AE 312 – SHEAR FLOWS

Course Project

Flow control strategies to mitigate Boundary Layer Separation

Members

Aatif Hasan - 220018

Ajay Singh - 220089

Aryan Gautam - 220222

Bhooshi Anirudh - 220298

Gorre Karthik - 220412

Surendra Prasad - 221108

Abstract

The boundary layer is a thin region of fluid near a solid surface where viscous effects play a significant role. This concept emerged when inviscid flow models failed to predict drag, flow separation, and lift generation on air foils. The boundary layer is proposed to exist near solid surfaces where viscosity dominates.

Boundary layer separation is a fundamental issue in fluid mechanics that significantly impacts aerodynamics, drag, and efficiency in engineering applications. Separation occurs when the fluid flow near a surface loses momentum due to an adverse pressure gradient, causing it to detach from the surface. This leads to increased drag, loss of lift, and reduced efficiency.

Various passive and active control techniques can be employed to delay or prevent separation. Passive control methods naturally modify the flow without additional energy input; examples include vortex generators, porous walls with suction, and leading-edge extensions. Active control methods require energy to manipulate the boundary layer, such as rotating cylinders, plasma actuators, and oscillating walls. By implementing these passive and active control strategies, we can delay the separation point in the boundary layer, which will help reduce drag, improve lift, enhance noise reduction, and increase stability.

Motivation and Background

In aerodynamics, the problem of boundary layer separation is very important. It makes many engineering systems work inefficient, like airplanes, wind turbines, and cars. When the

boundary layer separates from the surface, it causes more drag, less lift, and makes the flow unstable. This is bad for performance and control.

To fix this, people use flow control strategies. Some are simple and don't need extra energy, like vortex generators or changing the surface shape. Others are more active, like suction, blowing, or plasma actuators, which can change the flow as needed. These methods are studied a lot today to make things more efficient, stable, and better in performance.

This topic is useful in many areas. For airplanes, good flow control can save fuel and help with handling. For wind turbines, less separation means more energy. For cars, less drag means better fuel use. By looking at different flow control ways, this project wants to help make better and cleaner aerodynamic solutions.

Methodology

Major publications relevant to the study of boundary layer dynamics and control include the following

Rotating cylinder mounted near trailing edge

The Effects of rotation on boundary layers in Turbomachinery rotors

Vortex generators to control boundary-layer separation

Morphing

Plasma Actuator

Suction and blowing

Timeline: Click here

Gantt Chart