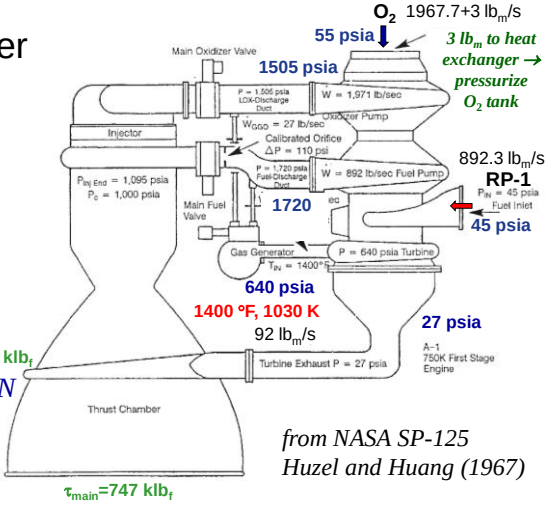
Example: A-1 Pump/Turbine Analysis

- Recall A-1 booster engine
  - gas-generator
  - single-turbine
  - RP-1/LOX
  - 262.3 s
  - 165 s duration
  - 750 klb_f 3.34 MN
- Turbomachinery power ?



from NASA SP-125 Huzel and Huang (1967)

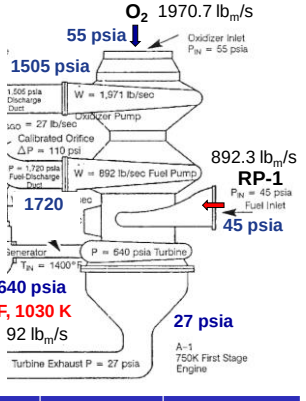
Pump Requirements

- How much power into pumps?
- **Fuel** $\Delta p_{\substack{fuel\\pump}} = 1675\,psia$ 11.55 MPa

$$H_{\substack{fuel\\pump}} = \frac{\Delta p}{\rho g_o} = 4781\,ft \quad 1.457\ km$$

$$\dot{W}_{p,\,fuel} = 6.483\times10^5\,\frac{ftlb_f}{s} = 11790\,HP \quad 8.791\ MW$$

$$HP = 550\ ftlb_f/s$$



- **Oxidizer** $\Delta p_{\substack{oxy\\pump}} = 1450\,psia$ 9.997 MPa

$$\dot{W}_{p,oxy} = 8.154\times10^6\ ftlb_f/s = 14820\,HP \quad 11.05\ MW$$

	LO_2	RP-1
ρ lb_m/ft^3 (kg/m³)	71.38 (1143)	50.45 (808.1)
Pump Efficiency %	70.7	65.8

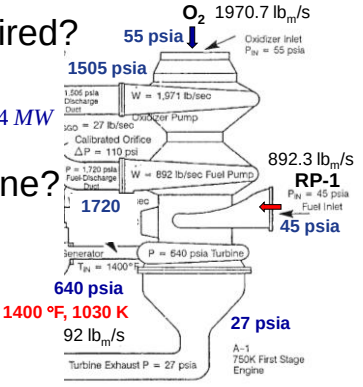
Turbine Requirements

- Minimum turbine power required?

$$\dot{W}_t \geq \dot{W}_{p,\,fuel} + \dot{W}_{p,oxy}$$

$$\geq 14.64\times10^6 \; ftlb_f/s = 26610 HP$$ 19.84 *MW*

- How much power out of turbine?



Turbine Requirements

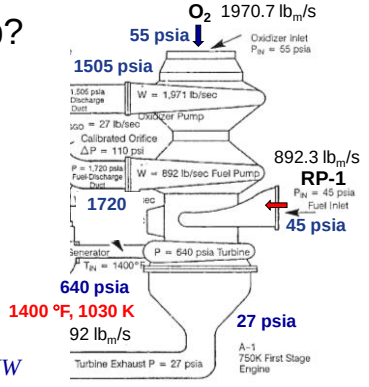
- Required turbine press. drop?

$$Pr_t =$$

$$\geq 22.1 \qquad Pr_{t,actual} = \frac{640}{27} = 23.7$$

$$\dot{W}_{t,actual} = 27110 HP$$ 20.22 *MW*

$$\dot{W}_t - \dot{W}_p = 500 HP$$ ***WHY?***



Turbine Effic. %	58.2