"DESIGN & FABRICATION OF EXPERIMENTAL SET UP FOR VORTEX FLOW VISUALISATION"

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Abstract- In this paper, by using a towing tank surface visualization of vortex flows around simple geometrical bodies have been investigated to understand the basic nature of resistance offered by the flows to the moving body .Flow visualization is the process of making the physics of fluid flows (gases, liquids) visible .In this paper, we have explored a range of techniques for creating images of fluid flows .The work is motivated not just by the utility and importance of fluid flows, but also by the beauty. The Flow Visualization course is designed for mixed teams of engineering and fine arts photography and video, but anybody who has paid attention to the patterns while stirring milk into coffee or stared at the curl of a rising tendril of smoke has participated inflow visualization, and will understand the purpose of this paper. Surface flow visualization around 2D objects is used to determine qualitatively the extent of resistance offered by the flow to the motion of the body .Surface visualization can be achieved either by moving the flow around the body or by moving the body in a static fluid. In this paper, we explore a range of techniques for creating images of fluid flows. The work is motivated not just by the utility and importance of fluid flows, but also by the inherent beauty. Vortex flows Is very predominant in determining the resistance offered during the motion of a body in a medium. These flows have a characteristics which is independent of the media of the flow and its velocity, but depends only upon a parameter called Reynolds number which is a non dimensional number formed by the velocity, geometrical parameter and kinematic viscosity of the fluid. Surface streaks accurately map out

Keywords-vortex, Flow visualization, fluid behaviour, Streaklines, Dye-injector.

1 INTRODUCTION

Fluid dynamics, a vortex (plural vortices/vortexes) is a region in a fluid in which the flow revolves around an axis line, which may be straight or curved Vortices form in stirred fluids, and may be observed in smoke rings, whirlpools in the wake of a boat, and the winds surrounding a tropical cyclone, tornado or dust devil.

Vortices are a major component of turbulent flow. The distribution of velocity, vorticity (the curl of the flow velocity), as well as the concept of circulation are used to characterize vortices. In most vortices, the fluid flow velocity is greatest next to its axis and decreases in inverse proportion to the distance

Rotational vortices:-The one which has non zero vorticity away from the core can be indefinitely in that sate only.

from the axis. In the absence of external forces, viscous friction within the fluid tends to organize the flow into a collection of irrotational vortices, possibly superimposed to larger-scale flows, including larger-scale vortices. Once formed, vortices can move, stretch, twist, and interact in complex ways. A moving vortex carries with it some angular and linear momentum, energy, and mass.

Irrotational vortices:-In the absence of external forces, a vortex usually evolves fairly quickly toward the irrotational flow pattern, where the flow velocity *u* is inversely proportional to the distance *r*. Irrotational vortices are also called *free vortices*.

• Flow visualisation is important in both science and engineering

• From a "theoretical" study of o turbulence or o a fusion reactor plasma,

• to the "practical" design of o airplane wings or o jet nozzles.

• The main challenge

• Find ways to represent and visualize (very) large, multidimensional, multi-variety data. • Do this accurately, and

• Be computationally tractable

• Flow data in an N-dimensional space can be
• univariate (N-dimensional scalar fields),

• N-variate (N-dimensional vector fields) or even • N2-variate (N-dimensional second order tensor fields)

• Visualisation of results from a numerical flow simulation,

• Often a Computational Fluid Dynamics (CFD) calculation • CFD studies the flow of fluids in and around complex structures

2. BACKGROUND

• Large amounts of supercomputer time are often required to derive the scalar and vector data in the flow field

• Flow visualization will typically consist of 3 phases Grid generation, where the grid may be o rectilinear, o curvilinear, o unstructured, or a o hybrid - structured and unstructured. o Typically the calculation over 105-106 grid points Flow calculation

• Solution of a system of Navier-Stokes equations that simulate the flow conditions • computationally intensive –

• generates data for several quantities – typically, momentum, density, energy – and velocity

• Equations may be solved for 104+ time steps.

Visualization • Render results obtained from phases 1 and 2 into a form easily understood by humans

• We are already familiar with many of the issues associated with visualization

• Interactive visualization is not possible because of the size of the problem

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3. OBJECTIVE

- Study of flow behavior of water using dye
- Visualization of vertex flow bye dye method
- Design and fabrication of an experimental setup for vortex visualization

4. DESCRIPTION

TYPES OF VORTICES

Two types of vortices are distinguished in the dynamics of the motion: forced and free vortices. The forced vortex is caused by external forces on the fluid, such as the impeller of a pump, and the free vortex naturally occurs in the flow and can be observed in a drain or in the atmosphere of a tornado.

FREE VORTEX

A free vortex is formed when water flows out of a vessel through a central hole in the base . The degree of the rotation depends on the initial disturbance. In a free cylindrical vortex, the velocity varies inversely with the distance from the axis of rotation .

The equation governing the surface profile is derived from the Bernoulli's theorem:

$$\frac{v^2}{2g} + z = C \qquad (2)$$

Substituting Equation (1) into (2) will give a new expression:

$$\frac{k^2}{2gr^2} + z = C \qquad (3)$$

or:

$$C - z = \frac{k^2}{2gr^2} \qquad (4)$$

which is the equation of a *hyperbolic curve* of nature

This curve is asymptotic to the axis of rotation and to the horizontal plane through z=c.

FORCED VORTEX

When water is forced to rotate at a constant speed (ω) , the velocity will be also constant and equal to:

$$v = \omega r \qquad (5)$$

The velocity head (or kinetic energy) can be calculated as:

$$h_c = \frac{v^2}{2g} \qquad (6)$$

Substituting Equation (5) into (6) results in:

$$h_c = \frac{r^2\omega^2}{2g} \qquad (7)$$

If the horizontal plane passing through the lowest point of the vortex is selected as datum, the total energy is equal to:

$$H = h_o + h_c \qquad (8)$$

where h_o is the pressure head at the datum. Substituting h_c from Equation (7) into (8) gives:

$$H = h_o + \frac{r^2\omega^2}{2g} \qquad (9)$$

At *r=0: H=0*, therefore, $h_o=0$, and :

$$H = \frac{r^2\omega^2}{2g} \qquad (10)$$

4.1 Post- visualisation several approaches:

1. Load into memory as many time steps of the saved data as possible, • For small dataset o this approach is attractive, and o interactive visualization is possible • For large dataset o only an unacceptably small number of time steps can be loaded

2. Sub-samples the saved data at lower grid resolution so that more time steps can fit in memory • Not favored approach because • it is expensive to sub-sample, and • resolution of the flow is poor Important flow features, eg vortices, can be missed

3. Load into memory every step of the saved data without sub sampling • This requires that the system has enough memory to store at least a few time steps of the data • This approach of visualizing flow data at instants in time is sometimes referred to as instantaneous flow visualization.

Visualization mappings

• The process of visualization involves

• Data processing, which can involve

1. Interpolation
2. Filtering
3. Deriving fitted functions

* Visualization mapping – Translation of data into a suitable (iconic) representation (which involves deciding which features in the data are meaningful)

*Rendering – The generation of the final image that conveys the information to the user

- **Streamlines** – Streamlines at time t0 are curves that are everywhere tangential to the vector field v(x, t0). – A collection of such streamlines therefore provide an instantaneous “picture” of the flow at time t0
- In general, particle traces, streaklines, and streamlines are distinct from each other, but these 3 families of trajectories coincide in steady flows.
- Some important features that were 'hidden‘ before are now visible

- Particle traces are clearly better here.

5. CALCULATIONS

VOLUME OF TANK

V=(3.14*d^2*h)/4

Where,

D=diameter

h=height .

1m3=1000 ltr.

Trial 1:

D=0.45m , h=0.914m

V=(3.14*(0.45)^2*0.914)/4

V=0.15 m^3

V=150 ltrs.

Trial 2,

D=0.3m , h=0.762m

V=(3.14*(0.3)^2*0.762)

V=0.05 m^3

V=50 ltrs.

GLASS:POLYMER GLASS

(TRANSPERENT)

GLASS SIZE:

d=0.3m

h=0.762m
PUMP:0.5 HP

6. FUTURE SCOPE

1. Flow visualization may be carried out using appropriate flow visualization technique.

2. The flow may be surveyed within the casing of different shape and behavior may be determined within the volute at different rotational speed .

3. It can be used to clean the dust from the lake .

7. CONCLUSIONS

1. Based on the literature review we have produced the material for fabrication of model.

2. All the parts are connected such a way that it can be rearranged for different stages , we can study vortex flow of visualization.

3. The results collected from above study, can be used to study the nature of fluid.

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7. Flow visualization may be carried out using appropriate flow visualization technique

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