Preparation of Morpheus Vehicle for Vacuum Environment Testing

NASA Johnson Space Center
Project Morpheus
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The main objective for this summer 2016 tour was to prepare the Morpheus vehicle for its upcoming test inside Plum Brook's vacuum chamber at NASA John H. Glenn Research Center. My contributions towards this project were mostly analytical in nature, providing numerical models to validate test data, generating computer aided analyses for the structure support of the vehicle's engine, and designing a vacuum can that is to protect the high speed camera used during testing. Furthermore, I was also tasked with designing a tank toroidal spray bar system.

Throughout the summer, individual component tests were conducted prior to system integrated testing at Plum Brook. One of the components tested was the igniter; whose performance was validated by a combustion model created using Microsoft Excel. This model was developed on the basis of theoretical formulas and it was interfaced with a combustion data sheet based on NASA's Chemical Equilibrium and Applications (CEA) in order to provide an iterative error solver that yields the chamber pressure required for different inlet combination parameters. The end result of the model were a series of plots that mapped ignitability in terms of mixture ratios, inlet pressures, and inlet temperatures.

After completing the combustion model, I proceeded to work on simulating an engaged load case for the vehicle's engine thrust arm/ring structure. The purpose behind this analysis was to ensure that the bending stresses and displacements were reasonable enough to allow the integration of a load cell on the thrust arm for clear thrust reading during testing. After the analysis was completed, the results were presented to a structures specialist, with the purpose of attaining a more intricate opinion on the feasibility of the intended component integration.

Moreover, because the thrust expelled by the engine is quite large, a protective camera casing is required for the Phantom V12 high speed camera that is to be used during testing. The main driver for this design was to provide a rigid camera mount inside of a limited space vacuum can in order to maintain camera safety, should any incidents occur during testing, while at the same time providing an adequate feedthrough interface for successful system integration. The finalized designed is shown in Figure 1, and the components are already on a lead time to arrive.

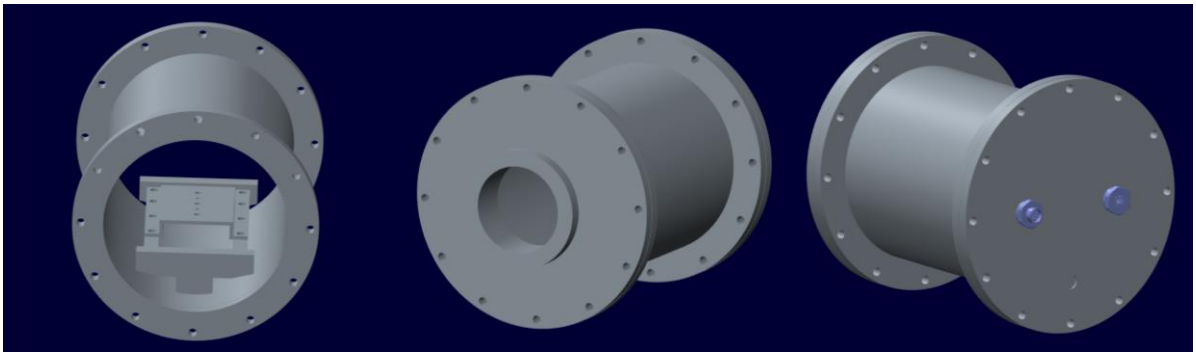

Figure 1: Finalized Camera Vacuum Can Design

During the last weeks of my internship experience here at Johnson Space Center, I focused on designing a diffuser system to be integrated inside of the Morpheus tanks. The purpose behind this design is to chill the tanks as fast as possible by using the least amount of propellant. A numerical model was developed using Microsoft Excel to prove the feasibility of this design. It focuses on calculating mass flow rates, velocities, and droplet trajectory for different orifice configurations to ultimately yield a total mass of propellant actually reaching the tank walls. Further design work will be continued, should a consensus be reached on the validity of the design.

Aside from the analytical work I accomplished throughout the summer, I was also provided the opportunity to do some hands on work. Upon the arrival of the new engine injector for example, I was called upon to witness how welding is done on aerospace components. At the conclusion of the welding process, I was taught how to examine and identify welding imperfections using a borescope; which I then proceeded to do on the newly welded injector in order to avoid any type of leakage. Furthermore, I also got the opportunity to assemble an experimental set-up to run water tests on the injector. Another example of hands on work I accomplished during this summer, is the installation of multilayer insulation (MLI) on the Morpheus tanks. This particular task, though it was tedious, was also very important as it required close carefulness and precision.

Overall, this internship experience has refined my skills in design and modeling. My duties here have broadened my attention to detail while going through the design and modeling process, and at the same time have provided me with a great amount of appreciation for system integration and its many subcomponents. Moreover, my analytical skills were also significantly refined by this experience, motivating me to continue pursuing a career in the aerospace industry.