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Wave making drag prediction for improved design of marine crafts

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Background

- With globalization and associated rising demand on transportation, the volume and size of the merchant fleet will also increase since the majority of goods are transported by sea.
- In shipping, a significant cost both to the ship owners and the environment is the fossil fuels used for propulsion. With the rising price of oil and the growing environmental concern, the motivation to reduce oil consumption has never been higher.

Motivation

- About 50% of the resistance of a fast container ship is due to wave resistance. This means that even a small reduction in the wave resistance can bring considerable reductions both in operating costs and emissions.
- When designing a ship it is important to be able to make fast and accurate prediction of its resistance so that more efficient hull forms can be selected early in the design process. A RANS solver based CFD software is still too time-consuming to be adopted in the initial design process

Figure 1: Left : Wave patterns behind sailing boats [1]
Right: Wave pattern behind a small boat [2]

Aim

- To develop an efficient numerical method for wave drag based on a dissipative potential theory

Objectives

- To derive a 3-D dissipative Green's function for free surface flow with forward speed.
- To formulate a numerical scheme of study within the frame work of a panel approach.
- To validate and tune the method for wave drag predictions with available data.

Method

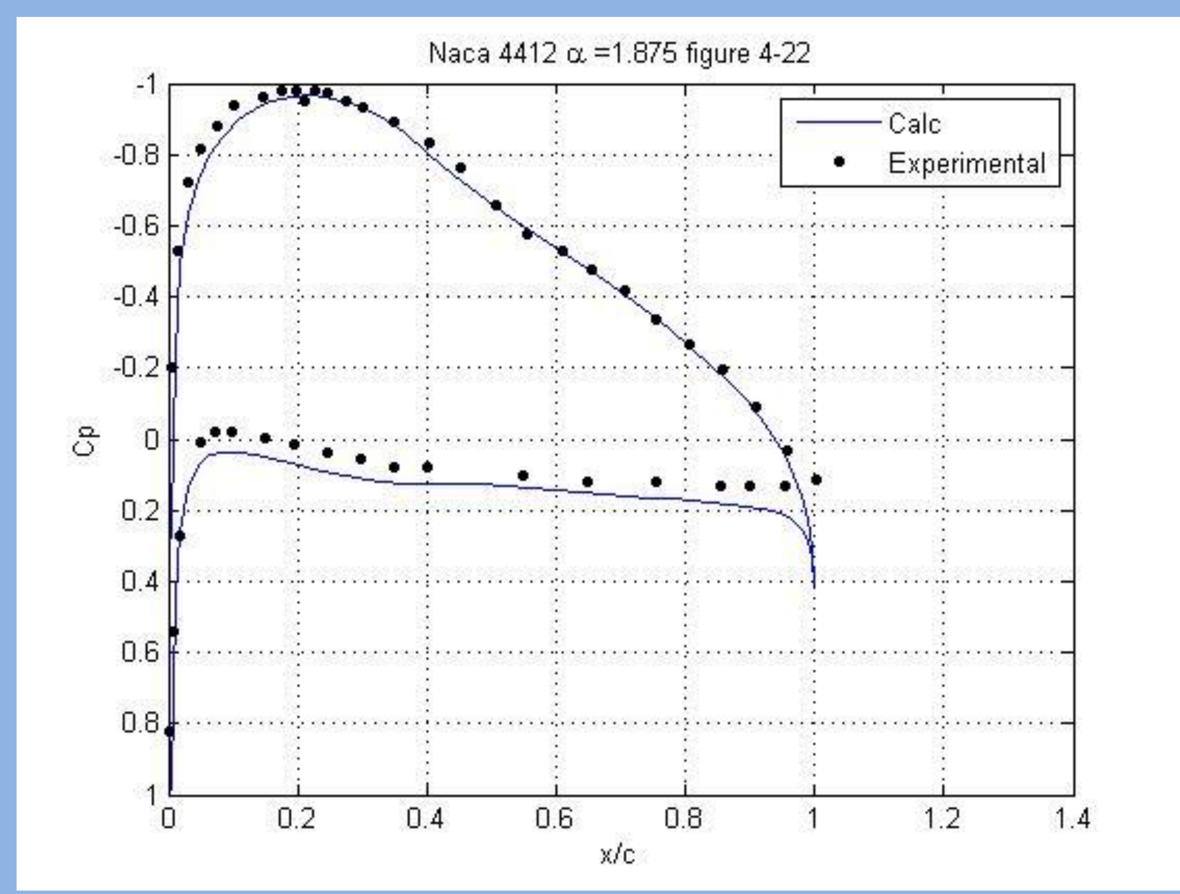
- The principal equation of incompressible fluid dynamics the Navier–Stokes equation will in 2D be

$$\underline{v}_t + \underline{v}\cdot\nabla\underline{v} + \frac{1}{\rho}\nabla p + \mu'\underline{v} - \upsilon\nabla^2\underline{v} = \underline{f}$$

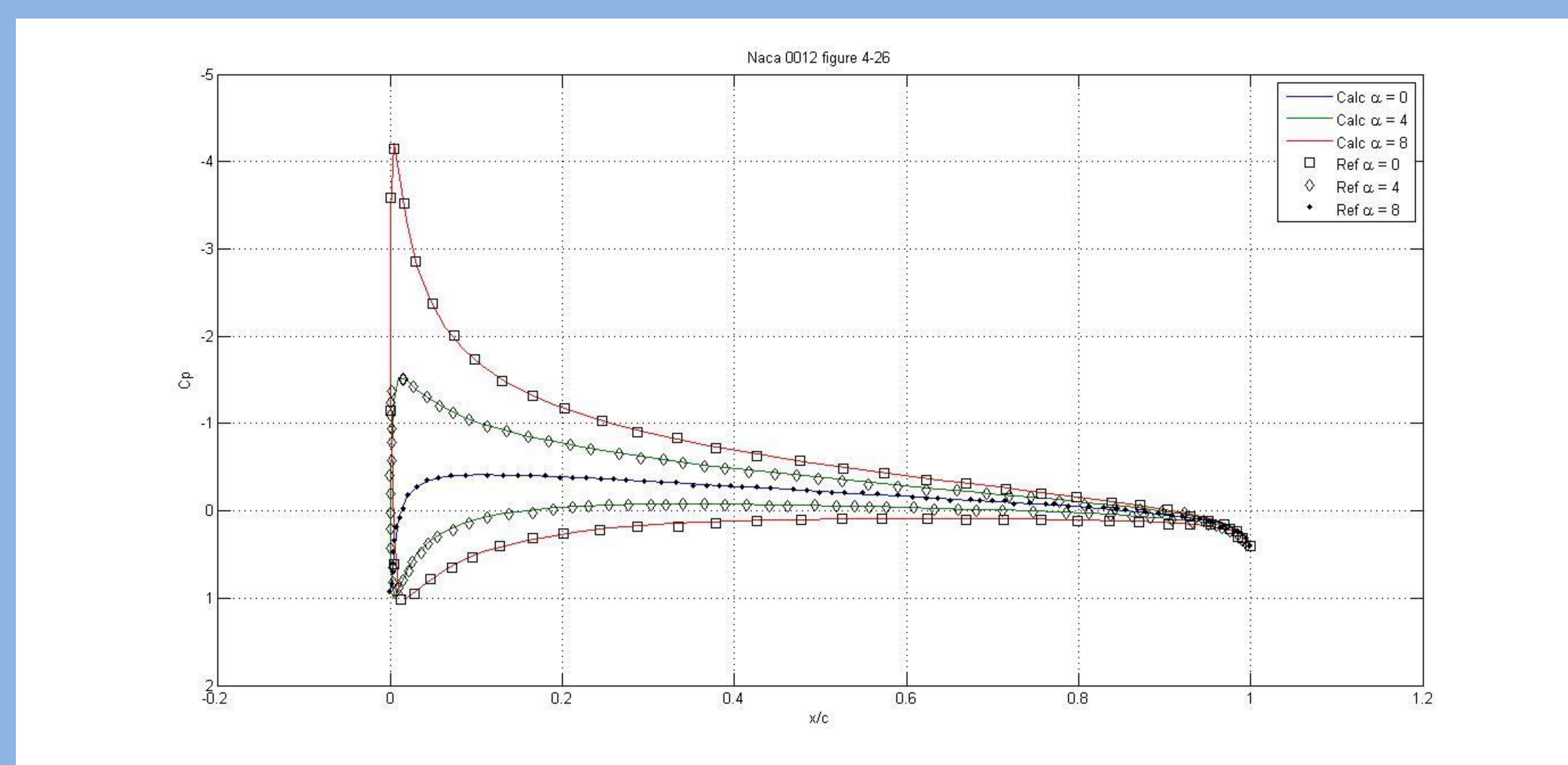
- Where $\mu'v$ is the Rayleigh parameter
- Potential flow assumptions but energy dissipation is present in the model.
- Panel approach using a new dissipative Green's function.

2D evaluation

- A single NACA hydrofoil is modelled in deep water
- Hydrofoils are suitable since the flow around a hydrofoil is stationary in the transverse direction and therefore suable for 2D evaluations. The shape is also commonly used which makes comparisons to excising models easy.



- Figure 2: The pressure on a NACA4412, cambered hydrofoil compare to experimental results by Mason [3]



- Figure 3: The pressure on a NACA 0012, a symmetric hydrofoil at different angles of attack compare to numerical results by Mason [3]

Outcome

- A fast and reasonably accurate method for ship wave drag prediction.
- A tool for early hull design or optimisation, capable of taking some finer features into consideration.

References

1. http://web.me.com/dtrapp/ePhysics.f/labVII_2.html
2. http://202.116.45.198/zrdlx/KC/zyk-06.html
3. http://www.aoe.vt.edu/~mason/Mason_f/CAtxtTop.html

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