PHANTOM®

2017
CASE STUDY

Outcomes of Mid-air Collisions Between Drops and Solid Particles

Experimental equipment for studies of collisions between drops and solid particles.

One of the major turning points in world history was the birth of the first industrial revolution, which is said to have begun as early as 1760. This groundbreaking time period refers to when rural societies moved from hand production to machine use, chemical manufacturing, and iron production processes (to name a few advancements). Quite simply, the industrial revolution marked a significant shift to powered, special purpose machinery and has had a major positive affect on every aspect of our lives.

Today, scientists and engineers around the world continue to conduct experiments that glean insight and provide valuable data for different industrial processes. In doing so, they are taking advantage of the latest digital high-speed imaging technologies. Vision Research, manufacturer of the Phantom digital high-speed cameras, has the most comprehensive and competitively-priced line of digital high-speed imaging products and accessories on the market today. Phantom cameras can record events that occur at speeds too fast for the human eye. By slowing the images to visible level, critical data can be analyzed in the fields of science, aerospace, and medicine. Through the use of such sophisticated technology, scientists, doctors and engineers around the world are furthering their fields of research to help develop new and useful technologies in a variety of areas that impact daily life.

VISION RESEARCH

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MATERIALS ANALYSIS DIVISION

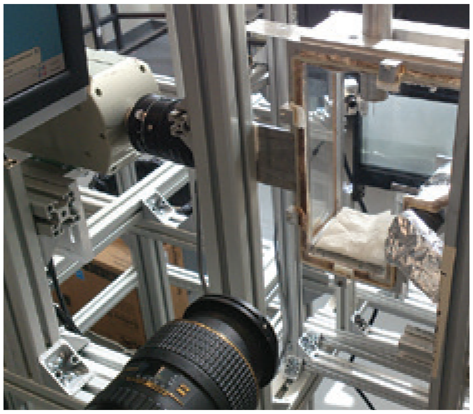
One such experiment is the study of drop-particle collisions, which involves examining the outcome of the impact of a particle onto a drop of liquid in mid-air. This project was recently conducted at Toronto's York University in the Lassonde school of Engineering and spearheaded by Dr. Vitaliy Sechenyh, research fellow at the University of Brighton in the UK.

Dr. Sechenyh explained that particle wettability studies are crucial to the advancement of a variety of different fields, such as tablet coating within the pharmaceutical industry and the refining of heavy crude oil by fluid catalytic cracking. "In applications like these, at some point there is a drop of liquid that collides with solid particles of all different shapes, so it's important for us to examine this phenomenon and report back to the industry on what we've uncovered. Data like this has a significant impact on the way we move forward with certain industrial and medical applications," he said.

Enter the Phantom Miro M310 and Phantom v4.3

Keen to get his project underway, Dr. Sechenyh quickly realized that he would need reliable high-speed digital camera that would be able to slow down the action and record the experiment at a speed he could easily examine with his own eyes. After carefully evaluating the market, he turned to Vision Research for the company's flexible and cost-effective Phantom v4.3 and Phantom Miro M310 digital ultra-high-speed cameras. "We worked very closely with Vision Research and relied on their expertise to help us select the right cameras for this study, especially because speed and accuracy are so important in a project like this," he commented.

The mid-sized Phantom Miro M310 used by Dr. Sechenyh offers a maximum resolution of 1280x800. At full resolution and 3.2 Gigapixels/second (Gpx/s) throughput, the camera delivers frame rates up to 3,200 frames-per-second (fps). To go even faster, the resolution can be reduced to record at speeds upwards of 650,000 fps. Compatible with Vision Research's CineFlash removable, non-volatile memory magazine, the Phantom Miro M310 gives users the ability to quickly save shots from the camera's memory without the need for time-consuming and costly downloads. The CineFlash magazine can be removed and inserted into a docking station which can safely transfer the files to a computer for editing and analysis.



Phantom v4.3

With the Phantoms in tow, Dr. Sechenyh was ready to kick things off. Along with the cameras, his equipment setup consisted of a drop generator, a particle launcher, a timing/triggering system and two powerful LED lights. Dr. Sechenyh used pure deionized water as his liquid source and he used two different types of particles – soda lime glass (hydrophilic) and polystyrene beads (hydrophobic) that measured 2mm in size. He positioned each Phantom camera at a 90-degree angle and he time-synchronized

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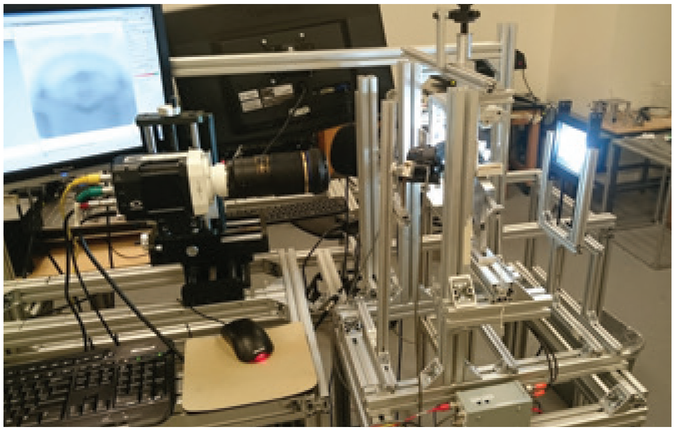
them to acquire the same capturing speed at 4,000 frames per second. Then, beads were manually placed inside the barrel of the launcher, which shot the particles by releasing a pre-tensioned spring. The launcher includes a mechanism that allowed Dr. Sechenyh to increase the value of the particle velocity by adjusting a screw, which changes the pre-tension of the spring.

The timing/triggering system included a triggering laser, a photo transducer, timing control electronics, and a solenoid trigger. To illustrate how this worked, Dr. Sechenyh explained that the drop passes between the photo transducer and the laser diode, it triggers the electrical circuit to become open, and then the solenoid trigger removes a pin from the launcher simultaneously releasing the pre-tensioned spring. With the Phantom cameras capturing the experiment at 4,000 frames per second, combined with the power of the LED lights, he was able to examine the shadow of the objects as they collided. This gave way to uncovering several useful parameters including, the drop diameter, the particle diameter, and drop and particle velocities before the impact. For example, he was also able to closely inspect the morphology of the lamella and ligaments, which increased during the growth stage, reached maximum value as the particles detached from the liquid, and then began to decrease until the beginning of the breakage stage. "All of the collisions were happening incredibly fast. The total duration of each impact was between 3-7 milliseconds, which is obviously not something we'd be able to record without high speed cameras," he commented.

As a first-time user of cameras of this pedigree, Dr. Sechenyh said the Phantom models were a natural fit for his project. "We were delighted that the cameras were not only easy to set up but that they worked flawlessly over the three months we conducted the study. Their speed and accuracy was impressive, and the time synchronization function was a huge advantage to our project because we could record images simultaneously from two different angles. This saved us a lot of time in the end. In working with these cameras for three months, it's evident that Vision Research takes great pride in the research and development of its products and the market-leading technology that they provide," he commented.



Phantom Miro M310

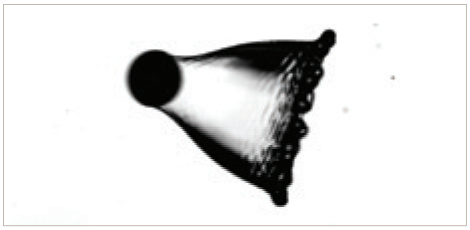
Dr. Sechenyh generated some incredibly useful qualitative and quantitative analysis of mid-air collisions that he believes will benefit a host of applications in the future with regard to the fields of chemical engineering, academic science, and medicine. "I have Vision Research to thank for that," he said.

Below are some links to Youtube footage in reference to the influence of particle wettability on outcome of mid-air collisions with drops.

Collision between water droplet and polystyrene.

Particle velocity 4.7 m/s

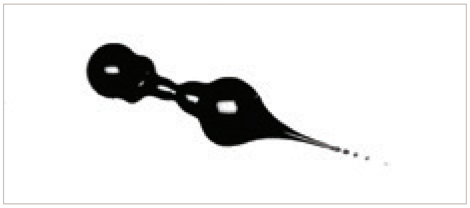
https://youtu.be/5xXsv_2wcSI



Collision of water drop with glass particle

Particle velocity 2.1 m/s

https://youtu.be/fGtwid4QZN8



Polystyrene particle collides with water drop

Particle velocity 8.1 m/s

https://youtu.be/fxEvX_MjfXM

Drop onto particle impact in mid-air

Side view camera

https://youtu.be/oOWQXL4d984

More details are available here:

http://www.sciencedirect.com/science/article/pii/S0889974616301384?np=y