Analysis of Fuel Droplet Parameter using Laser Diagnosis System

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Abstract - Particle image velocity (PIV) is the newest entrant to the field of fluid flow measurement and provides instantaneous velocity fields over global domains. As the name suggests, PIV records the position over time of small tracer particles introduced into the flow to extract the local fluid velocity. Thus, PIV represents a quantitative extension of the qualitative flow visualization techniques that have been practised for several decades. The basic requirements for a PIV system are an optically transparent test-section, an illuminating light source (laser), a recording medium (film, CCD, or holographic plate), and a computer for image processing. This review article addresses the basics of the PIV technique such as PIV algorithms, optical considerations, tracer particles, illuminating lasers, recording hardware, errors in PIV measurements, and PIV vector processing.

Key Words: CCD Camera, PIV, Nd-YAG.

1. INTRODUCTION

There are two types of laser diagnosis system,

1)PIV systems - consist of tracer particles, one or more light sources, and one or more cameras. Solid particles or droplets are commonly used as tracer particles but bubbles inherent in the flow may also be used as tracer particles. The camera(s) then image(s) scattered or emitted light from the tracer particles after they are irradiated by the light source(s). Amongst the broad range of variations 1,2 the most common one captures two velocity components in a plane at a rate of a few frames per second. PIV determines a velocity field by tracking the average motion of particle groups from a pair of images that are separated by a known time delay. Each image is divided into a grid of regularly spaced interrogation windows.

2) shadowgraphy- The shadowgraphy technique (backlighting) is used to visualize particles (e.g. Droplets from a spray or bubbles in liquid). The technique is based on high resolution imaging with pulsed backlight illumination. The measurement volume is defined by the focal plane and the depth of field of the imaging system. It is use to find out the diameter of the spray droplet, here a diffuser head is connected to the Nd-YAG laser to convert the green laser light to yellowish light i.e., to shift the wavelength and also, the light will be inherently diffused. This technique is independent of the shape and material (either transparent or opaque) of the particles and allows to investigate sizes down to 5 micro metre using an appropriate imaging system and light source.

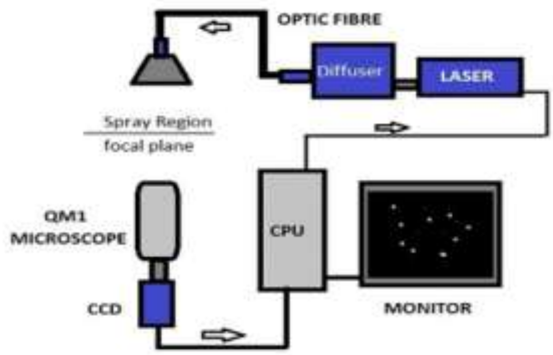

Fig 1: Working Diag. of Shadowgraphy

1.1 What is combustion?

Combustion is chemical reaction in which fuel is oxidized and large amount of energy is released. When fuel is burnt, flame is generated. Hence, the study of lifted spray flames is important to understand the flame dynamics.

2. METHODOLOGY

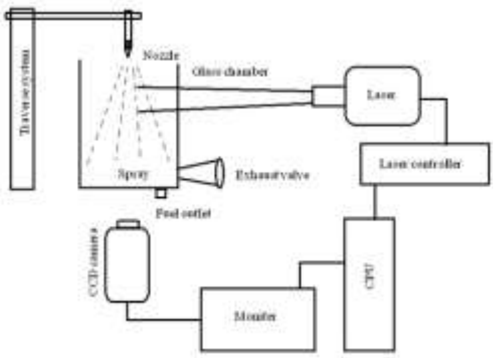

Figure 2 : Working diag. of PIV

To analyse the liquid fuel spray structure, optical methods needs the setup to be studied Particle Image Velocity (PIV). A CCD camera imager pro SX 5M having resolution 2448 x 2050 pixel.at last a traversing system on which a fuel nozzle is mounted, which has a two directional movement. Also there is a glass chamber circulated around the nozzle to avoid the dispersion of fuel. The chamber is comprised of suction valve which sucks the atmospheric air.

2.1 Components of PIV:

1) CCD:

- Fast in recording double-frames (2 pics, ›1 ms apart)
- Slower in overall acquisition rate: 1-20 Hz
- Best s/n-ratio, highest sensitivity
- Established technology.

2) Nozzle

The nozzle that we use is called swirl nozzle. It consists of one piece cast body with a removable vane type core. This core features a cylindrical core that functions as plain orifice atomizers to provide drops at the center of the conical spray pattern. It is designed to provide the sensibly uniform distribution of drops in a square pattern.

3) Nd:YAG laser

Nd: YAG lasers are optically pumped using a flashtube or laser diodes. These are one of the most common types of laser, and are used for many different applications. Nd: YAG lasers typically emit light with a wavelength of 1064 nm, in the infrared. However, there are also transitions near 940, 1120, 1320, and 1440 nm. Nd:YAG lasers operate in both pulsed and continuous mode.

3. Procedure of PIV

1. Scaling

Before starting to conduct an experiment, the scaling and calibration has to be done. In order to do this, a simple ruler scale is fitted in the plane of interest and the image of the same is captured without any illumination.

2. Recording

Following are some steps that should be carried out before recording.

(a) The laser must be switched on.
(b) The laser beam must be adjusted to illuminate the flow inside the experiment.
(c) The camera must be focused on the particles illuminated by the laser.
(d) Timing: Correct trigger source and suitable pulse separation dt.

3. RESULTS AND DISCUSSION

The non-reacting spray is investigated for different parameters.
(a) To understand the droplet dynamics, parameters from velocity distribution to vorticity distribution needs to be analyse critically.
(b) To study the effect of velocity on spray characteristics.
(c) To study the air entrainment and its effect on droplet velocity.

1) Velocity analysis of kerosene and diesel

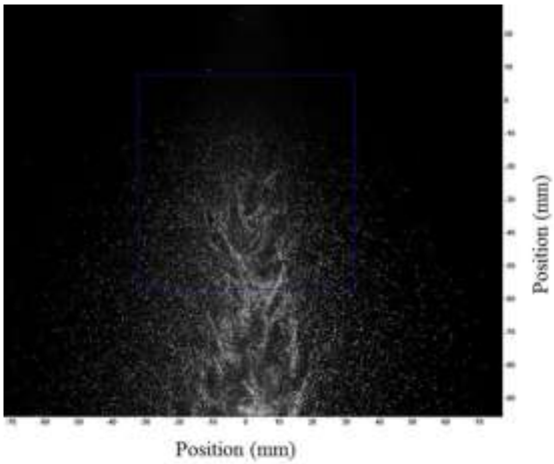

Figure 3 : Raw image of kerosene at 4 bar

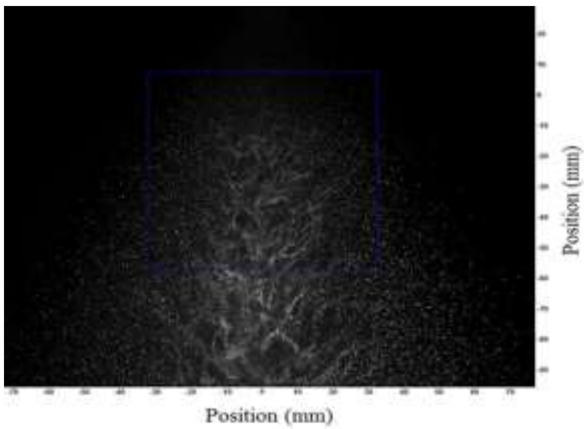

Figure 4 : Raw image of kerosene at 6 bar

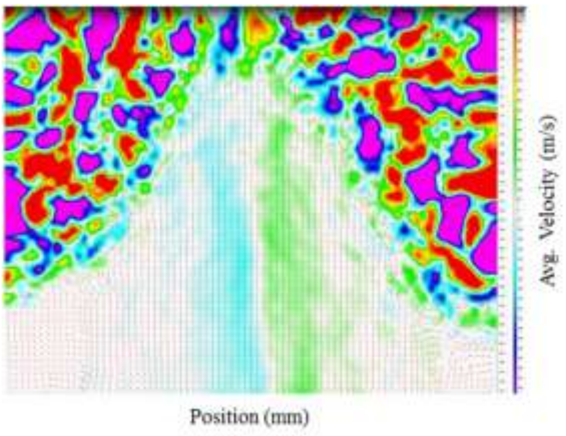

Figure 5: Image of velocity droplets

2) Vorticity analysis of kerosene and diesel

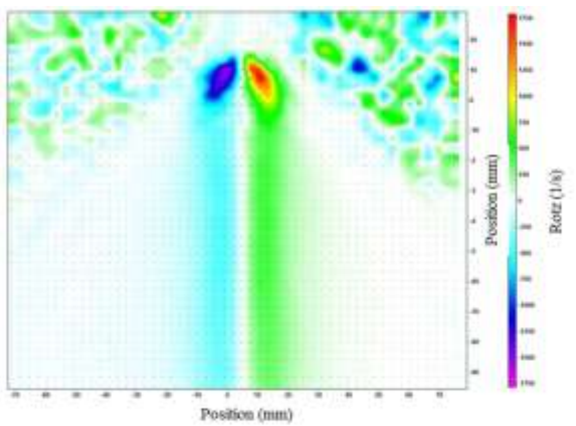

Figure 6: Vorticity variation with position at 6 bar

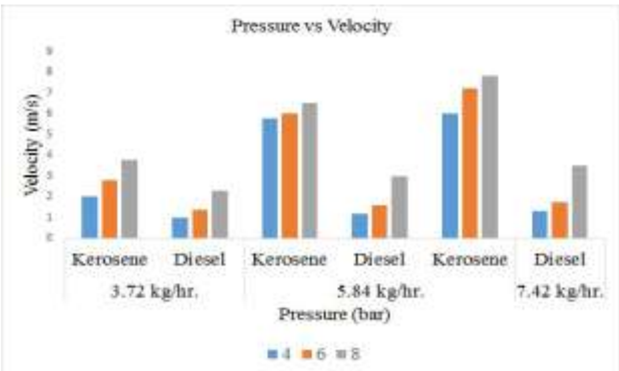

Figure 7: Comparatively graphical representation of average velocity variation with pressure

4. CONCLUSION

It is observed that, the velocity variation is in the range of 2 to 8 m/s for kerosene and for diesel it is in the range of 1.2 to 4 m/s at the mentioned pressure as well as on the mass flow rate Addition of co-flow reduces the droplet velocity for kerosene it is in the range of 1.5 to 6.5 m/s and for diesel it is increasing in the range of 2.8 to 7 m/s. Similar trends were observed for vorticity, it is maximum at the nozzle tip and decreases as the flow moves in downward.

5. ADVANTAGES

- Entire velocity speed can be calculated
- Capability of measuring flow in 3-d space
- Generally the equipment is nonintrusive to flow
- High degree of accuracy

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