Motor Free Air Compressor

ENGR 2050 - Introduction to Engineering Design
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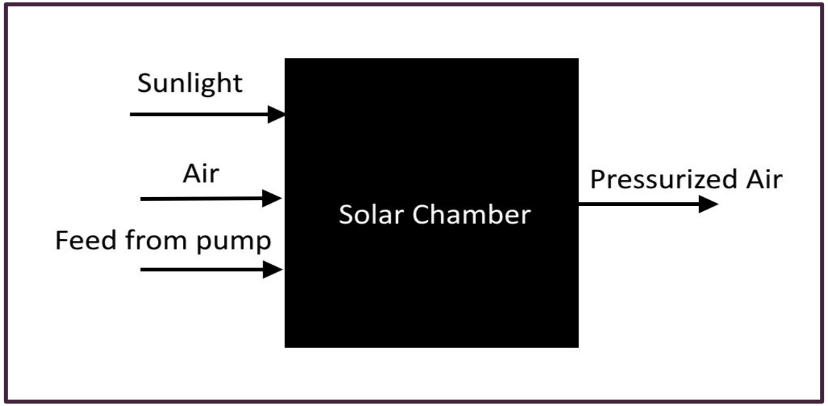
Team Seven - Nathan Anthony, Fanta Cisse, Kismet Crossdale, Kamsi Dozie-Obele, Hayden Fuller, Jameson Giannattasio

Milestone 4 - Subsystems Presentation + Demonstration

Subsystem #1: Solar Chamber



Subsystem Specifications:

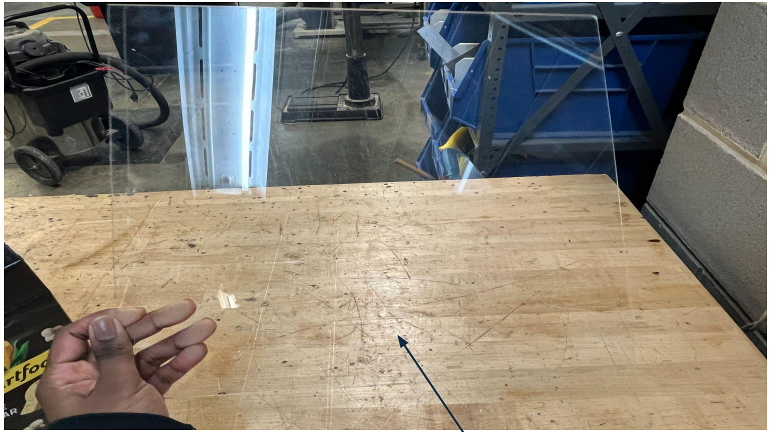
- Amount of pressure it can withstand (50 psi)
- Amount of temperature it can withstand (150 degrees Fahrenheit) [1]
- Minimize the volume (2 gallons) so pressure builds faster
- 1 inch hole for pipe connection (to match pipe diameter)

Characteristics:

- Critical Function: House pressurized air and absorb sunlight
- Inputs: Sunlight, air, feed from pump
- Outputs: Pressurized air
- Important subsystem dependencies:
    - Subsystem 2 - feeds solar chamber with mechanically pumped air from Subsystem 3; allows output of pressurized air through Subsystem 3 (air hose connection valve)
- Subteam: Nate, Kamsi, and Hayden

Subsystem #1: Solar Chamber

Cardboard box with insulation,
11 ⅞ in x 9 ¾ in x 10 in (Outer chamber)



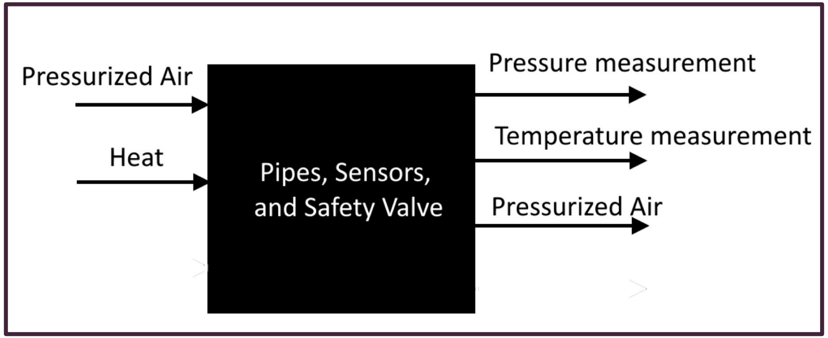
Plastic glass (hard to tell since it's transparent) 13 in x 13 in

Subsystem #1: Solar Chamber

Heat resistant black paint & teflon tape

2 gallon (empty) gasoline container (inner chamber)

Subsystem #2: Pipe, Sensors, & Safety Valve



Subsystem Specifications:

- Pipe dimensions: 1” diameter, 8” length
- Amount of pressure it can withstand (50 psi)
- Amount of temperature it can withstand (150 degrees Fahrenheit) [1]
- Airtight connections

Characteristics:

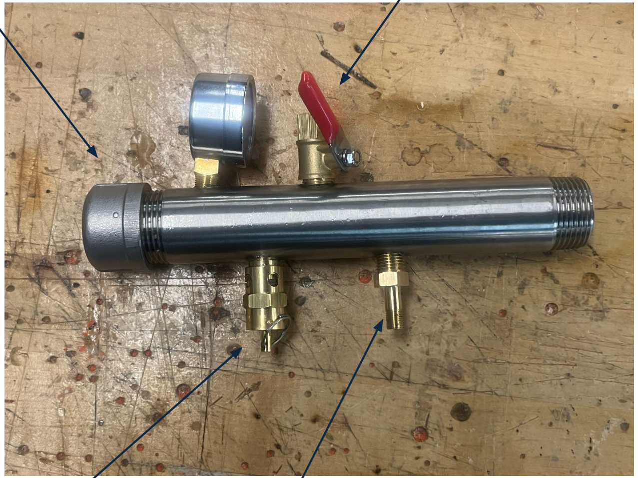
- Critical Function: Main connection between Subsystem 1 & 3; allows pressurized air to travel between subsystems; detects pressure and temperature of device
- Inputs: Pressurized air, heat
- Outputs: Pressure measurement, pressurized air
- Important subsystem dependencies:
  - Subsystem 3 - Increase pressure in subsystem, allow pressure from pipe to be released;
  - Subsystem 1 - Increases temperature and pressure that S2 senses and holds
- Subteam: Fanta, Kismet, and Kamsi

Subsystem #2: Pipe, Sensors, & Safety Valve

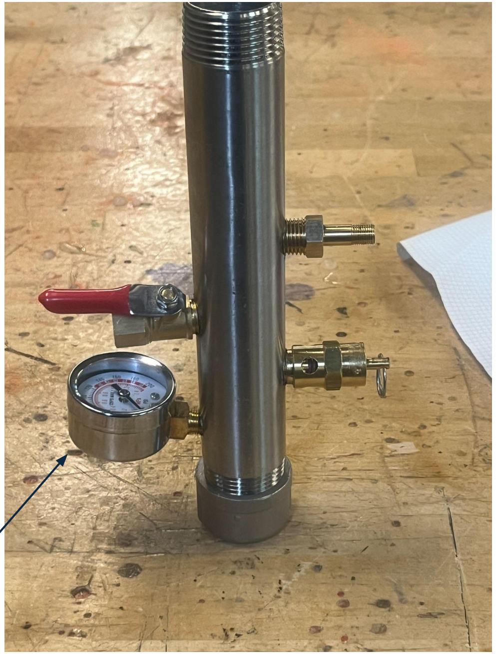
Pipe Cap to contain air in pipe

Air outlet (Ball valve)

Top View of pipe



Flat view of pipe



Side view of pipe

Safety valve

Pressure sensor

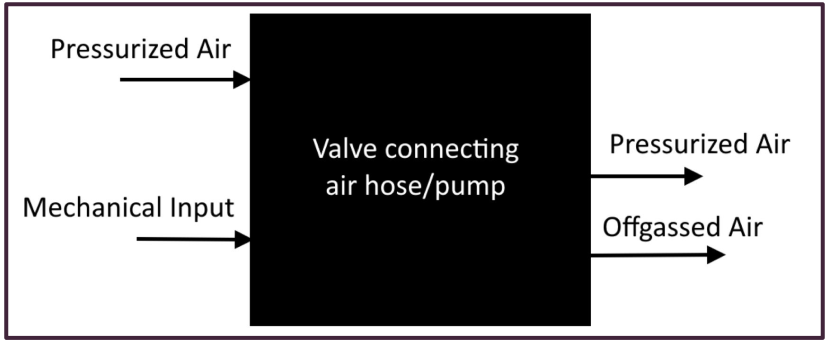
Air feed from pump

Subsystem #2: Pipe, Sensors, & Safety Valve

Iteration

- Our current prototype does not have a temperature sensor due to the sensor being too large for the pipe. Another iteration would include the temperature sensor so that the user will know the exact temperature of device before handling it.
- Adjusting pressure gauge and valve to be more user friendly

Subsystem #3: Connecting Valves



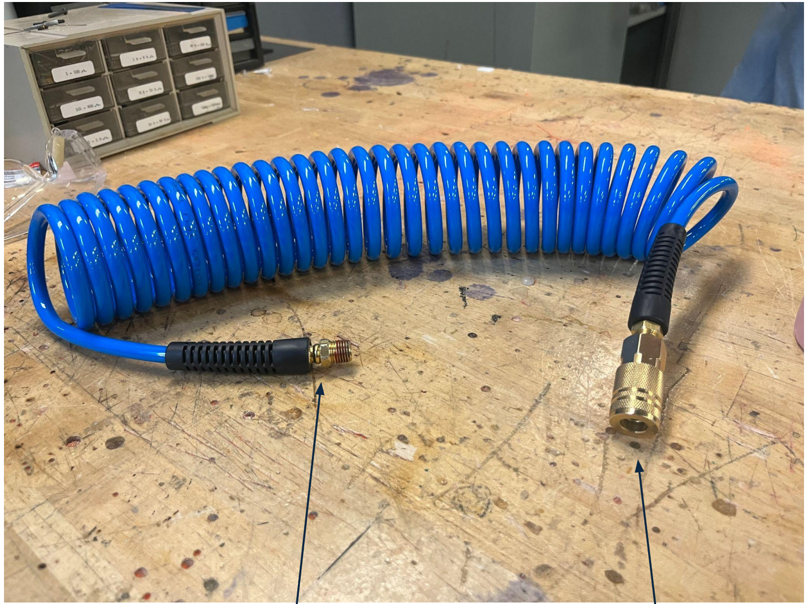
Subsystem Specifications:

- ¼” NPT Connection Valves
- Hose not affected by psi
- Nozzle blow rate is 30 m/s [2]
- Pump can supply 50psi without air loss
- Lever contains air in SS2 without air loss

Characteristics:

- Critical Function: To supply initial pressure buildup to system and release pressurized air in the other direction
- Inputs: Pressurized air, mechanical input
- Outputs: Releasing pressurized air
- Important subsystem dependencies:
    - Subsystem 2 - Connections between S2 and S3 must be airtight
    - Subsystem 1 - Needs enough air pressure to travel through S2 to reach S3
- Subteam: Kismet, Hayden, and Jameson

Subsystem #3: Connecting Valves



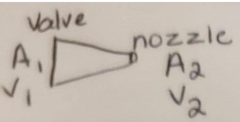
Air Pump

Connection to ball valve

Connection to air nozzle

Air spray nozzle

Calculations/Modeling



$$A_1 v_1 = A_2 v_2$$

valve diameter = 1/4 inch

valve radius = $\frac{1}{8}$ inch

$R_v = 0.003175$ meter

$A_v = \pi(0.003175)^2 = 3.1669\times10^{-5}\,m^2$

nozzle diameter = 1/8 inch

nozzle radius = $\frac{1}{16}$ inch

$R_n = 0.0015875$ meter

$A_n = \pi(0.0015875)^2 = 7.9173\times10^{-6}\,m^2$

Assume $v_2 = 30$ m/s

$$(3.1669\times10^{-5}\,m^2)\,v_1 = (7.9173\times10^{-6}\,m^2)(30\,m/s)$$

$$\boxed{v_1 = 7.5\,m/s}$$

Assume air is inviscid, $\rho = 1.04215\,kg/m^3$ at $T = 338.706\,K$

$$\frac{P_1}{\rho} + \frac{1}{2}v_1^2 + \cancel{gz_1}^{\,z_1=0} = \frac{P_2}{\rho} + \frac{1}{2}v_2^2 + \cancel{gz_2}^{\,z_2=0}$$

$$\frac{P_1}{1.04215\,kg/m^3} + \frac{1}{2}(7.5\,m/s)^2 = \frac{101325\,Pa}{1.04215\,kg/m^3} + \frac{1}{2}(30\,m/s)^2$$

$$\boxed{P_1 = 101{,}764.657\,Pa}$$

[2]

Calculations/Modeling

Assume ideal, $T = 338.706\ K$

Average temp solar panel can reach in direct sunlight

$$PV = RT$$

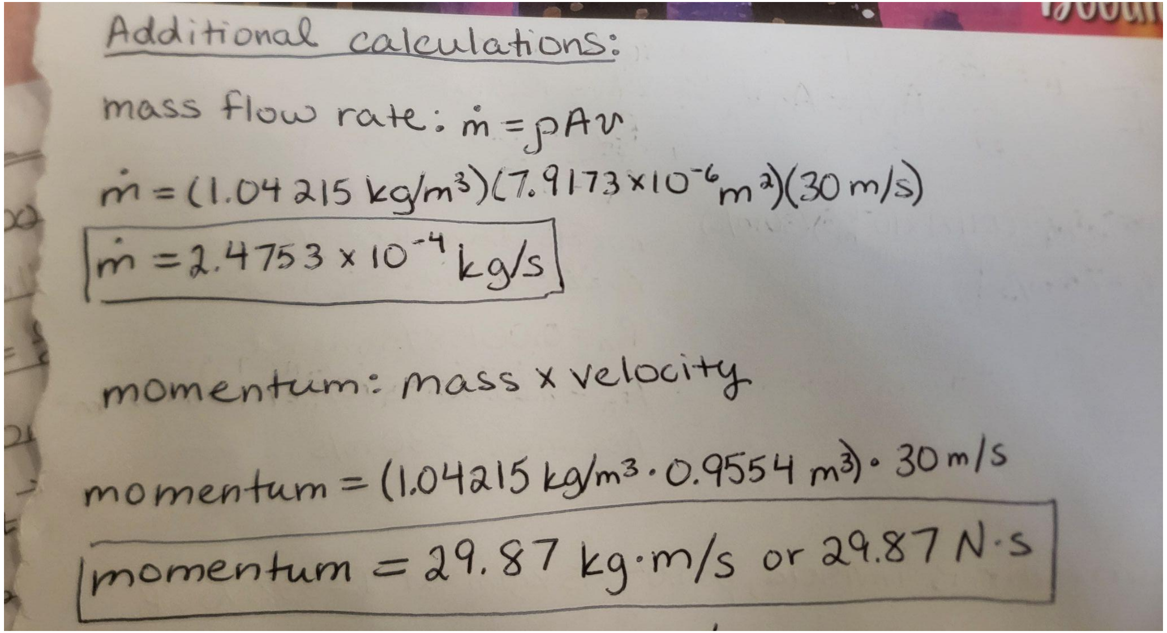
$$(101{,}764.657\ Pa)V = (287.052874\ J/kg\cdot K)(338.706\ K)$$

$$V = 0.9554\ m^3/kg$$

$$\boxed{\text{Ideal volume: } 0.9554\ m^3/kg \text{ of air}}$$

[1]

Additional calculations/modeling


Additional calculations:

mass flow rate: $\dot{m} = \rho A v$

$\dot{m} = (1.04215\ kg/m^3)(7.9173 \times 10^{-6}\ m^2)(30\ m/s)$

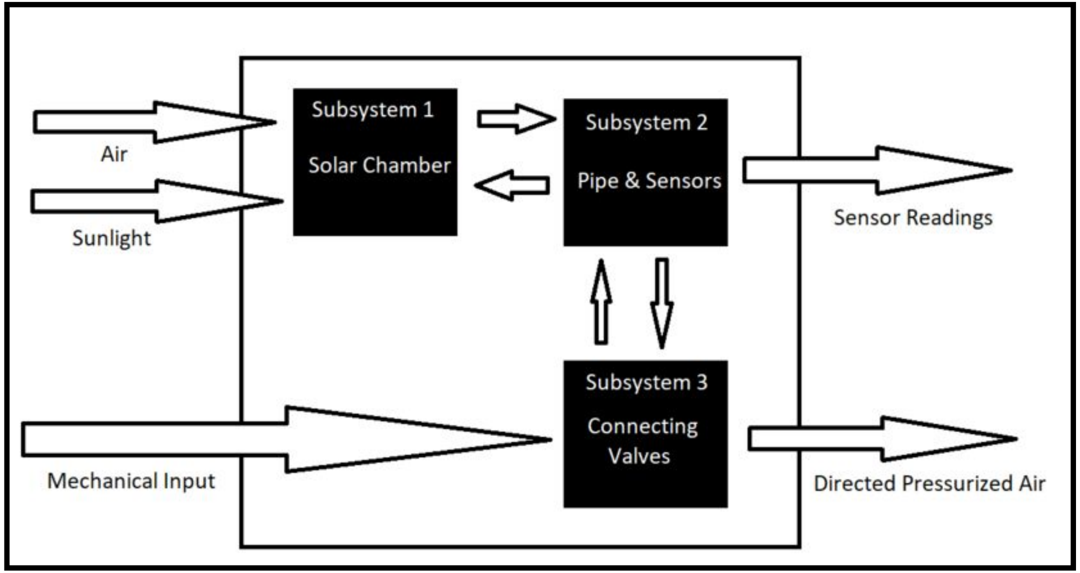
$\boxed{\dot{m} = 2.4753 \times 10^{-4}\ kg/s}$

momentum: mass x velocity

momentum $= (1.04215\ kg/m^3 \cdot 0.9554\ m^3) \cdot 30\ m/s$

$\boxed{\text{momentum} = 29.87\ kg \cdot m/s \text{ or } 29.87\ N \cdot s}$

SIT: System Overview



- SIT Team: Nate, Fanta, and Jameson
- Inputs: Air, Sunlight, Mechanical Force
- Outputs: Readings from Sensors, Pressurized Air

- Subsystems:
  - Solar Chamber
    - Nate, Kamsi, and Hayden
  - Pipe & Sensors
    - Fanta, Kamsi, and Kismet
  - Connecting Valves
    - Kismet, Hayden, and Jameson

SIT: Planning

Gantt Chart:

Project Name	Status	Comment	Owner	Start	End	18-Mar-24	19-Mar-24	20-Mar-24	21-Mar-24	22-Mar-24	23-Mar-24	24-Mar-24	25-Mar-24	26-Mar-24	27-Mar-24	28-Mar-24	29-Mar-24	30-Mar-24	31-Mar-24	1-Apr-24	2-Apr-24
MS4	30%		All	18-Mar-24	2024-04-02																
Order/buy materials	100%		All	19-Mar-24	22-Mar-24																
Presentation	20%		All	19-Mar-24	1-Apr-24																
Plan tests	50%		All	19-Mar-24	25-Mar-24																
Build inner chamber + outer chamber	70%		Hayden, Nate, Kam	25-Mar-24	27-Mar-24																
Build connecting valves	0%		Hayden, Jameson, Kismet	25-Mar-24	27-Mar-24																
Fill pipe with sensors and safety valve	0%		Kam, Fanta, Hayden	25-Mar-24	27-Mar-24																
Troubleshooting	0%		All	28-Mar-24	29-Mar-24																
Testing	0%		All	28-Mar-24	31-Mar-24																
Day of Presentation	0%		All	7-Feb-24	27-Feb-24																

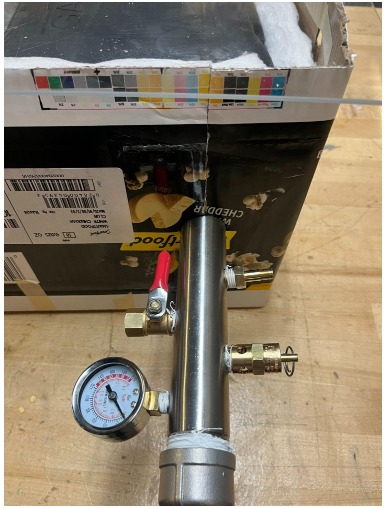
SIT: Planning

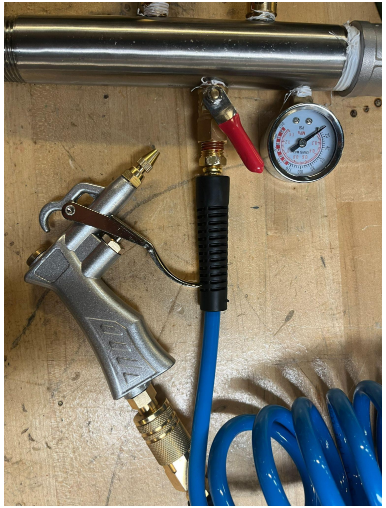
Materials & Purchase List:

Member	Item	Subfunction #	Quantity	Cost per unit	Total Cost	TOTAL COST PAID	Purpose	Merchant suggestion	Possible Link	Delivery Times	Status	SUM
Hayden	Insulation (4 sq ft)	1	1	$14.99	$14.99	**$16.19**	Insulation	Amazon	https://www.amazon.com/Ce	1 Day	Delive...	$160.92
Hayden	Mylar blanket	1	1	$0.00	$0.00	**$0.00**	Reflective coating	Have	https://www.amazon.com/	0 Days	Delive...	
Hayden	Steel	1	1	$0.00	$0.00	**$0.00**	Steel plates	Find or McMaster	1/8" avalible at JEC machine	TBD	Delive...	
Hayden	Glass	1	1	$0.00	$0.00	**$0.00**	Glass	Find or McMaster	Need to find: tech dumps	TBD	Not Aq...	
Kismet	Black Paint	1	1	$6.98	$6.98	**$9.00**	Black Paint (heat resistant)	Walmart	https://www.walmart.com/ip/E	2 Days	Delive...	
Hayden	metal bars	1	1	$0.00	$0.00	**$0.00**	Handle material	Have	Have in EHC	0 Days	Delive...	
Hayden	plastic	1	1	$0.00	$0.00	**$0.00**	Plastic Container	have	JEC machine shop	0 Days	Delive...	
Fanta	Pressure Sensor	2	1	$6.11	$6.11	**$6.11**	Pressure Sensor	McMaster or Amazon	https://www.amazon.com/	1 Day	Delive...	
Fanta	Temperature Sensor	2	1	$12.99	$12.99	**$12.99**	Temperature Sensor	McMaster or Amazon	https://www.amazon.com/	2 Days	Delive...	
Fanta	Safety Valve	2	1	$11.41	$11.41	**$13.85**	Safety Valve	McMaster or Amazon	https://www.amazon.com/Mil	1 Day	Delive...	
Hayden	pipe	2	1	$10.99	$10.99	**$11.87**	Connecting Pipe	Amazon	https://www.amazon.com/DE	1 Day	Delive...	
Hayden	pipe cap	2	1	$11.89	$11.89	**$12.84**	1" pipe cap	Amazon	https://www.amazon.com/uxc	2 Days	Delive...	
Kismet	Air Gun	3	1	$11.99	$11.99	**$12.95**	Blow Air	Amazon	https://www.amazon.com/Ind	4 Days	Ordered	
Kismet	Air Hose	3	1	$19.99	$19.99	**$21.62**	Air Hose	Amazon	https://www.amazon.com/YO	1 Day	Delive...	
Nate	Bike Pump	3	1	$24.00	$24.00	**$24.96**	Mechanical Pump	walmart	IN PERSON		Delive...	
Fanta	Connections	3	1	$6.98	$6.98	**$7.54**	Connecting Air Valve (pump) (1/4 in)	Amazon	https://www.amazon.com/Bre		Delive...	
Hayden	Valve	3	1	$7.99	$7.99	**$8.63**	Conncect to air hose	Amazon	https://www.amazon.com/WY	Monday	Delive...	
Hayden	teflon tape	ALL	1	$2.19	$2.19	**$2.37**	seal threads	Amazon	https://www.amazon.com/Dix	1 Day	Delive...	
							compressed air tank and 100psi line avalible in EHC as needed					

SIT: Interface Standards/Protocol

- Connections between subsystems must have minimal air loss to contain and build pressure.
  - 1” diameter connection between S1 and S2
  - Correct valves/fittings for connections between S2 and S3
  - Tight connections between components





SIT: MS5 Plan (Demo)

Proposed Demos

Demo 1

- Initially supply 20 psi to system using mechanical pump (S3) (Well within safety margins)
- Allow solar chamber (S1) to heat up for a long duration
  - Chamber heats up through solar radiation/outside temperature in ideal situations
  - May need to increase temperature using alternative method (Heating lamp)
- Measure increased pressure using gauge (S2) from the rise in temperature
  - Aim for pressure to be around 25 psi (25% increase)
- Calculate nozzle (S3) air velocity and confirm blow rate is high enough for cleaning debris

Demo 2

- Supply 20 psi to system then measure pressure readings on set intervals to see if product is airtight and does not lose air due to faulty connections

SIT: MS5 Plan

- Integration:
  - **Our Goal:** 3 Subsystems integrated together (having an air compressor that outputs pressurized air strong enough to blow debris/cotton balls)
  - Conduct various test to prove the functionality and quality of our product (air tightness, air distribution, heat absorption)
- Creativity:
  - Compile sketches/diagrams, calculations, and prototypes that demonstrate original and innovative thinking
- Aesthetics:
  - **Continuing**: To hold meetings at least twice a week with a clear agenda
  - **Improvement**: Holding each other accountable, welcoming all/new voices to a conversation, individual check-ins (more consideration)
- Robustness:
  - Verify that all parts and subsystems work individually and together
  - Run multiple test to see how we might make new adjustments to our systems, so when we actually present we won’t have to alter it everytime we use it
- Safety:
  - Checking our calculations so that our system won’t overheat, combust, or implode
  - Our system already consists of a pressure sensor and safety valve to ensure the users and builders safety.

SIT: MS5 Plan

P&S+DEI Considerations:

- Public Health:
  - Relates to access to healthcare, disease prevention, sanitation, and overall well-being.
  - Involves ensuring the motor-free air compressor cleaner contributes to public health by providing reliable energy for medical facilities and supporting healthcare delivery systems.
- Global & Cultural Factors:
  - Providing people across the globe a faster way to clean; not limited to solar panel (ex: leaf blower)
  - Includes ensuring the cleaner is culturally appropriate for diverse populations and considering global implications such as international regulations, market dynamics, and cultural preferences.
- Societal Factors:
  - Considers social and cultural dimensions, including accessibility, equity, and diversity.
  - Involves ensuring the cleaner is accessible, affordable, and culturally appropriate for diverse populations, fostering social inclusion and equity.
- Environmental Factors:
  - Includes assessing the cleaner's environmental footprint, energy efficiency, and contribution to mitigating environmental degradation.
  - Concerns the impact of human activities on the natural environment.
- Economic Factors:
  - To build our current prototype we spent roughly around $160 USD
  - Involves prioritizing affordability to ensure the motor-free air compressor cleaner is accessible to low and middle-income populations, thereby maximizing its reach and impact.

Citations

[1] “How Do Temperature and Shade Affect Solar Panel Efficiency” Boston Solar. [Online]. Accessed April 1, 2024. Available: https://www.bostonsolar.us/solar-blog-resource-center/blog/how-do-temperature-and-shade-affect-solar-panel-efficiency/#:~:text=Residential%20solar%20panels%20are%20generally,150°F%20or%20higher.

[2] “CFM vs MPH” The Rop Shop.[Online]. Accessed April 1, 2024. Available: https://theropshop.com/rugged-u/blog/leaf-blower-tips-cfm-vs-mph#:~:text=You%20should%20look%20for%20a,and%20150%2D190%20MPH%20ratings.

THANKS FOR LISTENING!

QUESTIONS?