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For this project our group split up into two parts. My half decided to go to Lockheed Martin to witness a LOX testing. LOX stands for liquid oxygen, and the test basically determines whether or not a sample material will react with the liquid oxygen. This test is performed by Lockheed to determine if a spark occurs in the liquid oxygen tank, of a rocket, will the container material react/explode. To perform this test, all the testing equipment is pre-chilled in liquid nitrogen. This is done to prevent the LOX from evaporating during the test and prevent miss-firings. Our goal for this trip was to capture images of the sample reacting with the liquid oxygen and those resulting in an explosion. As an unexpected bonus, before we started the experiment there was a container of liquid nitrogen. The container was venting nitrogen and a stalagmite of ice crystals formed as the air around the venting nitrogen condensed.

To conduct this experiment, Lockheed uses a simple impact tester. A 20 lb weight is suspended 43 inches above the impact site by an electromagnet. The magnet releases the weight with enough force to strike the impact zone at 72 ft-lb. For combustion to occur you need fuel, an oxidizer, and a source of energy. The sample material acts as the fuel and the liquid oxygen is obviously the oxidizer. The source of energy comes from the impact. The impact is essentially the same concept as striking a flint. The impact of the striker stone on the flint causes a spark, and in this case the impact of the weight on the impact zone causes a transfer of energy. This transfer of energy is the key ingredient for this combustion. When Lockheed does actual material testing using the LOX test the desired result is no reaction. No reaction means that even if there was a source of energy in the oxygen tank, the tank's housing would not act as a fuel. This is good for rocket ships but not very interesting to take photos of. For our images we used a sample that is none to react with the oxygen, called lacing tape.

To produce the best reaction the impact site, the sample holder (a cup), the sample, the striker pin, and the locking mechanism must all be pre-chilled with liquid nitrogen up until moment of testing. This insures that as little oxygen as possible evaporates before the weight impacts the striker pin. The setup for this experiment is pretty simple. The sample is placed in side the cup and then the cup is suspended in a dish of liquid nitrogen a long with the striker pins. The cup is then emptied of liquid nitrogen and placed in the impact site. The striker pin is then position directly on top of the sample and locked in place. Next, you fill the cup to the brim with liquid oxygen and then drop the weight. The impact of the weight then causes the sample to react with the oxygen and an explosion occurs. This particular type of combustion is known as a detonation, where the entire reaction occurs instantaneously. To view the explosions we had to situate our cameras to get the best shots from the outside of the blast door. The blast door had three windows that were around two inches in diameter, and these windows were about 20 inches from the actual impact site. The windows were located about 16 inches above the impact site so we had to angle or cameras to get the desired shots.

The visualization technique used to make these images is either to simple to mention or too complicated to be understood. We simply set up or cameras and took the pictures, no other techniques were used. Lighting for these images was produced only by the light of the explosion. No other sources of light were utilized.

Each one of these images has a field of view of about six inches in diameter. The camera was approximately 26 inches from the impact site with a focal length of around 1.8 meters. I used a Nikon D70 digital SLR camera with a fully manual 50mm lens. The D70 is 6.2 megapixels and has a maximum picture size of 3800 X 2700 pixels. The shots were taken with a four second shutter speed, an ISO value of 200, an f-stop of 2.8, and an exposure value of +0.0. To edit these photos I only cropped away some distracting elements and brightened some of the really dim shots. I then used Photoshop to resize the images and place them on one background.

Even though these images were very fun to make and very interesting by nature, the lack of actual flow visualization is a concern. Each one of these images is to far away from the actual reaction, so that any information about the flow is impossible to relate. If I were to do this again, I would place the camera inside the blast door, behind a Plexiglas shield, level with the impact site. That way the camera would not get damaged and the actual fluid flow could be seen. Remember the ice stalagmite I mentioned in the beginning. This image does show a lot of interesting fluid physics. However, the original image showed more of the vapor trail emanating from the nitrogen bottle. That is what I was trying to visualize but the vapor trail did not come out.

Reference:
Impact Sensitivity Threshold and Pass-Fail techniques