Shot Stream

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Abstract

The Shot Steam image was taken for the third group assignment of the University of Colorado at Boulder Mechanical Engineering course MCEN 5228 – Flow Visualization. The objective of this assignment was to create fluid phenomena and capture the phenomena in an image. The Shot Steam image was intended to demonstrate the phenomena of fast moving water explosions and the dynamics of high speed impacts with water. The image was taken in the hope that with this visualization more individuals will be able to appreciate and understand the complex fluid relations behind this phenomenon.

Image Set Up

The image was taken outside and illuminated by natural sun light coming from 45 degrees above the splash. The camera was located on the side of the splash, 45 degrees to the side of the direction of the fired gun shot. The background of the pictures was set up so that behind the splash was a scene of natural foliage so that the background would have good contrast. Additionally, the image was taken at approximately 120 degrees from the light source so that the reflection off of the splash would be the most noticeable.

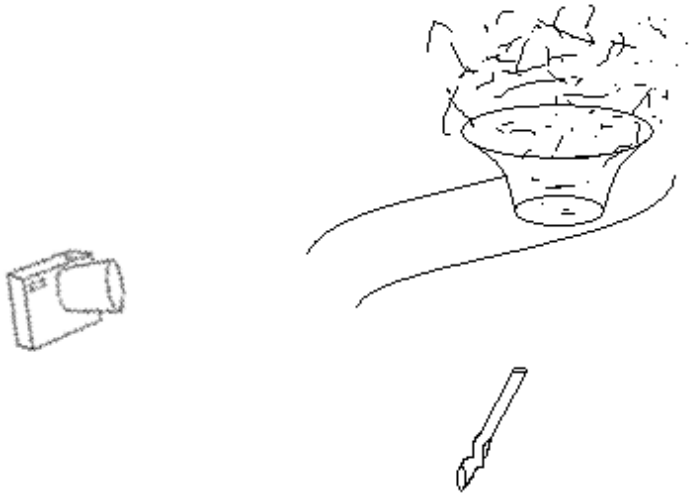

Figure: 1
Set up for Shot Steam image.

The splash present in the image was created firing a Remington 870 express shotgun. The shot was fired from a distance of 15 yards at an incoming angle of roughly 15 degrees. The image was taken less than one half second after the impact of the round onto the stream surface. Water splashed strait up into the air about twenty feet before turning around and falling back to the ground.

Phenomenon Explanation

The phenomenon seen in the image is an example of a splash in which the formation of a thin sheet of water eventually breaks apart and forms small drops. The shotgun shot hits the water and transfers some of the shots kinetic energy to the water causing the water to splash up and travel away from the stream. The phenomenon seen in the image is an example of the Surface tension effect which describes how liquids hold onto each other and create spheres due to that shape being the lowest energy state. The thin sheet of water in the image exists because the surface layer of the water has a high surface tension. As the sheet of water stretches and thins out the water breaks into tiny drops because the water wants to be in its lowest energy state which happens to be a sphere. The spherical shape is also caused by surface tension effects. This surface tension causes the water to form a sphere, because a sphere has the smallest possible surface area per volume. In addition to the simple splash seen in the image, a very tall and vertical splash occurred. The vertical splash can be attributed to the extremely fast shock wave that travels through the water when the shot hits. This shock wave attempts to compress the material that it is traveling through, however due to waters incompressible nature, large movement of water must occur. In this scenario the shock wave travels radially into the water from the point of impact and at the location of the water air interface an imbalance of pressure occurs. The shock wave traveling in the water creates high pressure on the bottom side of the water-air interface and the surrounding air on the top side has a relatively low pressure. This pressure differential causes the water at the surface to travel upward creating the large vertical splash. There is no horizontal splash created by this phenomenon because the pressure is balanced by the surrounding water on the sides. This vertical splash is intensified by the impact angle that the shot has to the water surface because

the shock wave intensifies with increasing the impact angle from normal. In fact the shock wave pressure doubles from its value when impacting at 90 degrees to when it impacts at 55 degrees. This increase in pressure will eventually fall off however when the angle approaches 0 degrees.

Camera Settings

The photo was taken as a digital image with a Nikon D90 camera set with a focal length of 52 mm in order to capture the impact location of the splash and not the entire 20 foot tall splash. F-Stop of 5.0, exposure time of 1/1250 sec, ISO of 800, size of 4288x2848 pixels, and an aperture value of 4.6 was chosen to attempt to capture the clearest image of the splash. Cropping of the image as well as an adjustment and increase in the green levels. However, other colors were not adjusted to create a high contrast between the fresh green foliage and the harsh brown splashing water. Brightness levels were also minimally adjusted to incorporate a slight feeling of mysteriousness to the image.

Conclusions

This image shows the beauty that fluid flows can have and the complex physical phenomena that can produce these events. Overall the image that was captured came out well. The photo presented the phenomenon that it attempted to convey and it was done in a visually pleasing way. In the future, capturing this image would be easier if it could be done in a more controlled manner and with a camera that was linked to the firing of the shotgun.

Works Cited

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Original photo, pre-Photoshop edit.