Clean Energy Systems, Inc.
Power Without Pollution

Written By: Brett Hodge

CES Technology:

Clean Energy Systems (CES) is a start-up energy company located in Rancho Cordova, CA, with a test facility in Bakersfield, CA. CES's main focus is on creating energy by using a steam turbine fueled by their unique gas generator. CES is clean because the combustion process takes place within a pure oxygen environment, as opposed to air. Using a pure oxygen environment gets rid of the extra pollutants, mainly nitrogen oxides (NO_x). In the gas generator a stoichiometric amount of natural gas, water, and oxygen are injected and ignited to create steam and carbon dioxide (CO_2). The steam and CO_2 mixture will then be used to turn a specially modified turbine. This turbine is modified for CES to have a steam inlet, instead of a compressor, because there is no need for the air. After spinning the turbine, the steam and CO_2 mixture can be separated by condensing the steam. The CO_2 can then be captured and used in a variety of situations, namely petroleum fields.

Figure 1.1 CES Gas Generator

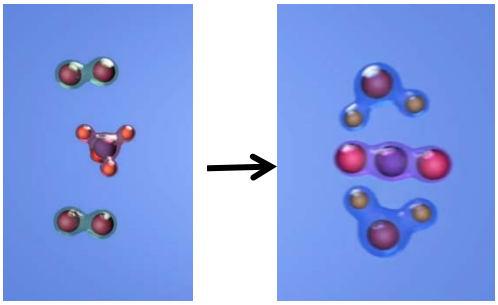

Figure 1.2 Complete Combustion

During my summer at CES, I was able to experience an array of all sectors of the business. I did work in: aerospace engineering, management, inventory, business, economics, materials engineering, construction management, and mechanical engineering. Being able to see all aspects of the company was extremely important in my understanding of how much work needs to be put in to a business to make it run smoothly. Here are some examples of some of the problems that were faced, and how they turned out.

Breaking Thermocouples:

The first engineering problem that I faced was to find a fix for ceramic tubes that were breaking inside our test reheater. The thermocouples tubes were oriented across the reheater cylinder directly in the flow of the steam mixture. A previous analysis showed that the ceramic tubes cannot be breaking due to static force. Therefore, there must be some sort of critical frequency that must be affecting the tube. Since the tubes were cylinders, a vortex street was created, and the frequency at which the vortex street alternated was causing the tubes to break. I then tried to manipulate the environment that the ceramic tubes were in so that a critical frequency was not achieved. I can either manipulate the pressure, temperature or velocity.

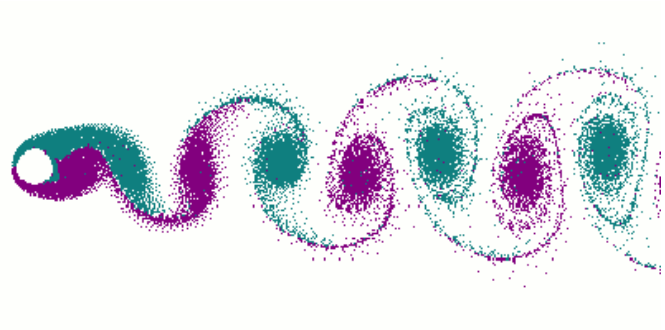

Figure 2.1 Von Karman Vortex Street

Using this equation:

$$\mathrm{Re} = \frac{Vd}{\nu}$$

I tried to increase or decrease the Reynold's Number out of the critical range. Temperature was the easiest to change, so I started with that. As you can see, the Reynold's Number equation given does not have a temperature related variable, and is therefore not dependent upon temperature. I then tried to manipulate velocity, which was unfeasible for the project, and finally pressure, which ended similarly. So to stop the tubes from breaking we had to change the material. Inconel 625 with a thermal-fabric wrap was decided upon. The Inconel is a high temperature alloy, but cannot survive by itself in this temperature range. That is why there was a thermal-fabric added, and we supplied it with minimal air cooling.

Oxygen Pump Explosion:

When I arrived at CES, I learned that they had previously had an oxygen pump explode while testing about a month prior. When it came to start testing with a new pump, I experienced a second oxygen pump explosion. This pump had been run previously for seven years without a problem. After much speculation and still not exact reason why the pumps were exploding, we had to try something else out. To fix the problem, a Monel lined piston and cylinder were used as opposed to stainless steel. This should stop the pumps from creating am ignition source due to any contact. The contact between stainless steel can cause a spark, but it isn't likely. Monel is a nickel alloy that resists any kind of sparking. My internship ended before we were able to test again, but the replacement pump was pumping oxygen without a problem before I returned to school.

J79 Report:

When I first arrived at CES I was put on a team of a couple people to assist with writing an in depth summary report for one of our test turbines, the J79. I helped with scheduling, collecting and analyzing data. I didn't write any of the report because I was not nearly as versed as the employee for obvious reasons, but I was able to contribute what help I could. The main data collection points for me were to be able to show graphs of critical dimensions for normal, stable runs and for problem runs.

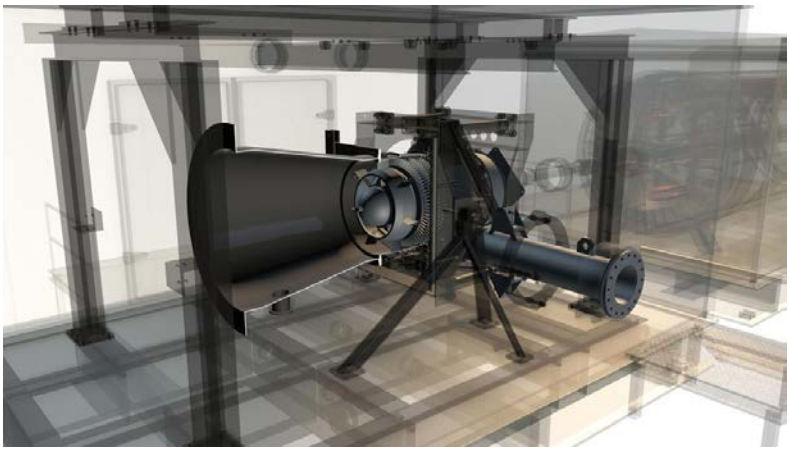

Figure 3.1 J79 Turbine

OFT-900:

I spent the most time assisting in the construction of a newly modified, and much larger turbine than the J79. This is where the contruction management came into play. There were many variables in setting up the location for placing the turbine. Electrical, materials, mechanical, and aerospace engineering were all used in the design of the turbine and it's suooort system. Speculating parts for design was where most of the engineering took place, but then there was either ordering the parts or getting the parts made, storing them if they aren't going to be used immediately, and finally fitting them in the field. This process is must go through a few people, and communication is a key acpect of the process. Bad communication along the process can create costly

problems that are easily avoided. This experience is contruction showed me that there is a lot of work and time that must be put into these large projects, and any one mistake can have a shockwave effect and delay the process.

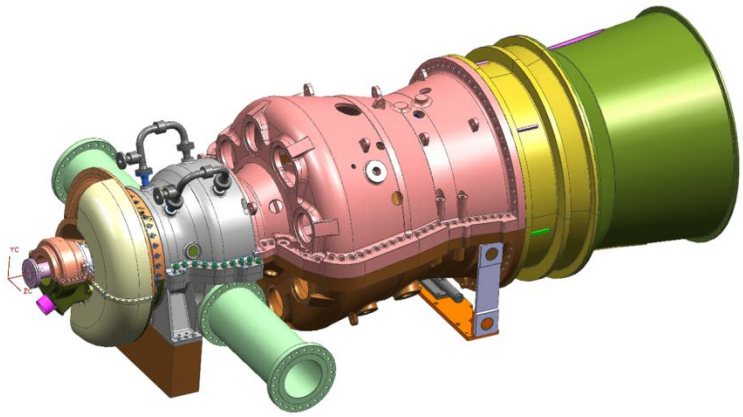

Figure 4.1 OFT-900

Conclusion:

Not only was my internship a summer job that kept me busy making money, it was an experience that was more valuable than the money. I learned why businesses value internship experience so much. There are a wide variety of subjects that a university will not be teaching you, and can only be learned on the job.