SNS COLLEGE OF TECHNOLOGY, COIMBATORE-35

DEPARTMENT OF MECHANICAL ENGINEERING

Fluid Mechanics and Machinery –

UNIT 3 FLOW OVER FLAT PLATE AND FLOW THROUGH CIRCULAR CONDUITS

Topic - Flow over a Cylinder – CBS

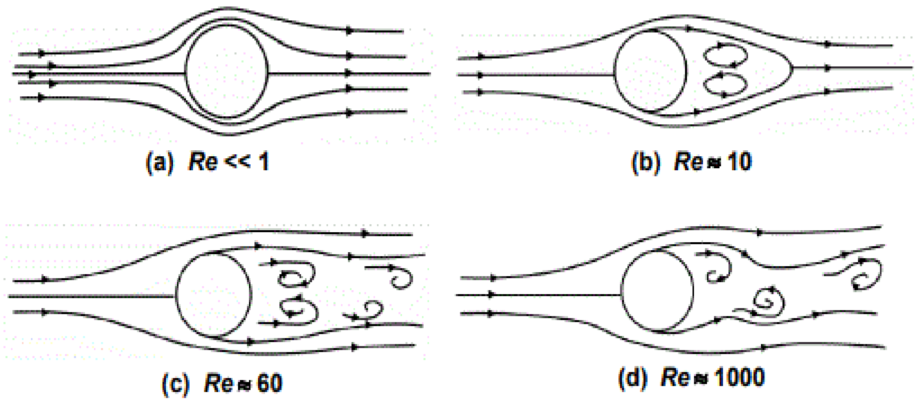

Figure 1. Flow pattern generated around a circular cylinder

From the literature:

Viscous flow around a cylinder has been an oft studied topic in the fluid community.

One of the first well-known cases of studying flow around a cylinder was carried out by Hiemenz (1911), who took quantitative measurements of the pressure around a cylinder.

Later, Homann (1936) used oil to visualize the fluid flow around cylinders.

Tests of flow around a cylinder, such as via simulations, have piqued the imagination of many scientists and engineers, and thus have continued to this day.

Flow around a circular cylinder is a fundamental fluid mechanics problem of practical importance. It has potential relevance to a large number of practical applications such as submarines, off shore structures, bridge piers, pipelines etc.

The laminar and turbulent unsteady viscous flow behind a circular cylinder has been the subject of numerous experimental and numerical studies, especially from the hydrodynamics point of view.

According to the observation of Sumer (1997); the flow field over the circular cylinder is symmetric at low values of Reynolds number.

As the Reynolds number increases, flow begins to separate

Different Patterns Observed from the literature:

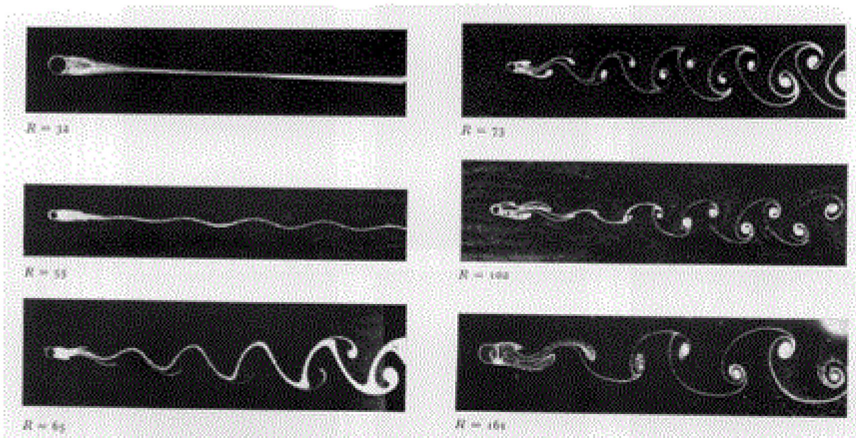

Fig. 1.—: Viscous flow around a cylinder for high Reynolds number. Originally from Homann (1936), but reproduced from Batchelor (1967).

behind the cylinder causing vortex shedding which is an unsteady phenomenon.

For the 40 < Re < 200, there is a laminar vortex shedding in the wake of the cylinder. The laminar wake transient to turbulence in the region of Re = 200 to 300.

In the subcritical region 300 < Re < 3×105 the wake behind the circular cylinder becomes completely turbulent and a laminar boundary layer separation occurs.

The unsteady flow was first studied by Payne (1958) for Reynolds number equal to 40 & 100.

The numerical study and physical analysis of the pressure and velocity fields in the near wake of a circular cylinder has been investigated by Braza *et al* (1986). Tuann & Olson (1978), Martinez

& Minh (1978), Loc (1980), Coutanceau & Defaye (1991) and recently Lakshmipathy (2004) and Reichl *et al.* (2005) have investigated this problem for different Reynolds numbers. Braza *et al* (1990) predicted the large-scale transition features in the wake of a circular cylinder for 2000 < Re < 10000.

The turbulent flow over cylinder was also investigated by Rai & Moin (1993) and Mittal (1995) for high Reynolds number.

The common points of interest of this work are the development of the primary unsteady wake behind the circular cylinder and the evaluation of the drag coefficient and the separation angle with time.

Most of the experimental studies investigated the steady and unsteady behaviors of the alternating vortices in the wake. The work of Tritton (1971), Lourenco & Shih (1993),and Anderson (1995) should be mentioned. Besides these theoretical and numerical investigations, some experimental visualizations have been described by Honji & Taneda (1969), Beaudan & Moin (1994) and Coutanceau & Bouard (1977).

All of the above numerical studies have some common characteristics: they solve the unsteady Navier- Stokes equation in two dimensional Helmholdtz (vorticity & stream function) formulation; they described the relevant flow by the global parameters such as Strouhal number as a main feature of the unsteady wake, drag and lift coefficients in the wall region; nevertheless, poor analysis is provided for the near wake characteristics.

The main goal of the present study is consequently to

(i) visualize the laminar and turbulent unsteady flow field for different Reynolds numbers;
(ii) check the capability of different turbulent models for the simulation the unsteady flow over circular cylinder.

(iii) compute drag coefficients along the surfaces of the cylinder for different Reynolds numbers;

(iv) plot contours of stream function, velocity vectors and static pressure to visualize vortex shedding at different time for Re=100, 1000 & 3900. Numerical results presented here are compared with experimental measurements and other numerical results and the agreements are found satisfactory.

Flow over cylinders: video

https://www.youtube.com/watch?v=8WtEuw0GLg0

Flow past a sphere at 10,000 Reynolds number

https://www.youtube.com/watch?v=2V5FufQKSr0

CFD Visualization Comparing Turbulent Vortex Shedding Between a Sphere and Golf Ball

https://www.youtube.com/watch?v=GHOoZYhF6r4

Direct Numerical Simulation of a NACA 0012 airfoil flow at M=0.4, Re=50.000, α=5°

https://www.youtube.com/watch?v=AfAM6mfuN3c