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FLUID STRUCTURE INTERACTION ANALYSIS ON ELLPISOIDAL SUBMERGED BODIES BY USING CFD

Y.Amar Babu[*], Dr. S. Adinarayana, Md. Yousuf Ali[***].**

[*] Department of Mechanical Engg.M.V.G.R.College of Engineering

Abstract- The interaction between a semi- rigid structure and the surrounding fluid environmentis a sober issue in the stability investigation of different foil availabilities and design ofaircraft blade machinery. To Study about these types of phenomena, it requires the modelingof both fluid and structural domains. The two methods available to calculate the Fluid–Structure Interaction (FSI) effects in the time domain are the strongly coupled or partiallycoupled governing equations.In the fully coupled model, the flow field and structure respond simultaneously byexchanging the aerodynamic forces and structural displacement. Logically, the fully coupledmodel is rigorous in the physical sense, because the structural displacement respondsinstantly to the forces imposed by the fluid. In this algorithm, the fluid and structural analysisequations are combined together to form a unified set of equations. Then it is solved andintegrated simultaneously in time domain to update all the variables including those at thefluid–structure interface. This implies solving the complete system in one step; hence there isno information transfer in fully-coupled method. The fully coupled algorithm usually requiresan almost complete rewrite of the CFD and CSD codes into one single coupled code.In this project, the modeling is done in Creo Parametric 2.0 and Computational fluiddynamics analysis and fluid structure interaction (FSI) is done in ANSYS 15.0 solver. TheStatic structural analysis is carried out initially. The flow analysis of various angle of attacksare carried out and FSI is done for the respective models. The later and the former arecompared for pressure distributions and velocity magnitudes for various angles of attack. Thepressure coefficients and velocity magnitudes are comparably good for Fluid structureInteraction.

Index Terms*- Creo parametric 2.0, Fluid Structure Interaction, Pressure Distributions, Velocity Magnitudes.*

I. INTRODUCTION

Fluid–structure interaction (FSI) is the interaction of some movable or deformablestructure with an internal or surrounding fluid flow. Fluid–structure interactions can bestable or oscillatory. In oscillatory interactions, the strain induced in the solid structurecauses it to move such that the source of strain is reduced, and the structure returns to itsformer state only for the process to repeat.Fluid–structure interactions are a crucial consideration in the design of manyengineering systems, e.g. aircraft, engines and bridges. Failing to consider the effects ofoscillatory interactions can be catastrophic, especially in structures comprising materialssusceptible to fatigue. Tacoma Narrows Bridge (1940), the first Tacoma Narrows Bridge,is probably one of the most infamous examples of large-scale failure. Aircraft wings andturbine blades can break due to FSI oscillations. Fluid–structure interaction has to betaken into account for the analysis of aneurysms in large arteries and artificial heartvalves.

A reed actually produces sound because the system of equations governing itsdynamics has oscillatory solutions. The dynamic of reed valves used in two strokesengines and compressors is governed by FSI. The act of "blowing a raspberry" is anothersuch example. Fluid–structure interactions also occur in moving containers, where liquidoscillations due to the container motion impose substantial magnitudes of forces andmoments to the container structure that affect the stability of the container transportsystem in a highly adverse manner. The Propagation of a pressure wave through anincompressible fluid in a flexible tube is as shown in the Fig. 1

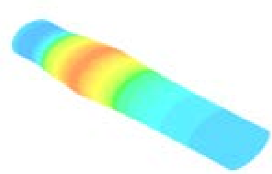


Fig. 1 Propagation of a Pressure wave

II. PROBLEM IDENTIFICATION

The present study made computational prediction of Fluid Structure Interaction ofsubmerged bodies using commercially available RANS code, Fluent, with suitable User DefinedFunctions (UDFs) as well as a CFD Code, developed in-house. The fluid and structure has beencreated with appropriate dimension for understanding the interaction between the fluid and thestructure. Fluid structure interaction is carried out at different angle of attack. The differences influid forces acting on a structural member for both the ways of coupling have been analyzed. Thepressure coefficient and the velocity magnitude are compared with interaction and withoutinteraction.

III. MODELING OF ELLIPSOIDAL MODEL

The modeling of the Ellipsoidal Body is done in Creo Parametric 2.0.

Introduction to Creo Parametric:

Creo Parametric is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Creo Parametric is a feature-based, parametric solid modeling system with many extended design and manufacturing applications.

Creo Parametric is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today many software producers have recognized the advantage of this approach and started to shift their product onto this platform.

Creo Parametric was designed to begin where the design engineer begins with features and design criteria. Creo Parametric's cascading menus flow in an intuitive manner, providing logical choices and pre-selecting most common options, in addition to short menu descriptions and full on-line help. This makes it simple to learn and utilize even for the most casual user. Expert users employ Creo Parametric's "map keys" to combine frequently used commands along with customized menus to exponentially increase their speed in use. Because Creo Parametric provides the ability to sketch directly on the solid model, feature placement is simple and accurate.

The model is as shown in the figure 1 as shown below:

Fig 1.Ellipsoidal Model

The drawing Specifications taken are as shown in the Figure 2 below:

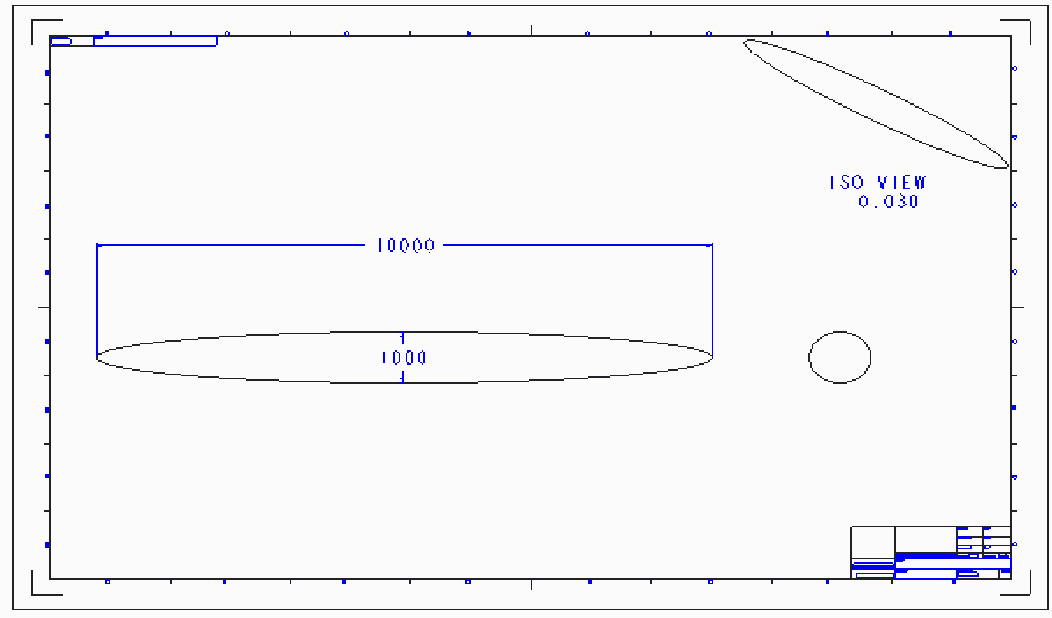
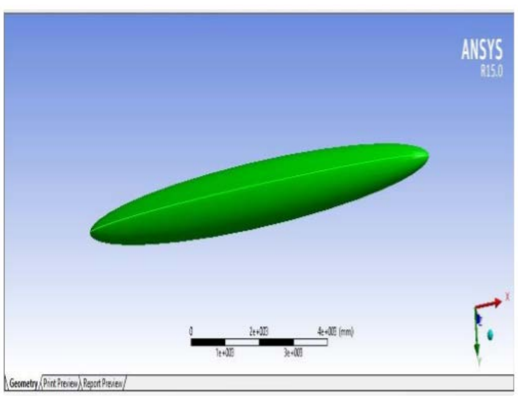


Fig. 2 Drawing Specifications for the Ellipsoidal Model.

IV. ANALYSIS OF ELLIPSOIDAL MODEL

The analysis of the Ellipsoidal Model is done in Ansys 15.0 and the analysis reports are as shown below. The geometry and the mesh model in Ansys are as shown in the Fig.3 and Fig. 4 below respectively.



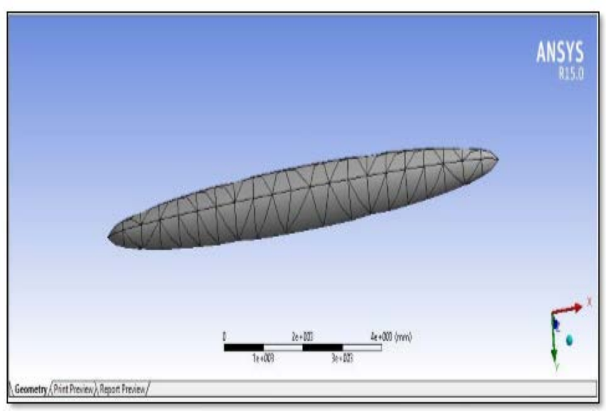


Fig. 3 Geometry of the Ellipsoidal Model **Fig.4 Mesh of the Ellipsoidal Model**

Analysis of Ellipsoidal Model:

The deformation and Equivalent Stress reports for the Ellipsoidal Models are are as shown in the Fig. 5 and Fig. 6 respectively.

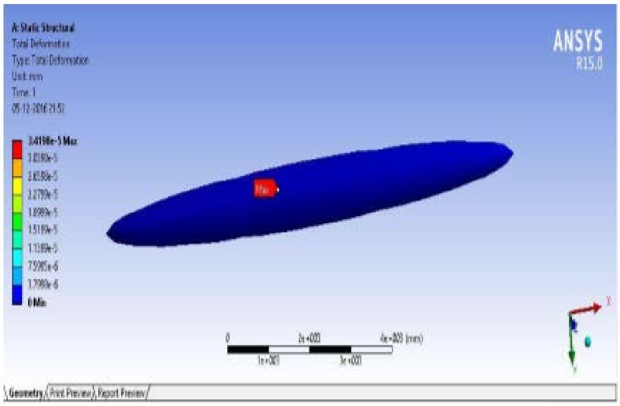


Fig. 5 Deformation of the Ellipsoidal Model

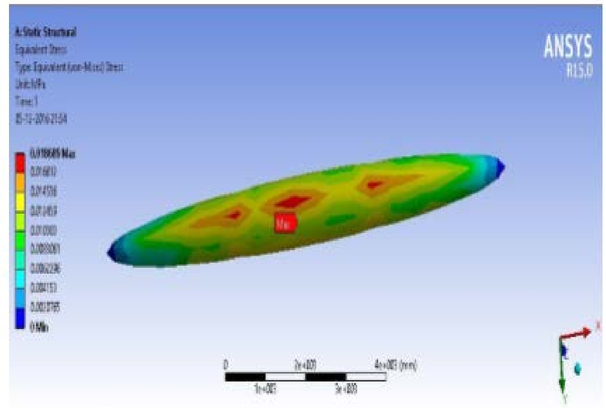


Fig.6 Equivalent Stress of the Ellipsoidal Model

The Pressure Coefficient and Velocity magnitude reports of Zero degree for the Ellipsoidal Models are are as shown in the Fig. 7 and Fig. 8 respectively.

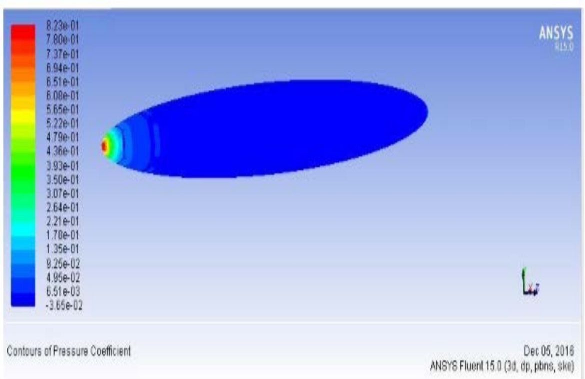


Fig. 7Pressure Coefficient of the Ellipsoidal Model

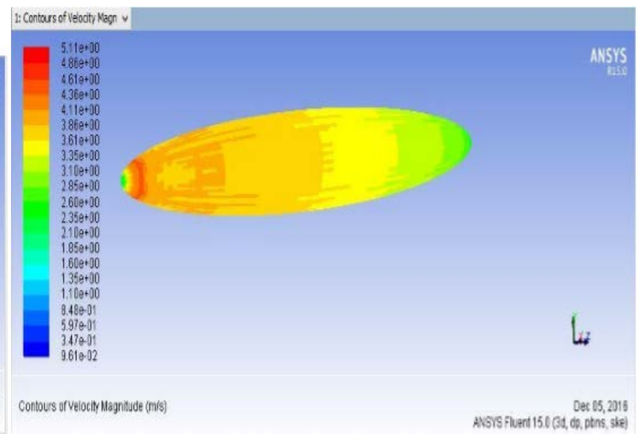


Fig.8Velocity magnitude of the Ellipsoidal Model

Also the analysis is carried out for the fluid structure interaction treating as a one way FSI. The Pressure Coefficient and Velocity magnitude reports of Zero degree with structural interaction for the Ellipsoidal Models are shown in the Fig. 9 and Fig. 10 respectively.

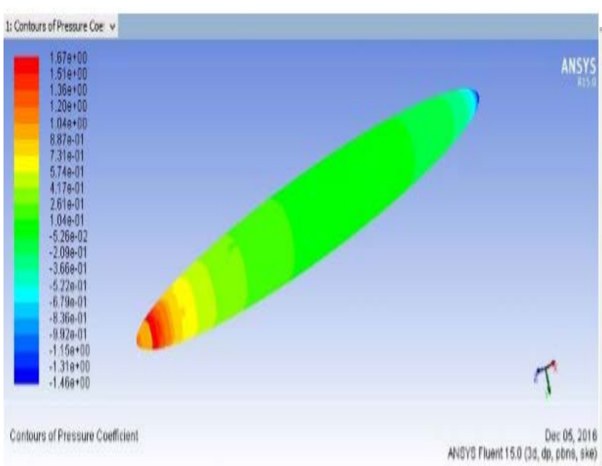


Fig. 97Pressure Coefficient of the FSIEllipsoidal Model

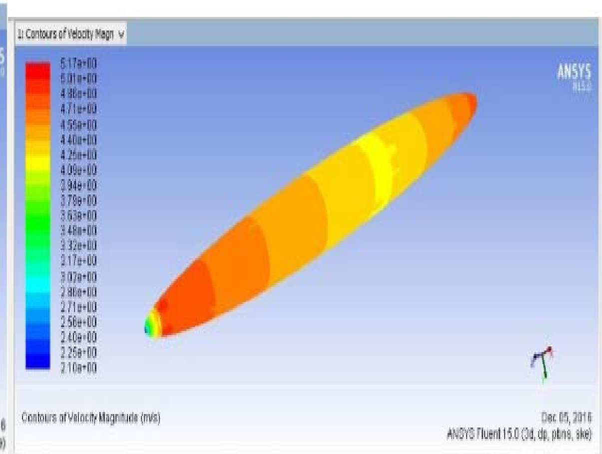


Fig.10Velocity magnitude of the FSIEllipsoidal Model

V. RESULTS AND DISCUSSION

The Pressure Coefficients for Various Angles of attack is as shown in the Table

Angle of Attack	Fluid Flow Analysis (Max) (m/s)	Fluid Structure Interaction (Max)(m/s)
0	0.8231	1.6702
2	0.8232	1.8243
4	0.8233	2.0036
6	0.8252	2.7496
8	1.1195	3.7181

The Velocity Magnitudes for Various Angles of attack is as shown in the Table

Angle of Attack	Fluid Flow Analysis (Max) (m/s)	Fluid Structure Interaction (Max)(m/s)
0	5.1093	5.1676
2	5.4836	5.2018
4	5.9352	5.3801
6	6.4099	5.5350
8	6.8643	5.6772

In the fluid structure interaction analysis of different angles of attack we observed the values of pressure coefficients are better than fluid flow analysis pressure coefficient values. The fluid structure interaction analysis is comparatively good. The work is performed by method of coupling ie. One way coupling. This is implemented by creating a large domain in which the structural member is placed in an appropriate position. The meshing of the ellipsoidal body is obtained good mesh quality which is best in the flow analysis.

And the same way we observed the velocity magnitude for the flow analysis and the fluid structure interaction analysis. The fluid structure interaction has much more max values at different angles of degree. The values of pressure coefficient and velocity magnitude are tabulated in the above. By comparing these fluid structure interaction analysis and the flow analysis results we notified that the fluid structure interaction analysis is best way to study the fluid flow over the structure. There are many instances of structural damages of such platforms due to extreme weather conditions like hurricanes. These circumstances have a created an awareness in offshore industries on things like structural durability and reliability and the requirements of setting a safer air gap.

By this analysis we conclude that the fluid structure interaction analysis is applicable for study more advancement in the underwater submerged bodies for new development in marine engineering.

VI. CONCLUSION

As a part of real time application model, an ellipsoid body of 1:10 is taken into consideration for evaluation. The model is run at a free attack at a velocity of 5m/s initially and pressure distribution along the run is observed. The fluid flow analysis for different angle of attacks is done. Pressure and velocity distributions are observed. The structure analysis is carried out. The fluid structure interaction for the model is run and pressure and velocity distributions are observed after CFD simulation considering it as an FSI application. The pressure coefficients and velocity magnitudes are comparably good for Fluid structure Interaction. As the angle of attack increases, the pressure coefficient is linearly increasing.

Scope for future work: 1. As CFD results were found in good agreement with standard or experimental results, more complex shapes of interest can be developed in order to find the variations of pressure coefficients and velocity distributions. 2. The present work contributes a one way method to the problem solution. Different other types of methodologies can be used to solve the problem using CFD Simulation.

REFERENCES

[1]Rammohan Subramania Raja, 2012 Master's Thesis 2012:55 ISSN 1652-8557 Department of Applied Mechanics Division of Fluid mechanics Chalmers University of Technology Sweden.

[2] E Reynolds, B Anderson and G Walker, "Effects of Turbulence and Velocity Profile Variation in a Circulating Water Channel as Determined by Sphere and Ellipsoid Tests", presented at MCMC'97, Croatia, and REPORT AME CRC C 98/17, 1997.

[3] K B S V D Prasad, Dr.K.Balaji Reddy,R Sam Sukumar,AmruthaluriSai Teja, VanamaliRambabu, Gubbala Rajesh, Ravi Wesley Moses, Pilli Ashok Kumar, "Fluid Structure Interaction of Liquid Lubricated Cylindrical Journal Bearing using CFD", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 3, March 2016.

[4] Dinesh Dhande, Dr D W Pande, VikasChatarkar, "Analysis of Hydrodynamic Journal Bearing Using Fluid Structure Interaction Approach", International Journal of Engineering Trends and Technology (IJETT) - Volume4 Issue8- August 2013.

[5] Thomas Ponweisera, Peter Stadelmeyer, TomášKarásek, "Fluid-Structure Simulations with OpenFOAM for Aircraft Designs", Partnership for Advanced Computing in Europe. 2013.

[6] Bruce Ralphin Rose. J, Jinu. G. R, Manivel. M, "Partly Coupled Fluid Structure Interaction Analysis of an Aircraft Wing at Subsonic Speeds", International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:14 No:03, 2014.

[7] G.Szabó, J.Györgyi, "Fluid-structure interaction analysis with the ANSYS software in bridge aero elasticity", EACWE 5, 2009.

[8] Gene Hou, Jin Wang, Anita Layton, "Numerical Methods for Fluid-Structure Interaction A Review", Global-Science Press, Vol. 12, No. 2, pp. 337-377 August 2012.

[9] Scott T. Miller, R. L. Campbell, C. W. Elsworth, J. S. Pitt, D. A. Boger, "An Overset Grid Method for Fluid-Structure Interaction", World Journal of Mechanics, 4, 217-237, 2014.

[10] Jon Tomas Gretarsson, NipunKwatra, Ronald Fedkiw, "Numerically Stable FluidStructure Interactions between Compressible Flow and Solid Structures", Stanford University, January 28, 2011.

[11] Stefan Frei, Thomas Richter, Thomas Wick, "Eulerian Techniques for Fluid-Structure Interactions - Part II: Applications", Published in Lecture Notes in Computational Science and Engineering Vol. 103, Proceedings of ENUMATH 2013, pp. 755-762, Springer, 2014.

AUTHORS

First Author*– Y. Amar Babu ,M. Tech, Machine Design, Department of Mechanical Engg, M.V.G.R.College of Engineering.
Second Author **– Dr. S. Adinarayana, Professor, HOD, Department of Mechanical Engg. M.V.G.R.College of Engineering.
Thrird Author **– Md. Yousuf Ali, Asst. Prof, Department of Mechanical Engg. M.V.G.R.College of Engineering.

Correspondence Author – Y. Amar Babu,yamarbabu@gmail.com