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Design, Construction, and Testing of a Fluidized Bed Reactor

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Introduction

Hypothesis: The fluidization behavior of a solid particle bed is described by the Navier-Stokes equation. Fluidization occurs when an upward flow of fluid is used to suspend and mobilize solid particles. Three key equations used in fluidization prior to designing and building the project included terminal velocity of a spherical particle as well as fluidization velocity based off of the particle's Reynolds number. The terminal velocity of a spherical particle is represented by the equation

$$V_{max} = (\pi r^2) \cdot \frac{d^2 \cdot (\rho_{solid} - \rho_{fluid}) \cdot g}{18 \cdot \mu_{fluid}}$$

The fluidization velocity for particles with a Reynolds number less than 20 is

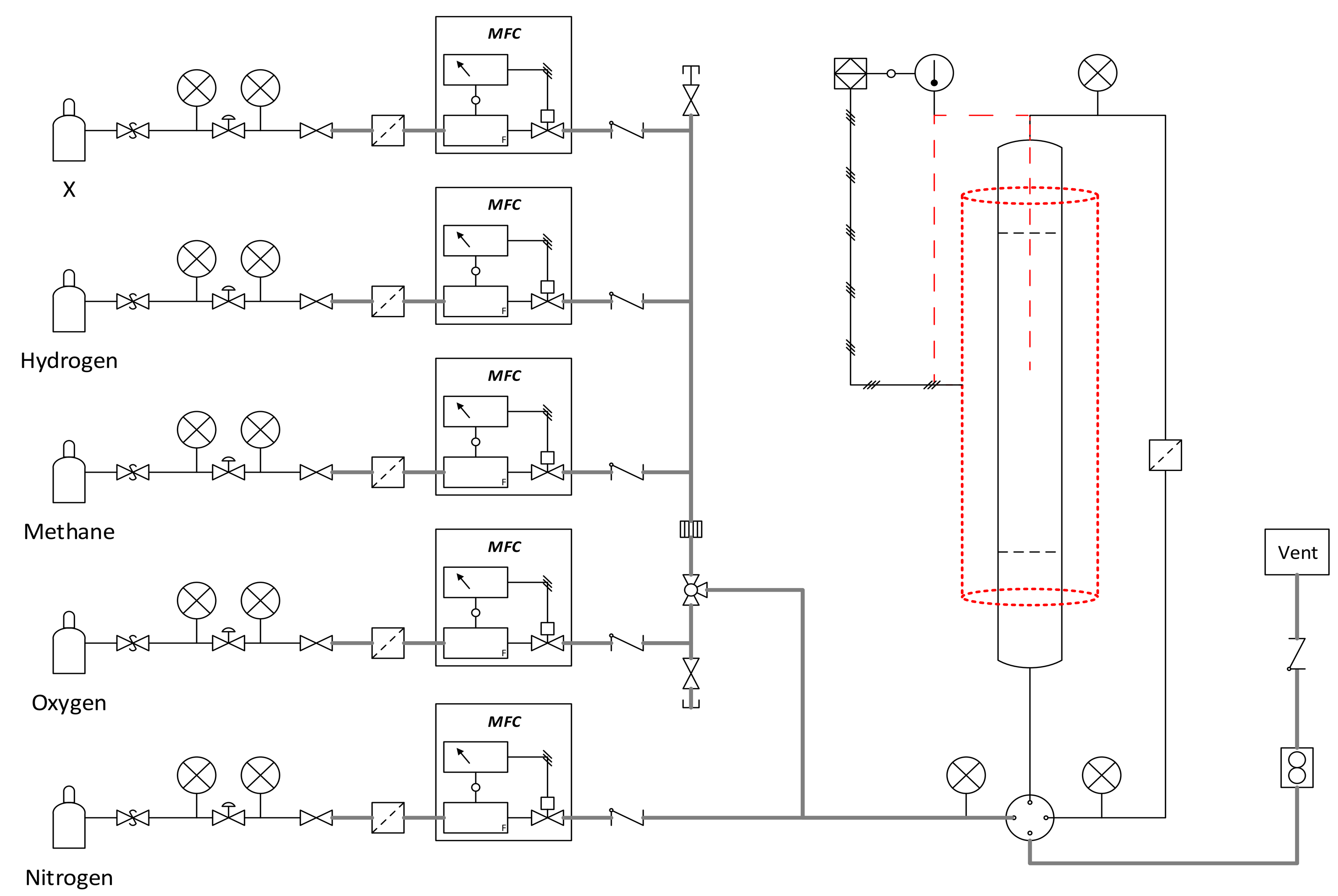
$$\dot{V}_{min} = (\pi r^2) \cdot \frac{d^2 \cdot (\rho_{solid} - \rho_{fluid}) \cdot g \cdot \varepsilon^3 \cdot \phi}{150 \cdot \mu_{fluid} \cdot (1 - \varepsilon)}$$

and for particles with a Reynolds number greater than 1000 is

$$\dot{V}_{min} = (\pi r^2) \cdot \sqrt{\frac{d \cdot (\rho_{solid} - \rho_{fluid}) \cdot g \cdot \varepsilon^3 \cdot \phi}{1.75 \cdot \rho_{fluid}}}$$

Fluid flow rate	$\dot{V}$	
Fluid density	ρ_{fluid}	$1.2\ kg \cdot m^{-3}$
Fluid viscosity	μ	$1.8\ Pa \cdot s$
Particle diameter	d	$0.15\ mm$
Particle density	ρ_{solid}	$1{,}500\ kg \cdot m^{-3}$
Particle sphericity	ϕ	1.0
Bed void fraction	ε	0.45
Bed radius	r	$10\ mm$
Gravity	g	$9.81\ m \cdot s^{-2}$

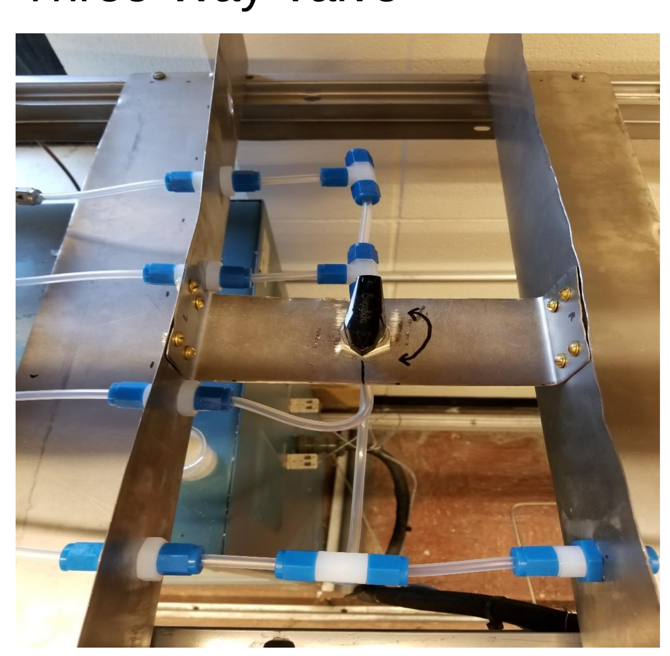
Design and Build Phase



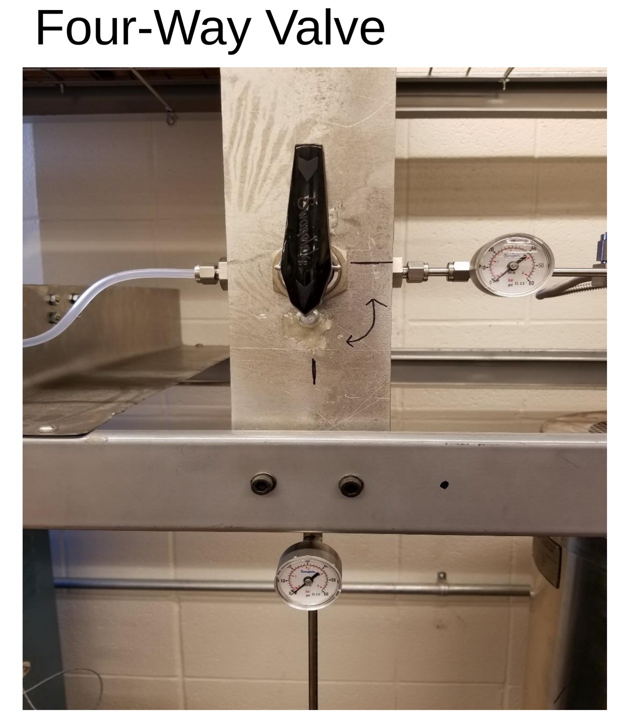
Gas Regulator

Mass Flow Controllers

Three-Way Valve

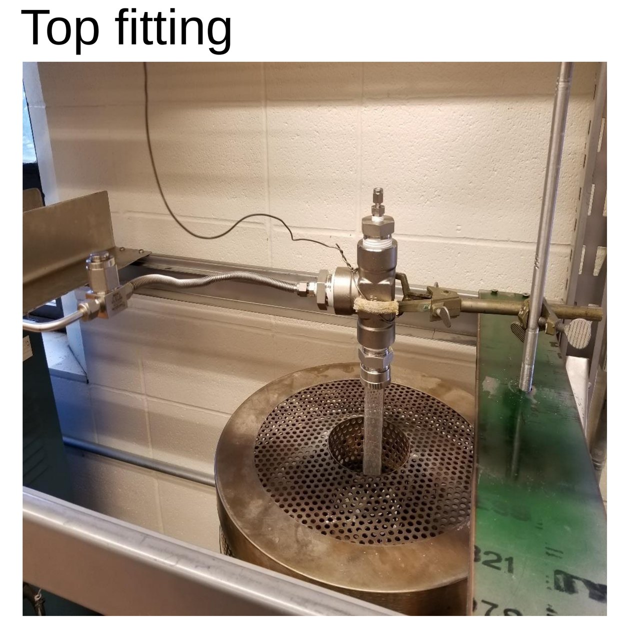


Four-Way Valve



Bottom fitting

Top fitting



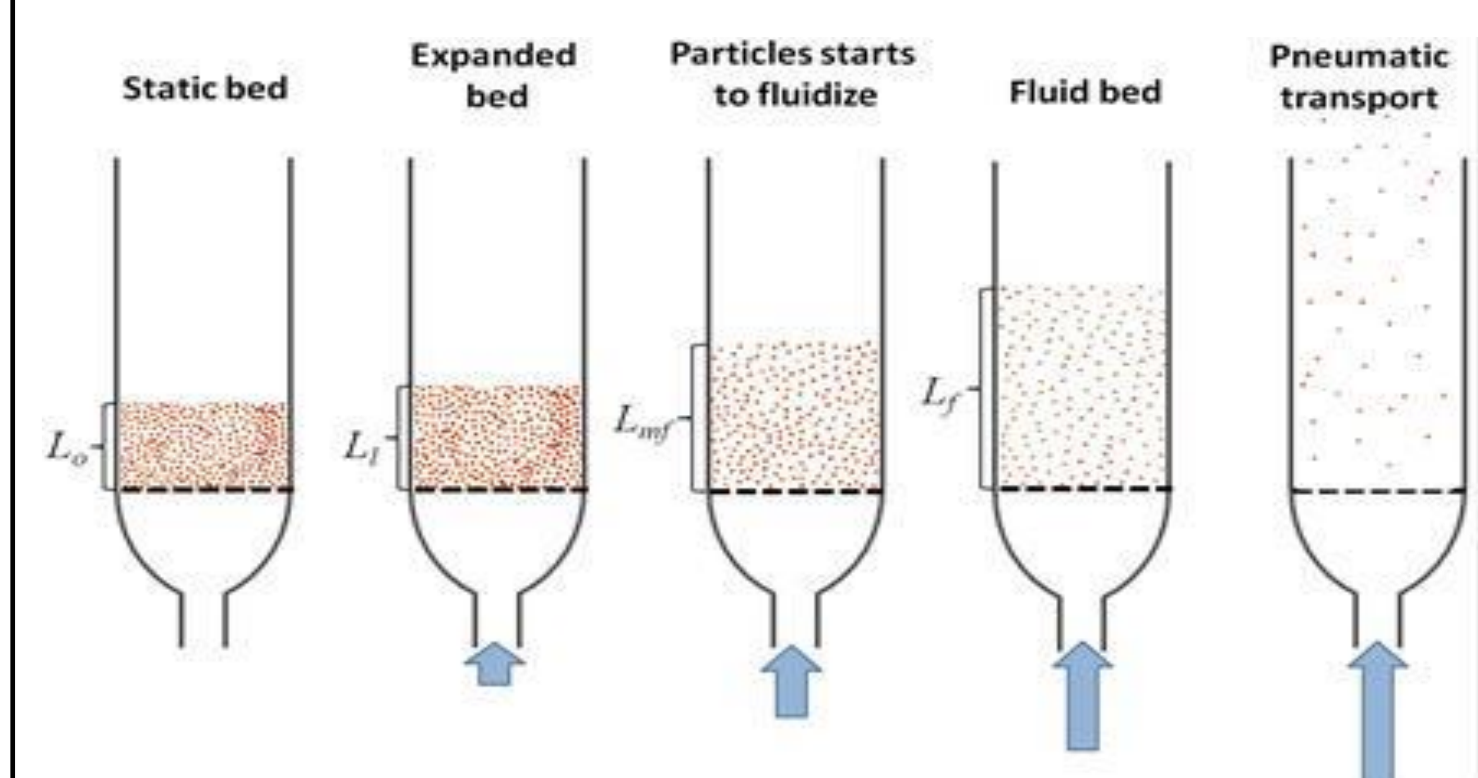
Testing and Conclusion

Sand was used for the fixed bed and air was used for fluidization. During testing, the flow of air was manually adjusted until fluidization of the sand bed was observed. Table 1 shows the observed flow rate as compared to the predicted flow rates, which were calculated using the fluidization equations.

Table 1: Predicted and Observed Fluidization

	$\dot{V}_{min}$ (L/min)	Reynold's Number
Prediction 1	0.321	461
Prediction 2	4.9	7031
Observed	4.0 ± 0.5	≈6000

Overall, Prediction 2 was closer to the observed value because prediction 1 did not satisfy the fluidization equation initially. In conclusion, the design of the FBR was assembled and is operational.



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