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Design and Analysis of a Marine Propeller

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ABSTRACT:

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modeled by both Bernoulli's principle and Newton's third law. A marine propeller is sometimes colloquially known as a screw propeller or screw.

The present work is directed towards the study of marine propeller working and its terminology, simulation and flow simulation of marine propeller has been performed. The von misses stresses, resultant deformation, strain and areas below factor of safety has been displayed. The velocity and pressure with which the propeller blade pushes the water has been displayed in the results.

Introduction:

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the airfoil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modeled by both Bernoulli's principle and Newton's third law. A marine propeller is sometimes colloquially known as a screw propeller or screw.

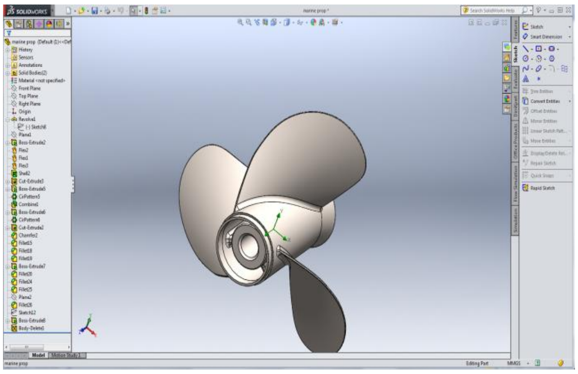
Figure.1. Marine propeller

HISTORY AND DEVELOPMNT :

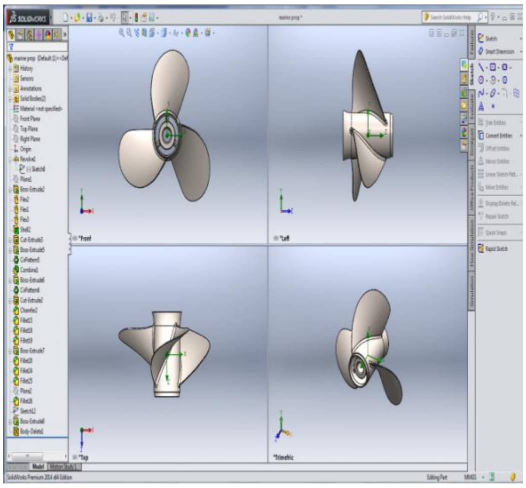
The concept of a propulsion device resembling what is now called the screw propeller is certainly not new. The experience of ancients with sculling oars, coupled with the later development of rotary engines, obviously suggested a combination of a series of inclined plates secured to a rotary hub. In 945 B.C., the Egyptians used a screw-like device for irrigation purposes. Archimedes (287-212 BC), the first scientist whose work had a lasting effect on the history of naval architecture and ship propulsion, has been credited with the invention of the screw.Hecreated the screw to pump out flooded ships.The screw pump, designed by Archimedes for supplying irrigation ditches, was the forerunner of the screw propeller. Drawings done by Leonardo DA Vinci (1452-1519) (Figure 1-1 below) contain pictures of water screws for pumping. However, his famous helicopter rotor more nearly resembles a marinescrew.Despite this knowledge, application of screw propulsion to boats and ships didn't take place until the advent of steam power.

Due to greater suitability with the slow-turning, early steam engines, the first powered boats used paddle wheels for a form of water propulsion. In 1661, Toogood and Hays adopted the Archimedian screw as a ship propeller, although their boat design appears to have involved a type of waterjet propulsion. At the beginning of the 19th century, screw propulsion was considered a strictly second-rate means of moving a ship through the water. However, it was during this century that screw propulsion development got underway. In 1802, Colonel John Stevens built and experimented with a single-screw, and later a twin-screw, steam-driven boat. Unfortunately, due to a lack of interest, his ideas were not accepted in America.

DESIGN AND MODELLING:



Four different views of marine propeller as shown below:

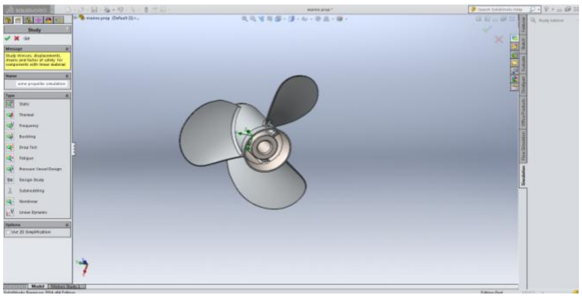


FINITE ELEMENTMODELLING:

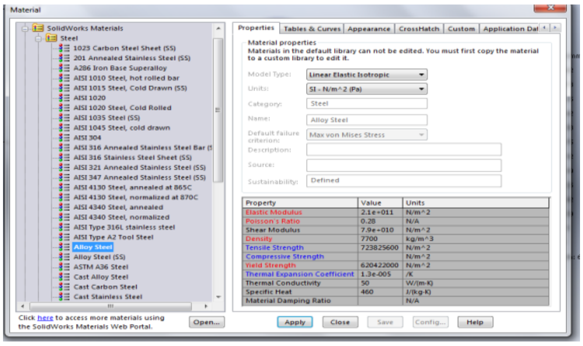
Many problems in engineering and applied science are governed by differential or integral equations. The solutions to these equations would provide an exact, closed form solution to the particular problem being studied. However, complexities in the geometry, properties and in the boundary conditions that are seen in most real world problems usually means that an exact solution cannot be obtained in a reasonable amount of time. They are content to obtain approximate solutions that can be readily obtained in a reasonable time frame and with reasonable effort. The FEM is one such approximate solution technique. The FEM is a numerical procedure for obtaining approximate solutions to many of the problems encountered in engineering analysis. In the FEM, a complex region defining a continuum is discredited into simple geometric shapes called elements.

The properties and the governing relationships are assumed over these elements and expressed mathematically in terms of unknown values at specific points in the elements called nodes. An assembly process is used to link the individual elements to the linked system. When the effects of loads and boundary conditions are considered, a set of linear or nonlinear algebraic equations is usually obtained. Solution of these equations gives the approximate behaviour of the continuum or system. The continuum has an infinite number of degrees of freedom (DOF), while the discretised model has a finite number of DOF. This is the origin of the name, finite element method.

SIMULATION OF MARINE PROPELLER:



ADDITION OF MATERIAL TO PROPELLER:



Material

- SolidWorks Materials
  - Steel
    - 1023 Carbon Steel Sheet (SS)
    - 201 Annealed Stainless Steel (SS)
    - A286 Iron Base Superalloy
    - AISI 1010 Steel, hot rolled bar
    - AISI 1015 Steel, Cold Drawn (SS)
    - AISI 1020
    - AISI 1020 Steel, Cold Rolled
    - AISI 1035 Steel (SS)
    - AISI 1045 Steel, cold drawn
    - AISI 304
    - AISI 316 Annealed Stainless Steel Bar (S
    - AISI 316 Stainless Steel Sheet (SS)
    - AISI 321 Annealed Stainless Steel (SS)
    - AISI 347 Annealed Stainless Steel (SS)
    - AISI 4130 Steel, annealed at 865C
    - AISI 4130 Steel, normalized at 870C
    - AISI 4340 Steel, annealed
    - AISI 4340 Steel, normalized
    - AISI Type 316L stainless steel
    - AISI Type A2 Tool Steel
    - Alloy Steel
    - Alloy Steel (SS)
    - ASTM A36 Steel
    - Cast Alloy Steel
    - Cast Carbon Steel
    - Cast Stainless Steel

Click here to access more materials using the SolidWorks Materials Web Portal.

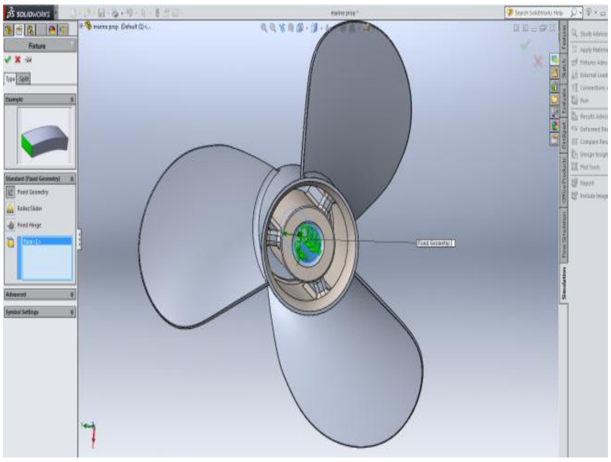
Material properties

Materials in the default library can not be edited. You must first copy the material to a custom library to edit it.

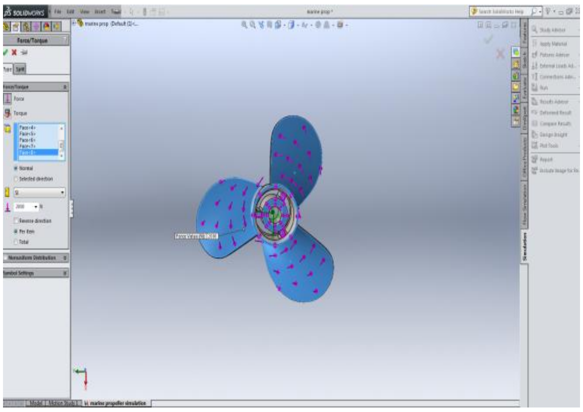
Model Type: Linear Elastic Isotropic
Units: SI - N/m^2 (Pa)
Category: Steel
Name: Alloy Steel
Default failure criterion: Max von Mises Stress
Description:
Source:
Sustainability: Defined

Property	Value	Units
Elastic Modulus	2.1e+011	N/m^2
Poisson's Ratio	0.28	N/A
Shear Modulus	7.9e+010	N/m^2
Density	7700	kg/m^3
Tensile Strength	723825600	N/m^2
Compressive Strength		N/m^2
Yield Strength	620422000	N/m^2
Thermal Expansion Coefficient	1.3e-005	/K
Thermal Conductivity	50	W/(m·K)
Specific Heat	460	J/(kg·K)
Material Damping Ratio		N/A

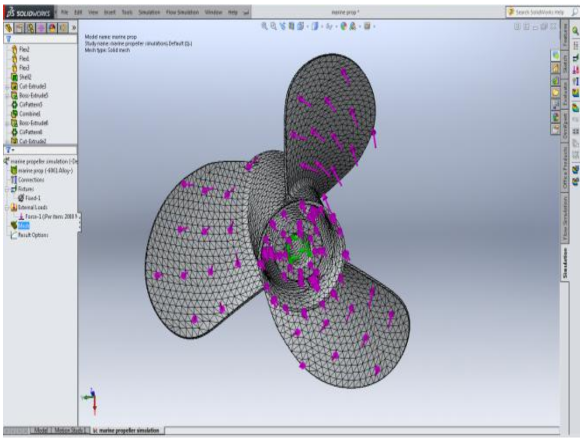
FIXING OF GEOMETRY:



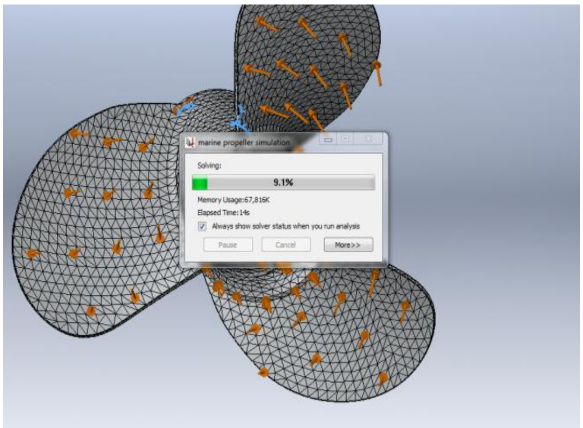
APPLICATION OF LOAD:



MESHING:



SOLVE:



marine propeller simulation

Solving:

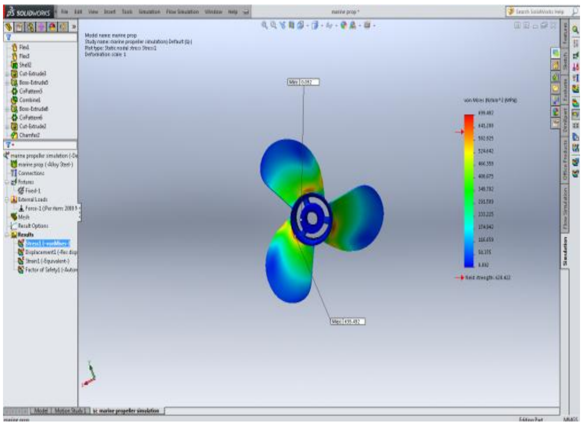
9.1%

Memory Usage:67,816K

Elapsed Time:14s

☑ Always show solver status when you run analysis

RESULTS:



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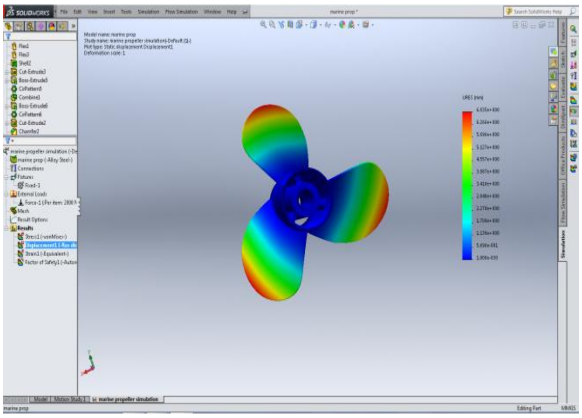
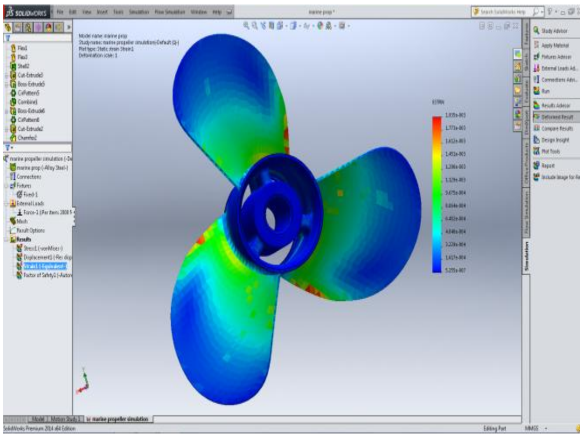
DISPLACEMENT



STRAIN:



AT 30^0 ANGLE OF BLADE

S.No	Material	Loads (N)	Stress (MPa)	Displacement(mm)
1.	Alloy steel	1000	328.32	2.61
		2000	656.64	5.22
		3000	984.97	7.84
2.	Magnesium alloy	1000	328.67	11.78
		2000	657.35	23.57
		3000	986.05	35.36
3.	Titanium alloy	1000	328.14	4.910
		2000	656.28	9.82
		3000	984.42	14.73

AT 50^0 ANGLE OF BLADE

S.No	Material	Loads (N)	Stress (MPa)	Displacement(mm)
1.	Alloy steel	1000	323.65	3.075
		2000	699.4	6.835
		3000	970.93	9.22
2.	Magnesium alloy	1000	319.03	13.73
		2000	700.18	33.52
		3000	957.22	41.20
3.	Titanium alloy	1000	321.26	5.75
		2000	249.19	4.77
		3000	963.81	17.26

AT 60^0ANGLE OF BLADE

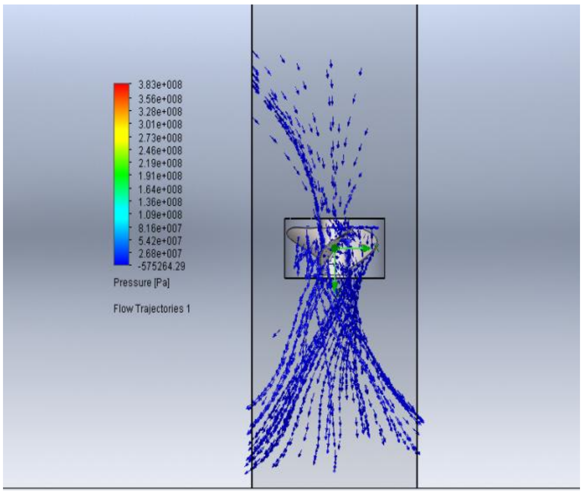
S.No	Material	Loads (N)	Stress (MPa)	Displacement(mm)
1.	Alloy steel	1000	814.59	7.97
		2000	677.06	7.26
		3000	2443.6	23.9
2.	Magnesium alloy	1000	813.59	35.4
		2000	676.47	32.3
		3000	2441.1	106.2
3.	Titanium alloy	1000	813.28	14.8
		2000	676.15	13.5
		3000	2439.7	44.6

FLOW SIMULATION

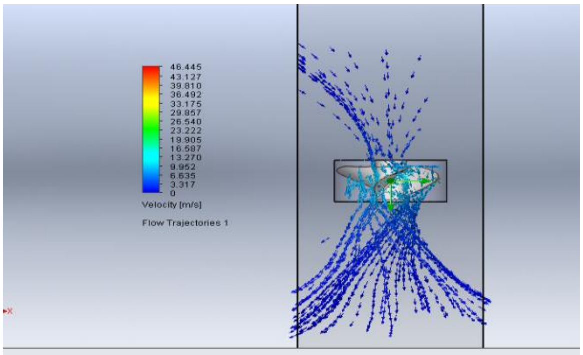
The process of setting up a Flow Simulation project includes the following general setting steps in order: choosing the analysis type, selecting a fluid and a solid and settings of wall condition and initial and ambient conditions. Any fluid flow problem that is solved using Flow Simulation must be categorized as either internal bounded or external unbounded flow. Examples of intemal flows include flows bounded by walls such as pipe- and channel flows, heat exchangers and obstruction flow meters. External flow examples include flows around airfoils and fuselages of airplanes and fluid flow related to different sports such as flows over golf balls, baseballs and soccer balls. Furthermore, during the project setup process a fluid is chosen as belonging to one of the following six categories:

gas, liquid, non-Newtonian liquid, compressible liquid, real gas or steam. Physical features that can be taken into account include heat conduction in solids, radiation, time-varying flows, gravity and rotation. Roughness of surfaces can be specified and different thermal conditions for walls can be chosen including adiabatic walls or specified heat flux, heat transfer rate or wall temperature.

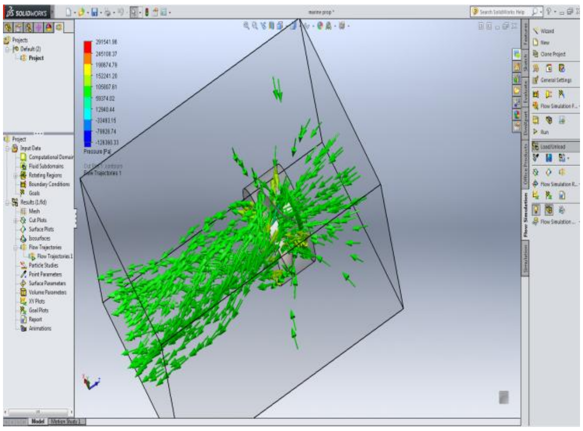
BLADE-ANGLE 30^0 PRESSURES TRAJECTORIES:



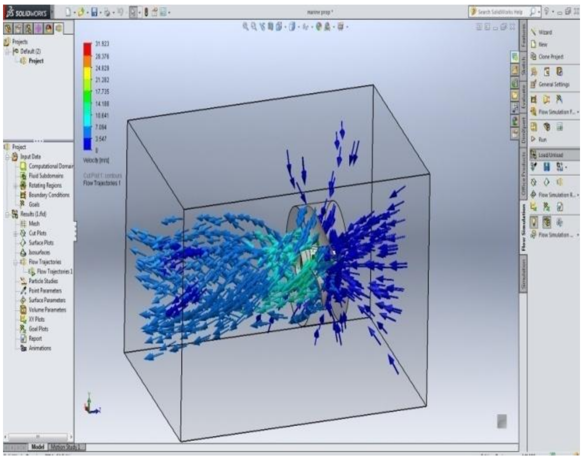
VELOCITY TRAJECTOROIES:



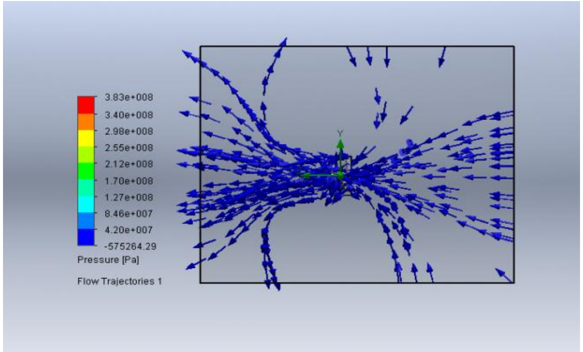
BLADE-ANGLE 50^0 PRESSURE TRAJECTORY:



VELOCITY TRAJECTORY:



BLADE-ANGLE 60^0 PRESSURE TRAJECTORY:



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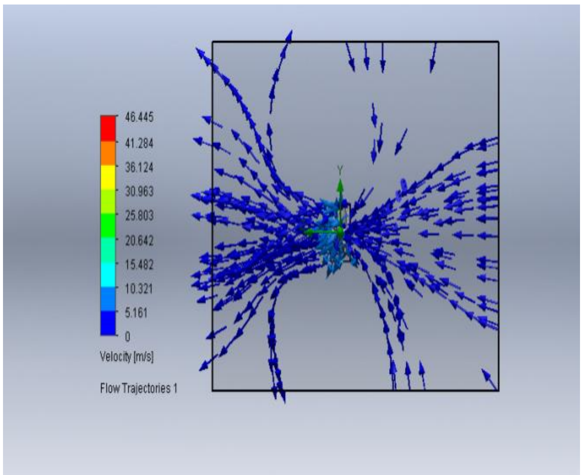
VELOCITY TRAJECTORY:



CONCLUSION:

- The marine propeller working and terminology has been studied.
- The marine propeller with 3 blades has been modeled in solidworks 2014.
- The solidworks simulation has been studied and the marine propeller simulation has been performed .
- The maximum induced stresses i.e, 699.4Mpa in propeller is greater than the material yield strength 620.4Mpa.This means that if the stress is greater than the yield stress the material will not break but will deform plastically.
- The propeller with blade angle 50 shown less stress values compared with the blade angle 30 & 60..
- The titanium alloy material has shown lower stress values compared with the other two material.
- In flow simulation analysis the blade angle with 60 has shows increase in its velocity trajectories.
- The resultant deformation ,strain and areas below factor of safety has been displayed.
- The solidworks flow simulation has been studied and the velocity and pressure with the blades of the propeller has been calculated.
- The flow trajectories for velocity and pressure has been displayed.

REFERENCES:

[1] Salvatore, F., Testa, C., Ianniello, S. and Pereira, F. 2006. Theoretical modeling of unsteady cavitation and induced noise, INSEAN, Italian Ship Model Basin, Rome, Italy, Sixth International Symposium on Cavitation, CAV2006, Wageningen, The Netherlands. International Journal of Computer Applications (0975 – 8887)Volume 55– No.16, October 201233

[2] Chang, B.1998. Application of CFD to P4119 propeller, 22ndITTC Propeller RANS/Panel Method Workshop, France.

[3] Sanchez-Caja, A. 1998. P4119 RANS calculations at VTT, 22nd ITTC Propeller RANS/Panel Method Workshop, France.

[4] Bernad, S. 2006. Numerical analysis of the cavitating flows, Center of Advanced Research in Engineering Sciences, Romania Academy, Timisoara Branch, Romania.

[5] Senocak, I. and Shyy, W. 2001. Numerical simulation of turbulent flows with sheet cavitation, Department of Aerospace Engineering, Mechanics and Engineering Science, University of Florida, Florida.

[6] Sridhar, D., Bhanuprakash, T. V. K., and Das, H. N. 2010. Frictional resistance calculations on a ship using CFD, Int. J. of Computer Applications, Vol. 11, No.5, pp 24-31.

[7] Salvatore, F., Greco, L. and Calcagni, D. 2011. Computational analysis of marine propeller performance and cavitation by using an inviscid-flow BEM model, Second International Symposium on Marine Propulsors, smp'11, Hamburg, Germany.

[8] Bertetta, D., Brizzolara, S., Canepa, E., Gaggero, S. and Viviani, M. 2012. EFD and CFD characterization of a CLT propeller, Int. J. of Rotating Machinery, Vol. 2012, Article ID 348939, 22 pages, doi:10.1155/2012/348939.

[9]Zhi-feng ZHU and Shi-liang FANG, 2012. Numerical investigation of cavitation performance of ship propellers, J. of Hydrodynamics, Ser. B, Vol. 24, No. 3, pp 347–353.

[10] Pereira, F., Salvatore, F., and Di Felice, F. (2004). Measurement and modeling of propellercavitation in uniform inflow, J. of Fluids Engineering, Vol. 126, pp 671-679.

[11] Pereira J. C. F. and Sequeira, A. 2010. Propeller-flow predictions using turbulent vorticityconfinement, V European Conference on Computational Fluid Dynamics, ECCOMAS CFD 2010, Lisbon, Portugal.