

Company Information

Company Name	<i>Siemens Energy</i>	Date Submitted	<i>5/25/2021</i>
Project Title	Design of a Pressurized Rotor Plug Seal (SIEM_PLUG)	Planned Starting Semester	<i>Fall 2021</i>

Senior Design Project Description

Personnel

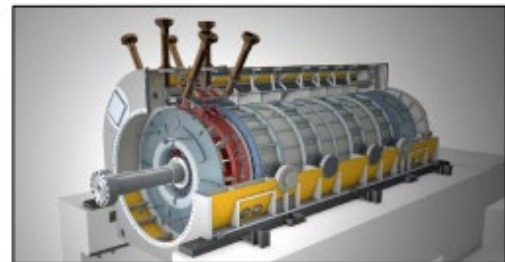
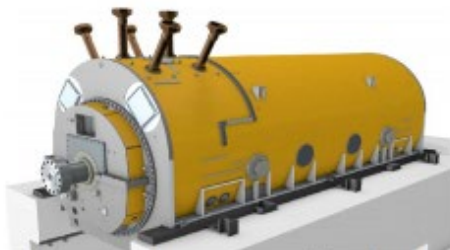
Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	5	Electrical	
Computer		Systems	
Other ()			

Company and Project Overview:

Company and Project Overview: The Siemens Charlotte Energy Hub is the company's worldwide hub for 60 Hz power generating equipment. Opened in 1969, the facility has manufactured and serviced generators and steam turbines for the power generation market for decades. In November 2011, the facility celebrated the opening of a new expansion, adding gas turbine production and service capabilities. The new Gas Turbine facility was designed based on LEAN manufacturing principles and certified for U.S. LEED Gold green building standards, making it the most advanced gas turbine production plant in operation. The expansion represents a \$350 million total investment in Charlotte, adding 1,000 jobs. With its current workforce of 1,500 and more than one million square feet of space under roof, Siemens Energy in Charlotte has become the largest manufacturer in the city and the second largest among the 250+ Energy companies based in Charlotte.



The project is sponsored by the Siemens Generator Engineering Department to develop alternate design

ideas for a rotor plug seal.

Project Requirements:

Siemens Energy is currently developing a pressurized (10 barg air) generator rotor to aid in increased power density (power output for given size/weight of generator) of the generator. Sealing of the generator rotor is the keystone to this technology improvement.

One concept that we see potential in but could use further development is the plug concept of sealing the end of the rotor slot as seen in the figures below. The following figures are from the patent application (PCT/US2021/022723).

The overall rotor is seen in the figure below:

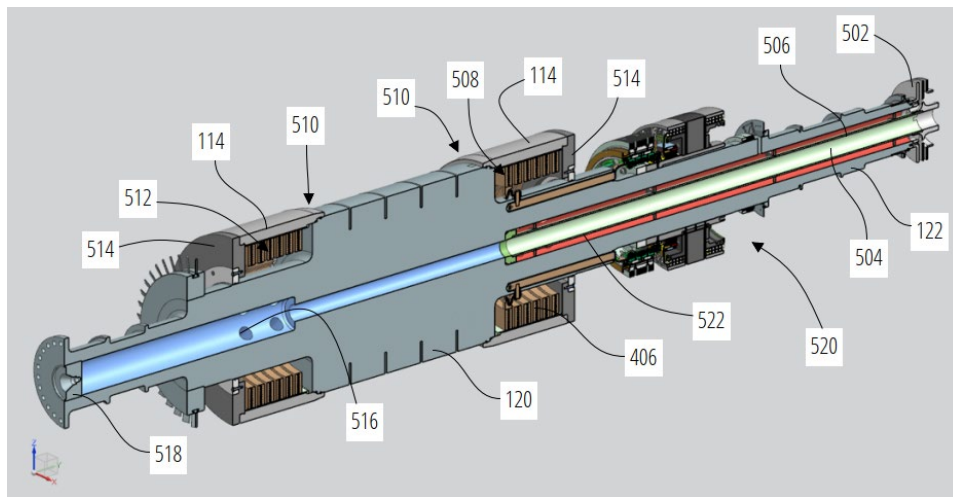
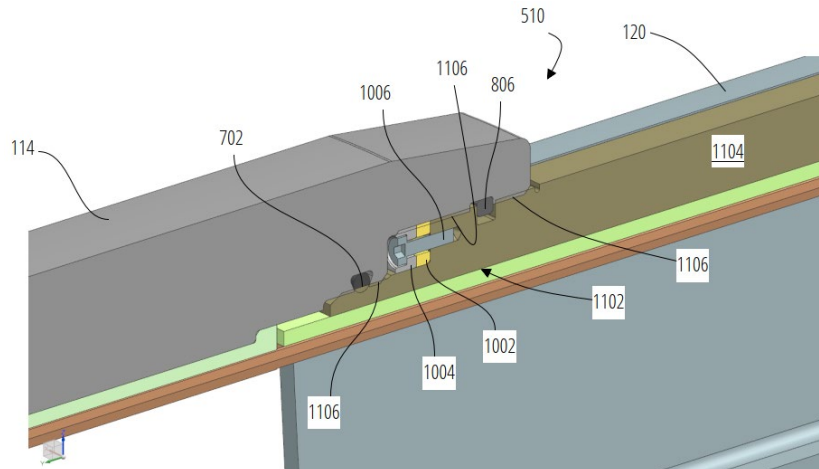


Figure 1: High Pressure Rotor Overview



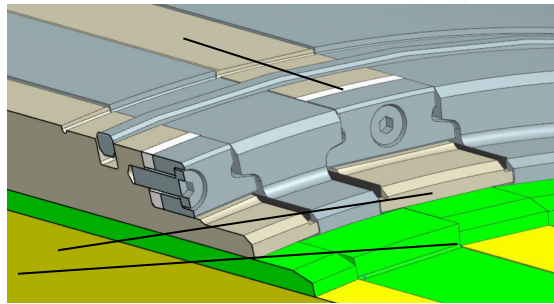
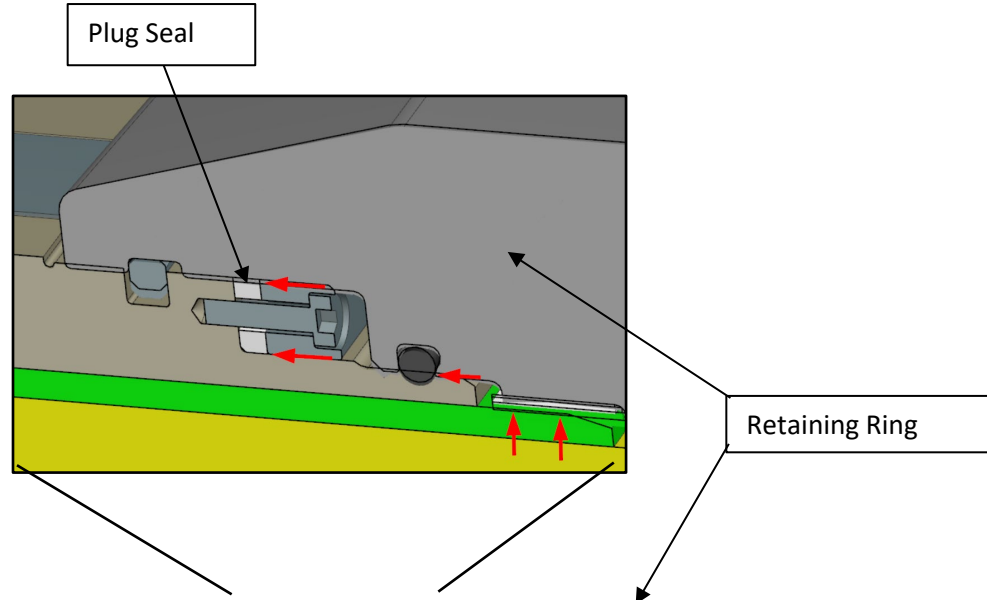


Figure 2: Plug Sealing Concept

In figure 2, a version of the plug seal is shown. The seal itself is item 1002. The version of a plug seal shown relies on a bolt and washer (item 1004) compressing the plug and creating lateral Poisson's expansion of the plug to seal against the rotor shaft (item 120) and the retaining ring (item 114). Remaining numbered items will be described to participants at the start of the project for further understanding of the rotor design but are not critical to the design of the plug. The rotor is internally pressurized as shown in Figure 3. The red arrows indicate the direction of air pressure.



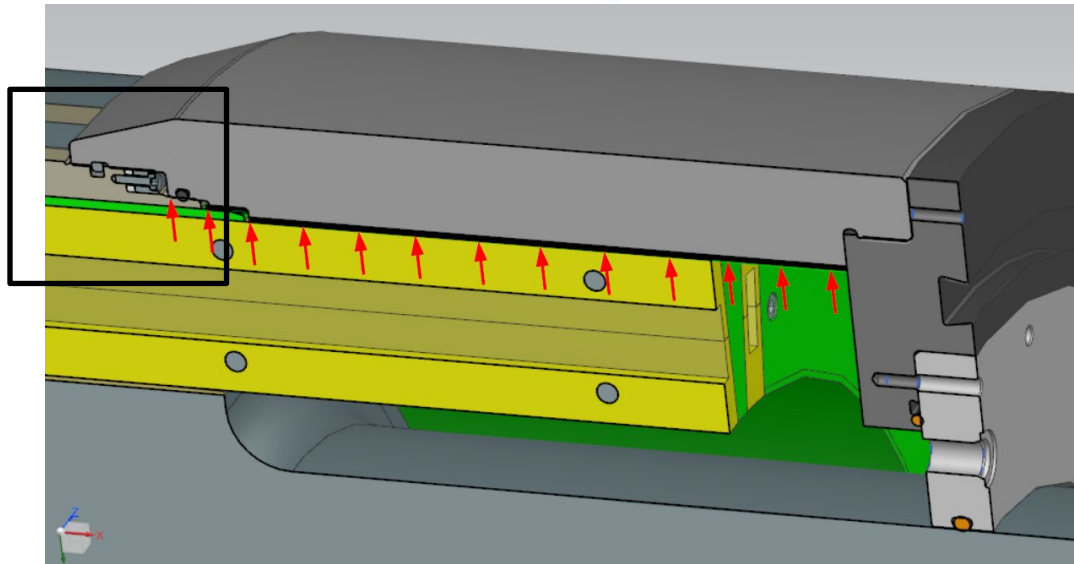


Figure 3: Pressurized Rotor

It is desired to have a UNC Charlotte team brainstorm and test additional concepts for a plug style seal. While the leak performance is not required to be absolutely zero, the goal would be to limit the leakage of air across the seal to approximately 0.005 ACFM @ 10 bar (gauge).

The project would most likely involve the following:

- Investigation into different plug materials and geometries
- Possible material testing if needed (by Siemens or UNCC)
- Plug manufacturing techniques (machining, waterjet, 3d printing, etc.)
- Plug seal performance testing

Siemens Energy would provide the following:

1. Initial boundary conditions and interfacing geometry for the plug design
2. Access to existing test fixtures that can be used for stationary plug performance testing. (See below for fixture descriptions)
3. Guidance throughout the concept development/design/manufacturing/testing process as needed.

Testing Fixtures Available

Single Plug Test Fixture

This fixture is designed to be a simplified representation of actual rotor slot geometry in order to perform rapid initial testing of plug concepts. If a plug does not seal well in this fixture, it will most

likely not seal well when placed in the actual product geometry.

With reference to the figure below, the wedge/plug seal/washer/bolt assembly is installed into the fixture body. The cover plate is installed onto the fixture body. Air pressure is introduced via the cover plate and a leakage rate is measured over time.

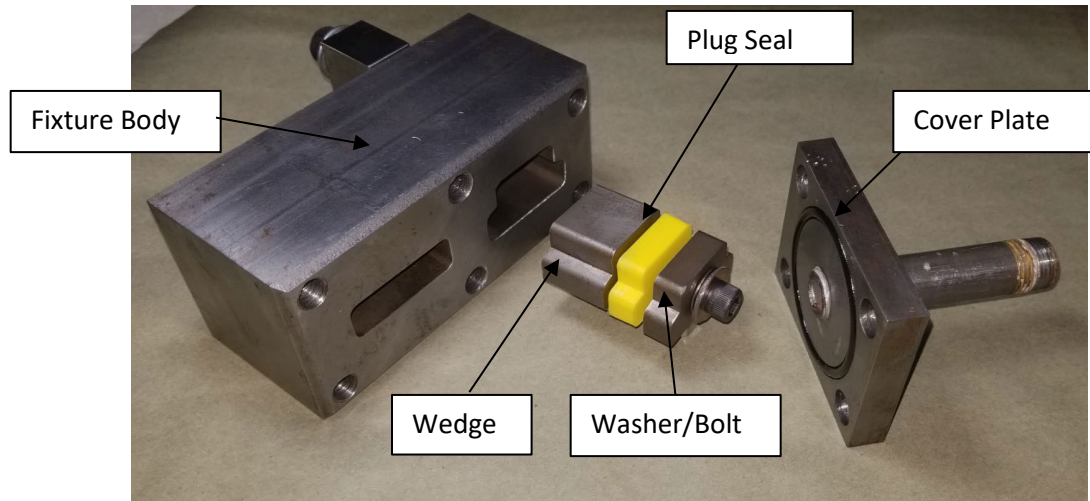


Figure 4: Single Plug Test Fixture

3 Slot Seal Test Fixture

This fixture was designed to represent the actual product geometry more closely. It includes 3 axial slots in the main body with wedges and hardware to simulate centrifugal loading during operation(as would be seen in the end product).

Due to the more complex nature of this fixture, this would be used to test the final plug seal concepts which had shown promise during testing in the single plug test fixture.



Figure 5: 3 Slot Seal Test Fixture

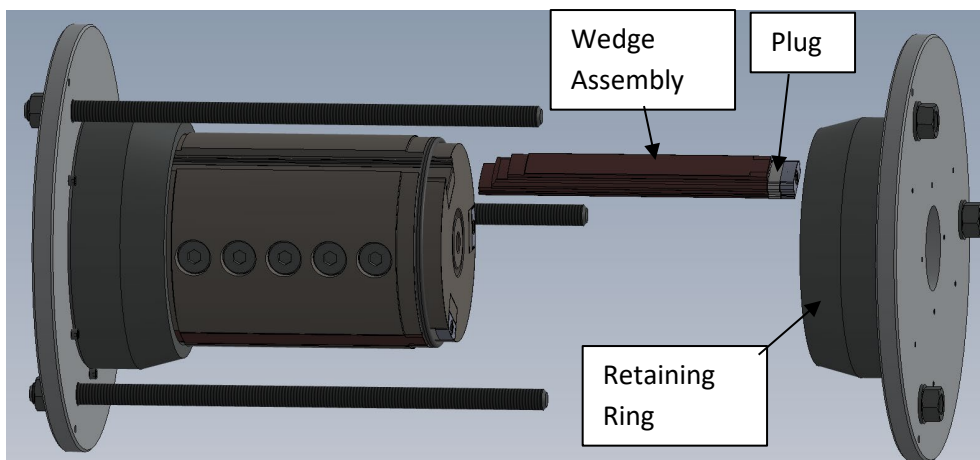


Figure 6: 3 Slot Seal Test Fixture (Exploded Model)

Expected Deliverables/Results:

1. Brainstorming and down selection to most promising concepts
2. Analytical/Manufacturing evaluation of the concepts → Design Review
3. Oversee manufacturing of the seal concepts (~ 10+ concepts)
4. Seal performance test of concepts in “single plug fixture”.
5. Select most promising concepts from step 4 and test in the “3 slot testing fixture”.

Disposition of Deliverables at the End of the Project:



The work product is displayed at the last Expo then immediately handed over to the supporter unless arrangements have been made to deliver at a future date.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Interest in Mechanical design and fabrication of pressurized devices
- Ability to travel to Siemens Charlotte location as required.