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Significance of Skeg in Course Stability using Computational Fluid Dynamics

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***Abstract* — All moving vehicles on the earth resist by the fluids which they are transmitting through. Fluids are of two types, liquids and gases. Resistance offered by the fluids depends on fluid properties, gases offer lower resistance than the liquids. All transporting and marine vehicles are subjected to various kind of resistance in which former is applicable to air resistance and latter is by fluid resistance. Moving bodies which are in direct contact with land , there is no point in considering course stability as it is zero or negligible, but for the moving bodies which floats on the fluid it is imperative to consider the course stability and calculated accordingly as proceeded or shown below, For ex: aerospace vehicles and moving marine vehicles. Course stability is the term which also means directional stability. The directional stability mainly depends on the geometry of moving body, environmental conditions also cause course deviation. Now a days marine vehicles are playing vital role to transport goods from one place to another. In the present study course study of ocean going barge is considered. Skeg is the sternward extensions to marine vehicles which is intended to keep the moving vehicle in straight path. Computations fluid dynamics (CFD) is the study of fluid flow around the objects which are subjected to fluid impact.**

Keywords — Resistance; Course stability; Barge; Skeg;

I.INTRODUCTION

i. Course stability

Course stability which means directional stability both in longitudinal and transverse direction of marine vehicles. Generally transverse directional stability is minor comparatively longitudinal directional stability, since dimensional variation and smooth profiles at stem and stern portions. A slight deflection in the course of marine vehicles by wind, wave or current may set up a condition of unbalance, moving the object sideways. This condition often shall induce an oscillating motion called yaw. In case of small amplitude of yaw, vessels may not affect the safety and performance, however it would be dangerous at large amplitudes. So it is necessary to oppose the course deviation of vessel from its original path by introducing course stabilizers.

Study of fluid flow properties is called computational fluid dynamics. To study the fluid flow around moving object there are several fluid software are available, out of these soft wares Ansys -FLUENT one of the user friendly and accurate. FLUIENT 14.0 is used to study the flow pattern around the skeg for present study.

ii. Skeg

Various devices have been developed and applied to stabilize the yaw motion. Compare to other developments, placing skeg found to be the more efficient to reduce yaw motion and to maintain course stability. Skeg is a sternward extension of the keel intended to keep the marine vehicles (ships, boats, barges etc...) moving straight and to protect the propeller and rudder from underwater obstructions. Skeg is the archaic concept as it was initially fitted to boats made up of wood. Later it was also applied to steel vessels. Skeg is required to place in front of the propeller for self-propelled vessels, and for towed vessels just behind the stern.

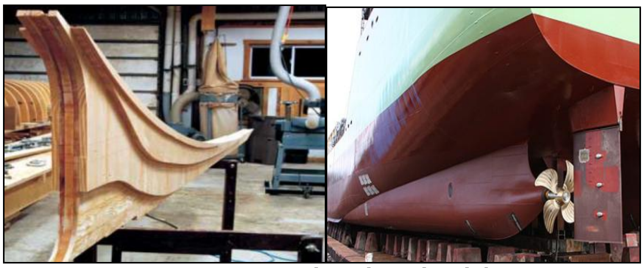

Figure 1 Conventional wooden and steel skeg

iii. Skeg role in course stability

Skeg improves the longitudinal directional stability of moving vessels. Because of a sudden change in the geometry of the stern profile, there is also a cause of geometrical change fluid flow at stern having turbulence properties. Turbulent flow creates currents at stern, inter-alia these currents reduce the vessel performance by reducing vessel speed. The main criteria behind this is skeg converts the turbulent flow in to laminar flow at stern.

Conventional skegs are like huge barn doors providing drag to keep the vessel towing linear/straight motion. Ocean going vessels are fitted with single skeg, and in the case of twin skeg there is a chance of skeg multiplying sometimes. For self-propelled vessels, the number of skegs depend on number of propellers in general. For ocean going towed vessels, the number of skegs depend on its dimensions, sometimes one may find vessels fitted with triple, multiple skegs as well.

iv. Course stability in other areas

Kayak **:** A lightweight narrow boat made with a light frame with a watertight covering having a small opening in the top to sit in. Skeg is employed to the kayak used on more open water such as sea and river. In the kayak the amount of the exposure of the skeg to the water and also its effect on the position of the boats center of lateral resistance (CLR) is freely adjustable by the crew. For kayak skeg plays vital role in course stability.

Figure 2 Conventional wooden kayak and skeg

Aircraft vertical stabilizer: The aircraft have two stabilizers at tail part those are horizontal and vertical stabilizers. Out of these two vertical stabilizer plays the role of skeg fir aircraft. The vertical stabilizer provides stability in yaw motion to conventional aircrafts. Skeg controls the yaw motion of aircrafts to maintain course stability.

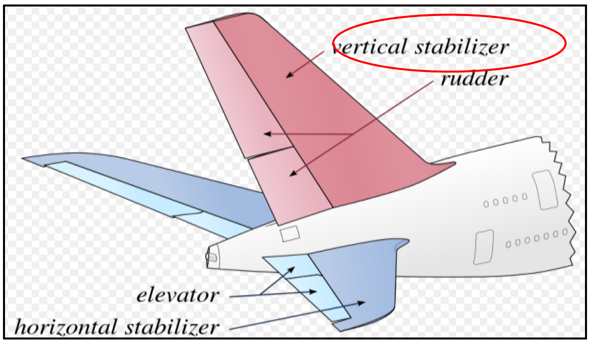

Figure 3 aircraft vertical stabilizer

Feather to arrow: Feathers at the tail of arrow acts like skegs to maintain the course stability. Skeg acts like stabilizer for barge similar manner as feathers add directional stability to an arrow.

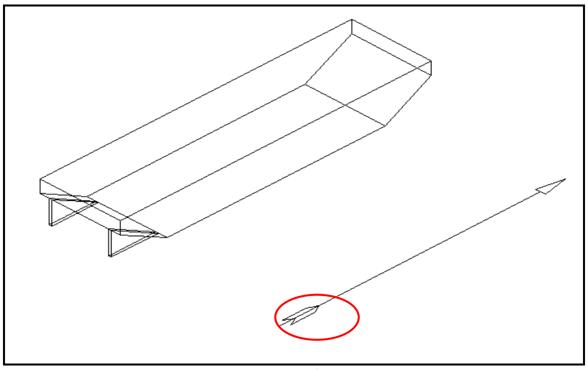

Figure 4 Feathers to arrow for directional stability

II. PROCEDURE

Skeg can be fixed to any ocean going vessels, but for the present study conventional ocean going barge is considered. To study the skeg role in directional stability two cases are considered. In the first case barge without skeg and in the second case barge with skeg is simulated with seawater as a fluid with a velocity of 12 knots (6.17 m/s). Barge dimensions considered for the present study, Length = 91.0 m, Breadth = 27.0 m, Draught = 6.2 m

III. MODELING AND BOUNDARY CONDITIONS

A cuboidal domain whose dimensions of 400 m x 120 m x 10 m respectively is created in AutoCAD to fit the barge inside the cuboidal domain. The important aspect while generation of domain is to ensure that, the walls has little effect on disturbance of flow around the barge, for this to achieve the length of domain must be at least three to four times the length of barge. Ansys Mesh tool is used for the meshing of computational domain. Non Uniform unstructured mesh elements have been used to divide the domain into small control volumes.

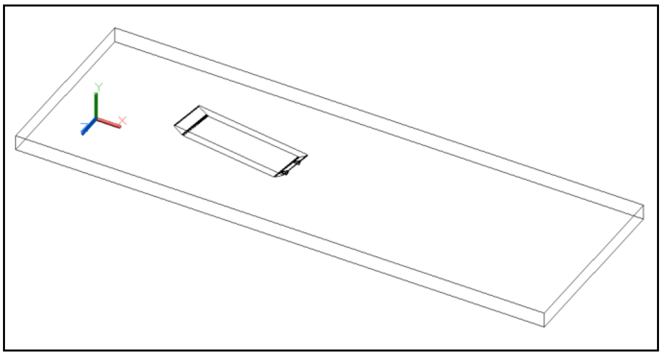

Figure 5 Barge & boundary model with skegs

The boundary conditions are given in the table1

Table-1

Boundary	Type
Left	Velocity inlet
Right	Pressure outlet
Barge surface	wall
Remaining sides	wall

In this work ANSYS 14.0 is used for performing simulations. The flow is assumed to be Incompressible, Pressure based, non-viscous and steady. *K-ω SST* (Shear Stress Transport) model is used as turbulent model for this setup.

Transport Equation for the SST k-ω model

$$\frac{\partial(\rho k)}{\partial t} + \frac{\partial(\rho k u_i)}{\partial x_i} = \frac{\partial\left(\Gamma_k \frac{\partial k}{\partial x_j}\right)}{\partial x_j} + G_k - Y_k + S_k$$

And

$$\frac{\partial(\rho \omega)}{\partial t} + \frac{\partial(\rho \omega u_j)}{\partial x_j} = \frac{\partial\left(\Gamma_\omega \frac{\partial \omega}{\partial x_j}\right)}{\partial x_j} + G_\omega - Y_\omega + S_\omega + D_\omega$$

In these equations G_k represents the generation of turbulence kinetic energy due to mean velocity gradients. G_ω represents the generation of ω, calculated as described for the standard k- ω model. Γ_k and Γ_ω represents the effective diffusivity of k-ω respectively. Y_k and Y_ω represents the dissipation of k and ω due to turbulence. Dω represents the cross diffusion term, calculated as described below. S_k and Sω are the user defined source terms.

IV. RESULTS AND DISCUSSION

Flow pattern: A particular type geometric distribution of the components is called flow pattern. Usually flow patterns are recognized by visual inspection. Fluid flow can differentiate in many ways, for the present study visual inspection is carried out based on streamlines and turbulence.

As mentioned earlier two cases are considered for CFD analysis, one is without skeg and the second one is with skeg. In the results streamlines and turbulence intensity are shown for better understanding the role of skeg in directional stability. Threes important physical observations are used to optimize the design for the stern hull form of vessels, 1. Stream line pattern inner and outer surface of stern skeg 2. The balance over the inner and outer skeg surface 3. Nominal wave distribution in the propeller plane for self-propelled vessels.

Results without skeg:

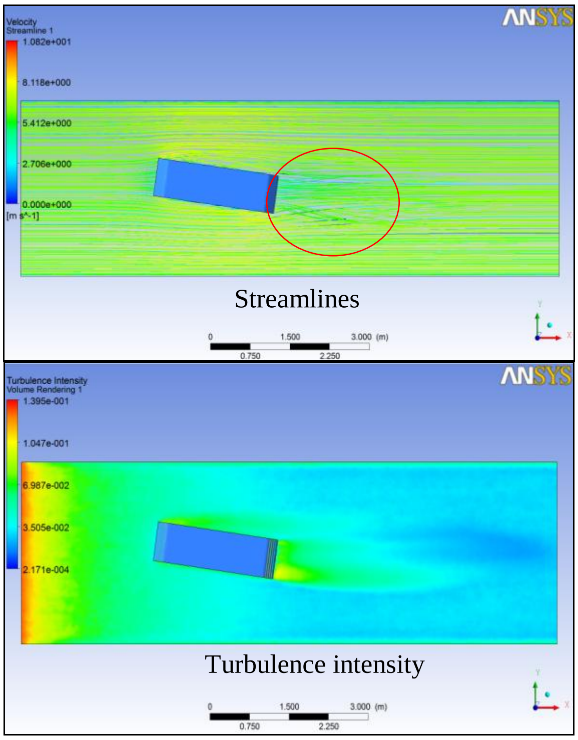

Figure 6 streamlines pattern and turbulence intensity on barge without skeg

Results with skeg:

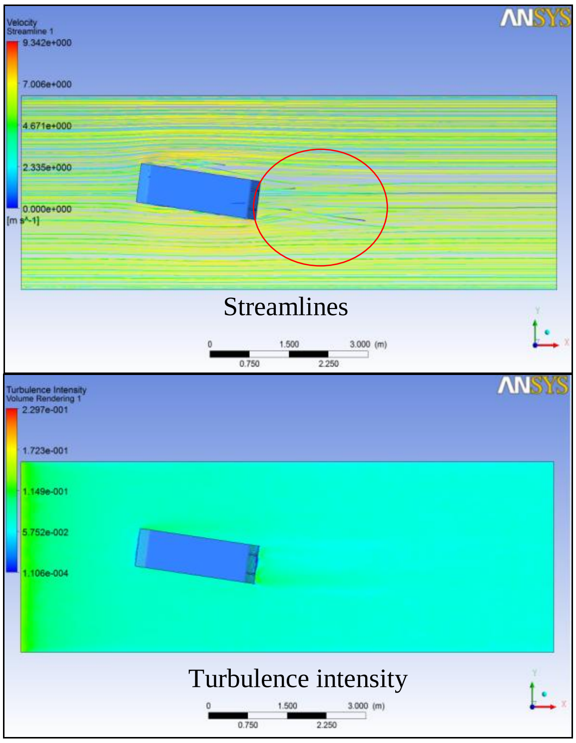

Figure 7 streamlines pattern and turbulence intensity on barge with skeg

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CONCLUSION

Stream line and turbulence intensity are given for two cases of analysed models with skeg and without skeg in figure 6 and figure 7 respectively. In the first case (results without skeg) by observing the stream lines pattern and turbulence intensity at stern profile, streamlines have curvature and turbulence have impact on the barge, so in turn these effects lead to course deviation from original course. In the second case (results with skeg) by observing the stream lines pattern and turbulence intensity at stern profile, streamlines are smooth profiles and turbulence impact on the barge is lesser comparatively with first case. So the presence of skeg changes the stream lines observed from curve profiles to smooth profiles and reduction in the turbulence impact on the side walls of the barge. So the conclusion and the bottom line of this paper is proved by which skeg maintains the course/directional stability.

V. REFERENCE

[1] The Free-stream characteristics of ship skeg – rudder – A.F. Molland
[2] The influence of skegs on course stability of a barge with a different configuration (Journal) – S.M Lee, C.K.Lee
[3] Hydrodynamics of high-speed marine vehicles – Odd M.Faltinsen
[4] Advanced skeg designs streamlines oceangoing barges – Alan Haig-Brown
[5] Ansys Fluent 14.0, "Theory guide", Chapter 4.4: Standard and SST k-ω turbulent models