

4.36

4.36 A nozzle is designed to accelerate the fluid from V_1 to V_2 in a linear fashion. That is, V=ax+b, where a and b are constants. If the flow is constant with $V_1=10$ m/s at $x_1=0$ and $V_2=25$ m/s at $x_2=1$ m, determine the local acceleration, the convective acceleration, and the acceleration of the fluid at points (1) and (2).

With u=ax+b, v=0, and w=0 the acceleration $\vec{a}=\frac{\partial \vec{V}}{\partial t}+\vec{V}\cdot \nabla \vec{V}$ can be written as

 $\vec{a} = a_x \hat{c}$ where $a_x = u \frac{\partial u}{\partial x}$. (1)

Since $u = V_1 = 10 \frac{m}{s}$ at x = 0 and $u = V_2 = 25 \frac{m}{s}$ at x = 1 we obtain 10 = 0 + b

25 = a + b so that a = 15 and b = 10

That is, $u = (15x+10)\frac{m}{s}$, where $x \sim m$, so that from Eq.(1)

 $a_X = (15x+10) \frac{m}{s} (15\frac{1}{s}) = (225x+150) \frac{m}{s^2}$

Note: The local acceleration is zero, $\frac{\partial \vec{V}}{\partial t} = 0$, and the convective acceleration is $u \frac{\partial u}{\partial x} \hat{i} = (225x+150) \hat{i} \frac{m}{s^2}$

At x = 0, $\vec{a} = 150 \hat{i} \frac{m}{S^2}$; at x = 1m, $\vec{a} = 375 \hat{i} \frac{m}{S^2}$