Colombia mar 2019

VI CONGRESO INTERNACIONAL DE DISEÑO E INGENIERÍA NAVAL

COPINAVAL

XXVI CONGRESO PANAMERICANO DE INGENIERÍA NAVAL, TRANSPORTE MARÍTIMO E INGENIERÍA PORTUARIA

Organizan

COTECMAR

ESCUELA NAVAL ALMIRANTE PADILLA

INSTITUTO PANAMERICANO DE INGENIERIA NAVAL

Colombiamar 2019
VI Congreso Internacional de Diseño e Ingeniería Naval
COPINAVAL
XXVI Congreso Panamericano de Ingeniería Naval, Transporte Marítimo e Ingeniería Portuaria

Implementation of Hydrodynamic protuberances in the design of stabilizing blades in a human-powered submarine.

Bryant E. Castañeda, bryantedmir@outlook.com
Jorge Romero, jorge_romero97@outlook.com
Mariana Silva-Ortega, marsilva@uv.mx
Aldo Barradas, albadi994@hotmail.com
Mariano A. Hernández, marianohernandez@uv.mx

UNIVERSIDAD VERACRUZANA

Index

- Introduction
- Problem Description
- Submarine Description
- Methodology
- Geometry of the tubercles
- Stabilizing blades
- Propeller
- Numerical Simulation
- Boundary conditions
- Mesh
- Results
- Future works

Introduction

- The study about sea species has been permitted the development of devices with better performance for the characteristics of this animals.
- Hydrodynamic characteristics of the Humpback whale specifically the
- Implementations (Hassen et all, 2009: H Ibrahim, 2015)

Figure 1 – Humpback Whale acrobatic jump.
Image from Pacific Whale Foundation.

The humpback whale

- Humpback whales utilize extremely mobile, wing-like flippers for banking and turning. Large rounded tubercles along the leading edge of the flipper are morphological structures that are unique in nature.

Submarine’s description

- The submarine “Arcangello” is a design generated based on the shape of the tuna fish. The hull has a length of 3 meters, a beam of 65 cm and a depth of 70 cm. Manufactured with fiberglass and aluminum reinforcements, it weighs approximately 60 kilograms.

Problem Description

- International Submarine Races (ISR)
- David Taylor Model Basin of the Carderock Division of the Naval Surface Warfer Center in Bethesta, M.
- Arcangello Sumbarine

FOUNDATION FOR UNDERWATER RESEARCH AND EDUCATION

INTERNATIONAL SUBMARINE RACES

- Enhance de current design which raced in the last competition (2017) for the next.
- Finding out all advantages for being faster design.
- Employ a humpback's whale fin geometry in the stabilizer fins and propeller

Methodology

Geometry of the tubercles

In previous studies were determined and used measures of amplitude and wavelength:
Bolzon et al. (2014).
Shi et al. (2016).
Ibrahim & New (2015).

With these values we determine the following profiles using the same length (. 86 m) and profile ratio:

A0L0: Amplitude 0% of the chord and wavelength of 0% of the ratio of the profile.
A5L17: Amplitude 5% of the chord and wavelength of 17% of the ratio of the profile.
A7L17: Amplitude 7% of the chord and wavelength of 17% of the ratio of the profile

Note: the term chord is referred for stabilizer fins, length over all the fin

Stabilizing blades

- Analysing all the transversal sections, it has a lot of irregularities so we decided to use the maximum wide section, as a result the stabilizer fins have a mean wide of 0.215 m.
- For length we will use the third part of the submarine body (2.6 m without the propeller) as a result we are going to have a fin length of 0.86 m
- The mid span section of humpback's whale pectoral fin is very similar to NACA 63(4)-221 air foil design

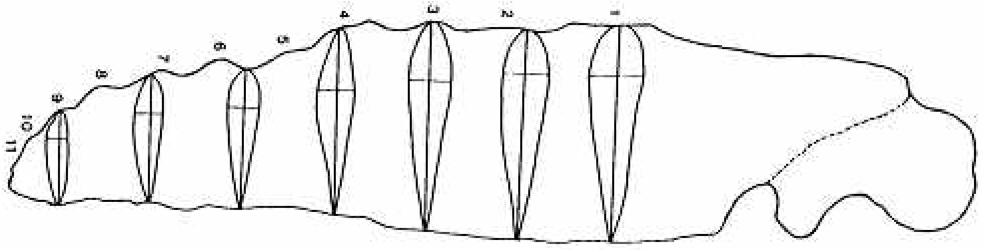


Figure 2 – Model of the stabilizer fins: A0L0

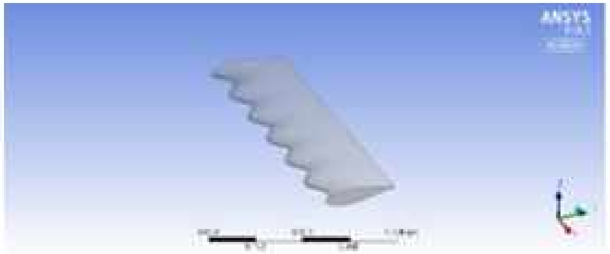


Figure 3 – Model of the stabilizer fins: A5L17

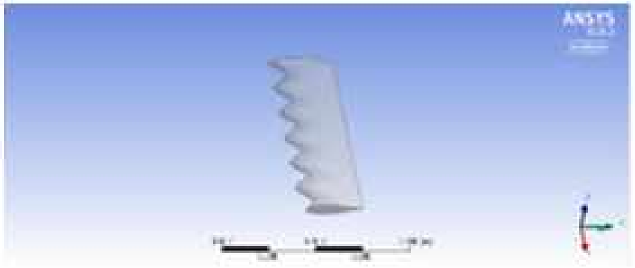


Figure 4 – Model of the stabilizer fins: A7L17

Modelling propellers

- The propeller design
- Open Prop
- Open Prop can make a geometry only using parameter in their data menu, those parameters are:

Specifications	Value	Unit
Number of blades	3	
Angular velocity	195	RPM
Propeller Diameter	0.65	m
Thrust Required	736	N
Submarine Velocity	3.5	m/s
Propeller Hub	0.08	m
Fluid Density	999.19	Kg/m^3

Propeller Performance		
Advance Ratio	1.65	
Torque	178.3	Nm
Power	3642	Watts

- Modifications to the original output in SOLID WORKS
- Two more geometries were made, with the implementation of the protuberances in the submarine's propeller with the same amplitude and wavelength ratios, A5L17 and A7L17.
- In the study the propeller A0L0 was determined to generate less resistance force.

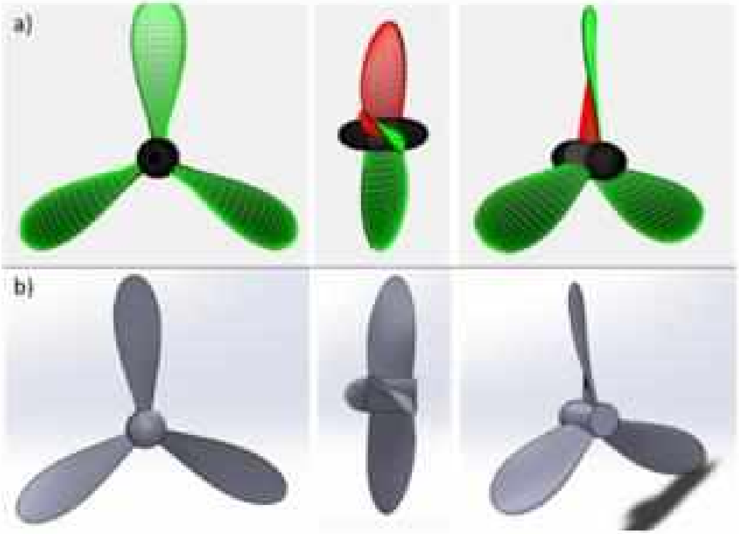
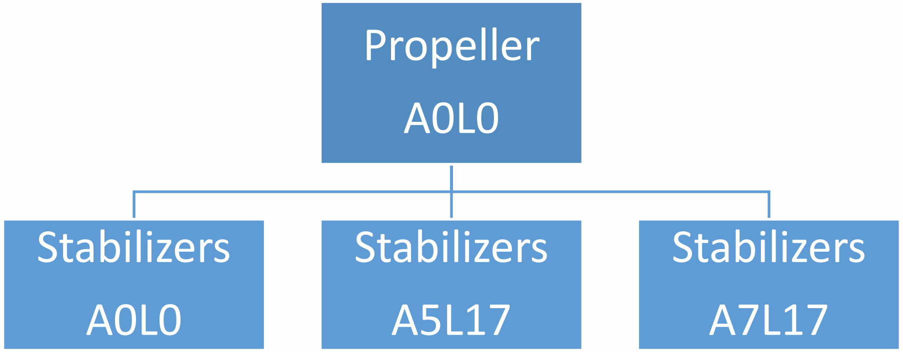


Figure 5– A0L0 propeller views. a) Output data in Open pro, b) Models in Solid Works®.

Numerical Simulation



- The comparison of the thrust coefficient, torque coefficient and efficiency will be made with the same advance ratio, using the following initial data and formulas:

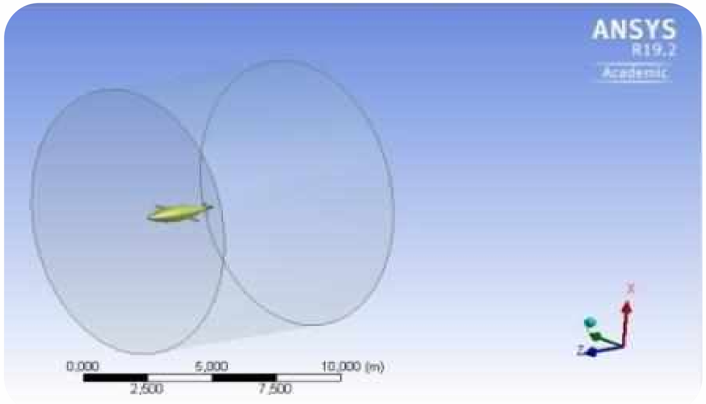
Analysis

- To determine the magnitudes of the drag force and torque, an analysis was made in CFD (Computational fluid dynamics), specifically the software ANSYS® 19.2 academic version.

Boundary Conditions

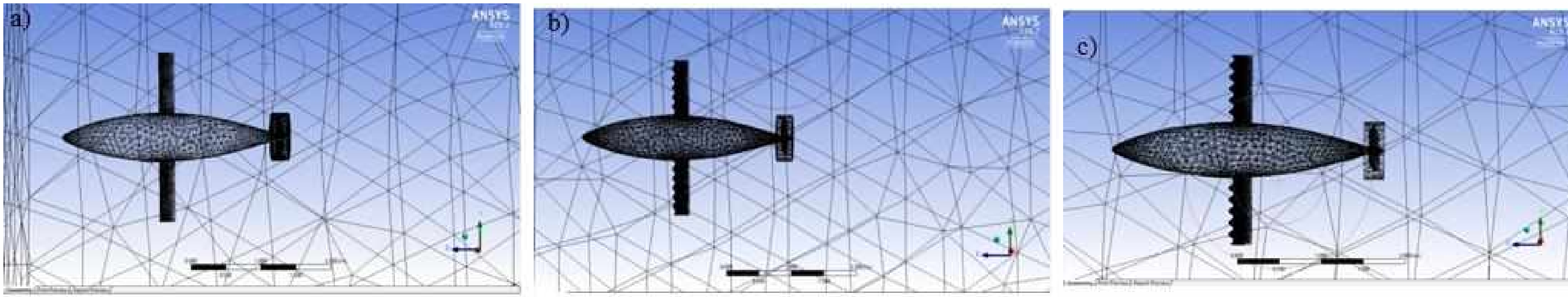
- For the different models an analysis was carried out using the same initial conditions; defining a cylindrical control region where the submarine is located.

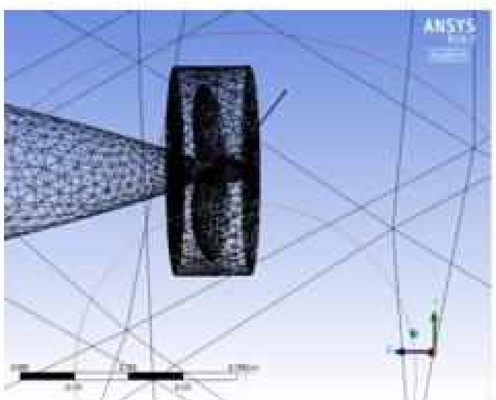
Specifications	Value	Unit
Number of blades	3	
Angular velocity	195	RPM
Propeller Diameter	0.65	m
Thrust Required	736	N
Submarine Velocity	3.5	m/s
Propeller Hub	0.08	m
Fluid Density	999.19	Kg/m^3



Meshing

- For meshing it was decided to use by default, the student version of ANSYS® having some operating limits, among them the number of nodes (520000), a fine or modified meshing exceeded the limit allowed by the license used.
- *Mesh for model: A0L0*





Blade model with propeller	Number of nodes	Number of elements
A0L0	71735	389703
A5L17	86585	468245
A7L17	93090	502850

Figure 7 – Meshing: a) Submarine A0L0, b) Submarine A5L17, c) Submarine A7L17

Setup

- Once the meshing is done, the input data is configured, the flow of water that passes around the submarine enters at a velocity of 3.5 meters per second, and as it is a dynamic analysis, the rotation velocity of the propeller is 195 RPM.

Results

- The results of the simulation are the drag forces and the torque and when included in the formulas outlined above are obtained:

Model	Zone	Force	Torque	Kt	Kq	µ
A0L0	Propeller	1065.51	490.43	.565	.260	.57
A5L17	Propeller	1081.13	510.04	.58	.270	.572
A7L17	Propeller	1163.54	512.31	.617	.271	.59

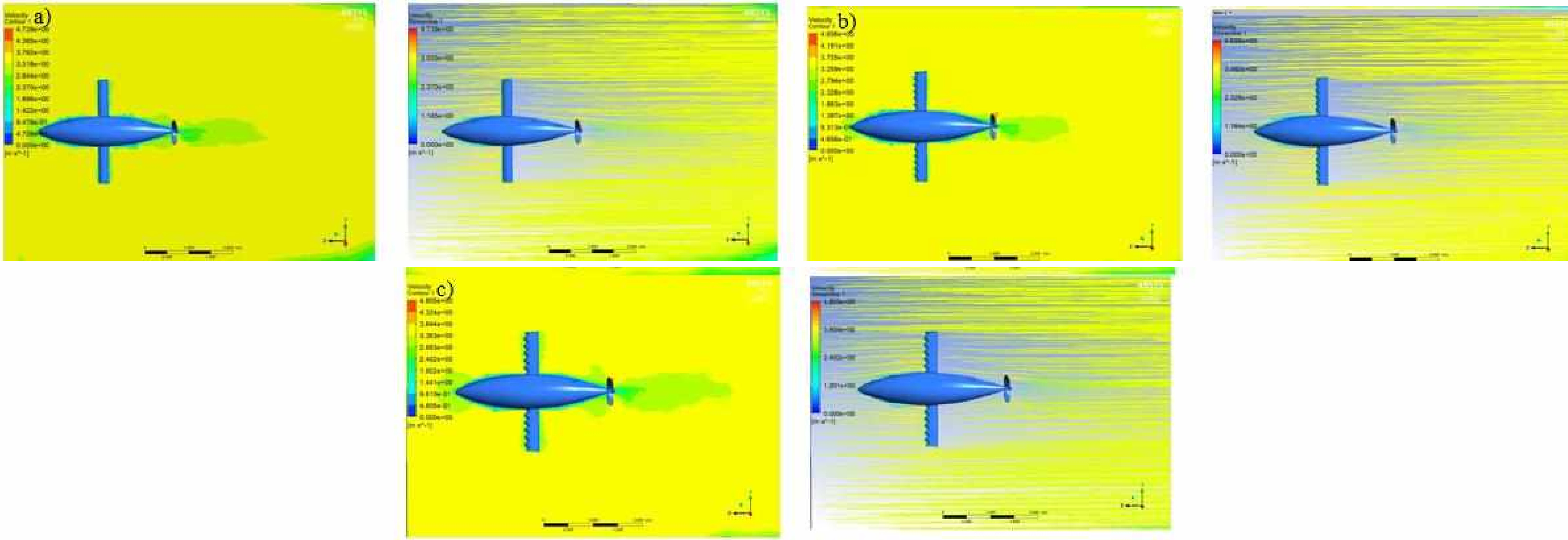


Figure 8 – Results with Contour and Streamline a) Submarine A0L0, b) Submarine A5L17, c) Submarine A7L17

Colombiamar 2019

VI Congreso Internacional de Diseño e Ingeniería Naval

COPINAVAL

XXVI Congreso Panamericano de Ingeniería Naval, Transporte Marítimo e Ingeniería Portuaria

Gracias por su atención
Obrigado
Thanks

Colombia
mar2019