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Flow Visualization
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Professor Hertzberg
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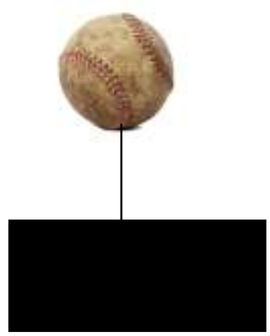
Bring the Heat

The purpose of this image was to observe the fluid flow around a baseball. I wanted to use fire to show boundary conditions and wakes as air flowed past the baseball. In this image I was trying to create the feel of a fastball being pitched; and often being referred to as bringing the heat, led me to use the fire to convey the feeling of the baseball moving at higher velocities. I had little success with my initial attempts at trying to force a clear image with the help from an aerosol jet impinging the ignited baseball; the tail of the flame grew too large and didn't enable me to get the baseball in clear enough focus to make a clean shot. After a few attempts with this, I found it best to let the fire do all the work by itself to illustrate the flow around the ball.

I set up my photo by first building an ignition rig for my baseball (roughly a 3 in diameter). My rig started with me drilling a ¼ in diameter hole 1.5 inches deep into my baseball, a ¼ in diameter hole 2 inches deep into a scrap piece of wood from the ITLL (3 ¼ x 3 ¼ x 4 ¾ in). I then went and bought a 7 ½ in bolt with a ¼ in diameter, cut the top off, and put one side in the wood while the other held the baseball in place. The holding apparatus was then painted black so it would disappear in the background of the photo.



The flow that you will see in my photos demonstrates convective flow over a circular object. The baseball in this image is acting as a very large candle. The acetone that the ball was submerged in is absorbed by the ball, but begins to evaporate after the ball is put on the stand which will aid the combustion process by spreading reactants around the ball. "Flame is the result of a slow combustion and is usually associated with light accompanying it. The flame of a candle is a typical heterogeneous diffusion flame because, at first, the initial substances and products of combustion are in different phases and, at second, a fuel is evaporated and is mixed with an oxidant in the process of diffusion. Reaction takes place in external layers of a flame. In narrow sense, properly reaction zone is called by flame. In dark zone reactions do not take place because the air does not penetrate into internal layers of a flame. In this zone the heat transfer goes due to convection and the heat spend to evaporate the acetone the ball was soaked in.

Convection transfers acetone into reaction zone. Luminescent zone emit light due to carbon particles which are intensively radiated while heated. The carbon is appeared because of condensation of *Ñ2* produced in reactions of pyrolysis, polymerisation and condensation of hydrocarbons. Specialists consider pyrolysis to be dominated. Convective movement up the surface of a flame is generated and supported due to non-uniform heating in external gravitation field. Convective hot gas flows outward to reaction zone form streams carried products of oxidation and surrounding air. In some cases the whirl structures may be produced." (Belarus Team) The heat from the fire causes the fluids near it to be less dense and rise thus causing a flow of the air around the baseball to occur. This flow allows us to visualize the boundary conditions and the wake conditions of the fire. While shooting with this apparatus outside there were occasional flutters of crosswinds impinging upon the flow which caused some vortices to occur in the wake of the ball rather than the laminar boundary layer that formed around the surface of the ball facing the flow with a narrow turbulent wake. After some research I was still having difficulty finding how to calculate the Reynolds Number for a combustion flow, but I was able to find a textbook online with a figure that estimated the number based on the behavior of the flow around a sphere in the middle of the flow. Based on these figures, the fluid flow around my baseball was between 10^2 and 10^5.

The visualization techniques I used were all based on all the light from my image to come from the subject itself, not from the background. I took my apparatus out to the grill, lined up the camera so there were no light sources in the background and began my photo shoot in that manner. In order to get a flame that had very little smoke that would distort the image, and burn clean enough to not burn my baseball, I used acetone. I dipped my ball in said acetone, and then lit it using a standard lighter that Hungry Buffs likes to give away. This allowed me to gain all my light from the subject itself through flame emission. (Natural Pollutant Inventory) Acetone does have a slight disadvantage to being used because it was found to be slightly toxic, "acetone has caused membrane damage, a decrease in size and decrease in germination of various agricultural and ornamental plants. The effects on birds or land animals have not been fully determined. Acetone is not expected to bioaccumulate in plants, animals or humans."

The camera that was used for this picture was Nikon D40X with a Tamron 28/300mm lens while using a 1/100 second shutter speed. This 2592 by 3872 pixel digital photo had an F-stop value and aperture value f/6.3, an ISO speed rating of 1600, and a focal length of 300 mm. I chose the field of view to be approximately 10 inches so that the baseball was very clear as well as the immediate boundary layers of the fluids around and behind it, with the background also being black, this also lent itself to the visualization of the wake of the baseball.

I like the images that I took so much that it was very hard to pick a finalist, so I decided to pick two. I picked one when the crosswinds were dead still to show the boundary flows and wakes in ideal conditions. I also chose a photo with a slight crosswind that caused vortices to start forming in the wake of the ball. I think that my technique really allowed me to illustrate fluid behavior rather well using the tails of the flame on the baseball. I feel as though I did a good job; the only thing I would want to do again is try a wide angle lens to capture the same image but be able to see the full extent of the flame trail while keeping the baseball in as much focus, as well as understanding the quantitative mechanics behind a combustion flow to better give numerical values.

Australian Depoartment of Sustainability, Enviroment,Water, Population, and Communities, . "Acetone: Environmental effects." *National Pollutant Inventory*. n. page. Web. 7 Feb. 2012. <http://www.npi.gov.au/substances/acetone/environmental.html>.

"Combustion." *Computational Fluid Dynamics Online*. n. page. Web. 7 Feb. 2012. <http://www.cfd-online.com/Wiki/Combustion>.

Glassman, Irvin. "Combustion." *Google Books*. n. page. Web. 7 Feb. 2012. <http://books.google.com/books?id=26lr8lOhCVgC&pg=PA245&lpg=PA245&dq=reynolds number in combustion&source=bl&ots=Q7hIasnu3Y&sig=yZtfXPsVntwfY4es1MHLyHDOYYA&hl=en&sa=X&ei=IUExT724EubJsQL95sSjBw&ved=0CGMQ6AEwCA

Princeton, . "Drag of Blunt Bodies and Streamlined Bodies." n. page. Web. 7 Feb. 2012. <http://www.princeton.edu/~asmits/Bicycle_web/blunt.html>.

Belarus Team. “Gas Flow”. <http://ilyam.org/CR-ROM_IYPT_1999/13_Gas_flow_Belarus_IYPT_149-152_1999.pdf>