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CFD models utilizing algebraic mixing length models

Computational Fluid Dynamics (CFD) has revolutionized the way engineers and scientists understand fluid flow phenomena. Within CFD, one prevalent approach involves the utilization of algebraic mixing length models, which are particularly useful for turbulent flow simulations.

Turbulent flows are characterized by chaotic, irregular motion, making them notoriously challenging to model accurately. In many cases, directly resolving all the turbulent scales in a flow is computationally infeasible due to the immense range of length and time scales involved. Instead, turbulence models, such as algebraic mixing length models, provide a pragmatic compromise between computational cost and accuracy.

The fundamental concept behind algebraic mixing length models stems from the idea of eddy viscosity. In these models, the turbulent viscosity is represented as a function of the local flow properties, typically the velocity gradients. The key assumption is that the eddy viscosity is proportional to a characteristic length scale in the flow and the rate of strain. The proportionality constant is often determined empirically or calibrated based on experimental data.

One of the most well-known algebraic mixing length models is the Prandtl mixing length model. In this model, the eddy viscosity is related to the local velocity gradient through a characteristic length scale, known as the mixing length. The mixing length is assumed to be proportional to the distance from the wall in wall-bounded flows or some characteristic length scale in free shear flows.

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$$\nu_t = l_m^2 \left| \frac{\partial u}{\partial y} \right|$$

Where:

- ν_t is the eddy viscosity,
- l_m is the mixing length,
- $\frac{\partial u}{\partial y}$ represents the velocity gradient in the direction normal to the flow.