

# Final Research Plan

## Computational Simulation of Accelerator Driven System

### Target Model

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***Introduction***

When involved in a large task with many different levels, it is sometimes easy to lose track of the goal. It often takes several failures before a system is developed, so that the goal is not only met but also met on time. My use of the following document, the final research plan, is to provide a system or guidance through the final stages of my research, so that my goals are met.

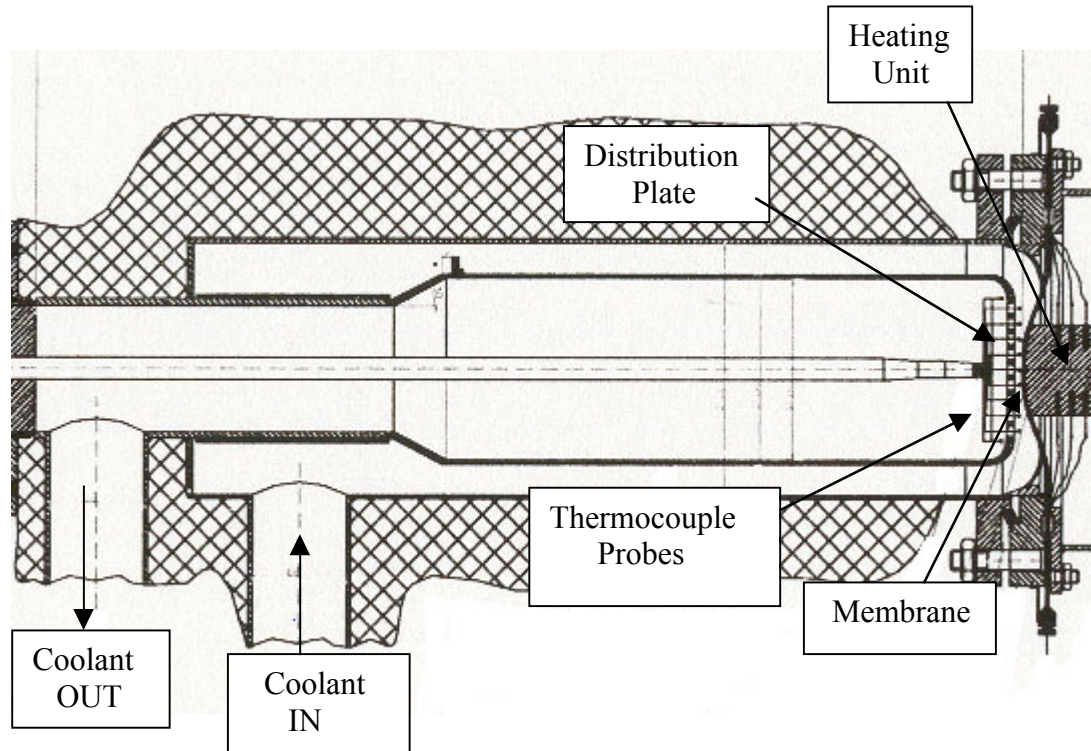
The system that I will use is a top down approach. I started with the goal of my research, to computationally simulate a target model, and worked down. This approach keeps the focus on the goal instead of the details, which can easily cause you to lose sight of the goal. The goal is broken down into three top-level tasks, which are further broken down into tasks. As each smaller task is completed, I see progress to achieving the overall goal – completing my research and degree. A schedule for the completion of the tasks is in place to ensure that the goal is met on time.

My goal, as set forth in the following document, is to defend my thesis on or before October 1, 2002 and graduate with a Master's Degree in December 2002.

***Review of Research***

The purpose of the AAA-UFP was to not only provide students with funding and research projects, but also help the development of several accelerator projects. The accelerator project with which I am working is ATW (Accelerator Transmutation of Waste) project. The goal of my research is to computationally simulate the thermal experiment of an accelerator driven target model. The experiment was conducted in

Russia at the Institute for Physics and Power Engineering and represents just one target model being considered. This particular target model is represented below in Figure 1.



*Figure 1: ADS Target Model*

The coolant – target flows into an outer chamber and towards the membrane. The membrane separates the target from the accelerator beam, which is represented by a heating unit. In this design, a distribution plate restricts the coolant flow. The restriction helps increase the coolant flow at the center of the membrane where the thermal stress will be the highest. Thermocouples measure the temperature of the coolant at various locations and the coolant flows out through the center chamber.

This test, conducted in Russia, provides data with which a numerical simulation is compared. Several laboratories have conducted numerical simulations of this system thus

far with good results. Each has performed this simulation using the k-<sub>ε</sub> turbulence model and various codes. I will conduct the simulation using a state of the art code called CFX, along with the Large Eddy Simulation turbulence model, and compare the results.

### ***Research Tasks***

Many of the details of my research are discussed in my thesis proposal submitted earlier to the University Research Alliance. This proposal addressed the relevance of the research topic to the Advanced Fuel Cycle Initiative program and specific steps that must be taken. Although all of the steps are important, develop model, refine model, and presentation are three main tasks that accurately describe my research plan.

### **Develop Model**

The computational model development turns out to be by far the largest task with the most overhead. As with any complex program, CFX requires a considerable amount of time and energy to learn the basics of the program before a complex geometry, such as the one being modeled, can be developed. Despite these hardships, the steps to develop the computational model are clear. I must build the geometry, generate a mesh, and define the model properties.

To build the geometry, a computer aided design program is used. Although CFX is capable of importing geometries from several popular CAD programs, it is a very specific and sensitive process. Luckily, a build program is integrated into the CFX preprocessor. Using techniques common to most CAD programs, the preprocessor is capable of building complex geometries to scale. The program generates a virtual model capable of capturing even the finest detail of the system being simulated.

CFX also comes with a quality mesh generator. This is important, because a good mesh is essential to developing an accurate model. This mesh generator is capable of generating different size grids, so that areas of more importance can be rendered with finer grids. This also helps to decrease the compilation time by rendering less important areas with course grids.

Compilation time is very important in this case, because the geometry is very complex. It is going to take a lot of nodes to render the detail of the system. For this reason, several attempts may be necessary to define the space accurately and efficiently.

To completely define the model, I must specify the model properties. The most obvious property to specify is the material properties of not only the target material, but also the target model structure materials. To accurately depict what will happen in the target model, the computational model must have well defined thermal and flow properties.

The computational model must also have well defined boundary conditions. Since the computational model results are completely dependent upon the boundary conditions, a considerable amount of care must be taken to specify accurate boundary conditions.

Defining only the boundary conditions of the computational model in this case is not enough, because the flow will be turbulent. Therefore, a turbulence model must be determined. My simulation of the target model will use large eddy simulation as the turbulence model. Although this will make the calculation more expensive, when compared to the popular k- $\epsilon$  model, the calculation should be more accurate and capture more detail.

**Refine Model**

As stated earlier, the development of the computational model is the largest task, but refining process may be the most time consuming. This is really the troubleshooting stage of the process. Once the model is developed, an iterative process must occur to yield accurate results. This may be as simple as refining the grid or refining the boundary conditions, so that an accurate computational model is the result, or as extreme as rebuilding the geometry and grid structure, so that the computation converges. I can only hope that this stage of the process occurs with very few setbacks, but allot extra time just in case there are.

**Presentation**

One of the most important aspects of a computational simulation is the presentation. This is far more involved than simply putting out the results of the simulation. The results must be presented in a manner that conveys information about the research performed. The presentation must not only show the similarities between the experiment and the numerical simulation, but also it must show the differences. Two effective ways are tabulated values at special points and flow visualization.

The tabulation of specific values at special points is particularly important when addressing areas of concern. The model being analyzed is susceptible to thermal stresses at the membrane interface. For this reason, it is particularly important to address the thermal intensity, to which the membrane will be exposed. It is also important to determine flow rates through the distribution plate and temperature of the coolant downstream of the distribution plate, so that a deeper understanding of the system dynamics is obtained.

Flow visualization is perhaps even more important than tabulation of specific values. It provides a visual description of the system. With computer graphics and plots, we can gain insight of the system at a new level. By analyzing specific points, we see very detailed information, but with flow visualization, we see the overall picture. Flow visualization gives us the ability to evaluate the overall system performance and see if the computational simulation really captures the aspects of the experiment.

### ***Administrative Tasks***

As stated in the previous section, three main steps must be taken to complete the research, but this section says nothing about fulfilling the requirements for a Master of Science degree. These tasks are general steps that must be completed along the way to administratively process a Master's Degree at \_\_\_\_\_ University.

First, a degree plan must be filed with the office of graduate studies. This degree plan consists of core courses, determined by the nuclear engineering department, and specialty courses, determined by my advisory committee to aid my research, which satisfy the requirements for a Master's Degree. The degree plan is currently approved and filed at the office of graduate studies. All courses on the degree plan are complete with the exception of one. I will complete this class the second half of the summer school session.

Second, a thesis proposal must be filed with the office of graduate studies. This is in many ways equivalent to the thesis proposal submitted to the University Research Alliance. It requires the objective of the research, the present status of the question, and the procedures that will be used to conduct the research. The office of graduate studies

requires it at least 14 weeks prior to graduation. My thesis proposal is currently on file with the office of graduate studies, far ahead of the 14-week deadline.

Third, my thesis must be submitted to the office of graduate studies for review. This must happen at least 6 weeks prior to graduation. To defend my thesis by October 1, 2002, I will submit my thesis proposal no later than September 15, 2002. This will be approximately one month prior to the office of graduate studies deadline.

### ***Schedule***

<b>Task</b>	<b>Completion Date</b>
Develop Model	End of May
Refine Model	End of June
Presentation	End of July
Thesis	Mid September
Defense	First October

### ***Conclusion***

As with any serious research project, there is a lot of work to be done on this research project. This document not only defines all the work that must be done, but also it establishes a clear timeline, so that my research is completed before the end of this year. My goal is to defend my thesis on or before October 1, 2002. With the plan set forth in this document, I will reach this goal and graduate in December 2002.

**Advisor's Approval of Final Research Plan**

I have read and approved this Final Research Plan written by AFCI Fellow,

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\_\_\_\_\_  
Advisor's Signature

\_\_\_\_\_  
Date