Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)

ISSUE (20), June (2019)

*ISSN :***2616-9185**

www.mecsj.com

The effect of dual port on gas flow model by using a high-speed PIV in a CI engine under various engine speeds

Aljarf Saad[1)] Gerard Ndizeye[2)] Saito Reina[3)] Sawamura Yuji[4)]

Daiki Goto[5)] Mitsuhisa Ichiyanagi[6)] Takashi Suzuki[7)]

Sophia University, 7-1 Kioi-cho, Chiyoda-ku, Tokyo 102-8554, Japan.

Abstract:

PIV is a method that used to obtain instantaneous velocity measurements of the swirl flow which contributes to the uniform mixing of air and fuel in a diesel engine. This paper came to investigate the effect of dual port on gas flow model by using a high-speed PIV in a CI engine under various engine speeds. It reveals the significant factor of inlet valve of the IC engine, which affects the fuel mixture quality and combustion of the gas flow during the intake stroke. The charged airflow through inlet valves is fundamentally influenced by the intake port design/opening. The experiment was done to find the Effect of Engine Speed on the Velocity. In this experimental analysis, PIV technique was used to observe the complex flow pattern of the charging gas. The experiments were conducted at various rpm of the engine on a glass single cylinder engine which comprises multi inlet port. It has been concluded that the intake port incredibly changes the inner flow structure. Moreover, at 132^0 crank angle the velocity value for 1500rpm reached to 0.6 while for 1000rpm it was 0.33 at full opening valve.

KEY WORDS: port, velocity values, piv, intake stroke, compression**.**

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)

ISSUE (20), June (2019)

*ISSN :*2616-9185

www.mecsj.com

1- INTRODUCTION:

Four stroke engines of diesel are mostly used in powering road vehicles, particularly big vehicles like trucks, although currently passenger vehicles are used as well. The higher efficiency contrasted with engine of gasoline, jointly with high reliability as well as power; clarify why they have emerged the typical engine for trucks of heavy duty (1). Rivalry amongst producers of trucks is thus lashing the study towards sophisticated power and higher efficacy, while augmenting limit of strict regulations reduces the noxious waste discharges permitted. Many strategies may be utilized to decrease emissions from engines of diesel. One of them consists in the exhaust gas treatment so as to lessen the content of soot and NOx unconfined in the air (2). Such systems have been demonstrated proficient, though also costly as well as complex to establish. Because the process of ignition is crucial in the engine function, another alternative entails in decreasing pollutants amount produced during the process of ignition, so that similar level of greenhouse gasses may be attained with few subsequent to treatment to decrease complexity and cost. The experimental results show the advantage of using PIV technique for investigating the complete flow structures evolved inside the cylinder. Therefore, it is essential to understand the flow structure inside the cylinder in order to improve combustion process and thus enhance IC engines performance. Flow structure investigations inside the cylinder can be characterized either experimentally or numerically. Optical engines along with the optical diagnostics are developed technologies that enable researchers to investigate the flow structures and fuel mixture inside engine's cylinder.

2. EXPERIMENTAL METHOD:

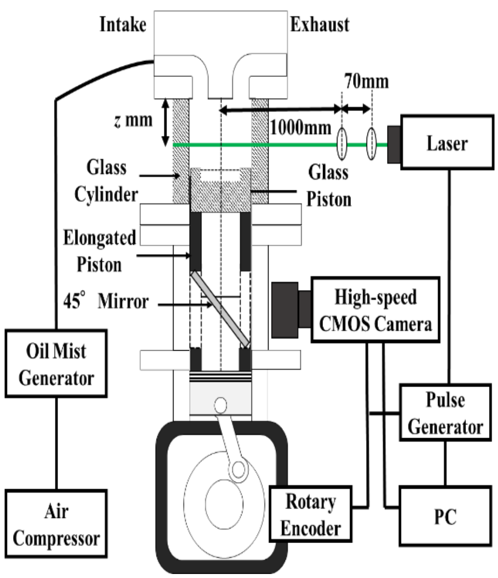
2.1. Principle of PIV method

The PIV method (particle image flow velocity measurement) is a method in which a mix of fluid particles movements in a flow field are traced, and then a scattered laser light in a two-dimensional cross section irradiated on a sheet-like, and then it is photographed with a high-speed video camera. Images are captured to show the distance traveled by the particles. In other words, it captures the moving distance of particles between images and the imaging time interval. Data obtained from (PIV) consists of one or more instantaneous velocity fields. To fully understand the flow of interest, usually other information can be obtained by capturing more than one field. Thus, several hundred or thousand velocity fields are captured, and then the average velocity field is calculated. The average velocity is an important sum in understanding the effect of fluid characteristics on its domain. A different method is also used to collect data is called time-resolved data. It may give a clearer picture of the flow by capturing a series of velocity fields that are correlated or related to each other in time. Another quantity is area average ensemble velocity, which provides additional information regarding the way the flow is varying over time, and it is a method to find a single velocity value for particles.

2.2 Experimental setup:

The schematic of the experimental setup is shown in fig. 1, the measured area is shown in fig. 2, and the engine specification used in this experiment are shown in table 1 where an optical engine test setup was developed for the specific purpose of enhancing the development and validation of piv approaches. The test setup features a glass single cylinder engine connected to an intake and exhaust. The engine has a bore of 85mm, a cavity of 51.6mm and the compression ratio was set to 16.3. Next, for PIV measurement the cylinder is made of quartz glass, the cavity of the elongated piston is made of sapphire glass, and the gas flow in the cylinder can be observed from the side and the bottom.

The tracer particle has an average particle size of about 3µm. Pumped gas pipe is connected to the intake pipe, and then it is induced into the cylinder simultaneously with the start of the intake stroke. The laser was a second harmonic (wavelength 532 nm) of Nd: YAG. It produces a sheet with a thickness of 1 mm formed by a cylindrical lens. High speed CMOS camera, laser, and engine can be synchronously captured by inputting the signal for every 1 degree of crank angle output from the rotary encoder of the engine to the camera and pulse generator. The camera was set to snapshot two frames consecutively every two signals, and the irradiation interval of the laser was adjusted within the range of 20µs to 30µs. Table 2 demonstrates the PIV system configuration.



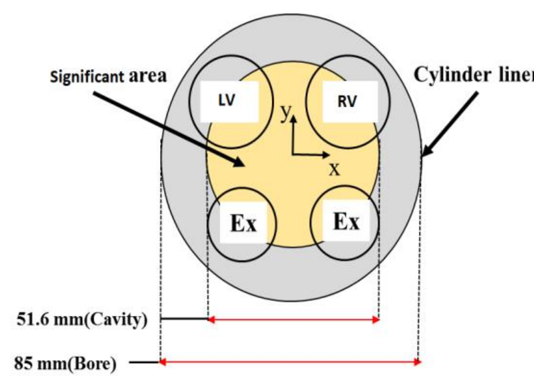


Fig. 1 Eperimental Apparatus

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)

ISSUE (20), June (2019)

ISSN :**2616-9185**

www.mecsj.com

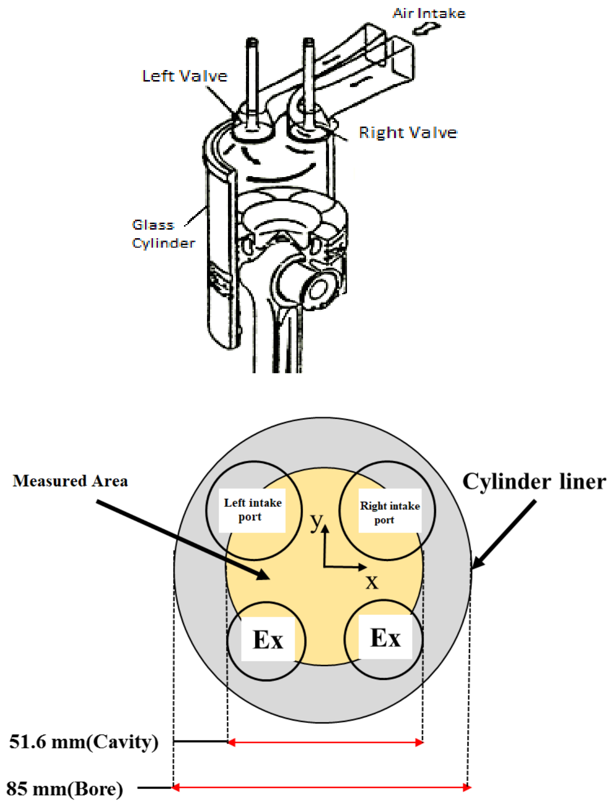


Fig. 2 Schematic of Intake ports

Table 1 Engine Specification

Engine	Optical single-cylinder diesel engine. Four valves.
Intake port	Left, Right
Bore	85 mm
Stroke	96.9 mm
Cavity diameter	51.6 mm
Compression ratio	16.3

ISSN **:2616-9185**
www.mecsj.com

Table 2 Experimental Apparatus

Laser	Continuum, Mesa-PIV	
	Nd;YAG, (532 nm), Double Pulse	
	Pulse width	<150 ns
	Pulse energy	18 mJ
Optical systems	Cylindrical lens	SIGMAKOKI
	Focal length	800 mm, -70 mm
Used High-speed camera	Photron, FASTCAM SA5	
Pulse generator	FLOWTECH RESEARCH, VSD2000	
Oil mist generator	FLOWTECH RESEARCH, FtrOMG	
Air compressor	EARTH MAN, ACP-25SLA	

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)

ISSUE (20), June (2019)

*ISSN :***2616-9185**

www.mecsj.com

3. Experimental Results and Discussion:

The table below shows the experimental outline. This experiment was carried out in order to clarify the influence of the engine speed on the velocity value 1000 rpm, 1200rpm, 1500 rpm. To clarify the influence of each intake port on the velocity value, different opening conditions of the intake port were set to be a both right valve and left valve “fully opened” (a), right valve (b), left valve(c) for the three engine speeds. Left valve fully open and right valve half open (d), left valve fully open and right valve one third open (e) for 1000rpm and 1500rpm. In order to understand the effect of each intake port on the flow structures, each port was examined separately. By reducing the right intake port aperture, the disturbance effect of the port on the flow reduces.

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
ISSUE (20), June (2019)
ISSN **:2616-9185**
www.mecsj.com

Table 3 Experimental Conditions

Engine speed	1000rpm, 1200rpm, 1500rpm	1000rpm, 1500rpm
Intake Port Configuration	(a) Both right valve and left valve "fully opened". (b) Right valve. (c) Left valve.	(d) Left valve fully open and right valve half open. (e) Left valve fully open and right valve one third open.
Measured Plane	60mm from TDC	60mm from TDC

3.1.Calculation method of velocity using PIV result:

From the instantaneous velocity of the in-cylinder measurement plane obtained by the high-speed PIV method, average flow velocity is calculated by the following equation:

$$U=\frac{1}{N}\sum_{i=1}^{N}u_i \quad (1)$$

N is the number of vectors in the entire measurement plane, (u_i) is the flow velocity on the measured plane in the vicinity of the wall surface, and then the velocity was found after firstly calculating the square of each value, secondly calculating the average of the squares and lastly calculating the square root of the average.

$$Vrms=\sqrt{\frac{U_1^2+U_2^2+U_3^2+\cdots\ldots\ldots+U_n^2}{n}} \quad (2)$$

Where U is the sum of velocities, n is a number of values.

3.2. Effect of engine speed on area averaged ensembled velocity value:

PIV method was used to obtain instantaneous velocity measurements of the swirl flow which contributes to the uniform mixing of air and fuel in a diesel engine. The strength of swirl flow is expressed as the ratio of the average swirl angular velocity on a plane, which was calculated by using the coordinates of the computed lattice points, to the engine rotational speed. Then velocity values were obtained after analyzing and calculating the swirl ratio from past experiments. As shown below in figure 3 the velocity has a similar approximate shape for the 1000rpm, as well as 1200rpm at the beginning of the intake stroke. When the value is high it becomes high because it is proportional to the engine rotational speed. All values seem to be high during the intake stroke and then they decrease gradually. From this, velocity value changes at each crank angle, and even when values change with the engine speed velocity value kept dropping. Lastly, high speeds were expected to show better results although at speed of 1500rpm and 1200rpm, the velocity dropped significantly faster than the lowest speed of 1000rpm. It is regarded as that the adjustment in the engine speed which causes adjustment in the circumferential speed, in that it doesn't apply a huge impact on the stream structure [(1)].

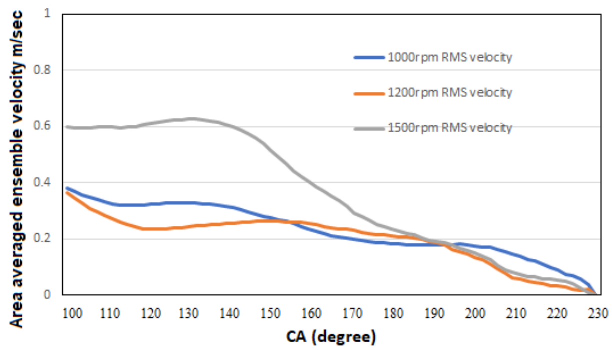


Fig. 3 Both intake ports were fully opened comparison of three engine speed. Impact of port shape on flow characteristics.

In breaking down in-barrel gas stream into three-dimensionally, stream investigation was completed by PIV estimation by changing the estimation plane to z = 60 mm. By expanding the opening region of the right port, the whirl proportion will have to decline in any plane (2). This is believed to be because of the way that the stream speed diminishes as the opening zone of the right port expands (see figure 4).

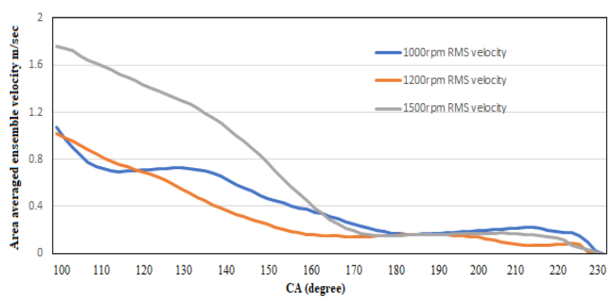


Fig. 4 Left intake port only was open, comparison of three engine speeds.

In Figure 4 above, similarly, the value is very high for 1500rpm, as well as 1200rpm at the beginning of the intake stroke. The value is high because it is proportional to the engine rotational speed. Values decreased dramatically and then remained constant (3). They also remained constant until the end of stroke. Lastly, at 1200rpm the velocity dropped slightly faster than other speeds.

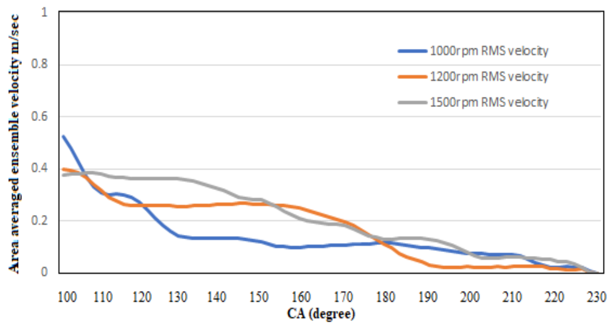


Fig. 5 Right intake port only was open, comparison of three engine speeds.

In figure 5 above, 1000rpm showed the highest value at the beginning and then it dropped significantly fast. Later, velocity value remained constant until the end [(5)], at 1200rpm the velocity dropped slightly faster than other speeds at the beginning and then remained constant, it did not increase during compression stroke. Lastly, at 1500rpm, velocity value kept dropping smoothly.

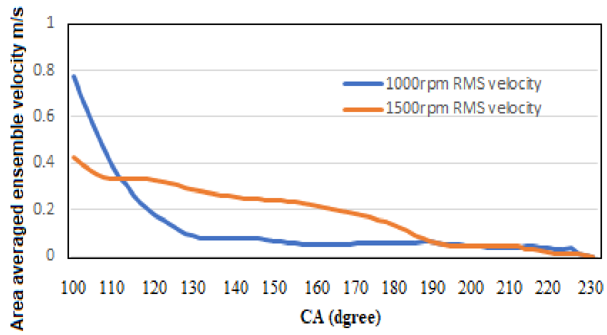


Fig. 6 Left intake port was fully opened; Right intake port was half opened. Two engine speeds comparison.

Figure 6 above shows a different case; in here the left valve was fully open and the right valve was half open. 1000rpm showed a higher value at the beginning and then it dropped significantly fast. Later, velocity value remained constant and smooth until the end [7],

at 1500rpm the velocity value was not as high as expected it indicated a lower value at the beginning and then maintained a good value.

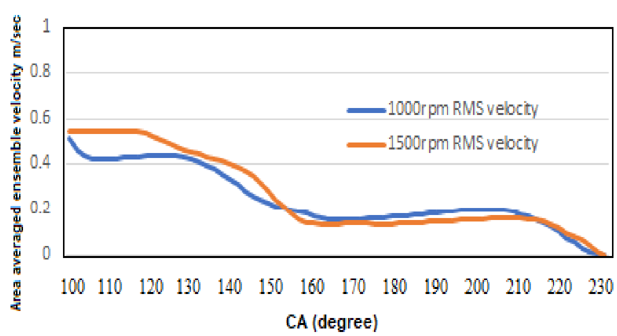


Fig. 7 Left intake port was fully opened, Right intake port was one third opened. Two engine speeds comparison.

Figure 7 above, the velocity was calculated for two engine speeds. The calculated velocity has a similar approximate shape for the 1000rpm, as well as 1500rpm. 1000rpm and 1500rpm maintained a good value during all strokes.

3.3. Discussion:

In this experiment, 3D-dimensional recreations have been led under consistent state conditions on a glass single cylinder engine with a confined rooftop type set out toward various settled valve lifts. To evaluate the impact of engine speed left port and right port on swirl stream in the diesel engine. It was possible in that to distinguish the speed appropriation of the swirl stream of a solitary chamber diesel engine utilizing PIV estimation and figure the accompanying discovered. First, Because of estimating by changing the engine speed, the vortex focuses were nearly at a similar position and a comparative stream structure was obtained. The high estimation of the circumferential speed is 1500 rpm, the value is bigger than 1000 rpm, yet when it is made dimensionless at the agent speed, it demonstrates a similar value. In addition, it was discovered that the focal point of the vortex changed with wrench edge. Second, through the estimation by shifting the opening region of the admission port, the vortex focus and the whirl proportion were unique. It was discovered that by expanding the opening territory of the right port, the vortex focus dismisses at a situation from the pit focus. It was likewise discovered that by expanding the opening territory of the right port, the whirl proportion ends up litter. Third, due to the estimation by changing the opening territory and having estimation plane of the admission port, the swirl proportion extraordinarily varies in every estimation plane amid the admission stroke, yet in the pressure stroke, the whirl proportion demonstrated a similar incentive in every estimation plane. Likewise, to the first two discoveries the swirl stream has a tendency in which the tendency point turns out to be extensive by expanding the opening zone of the right port. In Figure 8 below, a comparison of flow structure for each port condition is observed on a several crank angles degree 100˚ to 230˚. (a) shows the ensemble-averaged velocity distribution using streamlines for both ports fully open at 1500rpm. (b) shows the ensemble-averaged velocity distribution for the right valve. It shows a non-uniform flow structure. (c) is for the left valve only. It shows a well-organized flow structure as well as higher mean flow velocities compared to the right port.

Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications (MECSJ)
ISSUE (20), June (2019)
*ISSN :***2616-9185**
www.mecsj.com

This concludes that the right port disturbs the well-organized flow structure created by the left intake port when both ports are open as in (a). (d) is for left valve fully open and right valve half open (e) is for left valve fully open and right valve one third open. The last two test were created in order to reduce the effect of the right intake port on the overall in-cylinder flow structures, the right port aperture was modified from fully open. Each port was examined individually at the same speed to understand the effect of each intake port on the non-uniform flow structures.

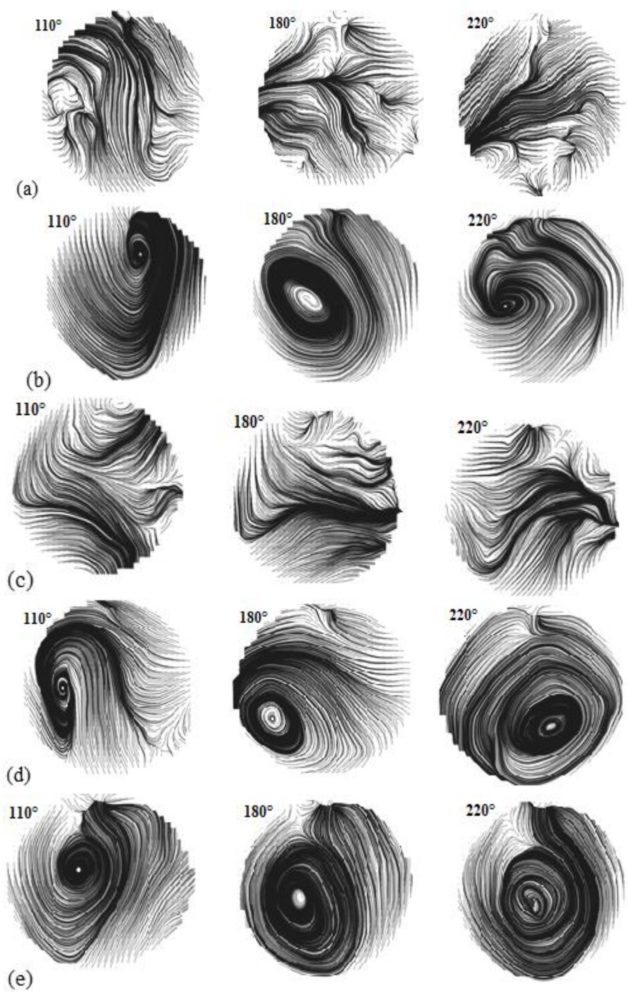


Fig. 8 The influence of each intake port on flow structure, engine speed of 1500rpm for crank angle 110˚, 180˚, and 220˚.

*ISSN :*2616-9185

4. Conclusion:

In this paper the experiment was done to find the Effect of Engine Speed on the Velocity. The experiment was aimed at having a better understanding and knowledge about the Impact of engine speed on swirl proportion. The results of the experiment demonstrate that the adjustment in the engine speed which case the adjustment in the circumferential speed in that it causes a huge impact on the stratum structure. According to the graphs, the value is high since it is proportional to the engine rotational speed and that the values decrease drastically and remain constant. The values of the calculated velocity are all the same as that of 1500rpm. The highest estimation of the circumferential speed is 1500 rpm, the value is bigger than 1000 rpm, yet when it is made dimensionless at the agent speed, it demonstrates a similar value. In addition, it was discovered that the focal point of the vortex changed with wrench edge. It was discovered that by expanding the opening territory of the right port, the vortex focus dismisses at a situation from the pit focus. It was likewise discovered that by expanding the opening territory of the right port, the whirl proportion ends up litter.

References

1. Melling, A. "Tracer particles and seeding for particle image velocimetry." *Measurement Science and Technology* 8.12 (1997): 1406.
2. Westerweel, Jerry. "Fundamentals of digital particle image velocimetry." *Measurement science and technology* 8.12 (1997): 1379.
3. Soloff, Steven M., Ronald J. Adrian, and Zi-Chao Liu. "Distortion compensation for generalized stereoscopic particle image velocimetry." *Measurement science and technology* 8.12 (1997): 1441.
4. Meinhart, C. D., S. T. Wereley, and M. H. B. Gray. "Volume illumination for two-dimensional particle image velocimetry." *Measurement Science and Technology* 11.6 (2000): 809.
5. Zhao, Z., A. Kazakov, and F. L. Dryer. "Measurements of dimethyl ether/air mixture burning velocities by using particle image velocimetry." *Combustion and Flame* 139.1-2 (2004): 52-60. Towers, D. P., and C. E. Towers. "Cyclic
6. Cao, Z-M., et al. "PIV measurement of internal structure of diesel fuel spray." *Experiments in fluids* 29.1 (2000): S211-S219.variability measurements of in-cylinder engine flows using high-speed particle image velocimetry." *Measurement Science and Technology* 15.9 (2004): 1917.
7. Malbec, Louis-Marie, and Gilles Bruneaux. "Study of Air Entrainment of Multi-hole Diesel Injection by Particle Image Velocimetry-Effect of Neighboring Jets Interaction and Transient Behavior After End of Injection." *SAE International Journal of Engines* 3.1 (2010): 107-123.
8. Krishna, B. Murali, and J. M. Mallikarjuna. "Effect of engine speed on in-cylinder tumble flows in a motored internal combustion engine—an experimental investigation using particle image velocimetry." *J. Appl. Fluid Mech* 4.1 (2011): 1-14.
9. Krishna, B. Murali, and J. M. Mallikarjuna. "Characterization of flow through the intake valve of a single cylinder engine using particle image velocimetry." (2010): 23-32.

10. Troolin D R; Longmire E K; Lai WT. "Time-resolved PIV analysis of flow over a NACA 0015 airfoil with Gurney flap," *Experiments in Fluids*, 41 (2006): pp. 241-54.