1. Introduction

1-1 Background
- Reactor containment may lose its structural integrity due to over-pressureization during a severe accident.
- For preventing the dispersion of these uncontrolled radioactive releases to the environment, several ways to capture or mitigate these radioactively source term releases are under investigation at KAIST.
- Example: air curtain, a chemical spray, and a suction arm.
- Treatment of the radioactive material captured by these systems would be required, before releasing to environment.

1-2 Current filtration system in nuclear industry
- Sand
- High efficiency particulate arresting (HEPA)
- Charcoal
- Multi-venture scrubber
- Combinations of the above.

1-3 Purpose of the Research
- Develop the conceptual design of a filtration system that can be used to process airborne severe accident source term.

2. Conceptual design

2-1 Conceptual model

Figure 1: conceptual design and work flow

2-2 Source term analysis
The simplest categorization of the material to be treated, that could be released from a nuclear power plant, is the mixture of noble gases, gaseous iodine, cesium particulate and other particulate.
In this simulation, the source term is presented as:

Fluid phase: air (containing gaseous iodine); Particle: CsI

2-3 Filtration technology and absorbents:
- Centrifuge:
  a) Currently not used in nuclear industry
  b) Flexible in dimension and widely used in industry
  c) Can act as a pre-filter
- TEDA Charcoal for gaseous source term
  a) Impregnated with TEDA (tri-ethylene-di-amine)
  b) Concern: Humidity control & temperature
- Water containing NaOH and Na₂SO₃
  a) Widely used in wet scrubber of filtered containment venting system (FCVS) in nuclear field

2-4 Geometry
- A typical standard cyclone design parameters, D=1m

<table>
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<tr>
<th>Cyclone</th>
<th>α/D</th>
<th>b/D</th>
<th>D/H</th>
<th>h/D</th>
<th>S/D</th>
<th>Bc/D</th>
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<tbody>
<tr>
<td>Standard design</td>
<td>0.5</td>
<td>0.2</td>
<td>0.5</td>
<td>4</td>
<td>1.5</td>
<td>0.5</td>
</tr>
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</table>
| Particle size and distribution
- The SEM images of aerosols from an impactor plate in the circuit of the Phobus FT70 test shows an agglomerated structure of particles typically in the range 0.1-0.5 mm
- Particle density: 0.1g-100g/m³
- Normal distribution

3. Simulation results

3-2 Cutoff diameter
The particle diameter corresponding to 50% collection efficiency

\[ D_{p50} = \frac{3 \mu D_p}{2 \rho_{i} u_i \tau_w} \]

\[ D_{p50} = 590 \text{mm} \]

\[ V = \text{volume of the cyclone} \]

\[ Q = \text{volumetric flow rate} \]

\[ \mu = \text{air dynamic viscosity} \]

\[ u_i = \text{gas velocity at the inlet} \]

\[ \tau = \text{residence time} t, t=V/Q \]

\[ \rho_i = \text{particle density} \]

\[ C = \text{slip correction factor of the particle corresponding to } D_{p50} \]

\[ N_t = \text{number of turns}, N_t = \frac{tU_i}{\pi D} \]

\[ \rho_{i} = \text{density of the material to be treated, that } \]

3-3 Simulation

4. Conclusion

4-1 Summary
- The current centrifuge can be used as a pre-filter to separated the gaseous compartment and particle.
- Because the particle size is relatively small, the current separation efficiency is not ideal.

4-2 Future work
- Cyclone efficiency analysis for different inlet velocity and pressure.
- Optimization of the cyclone design.
- Analysis of the absorbent and filter part.

Reference
- Centrifugal Separator and Filter Arrangement Having a Centrifugal Separator of Said Type, US 20140298761 A1
- Calculation of release of radioactive materials in gaseous and liquid effluents from pressurized water reactors, NUREG-0017, rev.1
- Status report on filtered containment venting, NEA/CSNI/R(2014)7
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