Contract No:

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SR19036 – Improve TRP Cutter Head Performance

Facility Need

The current Target Rod Preparation (TRP) Cutter Head suffers from overheating problems during TPBAR breaching operations. The overheating leads to work stoppage due to the periodic need to allow the TRP Cutter Head motor to cool. This work stoppage and allowance for cooldown of the motor leads to a very inefficient TPBAR breaching process. Due to the increased need for Tritium gas, the system must be improved to increase the efficiency of the TPBAR breaching process.

Potential Benefits

- [x] Cost Reduction
- [ ] Defect Reduction
- [x] Error Reduction
- [ ] Mission Diversification
- [x] Mission Viability
- [x] Obsolescence Solution
- [x] Process Optimization
- [ ] Safety

Project Summary

This project will assess the current performance of the TRP cutter head and the motor that drives it. The main purpose of the project will be to improve performance of the TRP cutter head through methods that will prevent or slow the overheating of the drive motor. This project will also analyze the heat load within the TRP cell and identify auxiliary equipment that could be replaced to prevent or slow overheating of the drive motor.

SR19036

Status

Started: Beginning FY19, Completed: FY20

Technology Readiness Level

Start of FY19:	4
End-of-FY19 Forecast:	6
End-of-FY19 Actual:	6

Financial

FY19 Project Cost:	$77,000
Cumulative Total Project Cost:	$77,000
FY19 Authorized Amount:	$77,000

Credits

Principal Investigators:	William Housley
	Joshua Slice
	Andrew McNight
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Facility Engineering Co-Lead:	Michael Harber
	Brian Black
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Milestones/Findings/Accomplishments

Project Milestone	Expected End	Actual End
Complete TPBAR breaching test with larger motor	7/17/20	NA
Analyze various equipment heat loading within the TRP cell	8/19/19	6/8/20
Design, fabricate, and test heat sink for larger motor	6/30/20	NA
Submit Year-End Report/Project Summary	9/18/20	9/18/20

*The test stand required to complete testing was removed from the site at the beginning of this PDRD and was not returned until after the end of FY20. The testing could not be completed due to the lack of the test stand.

Analyze various equipment heat loading within TRP cell

Auxiliary equipment necessary to cutting operations, but not directly responsible for the breaching of TPBARs, is co-located with the cutter motor in the TRP cell. These items are as follows: Turret drive motors, Collet drive motor, a vacuum cleaner, in-cell lighting, and cameras.

Some of these items (Cameras, in-cell lighting) are powered for the duration of all cutting operations. Other items such as the turret drive motors, collet drive motors, and vacuum cleaner, are on intermittently throughout cutting operations.

The turret motor is used to turn the TPBAR basket such that rods can be picked up by the cutting head. These movements are quite small and only require the turret motor to be active for less than 5 seconds. Movement of the basket is only required after a TPBAR has been completely breached and dropped back into the basket. This means the basket only needs to be moved slightly approximately every 90 seconds.

The motor that drives the collet runs for ~10s to grip the TPBAR in order for the cutter motor to prepare for cutting operations and then another ~10s to un-grip the TPBAR after the cutter motor has gripped the TPBAR. There is very little time between the grip and un-grip cycles of the collet motor, but the overall run time of the collet motor still remains under 20s. This action is only required once per TPBAR and there is a significant delay between duty cycles of this motor.

The collective heat generated by these motors is removed from the TRP cell's atmosphere through natural convection and radiative heat transfer. The heat added by these motors would not reach the local area of the cutter motor as it would be carried away due to the natural convection maintaining the negative pressure in the cell. Additionally, based on the results of the FY 19 PDRD, there are no motors that would both survive in the high radiation environment and operate more efficiently.

The vacuum cleaner runs for ~45 seconds while the cutter is actively breaching a TPBAR. This is a significant uptime during the TPBAR breaching process. A more efficient vacuum cleaner could reduce the amount of heat released into the TRP cell atmosphere, though some sacrifice to flow rate and flow velocity may be an artifact of a more efficient vacuum cleaner. The replacement of the vacuum cleaner could increase the number of TPBARs breached before the TRP cutter drive motor overheats. The replacement of this piece of equipment would require extensive design changes when compared to items such as the lights.

The lights in the TRP cell directly add heat to the cell through radiative and convective heat transfer. The in-cell lighting is near the TRP cutter motor and is powered even when the cutter motor is not operating. The in-cell lights could be replaced with higher efficiency lighting. Higher efficiency lights would reduce the amount of heat produced in the cell, but maintain adequate lighting for all operations in the cell.

Currently the TRP is lit by four (4) 175W Lithonia Lighting metal halide flood lights. Each of these lights is designed to deliver approximately 13,000 lumens, giving a ratio of 74 lumens per watt. However, the metal halide light bulbs within the flood light produce light in a 360-degree arc. The design of the flood light fixture redirects as much light as possible out into the cell, typically about half of the lumens are directed into the TRP cell. Meaning the metal halide lights have a field efficiency of ~50% and are effectively providing 6,500 lumens of light to the TRP cell (37 lumens per watt effective).

LED lights have a similar lumen to watt ratio (~38-40 lumens per watt), but LEDs emit light only in a 180-degree arc. This gives LED lights a higher field efficiency as they will be able to produce the same effective number of lumens for about half of the watts of a metal halide light. This means an LED light of about 80-90W will produce the same effective number of lumens as a 175W metal halide light. It is expected that installing LED lights in place of the metal halide lights would halve the overall heat load produced by the lights in the TRP cell. These lights remain on even when the TRP cell is not in use, which would provide a significant reduction in the heat load within the TRP cell.

Design, fabricate, and test heat sink for larger motor

A heat sink for the larger motor was fabricated to further reduce the buildup of heat in the motor. The heat sink attaches directly to the outer radius of the larger motor, for maximum contact area. The heat sink is four separate pieces that are connected by a series of bolts and springs that allow the heat sink to expand as the motor increases in temperature and expands. Generally, heat sinks perform best with forced convection to provide optimal cooling.

The heat sink was designed to be used in conjunction with an adapter that would provide forced convective cooling over the heat sink. The TRP cell contains a vacuum cleaner used during cutting operations and to clean the interior of the hot cell. This vacuum cleaner has two separate hoses for each of these tasks. The hose that is used to clean the hot cell is not utilized during cutting operations and lies on the floor of the hot cell. The adapter would allow the unused vacuum cleaner hose to be positioned to pull Argon across the heat sink, providing forced convection. This would remove the heat from the larger drive motor both directly and from the local area around the motor.

Future Work

- Perform successful breach of TPBAR with larger motor
- Reach steady state condition with larger drive motor with heat sink installed and forced convection cooling condition.
- Research alternative methods for breaching TPBARs