Rotational Compressor Valve

Group 18:
Alejandro Castro
Sam Leuthold
Andrew Borger

GE Oil & Gas

GE Sponsor: Todd Hopwood
Faculty Advisor: Dr. Van Sciver

Overview

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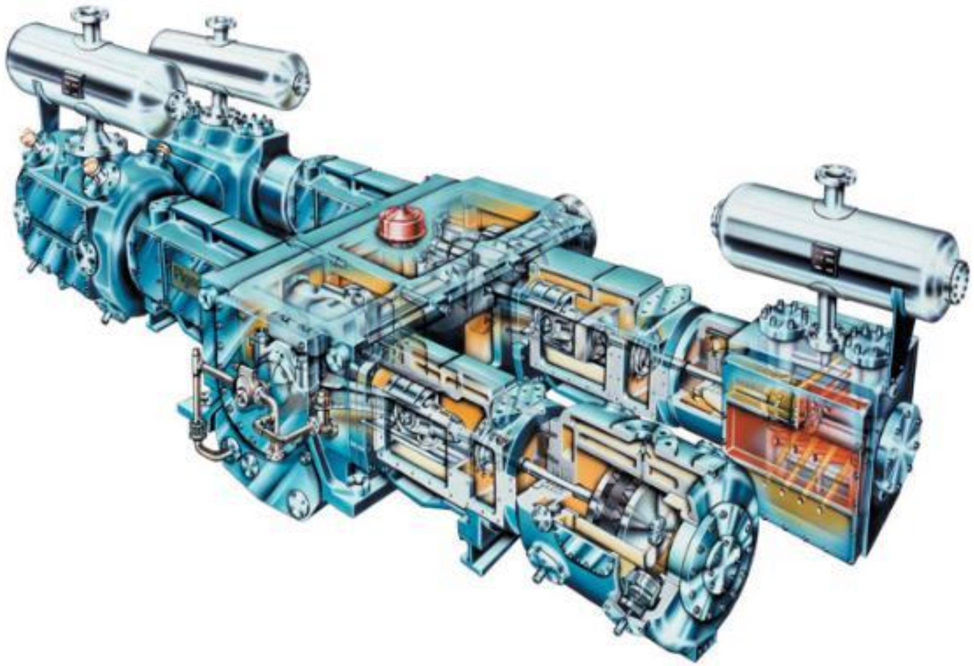
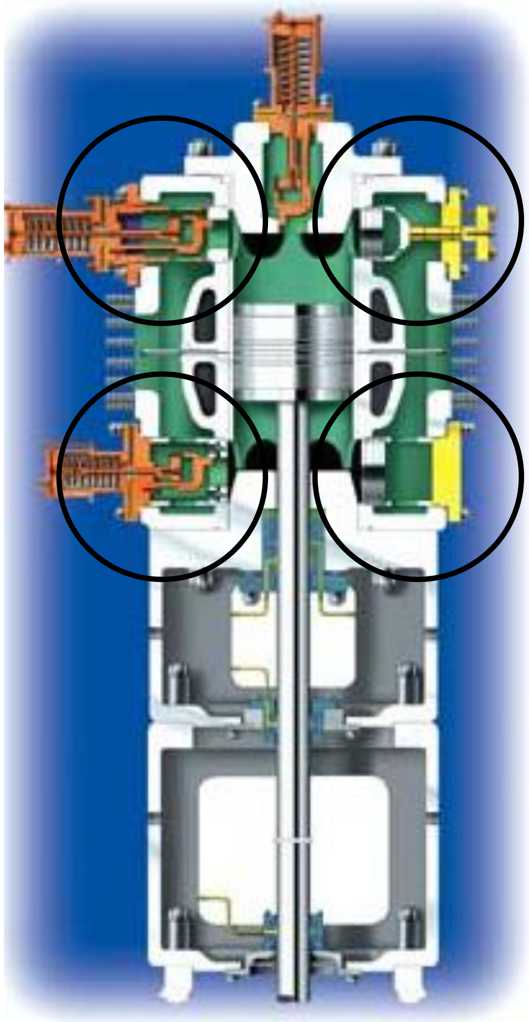
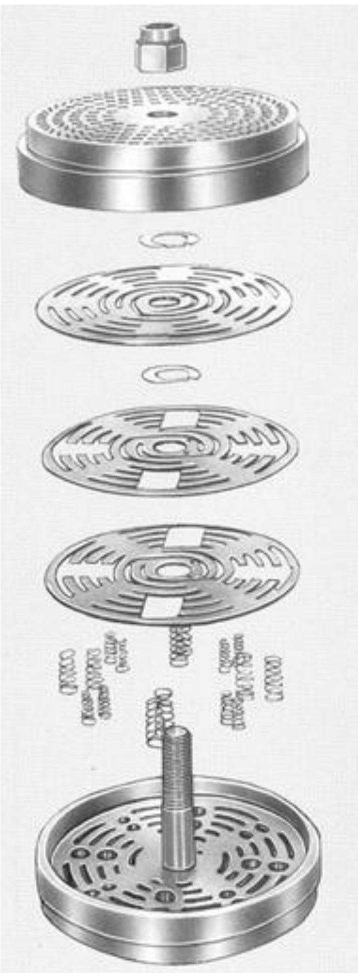
Application





Current Valves

Plate Valves



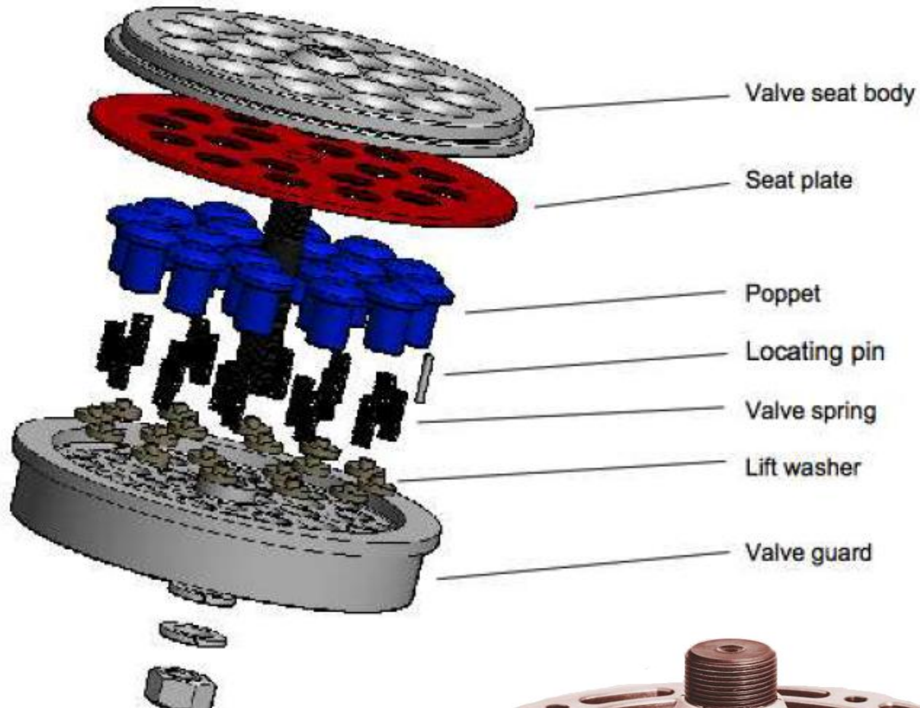
Valve Seat

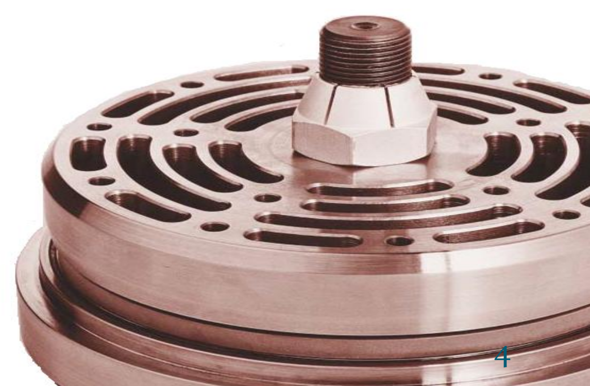
Valve Shutter

Valve Springs

Valve Stop

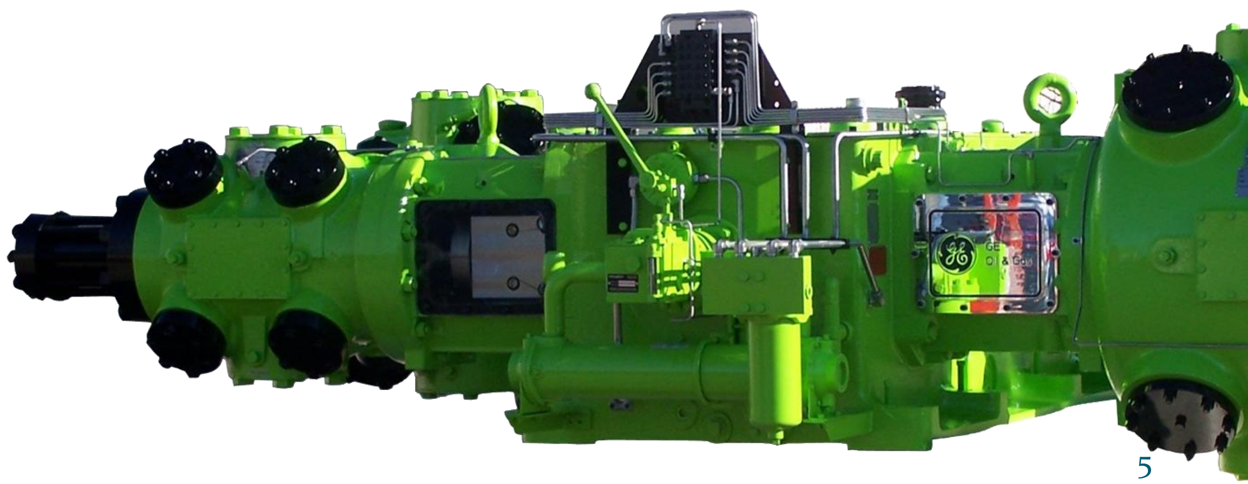
Poppet Valves





Problem Statement

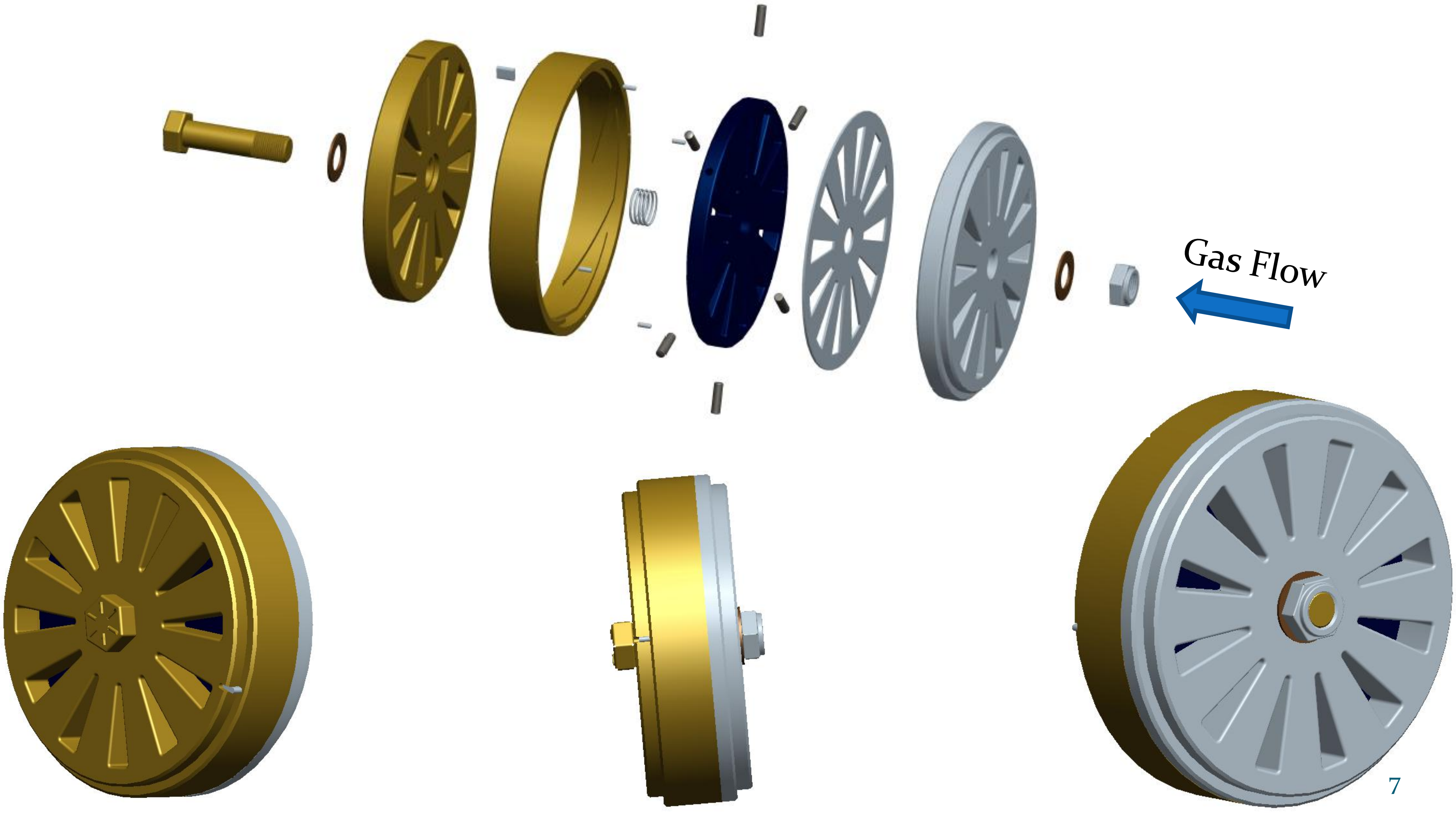
- Reciprocating compressors move large volumes of natural gas
- Current compressor valves are reliable but inefficient
- Inefficiencies caused from indirect flow path
- Project Goal: Obtain direct flow with a rotational type valve



Project Scope

- Must operate in a rotational manner and obtain direct flow
- Operate at pressures between 30 psi and 600 psi
- Materials must be able to withstand temperatures approaching 350F
- Modifiable to fit all current gas compressors used by G.E.
- Is to be easily replaced
- $2000 budget

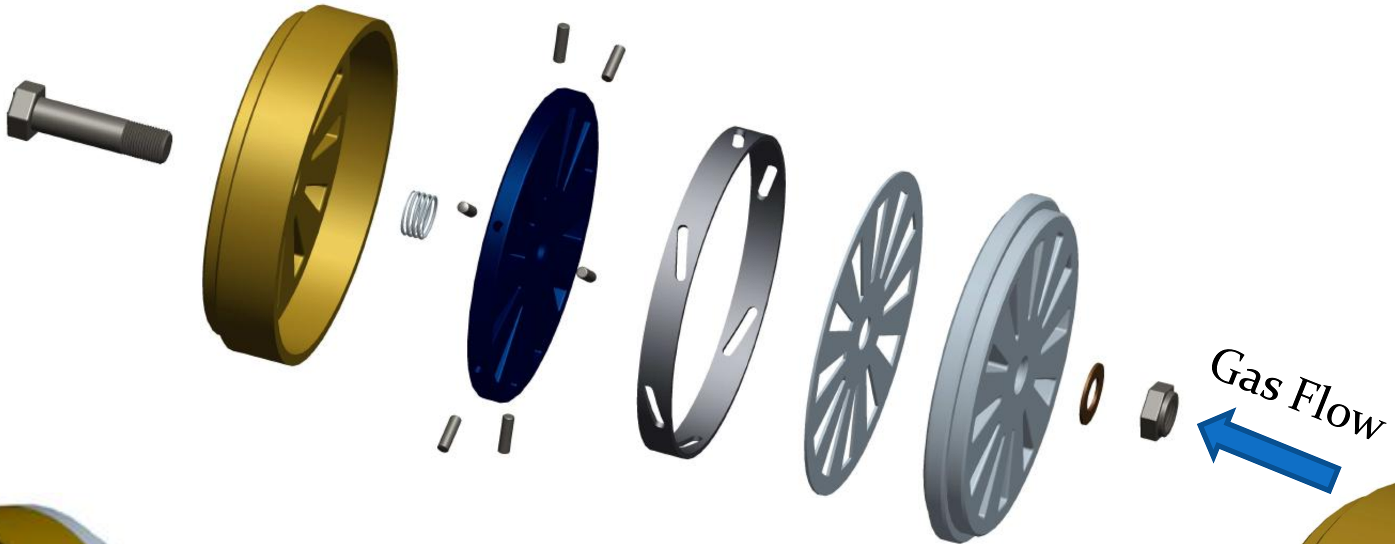
Final Design(initial)

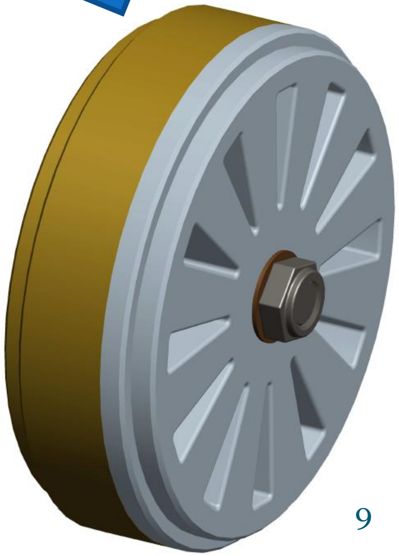


Problems Encountered

- Machining of the threads on the outer housing would have been overly complicated
- A separate threaded insert needed to be designed
- Thickness of back plate needed to be minimized to be easily milled
- Prototype materials have been changed from production materials due to cost

Final Design(Modified)

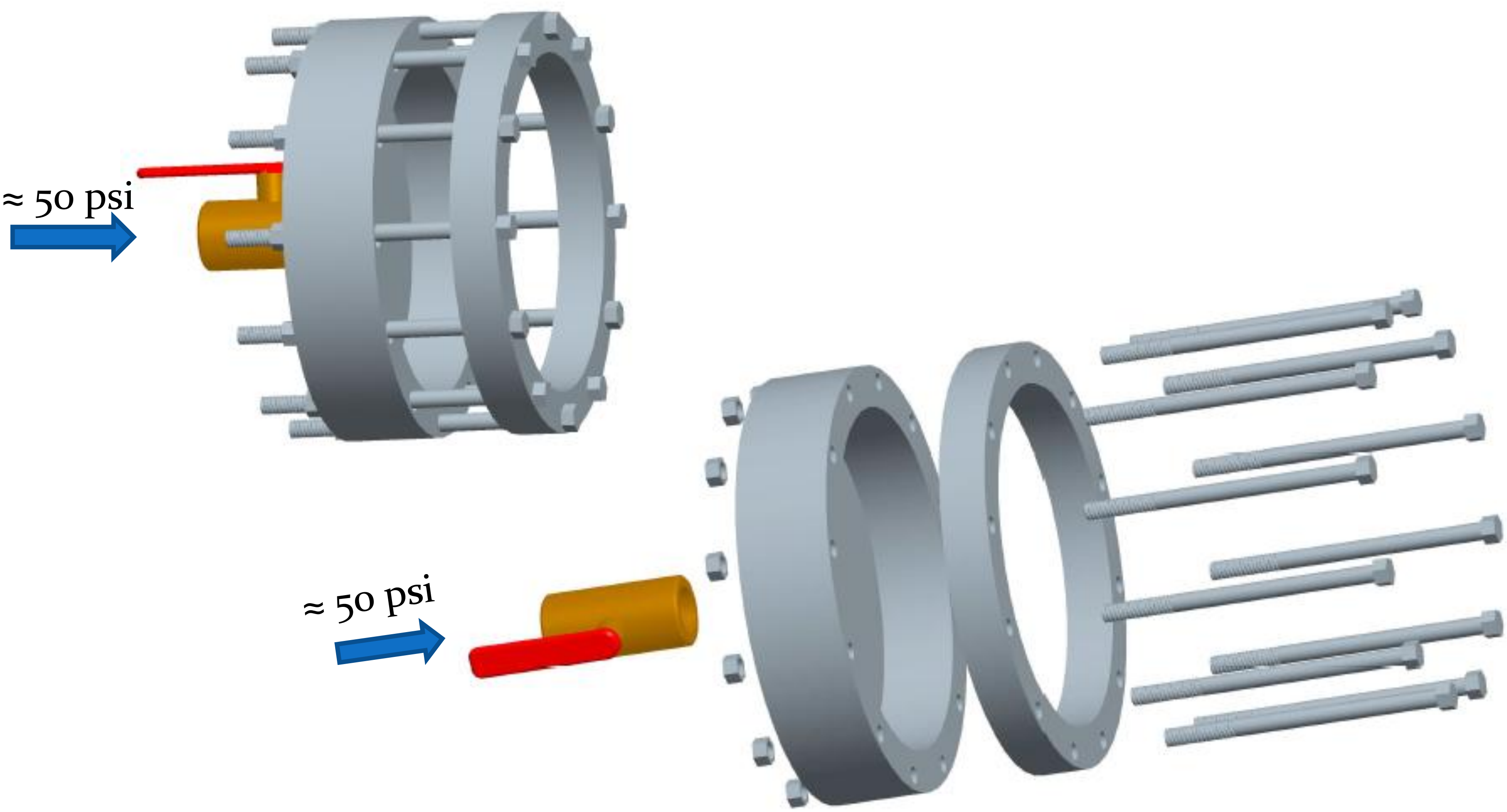




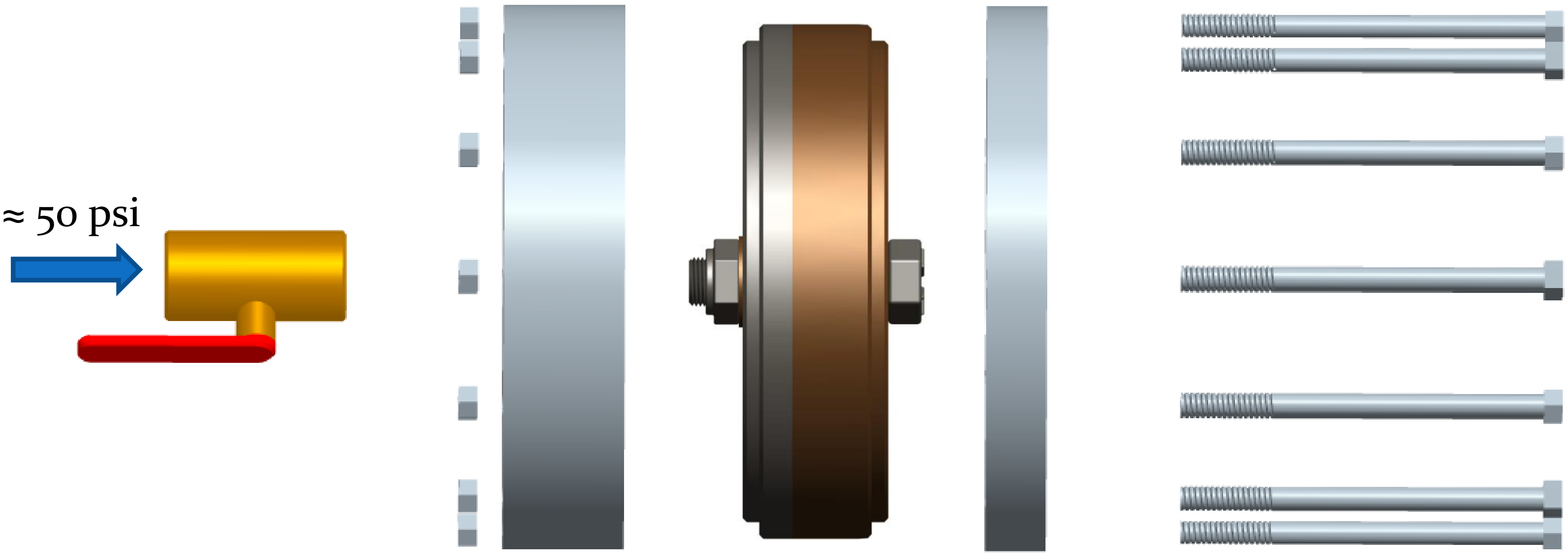
Current Progress(update)

- Final design changes have been made for ease of machining
- Valve machining in progress
- Materials for test rig in process of being ordered: $438.43
- Materials for flow visualization have been ordered: $243.67

Test Rig

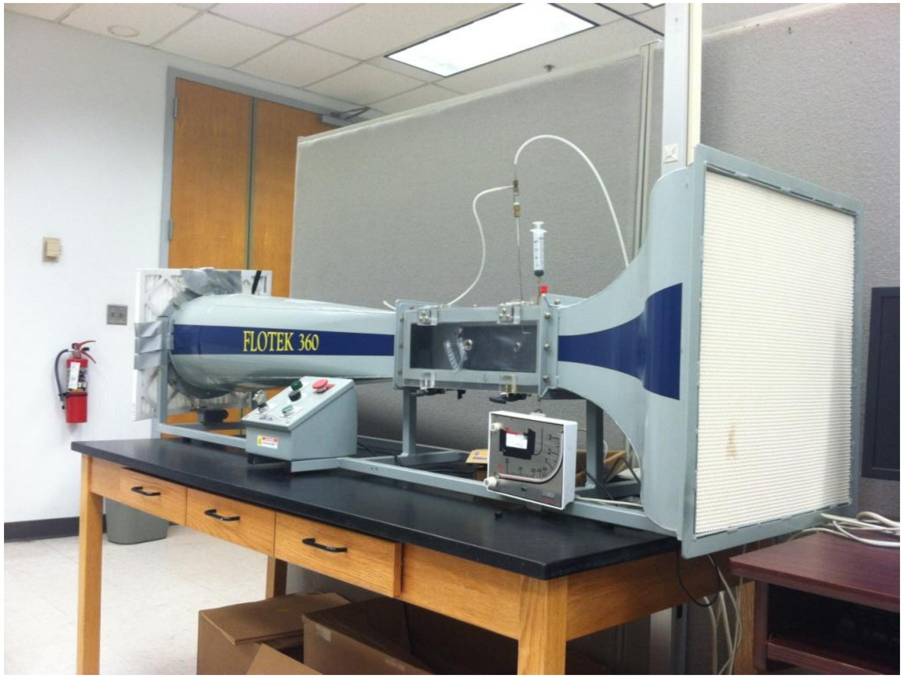


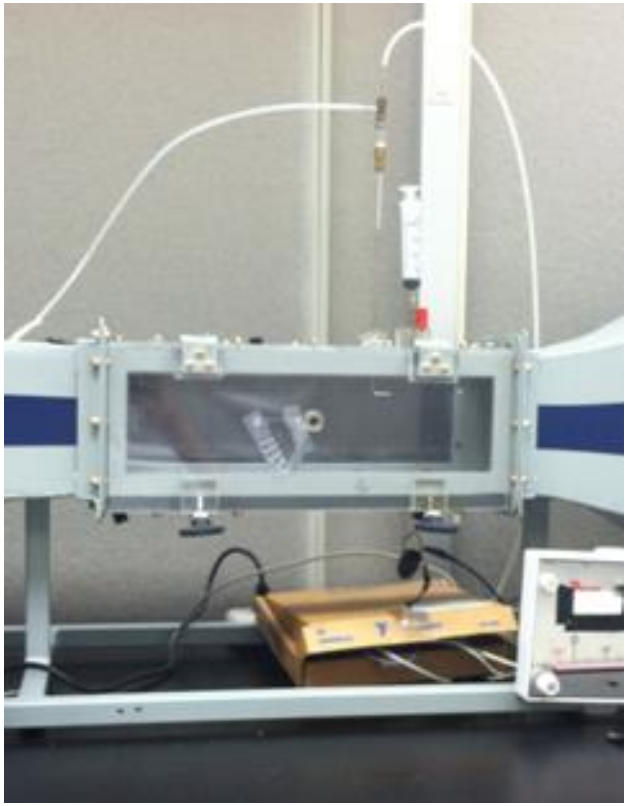
Test Rig



Wind-Tunnel Smoke Wire Test

- A simplified acrylic model will allow flow visualization through entire valve





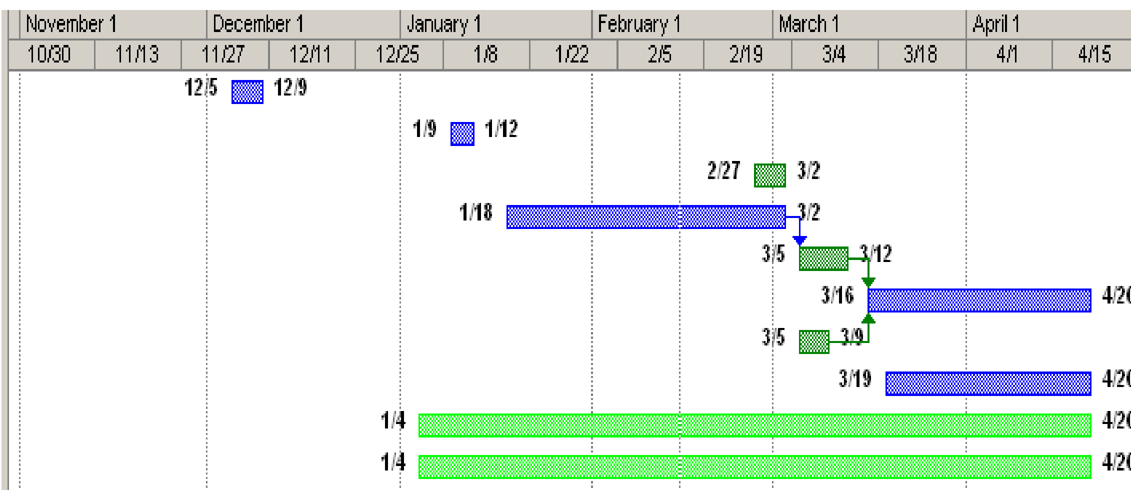
Potential Issues

- Valve does not completely open
- Test conditions are not the same as operating conditions
- Thread and/or pin binding
- Machining tolerances

Future Scope

- Machining in progress
- Parts for test rig being ordered
- Testing will follow for the remainder of the semester
- During testing valve performance will be optimized
- Collaboration with team 19 not likely

		Task Name	Start	Duration	Finish	Predec
1		3-D Print Prototype	Mon 12/5/11	5 days	Fri 12/9/11	
2		Order Materials and Parts	Mon 1/9/12	4 days	Thu 1/12/12	
3		Machine Parts	Mon 2/27/12	5 days	Fri 3/2/12	
4		Test Rig Design	Wed 1/18/12	34 days	Fri 3/2/12	
5		Test Rig Construction	Mon 3/5/12	6 days	Mon 3/12/12	4
6		Testing	Fri 3/16/12	26 days	Fri 4/20/12	7,5
7		Valve Construction	Mon 3/5/12	5 days	Fri 3/9/12	
8		Data Analysis/Redesign	Mon 3/19/12	25 days	Fri 4/20/12	
9		Progess Report	Wed 1/4/12	79 days	Fri 4/20/12	
10		Website Design	Wed 1/4/12	79 days	Fri 4/20/12	



Summary

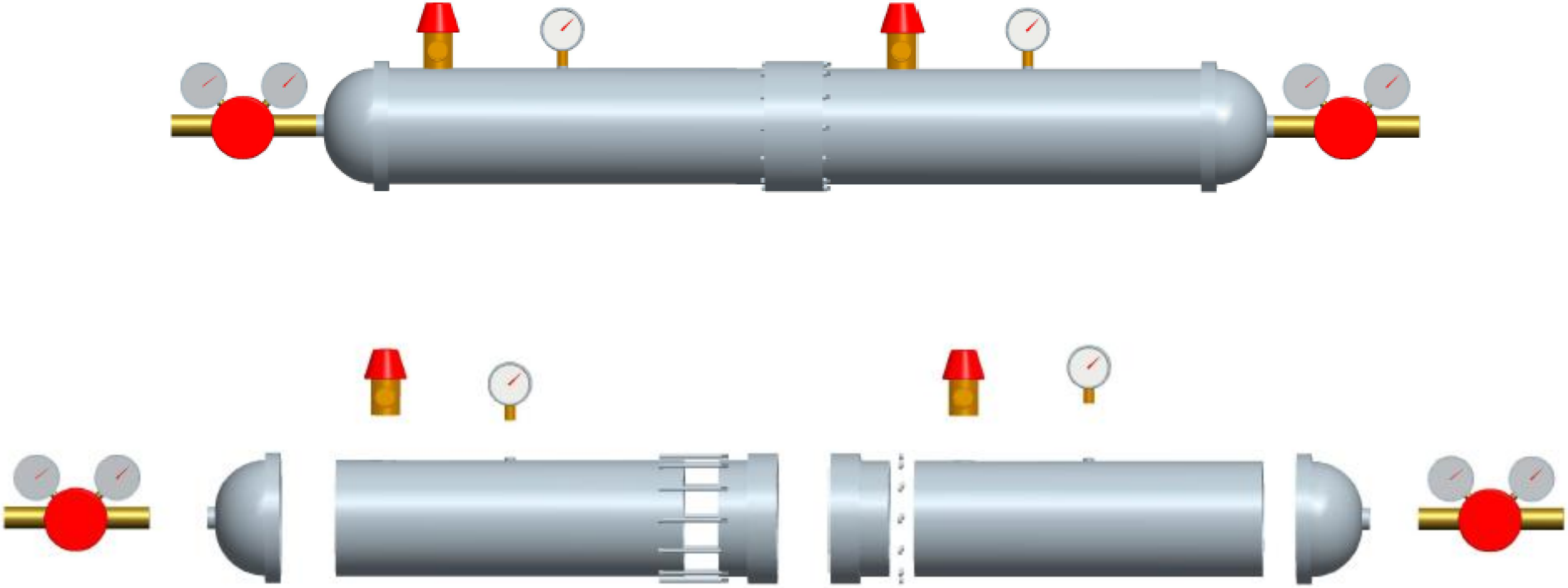
- 3-D prototype already implemented
- Design slightly changed for machining purposes
- Machining in progress
- Parts for test rig currently being ordered
- Total Budget: $2000
- Total spent: $879.86
- Project is running slightly behind accepted schedule due to machining difficulties

Questions

Bill of Materials

Part	Item #	Model #	Price	Source	Purpose
Kobalt 1/4" x 3/4" Air Hose Connector	172731	SGY-AIR34	$3.98	Lowes	Test Rig
1" Threaded Ball Valve	101417	M1001	$14.50	Lowes	Test Rig
1" x 18" Galvanized Pipe	24014	10617	$9.57	Lowes	Test Rig
8 Gal Air Compressor	340271	HG300000DI	$179.00	Lowes	Test Rig
Steel Plates 1" and 2" thick			$200	Jackson Cook	Test Rig
3/8-16 x 5.5" Bolts	91257A646		$24.87	McMaster	Test Rig
3/8-16 Nuts	90499A031		$6.51	McMaster	Test Rig
Steel Plates .5",1" ,and 2" thick			$197.76	Jackson Cook	Valve
Acrylic Plates			$243.67	McMaster	Flow Test
		Total:	$879.86		

Original Test Rig Design



Calculations

Compression Ration:

$R_c := 1.6342$

Cylinder

$Bore := 8.25in$

$Stroke := 6.0in$

$Volume := \pi \left(\frac{Bore}{2}\right)^2 \cdot Stroke$

$Volume = 5.256 \times 10^{-3} m^3$

$\omega := 1200rpm$

$\omega = 1.2 \times 10^3 \cdot rpm$

$time_{in} := \left(\frac{1}{\omega}\right) \cdot 0.5 \cdot 2 \cdot \pi$

approximation

$time_{in} = 0.025 \cdot sec$

Valve

$Area_{w\_holes} := 25.2773in^2$

$Area_{w\_holes} = 0.016\, m^2$

$diam_{in\_hole} := 1.375in$ $\quad$ $diam_{plate} := 6.9in$

$Area_{wo\_holes} := \pi \cdot \left(\frac{diam_{plate}}{2}\right)^2$

$Area_{in\_hole} := \pi \cdot \left(\frac{diam_{in\_hole}}{2}\right)^2$

$Area_{in\_hole} = 9.58 \times 10^{-4} m^2$

$Area_{wo\_holes} = 0.024 m^2$

$Area_{allcuts} := Area_{wo\_holes} - Area_{w\_holes} + Area_{in\_hole}$

$Area_{allcuts} = 8.774 \times 10^{-3} m^2$

$Area_{percut} := \frac{Area_{allcuts}}{Num\_cuts}$ $\quad$ $Num\_cuts := 12$

$Area_{percut} = 7.312 \times 10^{-4} m^2$

Intake

Assuming 100% intake effeciency

$P_i := 180.96psi$

$P_i = 1.248 \times 10^3 \cdot kPa$

$Temp_i := 322.04K$

$R_{gas} := 500 \frac{J}{kg \cdot K}$

$\rho_g := \frac{P_i}{R_{gas} \cdot Temp_i}$

$massrate_{in} := \frac{(Volume \cdot \rho_g)}{time_{in}}$

$\rho_g = 7.749 \frac{kg}{m^3}$

$massrate_{in} = 1.629 \frac{kg}{s}$

$Volume_{rate\_in} := \frac{massrate_{in}}{\rho_g}$

$Volume_{rate\_in} = 0.21 \frac{m^3}{s}$

Max Opening Force on Plate

assuming no back pressure and entire valve surface exposed.
This is done to analyze the most critical situation:

$F_{max} := (P_e)(Area_{w\_holes})$

$F_{max} = 33.251 \cdot kN$

if this valve were to be used on the most extreme compression ratio:

$P_{extreme} := 600psi$

$F_{max\_e} := (P_{extreme})(Area_{w\_holes})$

$F_{max\_e} = 67.463 \cdot kN$

Exhaust

Assuming 100% exhaust Effeciency

$P_e := (P_i)(R_c)$

$P_e = 2.039 \times 10^3 \cdot kPa$

$P_e = 295.725 \cdot psi$

$Temp_e := 380.65K$

$massrate_{out} := massrate_{in}$

$\rho_{out} := \frac{P_e}{R_{gas} \cdot Temp_e}$

$\rho_{out} = 10.713 \frac{kg}{m^3}$

$Vel_{out} := \frac{massrate_{out}}{\rho_{out} \cdot Area_{allcuts}}$

$Volume_{rate\_out} := Vel_{out} \cdot Area_{allcuts}$

$Volume_{rate\_out} = 0.152 \frac{m^3}{s}$

$Volume_{rate\_out} = 547.424 \cdot \frac{m^3}{hr}$

$Volume_{rate\_out} = 5.37 \cdot \frac{ft^3}{s}$