Marshall Problem/Project Statement - Senior Design Topic

Problem/Project Title: Clogging of the LSS introduced by Biofilm Detachment Post-Dormancy/ Biofilm Mitigation Technology

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Indicate which discipline(s) is/are most appropriate to work on this problem (e.g., aerospace, mechanical, electrical, chemical, industrial, civil, computer, physics, materials, test, nuclear, earth science, other)

Chemical engineering/ mechanical engineering/ physics/ microbiology/ materials

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Marshall Problem Statement

Background: The big picture with references to previous work (Why would a senior design student be excited about this work?)

The International Space Station (ISS) Environmental Control and Life Support System (ECLSS) waste water tank is base of concern for dormancy as biofilm structures may easily form at nutrient high levels and move on to clog downstream valves when the system is turned on after a long period of time after it has been shut down. The same concern will come for deep space travel, human habitats and other space hardware that might suffer through long-term use or shut down dormancy events.

Many mitigation efforts can be considered for this problem but, unluckily, the space environment is so unique that known techniques on Earth have to be re-evaluated, requalified and reinvented most of the time (1,2). Many strains of Bulkoldheria seem to be normal guests of the water processor, but its behavior might be different from the American Type Culture Collection (ATCC) strains used on the ground, such as the case of Pseudomonas. If you turn to ISS specific solutions, Pseudomonas is a good microbial model for your benchtop biofilm mitigation technique, but as the technology readiness level exceeds a maturation point it becomes unclear if the data obtained on ground benchtop experiments will still be relevant at the long term in microgravity. One of the main system parts capable of clogging downstream tubing and apparatus is the waste water tank. In its current form, this tank is a stainless steel bellows tank with a configuration as shown:

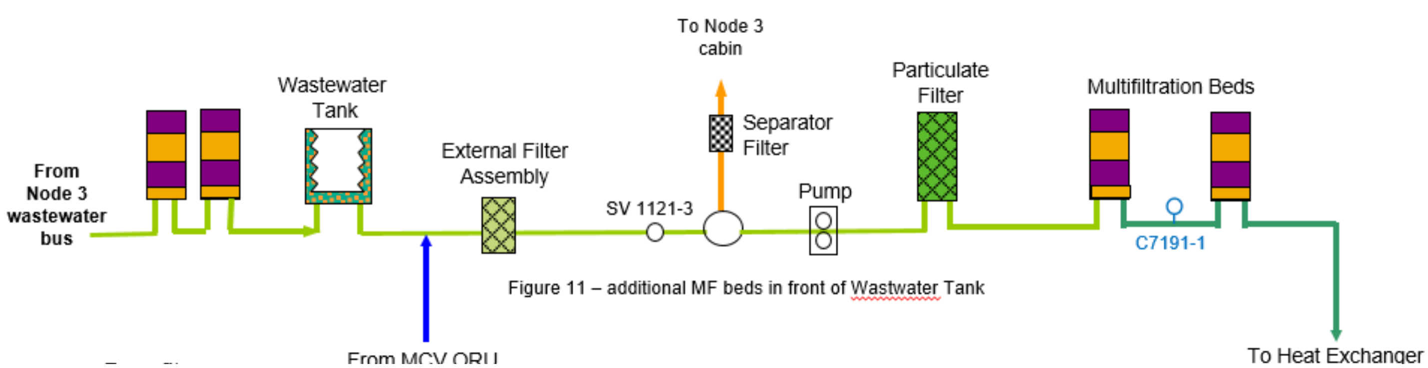

Figure 11 – additional MF beds in front of Wastwater Tank

In this same configuration, it would be efficient to explore if a removable plastic polymer bag could be used instead of a metal casing.

Recent/on-going research on the problem (What resources, if any, are available to the senior design team, such as equipment, software, facility utilization)

The Marshall Space Flight Center's ECLSS Development team is currently studying different test configurations for the waste water tank in a proof of concept phase. Having a bag in place of a metal tank is one of the recommendations from the biofilm expert community.

Resources:

- Description of baseline waste water tank configuration and materials to be modified.
- ISS strains for testing.

Details of the problem; design constraints, requirements (if any), outcome expected. One semester Senior Design course lasts 15 weeks; two semester course lasts 30 weeks. (What do you expect the senior design team to accomplish?)

Constraints:
Ullage, pH, T, operating pressure, and flow rate
Requirements:
Proof of system service optimized by the use of a polymer bag, system service equal to baseline or system service less optimal than baseline.

The aim of this project is to find an ***optimized or maintained*** configuration. If this is not found within the use of a polymeric plastic bag, proof of less optimal conditions is required.

1. System constraints shall be maintained, or optimized, or demonstrated less optimal for the LSS current requirements.
2. Biofilm formation shall be maintained, or optimized, or demonstrated less optimal for the LSS current requirements.
3. The system shall be compatible with standard launch loads from earth
4. The system shall preclude the permeability of gases
5. Other pros to the polymer bag configuration found (such as better visualization, reliability, and or flow) shall be demonstrated. (The same for the opposite.)

Outcome Expected:
Students must provide deliverables and demonstrate requirements were met.

Senior Design Project Rules:

1. Weekly telecons will be scheduled to maintain proper progress and prevent dead-end ventures.

2. Deliverable(s) required (e.g., one semester course – a written final report; two semester course – written final report and a prototype/model (if practical))

Deliverables expected:

1. For a one semester course – a written final report and presentation that must include an introduction, methods, results, discussion, conclusions, and raw data appendix.
2. For a two semester course – a written final report and presentation that must include an introduction, methods, results, discussion, conclusions, raw data appendix, and physical prototype delivered.

References:

1. Hummerick M. E. et. al. *Dormancy and Recovery Testing for Biological Wastewater Processors* (2015) ICES. Bellevue, WA.

2. Kloc J. et al. *The Study of Biological Wastewater Treatment through Biofilm Development on Synthetic Material versus Membranes* (2012) WPI, Worcester, MA.