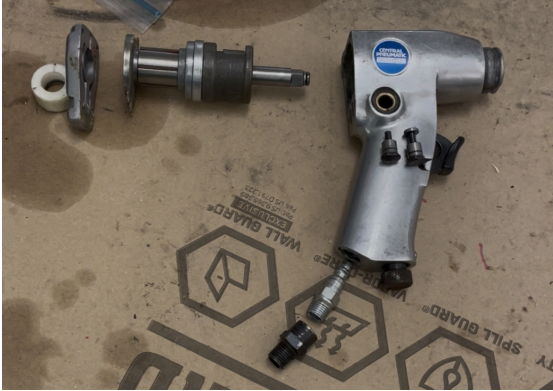


Fluid Mechanics Dissection



For this project, me and a group of students were tasked with dissecting a random mechanical object. The object we ended up dissecting was a pneumatic impact wrench. The goal was to understand how the object works using knowledge from fluid mechanics.

In addition to this, we made a 4 minute video explaining the fluid-dynamic operation of the tool—including mass-flow-rate control, the ideal gas law, and pressure-to-torque conversion inside the vane motor.

Throughout this project, I contributed through disassembly of the torque wrench, equation deriving, and presentation.

<https://youtu.be/fv1IIAWsVhk>

$T_{max} = 75 \text{ ft}\cdot\text{lb} = 900 \text{ in}\cdot\text{lb}$
 $\Delta p = \frac{1}{2} (U_{out}^2 - U_{in}^2) \rho \quad U_{out} = \sqrt{\frac{2\Delta p}{\rho} + U_{in}^2}$
 $T = \dot{m} (r_{out} U_{out} - r_{in} U_{in})$
 $\dot{m} = \rho A U = \rho Q$
 $\dot{m}_0 = \rho Q_0 = \rho A U_0$
 $U_{in} = \frac{\dot{m}_0}{\rho A}$
 $T = \dot{m}_0 \left[r_{out} \left(\frac{2P_1 \left(\frac{r_{out}}{r_{in}} - 1 \right)}{\rho} + \left(\frac{\dot{m}_0}{\rho A} \right)^2 \right)^{\frac{1}{2}} - r_{in} \left(\frac{\dot{m}_0}{\rho A} \right) \right]$
 $T = \rho Q_0 \left[r_{out} \left(\frac{2P_1 \left(\frac{r_{out}}{r_{in}} - 1 \right)}{\rho} + \left(\frac{Q_0}{A} \right)^2 \right)^{\frac{1}{2}} - r_{in} \left(\frac{Q_0}{A} \right) \right] \text{ ①}$
 $r_{out} = 0.3 \quad A = 0.13 \text{ in}^2 \quad Q_0 = 4 \frac{\text{ft}^3}{\text{min}} = 115.2 \frac{\text{in}^3}{\text{s}}$
 $r_{in} = 0.2 \quad U_0 = 30 \frac{\text{ft}}{\text{s}} = 360 \frac{\text{in}}{\text{s}}$
 $\rho = 0.0765 \frac{\text{lb}}{\text{ft}^3} = 0.00044 \frac{\text{lb}}{\text{in}^3}$
 $\Delta p = P_2 - P_1$
 $P_1 V_1 = P_2 V_2$
 $P_2 = P_1 \frac{V_1}{V_2}$
 $\Delta p = P_1 \left(\frac{V_1}{V_2} - 1 \right) = P_1 \left(\frac{r_{in}}{r_{out}} - 1 \right)$
 $P_1 - P_2 = \frac{1}{2} \rho (U_{in}^2 - U_{out}^2)$
 $P_1 = \frac{1}{2} \rho (U_{out}^2 - U_{in}^2) + P_2$
 $P_1 = \frac{1}{2} \rho \left(\left(\frac{Q_0}{A} \right)^2 - U_0^2 \right) + P_2 \text{ ②}$
 $\text{①} + \text{②} \Rightarrow T \approx 800 \text{ in}\cdot\text{lb}$
 $A = \pi \left(\frac{0.4}{2} \right)^2 \text{ in}^2$
 $A = 0.04\pi \text{ in}^2$
 $A = 0.13 \text{ in}^2$