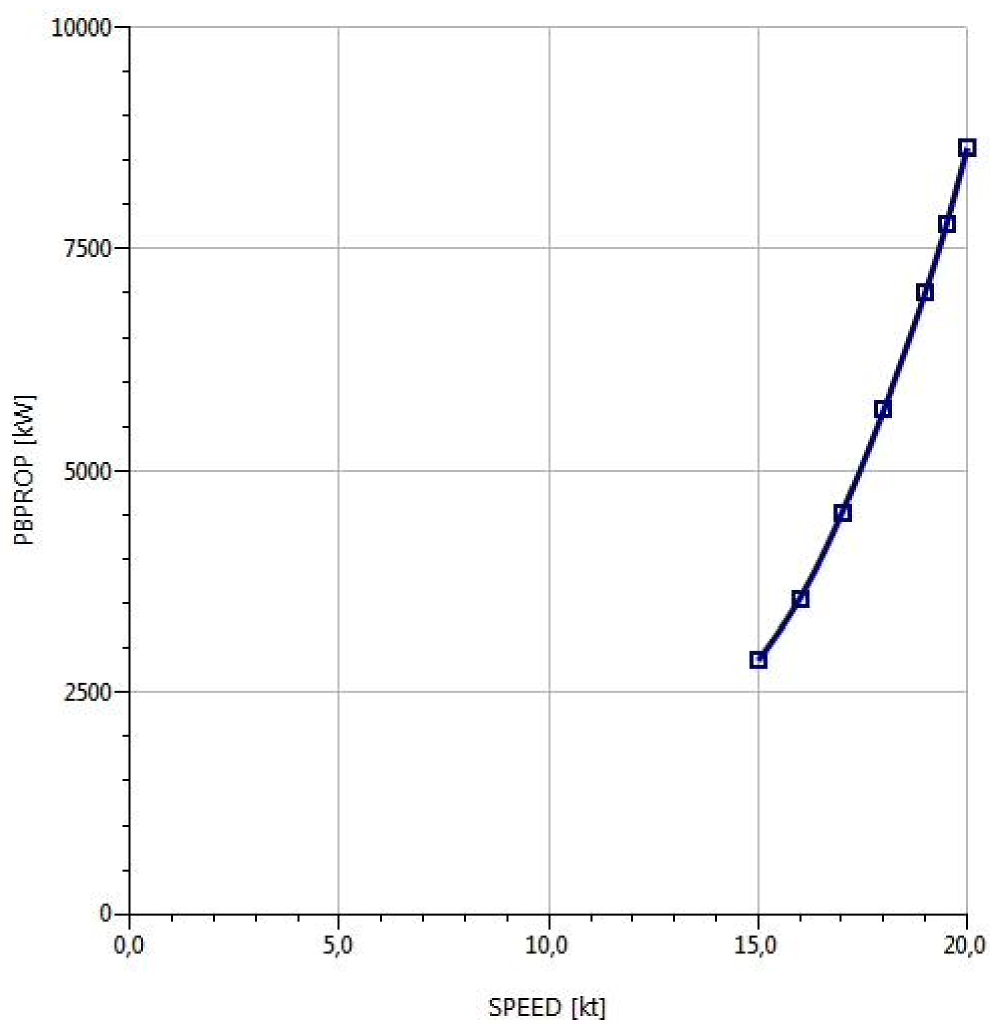
5 jun 2018 09:57
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		**System analysis**	
Technique:	**[Calc] Prediction**	Cavitation criteria:	**Keller eqn**
Prediction:	**Holtrop**	Analysis type:	**Free run**
Reference ship:		CPP method:	**Fixed RPM**
Max prop diam:	**4800,0 mm**	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	**[Off]**	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	**Salt**
Corr allowance:		Density:	**1026,00 kg/m3**
Roughness [mm]:		Viscosity:	**1,18920e-6 m2/s**
Ducted prop corr:	**[Off]**		
Tunnel stern corr:	**[Off]**		
Effective diam:			
Recess depth:			

Predicted propulsion



Propulsion

6 jun 2018 12:39
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction		System analysis	
Technique:	[Calc] Prediction	Cavitation criteria:	Keller eqn
Prediction:	Holtrop	Analysis type:	Free run
Reference ship:		CPP method:	Fixed RPM
Max prop diam:	4800,0 mm	Engine RPM:	
Corrections		Mass multiplier:	
Viscous scale corr:	[Off]	RPM constraint:	
Rudder location:		Limit [RPM/s]:	
Friction line:		**Water properties**	
Hull form factor:		Water type:	Salt
Corr allowance:		Density:	1026,00 kg/m3
Roughness [mm]:		Viscosity:	1,18920e-6 m2/s
Ducted prop corr:	[Off]		
Tunnel stern corr:	[Off]		
Effective diam:			
Recess depth:			

Prediction method check [Holtrop]

Parameters	FN [design]	CP	LWL/BWL	BWL/T
Value	0,31	0,59	5,77	2,40
Range	0,06··0,80	0,55··0,85	3,90··14,90	2,10··4,00

Prediction results [System]

	HULL-PROPULSOR				ENGINE				
SPEED [kt]	PETOTAL [kW]	WFT	THD	EFFR	RPMENG [RPM]	PBPROP [kW]	FUEL [L/h]	LOADENG [%]	
15,00	1774,2	0,2892	0,2094	1,0070	600	2808,2	---	39,0	
16,00	2303,1	0,2889	0,2094	1,0070	600	3514,0	---	48,8	
17,00	2990,0	0,2887	0,2094	1,0070	600	4470,2	---	62,1	
18,00	3788,8	0,2885	0,2094	1,0070	600	5627,8	---	78,2	
+ 19,00 +	4658,9	0,2884	0,2094	1,0070	600	6936,7	---	96,3	
19,50	5137,7	0,2883	0,2094	1,0070	600	7684,1	---	106,7	
20,00	5668,5	0,2882	0,2094	1,0070	600	8542,8	---	118,7	

	POWER DELIVERY								
SPEED [kt]	RPMPROP [RPM]	QPROP [kN·m]	QENG [kN·m]	PDPROP [kW]	PSPROP [kW]	PSTOTAL [kW]	PBTOTAL [kW]	TRANSP	CPPITCH [mm]
15,00	129	198,27	42,78	2669,5	2752,1	2752,1	2808,2	213,3	3350,6
16,00	129	248,10	53,54	3340,4	3443,7	3443,7	3514,0	181,9	3708,7
17,00	129	315,61	68,11	4249,4	4380,8	4380,8	4470,2	151,9	4116,9
18,00	129	397,33	85,74	5349,8	5515,2	5515,2	5627,8	127,7	4548,4
+ 19,00 +	129	489,74	105,68	6594,0	6798,0	6798,0	6936,7	109,4	4985,9
19,50	129	542,51	117,07	7304,5	7530,4	7530,4	7684,1	101,4	5215,1
20,00	129	603,14	130,15	8120,8	8372,0	8372,0	8542,8	93,5	5461,1

	EFFICIENCY				THRUST		
SPEED [kt]	EFFO	EFFG	EFFOA	MERIT	THRPROP [kN]	DELTHR [kN]	
15,00	0,5934	0,9800	0,6447	0,42819	290,83	229,92	
16,00	0,6158	0,9800	0,6688	0,45939	353,93	279,81	
17,00	0,6287	0,9800	0,6825	0,48776	432,47	341,89	
18,00	0,6329	0,9800	0,6870	0,50724	517,56	409,16	
+ 19,00 +	0,6316	0,9800	0,6853	0,51741	602,91	476,64	
19,50	0,6288	0,9800	0,6823	0,52024	647,83	512,15	
20,00	0,6241	0,9800	0,6771	0,5221	696,90	550,94	

Propulsion

6 jun 2018 12:39
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Prediction results [Propulsor]

	PROPULSOR COEFS								
SPEED [kt]	J	KT	KQ	KTJ2	KQJ3	CTH	CP	RNPROP	
15,00	0,5296	0,1147	0,01629	0,40889	0,10966	1,0412	1,7424	2,70e7	
16,00	0,5650	0,1396	0,02038	0,43708	0,11296	1,113	1,7948	2,71e7	
17,00	0,6005	0,1705	0,02592	0,47281	0,1197	1,204	1,9019	2,72e7	
18,00	0,6360	0,2041	0,03264	0,50444	0,12685	1,2845	2,0154	2,73e7	
+ 19,00 +	0,6715	0,2377	0,04023	0,52713	0,13284	1,3423	2,1106	2,74e7	
19,50	0,6893	0,2554	0,04456	0,5376	0,13607	1,369	2,162	2,75e7	
20,00	0,7071	0,2748	0,04954	0,54964	0,14016	1,3996	2,227	2,75e7	

	CAVITATION								
SPEED [kt]	SIGMAV	SIGMAN	SIGMA07R	TIPSPEED [m/s]	MINBAR	PRESS [kPa]	CAVAVG [%]	CAVMAX [%]	PITCHFC [mm]
15,00	9,97	2,80	0,55	32,54	0,454	21,62	2,0	2,0	3086,8
16,00	8,76	2,80	0,54	32,54	0,509	26,31	2,0	2,0	3327,4
17,00	7,76	2,80	0,54	32,54	0,578	32,15	2,0	2,0	3581,0
18,00	6,91	2,80	0,53	32,54	0,652	38,47	2,1	2,1	3833,7
+ 19,00 +	6,20	2,80	0,53	32,54	0,727	44,82	3,5	3,5	4078,4
19,50	5,89	2,80	0,53	32,54	0,766	48,16	4,5	4,5	4200,6
20,00	5,60	2,80	0,52	32,54	0,809	51,80	5,9	5,9	4325,6

Propulsion

6 jun 2018 12:39
HydroComp NavCad 2014

Project ID	**Atunero 3700 m3**
Description	
File name	**C6_NavCad.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:		**103,818 m**	*LCG fwd TR:*	*[XCG/LP 0,000]*	***0,000 m***
Max beam on WL:	[LWL/BWL 5,768]	**17,999 m**	*VCG below WL:*		***0,000 m***
Max molded draft:	[BWL/T 2,400]	**7,500 m**	*Aft station (fwd TR):*		***0,000 m***
Displacement:	[CB 0,551]	**7917,00 t**	*Deadrise:*		***0,00 deg***
Wetted surface:	[CS 2,712]	**2427,7 m2**	*Chine beam:*		***0,000 m***
ITTC-78 (CT)			*Chine ht below WL:*		***0,000 m***
LCB fwd TR:	[XCB/LWL 0,433]	**44,997 m**	*Fwd station (fwd TR):*		***0,000 m***
LCF fwd TR:	[XCF/LWL 0,369]	**38,277 m**	*Deadrise:*		***0,00 deg***
Max section area:	[CX 0,937]	**126,5 m2**	*Chine beam:*		***0,000 m***
Waterplane area:	[CWP 0,783]	**1462,7 m2**	*Chine ht below WL:*		***0,000 m***
Bulb section area:		**12,9 m2**	*Propulsor type:*		***Propeller***
Bulb ctr below WL:		**2,250 m**	*Max prop diameter:*		***4800,0 mm***
Bulb nose fwd TR:		**108,930 m**	*Shaft angle to WL:*		***0,00 deg***
Imm transom area:	[ATR/AX 0,008]	**1,0 m2**	*Position fwd TR:*		***0,000 m***
Transom beam WL:	[BTR/BWL 0,308]	**5,550 m**	*Position below WL:*		***0,000 m***
Transom immersion:	[TTR/T 0,042]	**0,315 m**	*Transom lift device:*		***Flap***
Half entrance angle:		**22,00 deg**	*Device count:*		***0***
Bow shape factor:	[BTK flow]	**-1,0**	*Span:*		***0,000 m***
Stern shape factor:	[WL flow]	**1,0**	*Chord length:*		***0,000 m***
			Deflection angle:		***0,00 deg***
			Tow point fwd TR:		***0,000 m***
			Tow point below WL:		***0,000 m***

Propulsor data

Propulsor				Propeller options	
Count:		**1**		Oblique angle corr:	**Off**
Propulsor type:		**Propeller series**		Shaft angle to WL:	**0,00 deg**
Propeller type:		**CPP**		Added rise of run:	**0,00 deg**
Propeller series:		**B Series**		Propeller cup:	**0,0 mm**
Propeller sizing:		**By power**		KTKQ corrections:	**Standard**
Reference prop:				Scale correction:	**Full ITTC**
Blade count:		**6**		KT multiplier:	**1,000**
Expanded area ratio:		**0,7434**	**[Size]**	KQ multiplier:	**1,000**
Propeller diameter:		**4800,0 mm**	**[Size]**	Blade T/C [0.7R]:	**Standard**
Propeller mean pitch:	[P/D 1,0520]	**5049,5 mm**	**[Size]**	Roughness:	**Standard**
Hub immersion:		**5400,0 mm**		Cav breakdown:	**Off**
Engine/gear				**Design condition**	
Engine data:		**Cuaderno_6**		Max prop diam:	**4800,0 mm**
Rated RPM:		**600 RPM**		Design speed:	**19,00 kt**
Rated power:		**7200,0 kW**		Reference power:	**7200,0 kW**
Gear efficiency:		**0,980**		Design point:	**1,000**
Load correction:		**Off**		Reference RPM:	**600,0**
Gear ratio:		**4,634**	**[Size]**	Design point:	**1,000**
Shaft efficiency:		**0,970**			

Propulsion

6 jun 2018 12:39
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Symbols and values

SPEED = Vessel speed

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
FUEL = Fuel rate per engine
LOADENG = Percentage of engine max available power at given RPM

RPMPROP = Propulsor RPM
QPROP = Propulsor open water torque
QENG = Engine torque
PDPROP = Delivered power per propulsor
PSPROP = Shaft power per propulsor
PSTOTAL = Total vessel shaft power
PBTOTAL = Total vessel brake power
TRANSP = Transport factor

EFFO = Propulsor open-water efficiency
EFFG = Gear efficiency (load corrected)
EFFOA = Overall propulsion efficiency [=PETOTAL/PSTOTAL]
MERIT = Propulsor merit coefficient

THRPROP = Open-water thrust per propulsor
DELTHR = Total vessel delivered thrust

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

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

6 jun 2018 12:38
HydroComp NavCad 2014

Project ID **Atunero 3700 m3**
Description
File name **C6_NavCad.hcnc**

Analysis parameters

Hull-propulsor interaction	
Technique:	**[Calc] Prediction**
Prediction:	**Holtrop**
Reference ship:	
Max prop diam:	**4800,0 mm**
Corrections	
Viscous scale corr:	**[Off]**
Rudder location:	
Friction line:	
Hull form factor:	
Corr allowance:	
Roughness [mm]:	
Ducted prop corr:	**[Off]**
Tunnel stern corr:	**[Off]**
Effective diam:	
Recess depth:	

System analysis	
Cavitation criteria:	**Keller eqn**
Analysis type:	**Free run**
CPP method:	**Fixed RPM**
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