

Consider the flow past a spinning cylinder. In a real fluid, the angular motion would act to impart a net circulation to the flow through the action of the fluid viscosity. This circulation (denoted by the constant Γ) may be incorporated artificially into an irrotational flow model by adding an irrotational vortex potential $\Phi = -\theta\Gamma/(2\pi)$ to the velocity potential deduced for potential flow over a cylinder. So the total potential will be of this form:

$$\Phi = U \left(r + \frac{a^2}{r} \right) \cos\theta - \theta\Gamma/(2\pi)$$

- (a) Calculate an expression for the resulting velocity field.
- (b) By examining the location of stagnation points in the flow, deduce the dependence of the form of the flow on the dimensionless spin number $S = \Gamma/(4\pi aU)$, and make rough sketches of the flow for $S < 1$, $S = 1$ and $S > 1$.
- (c) Demonstrate that the drag on the cylinder still vanishes regardless of the spin number.
- (d) Deduce an expression for the transverse force (or “lift”) on the cylinder.

Note: the generation of lift through the interaction of circulation and translation is the root of many interesting phenomena in the dynamics of sports (generically known as the Magnus Effect).

MIT OpenCourseWare
<http://ocw.mit.edu>

2.25 Advanced Fluid Mechanics
Fall 2013

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.