TEQIP Summer Internship Report 2019:

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Summary:

1. **Combustion:** Combustion is a high temperature exothermic reaction between a fuel and oxidizer, usually atmospheric oxygen. Combustion in a fire produces a flame and the heat produced can make combustion self-sustaining. A simple example can be seen in the example of hydrogen and oxygen in to water vapor, a reaction commonly used to rocket engines.

$$2\ H_2\,(g) + O_2(g) \rightarrow 2\ H_2O(g)$$

During the combustion process, as the fuel and oxidizer are turned into exhaust products, heat is generated. These substances are called exhaust. The fuel can be solid, liquid or gas. Most of the exhaust comes from chemical combinations of the fuel and oxygen. The temperature of the exhaust is high because of the heat that is transferred to the exhaust during combustion. Because of the high temperatures, exhaust usually occurs as a gas, but there can be liquid or solid exhaust products as well. **Soot**, for example, is a form of solid exhaust that occurs in some combustion processes. The efficiency and cleanliness of a combustion process depend upon several parameters such as oxygen supply, temperature history and mixing properties.

2.Candle flame: Candles produce light by releasing heat and all turn on the candle produces come from a chemical reaction known as combustion in which wax reacts with oxygen in the air to produce carbon dioxide. The substance that vaporize while burning produces the flame. Kerosene oil and molten wax are the two substances that are responsible for producing flame while burning.

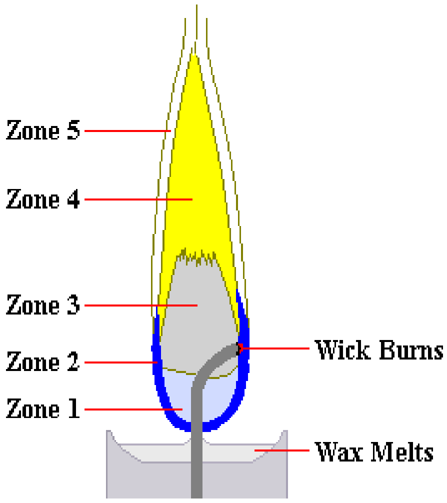
In a general candle, flame color depends on three factors:

- Nature of the substance that undergoes combustion
- Amount of oxygen and
- Temperature

There are two types of flames:

1. Non luminous flame and
2. Luminous flame.

Several zones of a candle flame can be seen with the eye.



Zone 1 (Non-Luminous Zone) - Fuel on the wick evaporates. There is insufficient oxygen for fuel to burn. Temperature is about 600°C near the wick.

Zone 2 (Blue Zone) - There is a surplus of oxygen and the flame burns clean and blue. Temperature is around 800°C.

Zone 3 (Dark Zone) - Pyrolysis (cracking) of the fuel begins due to the shortage of oxygen creating minute carbon particles. The temperature is about 1,000°C.

Zone 4 (Luminous Zone) - This area is bright yellow. There is still insufficient oxygen for complete burning. The temperature is around 1,200°C.

Zone 5 (Veil) - There are carbon particles burn faster and more completely at the boundary between Zone 4 and Zone 5. The temperature is around 1,400°C. If a draft lowers the temperature below 1,000°C, soot particles cease burning and end up on your pot or in your lungs.

On the basis of flow there are generally four types of flame:

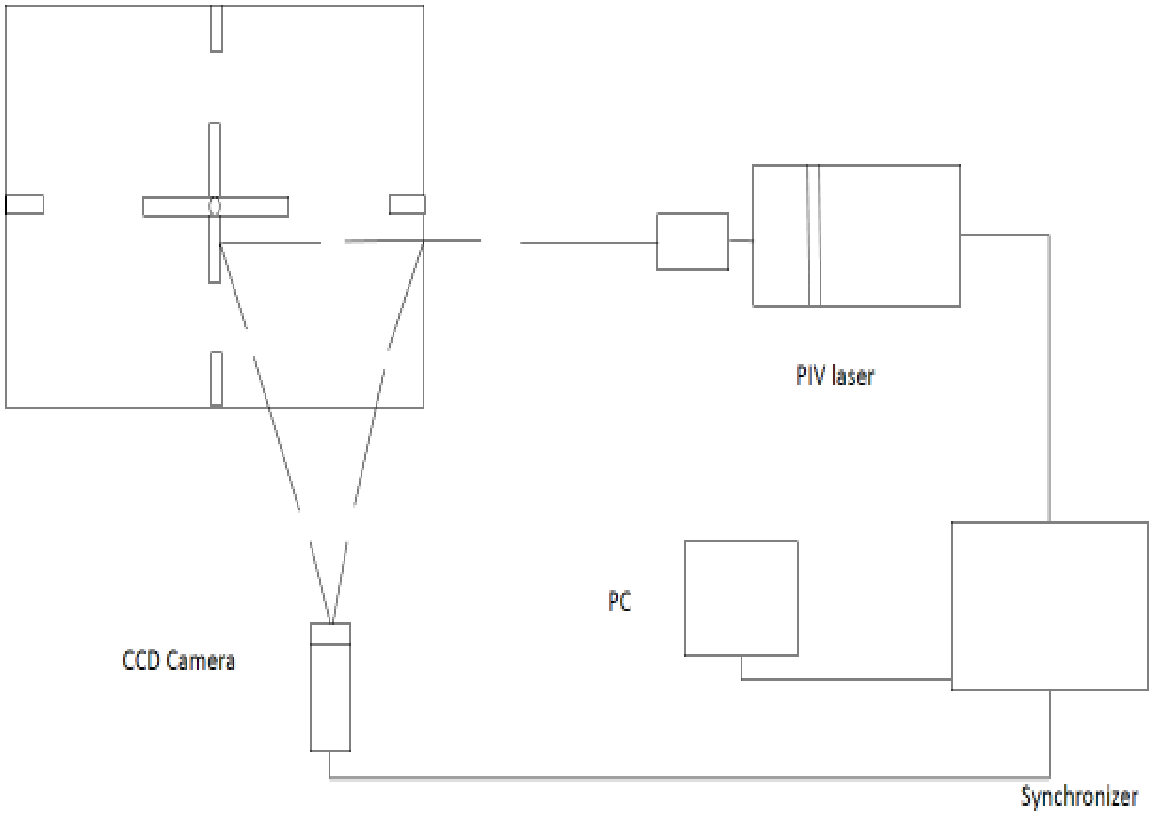
- Diffusion flame
- Premixed flame
- Partially premixed flame
- Stratified flame.

1. Diffusion flame: In combustion, a diffusion flame is a flame in which the oxidizer combines with the fuel by diffusion. As a result, the flame speed is limited by the rate of diffusion. The common flame of a candle is a best example of a diffusion flame. The yellow color of the flame is due to the large number of incandescent soot particles in the incomplete combustion reaction of the flame.

2. Premixed flame: A premixed flame is a flame formed under certain conditions during the combustion of pre-mixture of fuel and oxidizer. The premixed flame is characterized as laminar or turbulent depending on the velocity distribution in the unburned pre-mixture.
3. Partially premixed flame: Initiatory fires typically occur after the partial premixing of fuel and oxidizer. The mixing of product species into the fuel and oxidizer mixture influences flame stabilization and fire spread. It produce two or more reaction zones. Partially premixed regions are formed by gaseous fuel leaks and in evaporating liquids.

3. **Particle Image Velocimetry:** Particle image velocimetry (PIV) is an optical method of flow visualization used in education and research. It is used to obtain instantaneous velocity measurements and related properties in fluids. The fluid is seeded with tracer particles which, for sufficiently small particles, are assumed to faithfully follow the flow dynamics. Typical PIV apparatus consists of a camera (normally a digital camera with a CCD chip in modern systems), a laser with an optical arrangement to limit the physical region illuminated, a synchronizer to act as an external trigger for control of the camera and laser, the seeding particles and the fluid under investigation. A fiber optic cable or liquid light guide may connect the laser to the lens setup. PIV software is used to post process the optical images. The tracer particles form the basis of the velocity measurement in PIV. And particles should be as small as they should able to closely follow the flow. If the particles may not be so small, they will not scatter enough light, and therefore produces very weak images. Any particle that follows the flow satisfactorily and scatters enough light to be captured by the camera can be used. The synchronization between the camera and the laser is controlled by

the synchronizer.



4. **Solid Seeding Particles:** The seeding particles are a natural critical component of the PIV system. Ideal particles will have the same density as the fluid system being used, and are spherical (these particles are also called microspheres). While the actual particle choice is dependent on the nature of the fluid, generally for macro PIV investigations they are glass beads, polystyrene, polyethylene, aluminum flakes or oil droplets (if the fluid under investigation is a gas). The particles are typically of a diameter in the order of 10 to 100 micrometers. As for sizing, the particles should be small enough so that response time of the particles to the motion of the fluid is reasonably short to accurately follow the flow, but large enough to scatter a significant quantity of the incident laser light. For some experiments involving combustion, seeding particle size may be smaller, in the order of 1 micrometer, to avoid the quenching effect that the inert particles may have on flames. Due to the small size of the particles, the particles motion is dominated by stokes drag and settling or rising affects. Thus the particle size needs to be balanced to scatter enough light to accurately visualize all particles within the laser sheet plane, but small enough to accurately follow

the flow. The seeding mechanism needs to also be designed so as to seed the flow to a sufficient degree without overly disturbing the flow.

5. **Gas Turbine:** The gas turbine is the engine at the heart of the power plant that produces electric current. A gas turbine is a combustion engine that can convert natural gas or other liquid fuels to mechanical energy. This energy then drives a generator that produces electrical energy. Gas turbine is also called as combustion turbine, is a type of continuous combustion, internal combustion engine. The main components which are common in all gas turbine engines are:

- An upstream rotating gas compressor,
- A combustor,
- A downstream turbine on the same shaft as the compressor.

A fourth component is often used to increase efficiency (on turboprops and turbofans), to convert power into mechanical or electric form (on turbo shafts and electric generators). The basic operation of the gas turbine is a bray-ton-cycle with air as the working fluid.