Team project 3

Dry ice dives into the hot water and makes fogs

Flow Visualization

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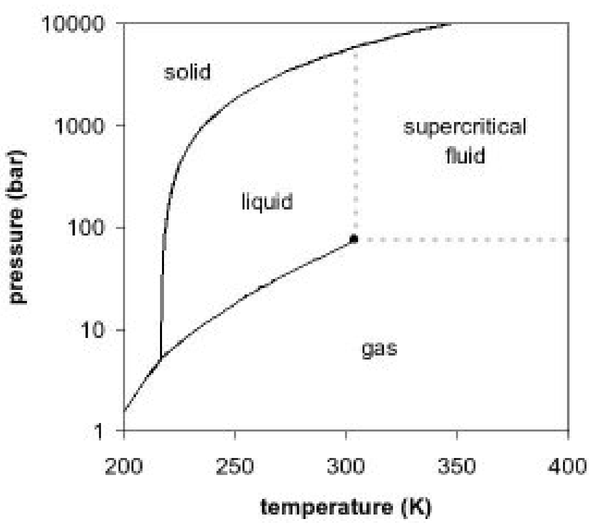
For project 3, original idea of team Delta is to generate fog in the wind tunnel using dry ice. However, setting up equipment for wind tunnel test is much more difficult than we expected, we end up with plan B to generate fog produced from dry ice sublimation in hot water [1]. In this work, we are observing laminar and vortex fog out from a guide hollow tube connecting to the source mentioned above.



Basically, dry ice is frozen Carbon dioxide that is different from most solids. It can not be melted to form liquid, but it can be made to change into a gas at atmospheric pressure. This process is called sublimation. The Carbon dioxide pressure-temperature phase diagram is shown as Figure 1[2]. Dry Ice is useful for freezing, and keeping things frozen because of its very cold temperature that is around -78.5 °C (-109.3 °F). More recently, dry ice is not only used for keeping items at low temperatures, but is also widely applied for industrial cleaning [3].

Experiment setup

To capture the laminar and vortex flow generated by dry ice, a strong and fast lighting is required. Thanks to Barry and Erik from fine arts prepared high power flash, the light intensity is close to what we need. With the powerful flash as background lighting, the camera flash light is also used to enhance the exposure strength. The smoke is guided into the hollow tube around 45 degree facing down. The above photo is taken with laminar flow in the upper section and then two vortexes in the lower section.

Conclusion

A lot of trial photo shooting is done for this project but hardly get a good one. Capturing vortex of smoke is not an easy task because the smoke is really unstable. A little wind can easily destroy the laminar flow and vortex. This image is the best of my whole pictures. But it's not good enough because there is shadow on the background. I believe with a better shutting location and angle the picture will be even more impressive. Some Photoshop work has done to reduce the shadow of the background, making the background looks like totally black color. Generally speaking, I am happy to have the image of the fog/ smoke by dry ice in the water, to do experiment with my teammates together. Thanks their help and assistant. Finally, for the team project 3 of the team delta, all teammates and I get good images we want

Reynolds number [4]

$$Re = \frac{\rho v_s^2/L}{\mu v_s/L^2} = \frac{\rho v_s L}{\mu} = \frac{v_s L}{\nu} = \frac{\text{Inertial forces}}{\text{Viscous forces}}$$

v_s - mean fluid velocity, [m s^{-1}] , L - characteristic length, [m]

μ - (absolute) dynamic fluid viscosity, [N s m^{-2}] or [Pa s]

ν - kinematic fluid viscosity: ν = μ / ρ, [m^2 s^{-1}] , ρ - fluid density, [kg m^{-3}].

L is around 1 meter. At room temperature, the viscosity of air is 1.78×10^{-5} kg/(m·s) [5], and dry air has a density of approximately 1.2 kg/m^3[6]. Because some parameters of the fog/smoke almost like the parameters of the air and then using these approximate numbers to calculate the approximately Reynolds number that is definitely less than 2100.. Thus, that is laminar flow

Camera information

Mark: Canon Model: Canon XTi Lens: Sigma 18-200mm

Shutter speed: 1/60 sec F-Stop: f/6.3 ISO: 400

Focal length: 200 mm Pixel Dimension: X: 1500; Y: 1200 Flash: Yes

References

[1]. http://www.dryiceinfo.com/

[2]. Carbon_dioxide_pressure-temperature_phase_diagram
http://en.wikipedia.org/wiki/Dry_ice

[3]. Dry-ice blasting for cleaning: process, optimization and application,G. Spur, E. Uhlmann and F. Elbing , Institute for Machine Tools and Factory Management, Technical University Berlin, Pascalstr. 8-9, 10587 Berlin, Germany.

[4].http://en.wikipedia.org/wiki/Reynolds_number

[5] http://en.wikipedia.org/wiki/Viscosity

[6].http://en.wikipedia.org/wiki/Density_of_air