

An Overview in the **Development of a Multi-Sensor Data Science System** for Monitoring a Solvent **Extraction Process**

July 2022

nanging the World's Energy Future Idaho National

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INL/CON-22-67703-Revision-0

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Prepared for the U.S. Department of Energy Under DOE Idaho Operations Office Contract DE-AC07-05ID14517

July 25, 2022

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Introduction – Beartooth Testbed

- Beartooth testbed in design phase.
- Beartooth will include:
 - Glove box lines
 - Dissolution equipment
 - Separations equipment
- Beartooth will allow for:
 - Nuclear fuel cycle stewardship
 - Increased understanding of separation science
 - Ability to test innovative technologies

Centrifugal Contactors



Overview - Multi-Sensor Data Science System for Monitoring

Goal 1	Integrate a variety of atypical sensors into a system of centrifugal contactors for signal discovery.
Goal 2	Use data science and signal analysis techniques to extract features that identify process stages and equipment usage in various stages of operation.
Local Impact	 Provide system operators with process awareness that can inform them of: Process conditions Normal/abnormal operations Ways to improve process operations Equipment failures and predictions of failures.
Broad Impact	If features provide evidence of diversion, this research has the potential to enhance nuclear safeguarding of special nuclear materials.

Traditional Monitoring

- Flow rate controllers
- Solution temperature probes
- Revolution per minute on contactor motors
 - Set by a variable frequency drive (VFD) controlling each contactor motor
 - Not currently recorded
- Current draw of contactor motors
 - Read by the VFD
 - Not typically utilized to inform the operator
 - Not currently recorded
- No real effort to utilize machine learning or signal analysis to inform operators.
 - "Read sensor, when needed" mentality

Installation of Atypical Sensors

- Vibration
- Acoustics
- Color
- pH
- Conductivity
- Ultrasonic liquid level
- Viscosity
- Density
- Infrared
- Multi-sensor units



SRD inline process density & viscosity meter, <u>"https://Rheonics/products/inlin-density-meter-srd/</u>". Accessed June 2022.

Two Data Collection Campaigns

- We have conducted two data collection campaigns.
 - 1 contactor campaign
 - Data formats
 - Data scientist tools
 - Sensor functionality
 - Installation methods
 - 30 contactor campaign
 - Data storage
 - Sensor functionality
 - Compare single contactor signals with signals emitted using multiple contactors

Preliminary Results - Vibration Sensors







Preliminary Results - Vibration Sensors



- RPM increased from 3000 to 3010 RPM in 1 RPM increments
- Sensor on block, position Y.

Acoustic Sensors







Preliminary Results - Acoustic Sensors



RPM increased from 3000 to 3010 RPM in 1 RPM increments

• Similar data to vibration data. May be possible to get information without having sensor attached to contactor.

Preliminary Results - Color Sensor



Infrared Camera Results for Aqueous Solution



No solution movement



Contactor 30 to 29



Solution enters contactor 27



Solution exits contactor 27



Flow is constant

Infrared Camera View of Contactor Motors

- The infrared camera was positioned towards the front of the contactor array
- The solutions were no longer heated
- Shortly after the contactors were set to 2000 rpm, the team noticed high temperatures in one contactor



Flooding

- Contactor 5 stopped running which caused flooding on the outlet of contactor 4
- Contactor 5 variable frequency drive (VFD) had to be reset for the contactor to run again
- Contactor 1 began to overheat, the feed leaked.
- Contactor 2 was getting hotter. Operators were informed before a leak.



Sensor showed changes before staff realized the failure.

Idaho National Laboratory

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