# Team #21: Inert Gas Recirculation System
# MakeSens Inc.

Sean Reardon, Tyson Hartle, Oscar Guan, Ahd Mufti, Réka Flikkema
Schulich School of Engineering, University of Calgary

## Abstract

**Goal of the System/Project**

- To design a system to separate particles from a gas stream in a closed system feed loop, allowing the inert gas to be recirculated, recompressed and reused in the system in a safe and efficient manner, reducing the amount of gas required saving the company money from wasted gases into the atmosphere once the comminution process is complete.

**Design Considerations/Constraints**

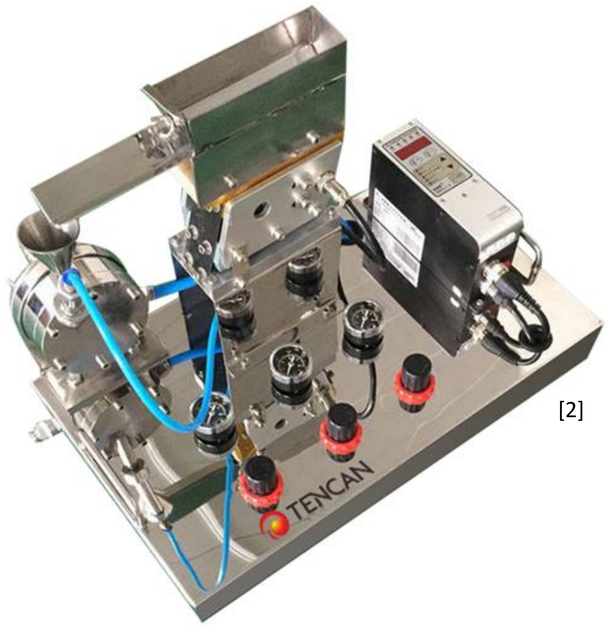
- Fit the filtration system within a 50”X32”x24” fume hood
- Maintain O2 levels below a 10% threshold
- Easy assembly and disassembly for cleaning
- Maintain dry compressed air throughout
- Separate particles between 1-10 µm

## Introduction

- **Background Information on the Jet Milling Process**
- Jet milling is a process of grinding materials using a high-speed stream of compressed inert gas to cause collisions between the particles as well as with the wall. This allows the materials to be broken into very fine particles, even below 1 micron in some cases.
- Jet milling is commonly used for chemicals, polymers and other friable materials that can be used for many different applications. Jet milling requires a large quantity of gas for operation and needs to be done under inert conditions for safety reasons.
- In this case, a silicon-based material is broken down, where the powder is used as a feed stock for advanced high density battery anode materials.

## Discussion

- The project has undergone many iterations on what the design should encompass. There were many different components that needed to be taken into consideration:
- A dual separation system consisting of a cyclone that was sized for optimum cutting removal and a second stage HEPA filter where the remaining particles are separated out of the gas stream.
- There had to be a containment designed where the particles are collected in the HEPA filter, while the gas could pass through and be recirculated.
- Pressure transducers were required to monitor the differential pressure between the inlet of the containment and the outlet of the HEPA containment.
- 3 Stage Dehydrator utilized to maintain dry air.
- Compressor is utilized to recompress the gas prior to being introduced.
- Oxygen sensor utilized determine if the O2 level is below threshold of 10% with a buffer tank to divert flow if not within tolerance.
- Initially a gas generation stage was considered, however this was removed due to budget constraints and complexity.




[2]

## Conclusions

- A system was designed to meet the constraints and allow for separation of particles while the gas is safety recirculated and reused in the system. This reduces gas consumption dramatically, saving money when compared to the current system which does not recirculate the gas in any capacity.

## Results

**Analysis Results and CAD design**

- Determined that pressure loss through the system was negligible along with temperatures through the filtration section.
- The cyclone was optimally sized for the removal of particles such that the size of these particles are within the specified range. This removes a large portion of the particles, and the HEPA filter removes the remaining particles.

**CAD Design**

- The CAD design was completed using SolidWorks. The components were all modelled digitally, and 3D printed at a 60% scale for visual representation.
- Some components such as the sanitary tri-clamps and gaskets were bought for the 3D printed model since these are easier to buy at standard sizes than to model and 3D print.
- Additionally, due to the unavailability of some sizes of tri-clamps at 60% scale, the connections of the outlets of the cyclone remain at full-scale sizing.

*Note: The wall thicknesses of components in the visual model are not to scale due to the limitations of 3D printing and the material strength of PLA.

## Methods and Materials

**Engineering Analysis Methods**

**Pressure Loss and Thermodynamic Analysis.**

- To perform engineering analysis through the system, the first step was to determine whether the pressure and temperature throughout each section of the system is conserved.
- First, the flowrate at the inlet of the system was determined. With this, the Mach number could be calculated. From there, since the Mach number was much below 0.3, the fluid was assumed to be incompressible.
- Next, the thermodynamic isentropic correlations and Bernoulli's principle were used to determine the velocity, temperature, and pressure throughout the system prior to the gas being recompressed.

**Cyclone Sizing**

- To determine the pressure loss , we were able to use a Stairmand Model [1]. Once were able the determine the pressure loss.
- particle size efficiency was determined using MATLAB and Model of Barth[1].

## References

1. [1] A. C. Hoffmann and L. E. Stein, *Gas Cyclones and Swirl Tubes: Principles, Design, and Operation*. Heidelberg: Springer, 2008
2. [2] Image provided by MakeSens Inc. (Photo of a Jet Mill Process)

**CONTACT**
**[Sean Reardon] Team Lead**
**Email: sean.reardon@ucalgary.ca**
**Phone: 403 620 0162**
**Website: QR Code**