

## Computational Fluid Dynamic (CFD) Analysis of Turbo Cyclone and Intake Manifold Spacer on Honda Supra Fit

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**Abstract.** The need for human mobility is constantly increasing over time, so the demand for vehicle production mass is still relatively high. A large number of conventional vehicle use makes the impact of dependence on fuel oil. This dependence is very threatening for various aspects. Increasing the combustion efficiency in the engine room is necessary. Turbo cyclone is an additional component applied to the intake manifold, which causes the originally linear inflow to rotate (swirl) and mix fuel with air more maximally in the combustion engine to increase the combustion efficiency. Recently, we fabricated and characterized turbo cyclone and intake manifold spacer to increase the combustion engine's performance. Turbo cyclone designed in two different blades with a degree  $40^0$  with an angle of inclination blade. Intake manifold spacer designed with 24 grooves with a  $40^0$  angle. A selected sample in this research is the Honda Supra Fit 125CC year 2006. In this study, to increase the combustion engine's performance, we applied the 3-blade turbo cyclone and 4-blade turbo cyclone in the air filter. We applied an intake manifold spacer between the combustion engine and carburetor. Computational Fluid Dynamic (CFD) of turbo cyclone and intake manifold spacer is shown the changing in velocity, pressure, and turbulence intensity. The specific result shown in 4-blade turbo cyclone with change in velocity is 0.14009 m/s, with pressure drop -0.04582 Pa, and the change of turbulence intensity value is 2.44536 % explain that the turbulence condition is a medium-turbulence case. The unspecific result in the intake manifold spacer shows only a change in velocity 0.26269 m/s with a pressure drop of only -0.00673 Pa, which means the inner flow profile is almost linear. It proves from turbulence intensity value only 0.41247 % explain that internal air-flow in low-turbulence flow condition. Based on turbulence case from turbulence intensity, it has shown increased performance in the medium-turbulence case. These results suggest that turbo cyclone and intake manifold spacer can increase the performance of combustion engines.

Keywords: Turbo Cyclone; Intake Manifold Spacer; Combustion Engine; Swirl Flow; Computational Fluid Dynamic.

### 1. INTRODUCTION

The need for human mobility is constantly increasing, then the demand for vehicle production mass is still relatively high. Vehicles based on electrical energy are popularly being developed around the world[1]. However, conventional motorized vehicles are still the main choice because the purchase price and daily operating cost are lower than electric vehicles[2]. The number of fuel oil used for vehicles in Indonesia is very high. Based on the Badan Pusat Statistik (BPS) census, more than 133 million units of motorized vehicles in 2019. This dependence can worsen by incomplete combustion in the combustion chamber, which causes low combustion efficiency, especially in an old motorcycle[3].

Various studies have been conducted to improve fuel efficiency[4]. Through the Turbo Cyclone invention, Sei Y Kim can increase the combustion efficiency in the engine room. Turbo Cyclone is an additional component applied to the intake manifold[5], which causes the originally linear inflow to rotate (swirl). Air circulation in the combustion chamber can mix the fuel with air more maximally; the Turbo cyclone can also improve the combustion quality, and the flame in combustion is more stable due to the influence of the rotation zone [6].



In previous studies, increasing combustion efficiency was carried out only by applying the turbo cyclone or intake manifold without combining and without analyzing the flow in the turbo cyclone or intake manifold spacer[7]. This study aims to analyze the airflow that occurs in the inner region of the turbo cyclone and intake manifold spacer by using Computational Fluid Dynamic (CFD) to determine changes in velocity, pressure, and turbulent intensity on the turbo cyclone and intake manifold spacer[5].

Therefore, the authors conducted research based on the development of an existing turbo cyclone by comparing the flow conditions that occur to vehicle performance when a 3-blade 40° turbo cyclone and a 4-blade turbo cyclone 40° are combined with the intake manifold spacer.

## 2. LITERATURE REVIEW.

Research by Muchammad (2007) entitled "Simulasi Efek Turbo Cyclone Terhadap Karakteristik Saluran Udara Sepeda Motor 4 Tak 100 cc Menggunakan Computational Fluid Dynamic". This study discusses the effect of the characteristics when the vehicle is applied with a turbo cyclone with various slope variations with the computational fluid dynamic method, which is a simulation of airflow. In this study, the results and conclusions are that the addition of a turbo cyclone can change the airflow characteristics in the form of pressure drop and an increase in the intensity of turbulent flow. Changes in pressure drop are influenced, and the shape of the blade influences flow intensity. The highest pressure drop is obtained by the turbo cyclone model 7, which has the greatest angle of 45° with no variations in holes [8].

Scientific journal by Dr. Pankaj N. Srirao and Dr. Rajeshkumar U. at the Jawaharlal (2012) entitled "Effect of Swirl Induction by Internally Threaded Inlet Manifold on Exhaust Emission of Single Cylinder (DI) Diesel Engine". This study aims to determine the effect of swirl flow on the performance of a diesel engine when several variations of thread are applied to the inlet manifold, of which there are three types of variations, namely acme, buttress, and knuckle threads of the constant pitch of 2 mm. The results and conclusions obtained in this study are the variations carried out in the thread in the manifold, causing increased turbulent flow and resulting in a better air mixing process. Thus, increased thermal efficiency and reducing BSFC and exhaust emissions. With the final result. The thread made to the inlet manifold provides the best trade-off between performance and emissions [9].

A scientific journal by Yusuf Rizal Fauzi (2018) aims to determine the flow velocity and pressure contours when a turbo cyclone is applied with the Fluent 6.2 software. In addition, testing of fuel consumption, volts, amperes, and flow velocity when applied to a Honda GL Pro motorcycle is also carried out. The results and conclusions obtained are that the axial turbo cyclone increases in size, increasing power, torque, fuel consumption, and thermal efficiency. [10].

The research was found by Somender Singh (2001), with the title "Design to Improve Turbulence In Combustion Chamber". First, low octane fuel can be used without the detrimental effect of existing compression performance. Second, the lesser ignition causes a high degree of turbulence which results in a fast and efficient combustion process that can improve torque and power output, reduce lesser emission and carbon, improve specific fuel consumption, and lower operating temperature and engine noise levels [11].

## 3. RESEARCH METHODOLOGY

The research method used is Computational Fluid Dynamic (CFD) simulation for airflow analysis[12]. Computational Fluid dynamics (CFD) enables simulated air that flows through design to calculate product performance and capabilities such as airflow velocity, pressure drop, and turbulence intensity[13]. The stages in Computational Fluid Dynamic (CFD) of airflow are following:

Firstly we determine the model of turbo cyclone and intake manifold spacer to be made (geometry) in SolidWorks. This model design is based on original part motorcycle measurement. After modeling geometry has been done, data input which is the domain of flow computation that will be analyzed and researched[14]. The next step is performing grid determination of geometry that flow will be through. This geometry will be analyzed and find the formulation and physical model of the problem (for example, the type of flow used is laminar, turbulent, transient, and involves the occurrence of heat transfer or not).

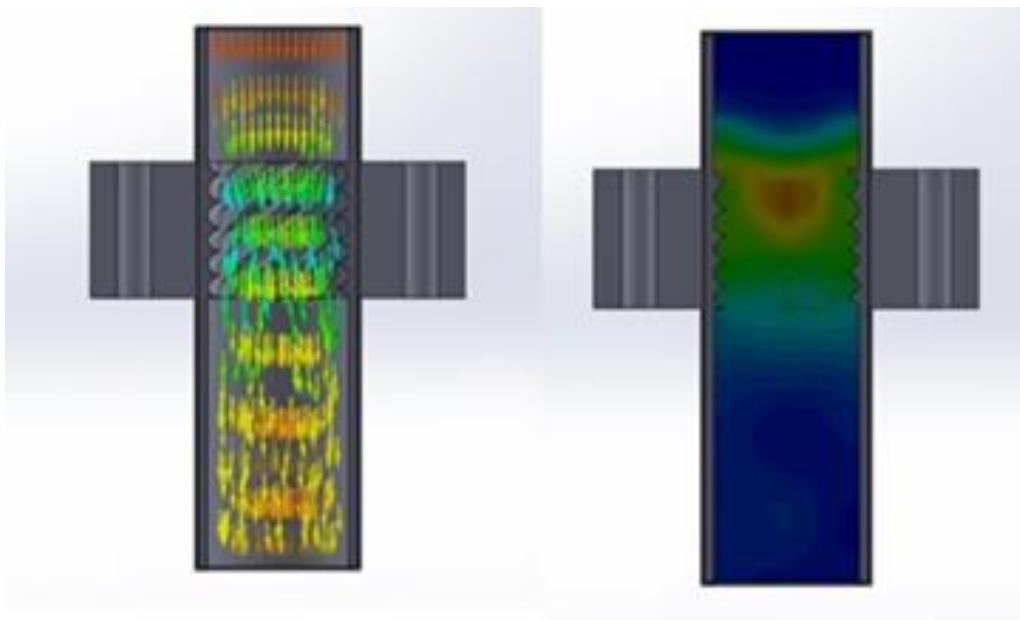
Furthermore, the next stage is determining the material's types and properties, then determining the boundary conditions of the material to be tested (the area through which the flow will pass), and determining solution control parameters. Finally, perform the calculation process manually (iteration) in SolidWorks to show the airflow velocity, pressure drop, and turbulence intensity can be displayed in contour image[15]. The specific value in each iteration and performance result can be exported into a table and graph directly.

#### 4. Result and Discussion.

The result of the simulation that has been running in SolidWorks 2021 shows that air profile in inner turbo cyclone and intake manifold spacer changes. Airflow before applied blade and groove show the linear airflow, but after the applied blade and groove changes into swirl airflow with turbulence condition.

##### 4.1 Computational fluid dynamic result of intake manifold spacer

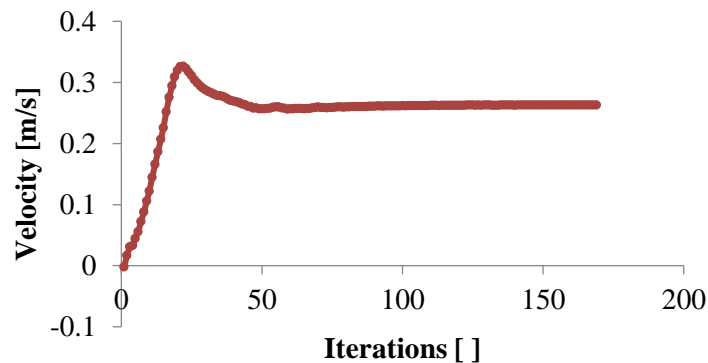
Airflow profile result can be shown in contour image after iteration of calculation computational. Based on **Figure 1**, airflow velocity shows an insignificant change in direction from input velocity to output velocity. Unsignificant airflow velocity showed that airflow not swirling in the intake manifold spacer. Pressure distribution of intake manifold shown more equally in input and output pressure.



**Figure 1.** Velocity distribution and pressure distribution of intake manifold spacer

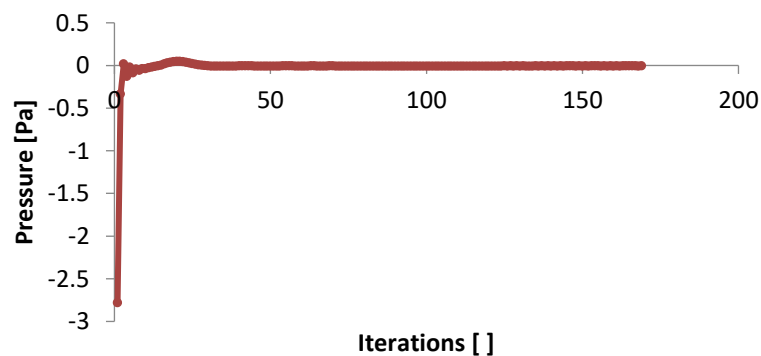
Intake manifold spacer change in velocity can be determined after 169 iterations of simulation and the value of change in velocity has been taken from average velocity from all iterations. From **Figure 2**, the minimum value of velocity in intake manifold spacer being 0.26188 m/s with the

maximum value of velocity is 0.26294 m/s. So, the change in velocity in the intake manifold spacer is 0.26269 m/s.



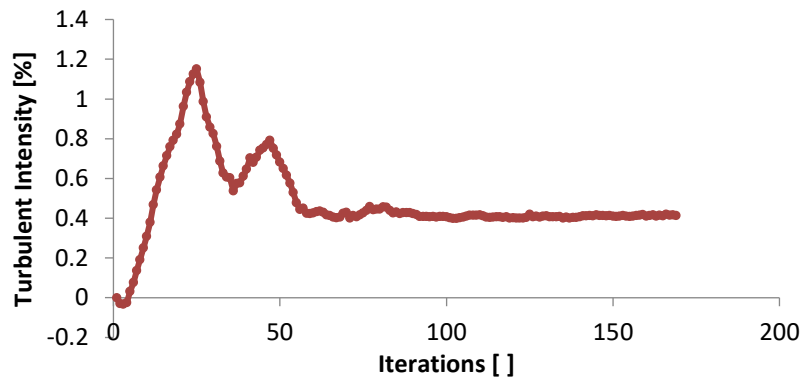
**Figure 2.** Change in velocity of intake manifold spacer

Intake manifold spacer change in pressure can be determined after 169 iterations of simulation and the value of change in pressure has been taken from average velocity from all iterations. From **Figure 3**, the minimum value of pressure in intake manifold spacer is -0.00712 Pa with the maximum value of pressure being -0.00665 Pa. So, the change in pressure in the intake manifold spacer is -0.00673 Pa.



**Figure 3.** Change in pressure of intake manifold spacer

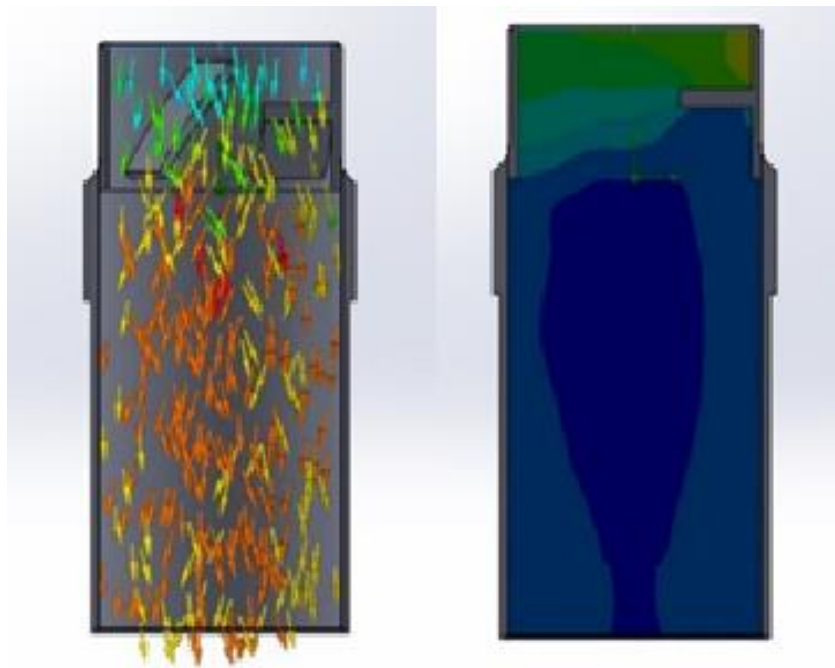
Intake manifold spacer change in turbulence intensity can be determined after 169 iterations of simulation and the value of change in velocity has been taken from average velocity from all iterations. From **Figure 4**, the minimum value of turbulence intensity in intake manifold spacer is 0.39947 % with the maximum value of turbulence intensity being 0.41974 %. So, the change in turbulence intensity of intake manifold spacer is 0.41247% which means is a low-turbulence case.



**Figure 4.** Change in turbulence intensity of intake manifold spacer

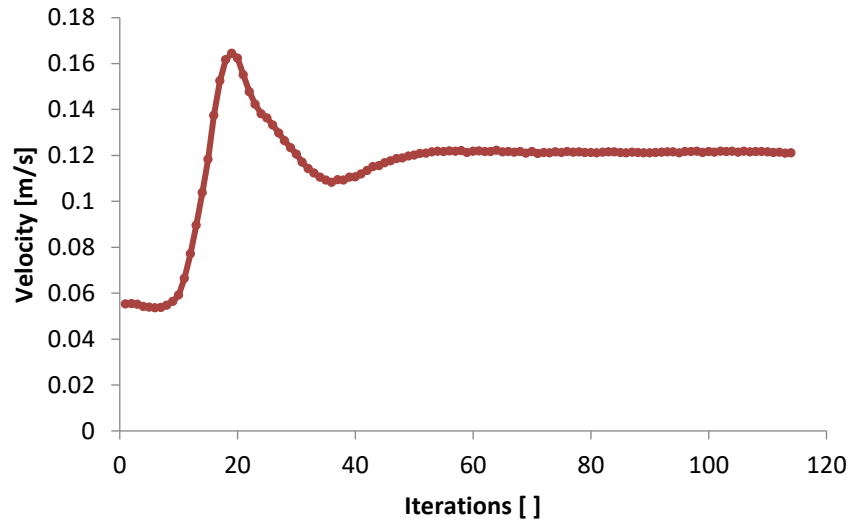
#### 4.2 Computational fluid dynamic result of turbo cyclone

Airflow profile result can be shown in contour image after iteration of calculation computational. Based on **Figure 5**, airflow velocity shown significant change in direction from input velocity to output velocity. A significant airflow velocity showed that airflow swirling in 3-blade turbo cyclone. Pressure distribution of 3-blade turbo cyclones showed more different output pressure.



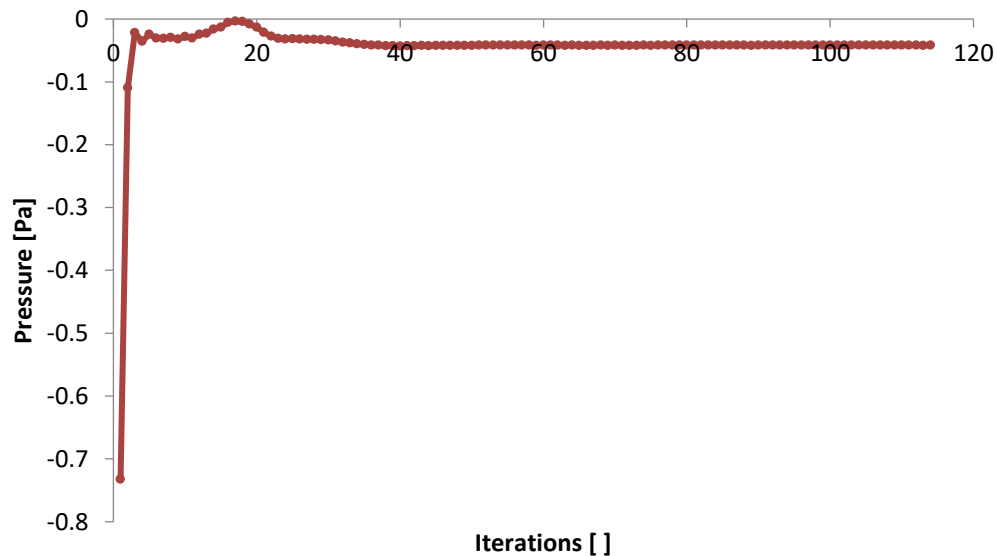
**Figure 5.** Velocity distribution and pressure distribution of 3-blade turbo cyclone

3-blade turbo cyclone change in velocity can be determined after 114 iterations of simulation and value of change in velocity take from average velocity from all iterations. From **Figure 6**, the minimum the value of velocity in a 3-blade turbo cyclone is 0.12088 m/s with the maximum value of velocity being 0.12218 m/s. So, the change in velocity of the 3-blade turbo cyclone is 0.12107 m/s.



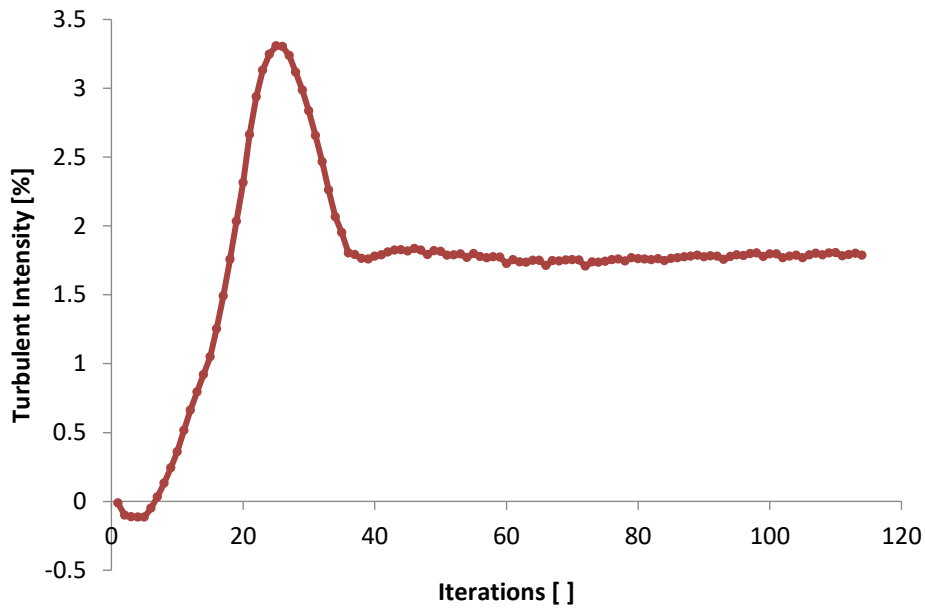
**Figure 6.** Change in velocity of 3-blade turbo cyclone

3-blade turbo cyclone change in pressure can be determined after 114 iterations of simulation and the value of change in pressure take from average pressure from all iterations. From **Figure 7**, the minimum value of pressure in a 3-blade turbo cyclone being -0.04212 Pa with the maximum value of pressure is -0.04141 Pa. So, the change in pressure of 3-blade turbo cyclone is -0.04181 Pa.



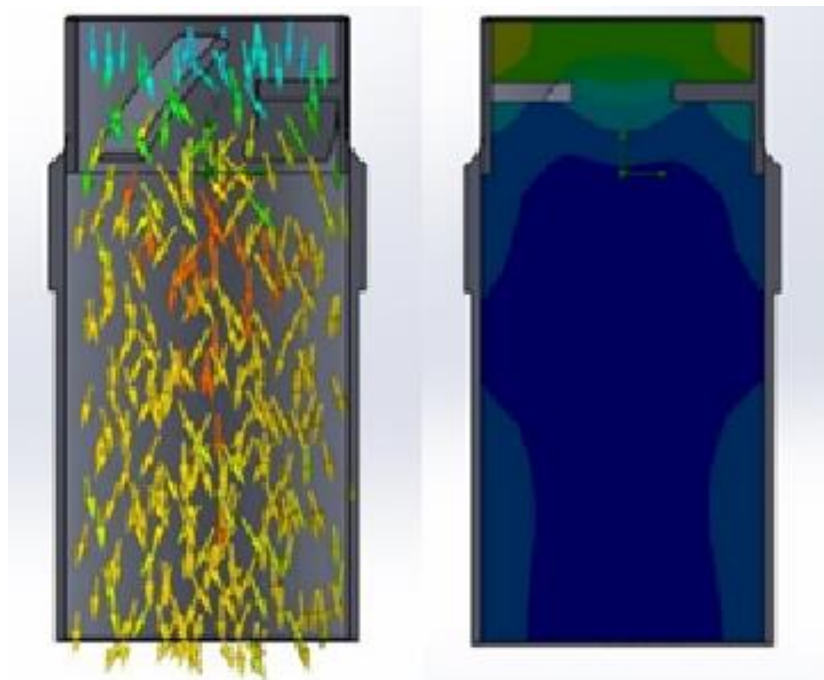
**Figure 7.** Change in pressure of 3-blade turbo cyclone

3-blade turbo cyclone change in turbulence intensity can be determined after 114 iterations of simulation and the value of change in turbulence intensity has been taken from average velocity from all iterations. From **Figure 8**, the minimum value of turbulence intensity of a 3-blade turbo cyclone is 1.70892 % with the maximum value of turbulence intensity 1.80541 %. So, the change in turbulence intensity of 3-blade turbo cyclone is 1.78710 % which means is a medium-turbulence case.



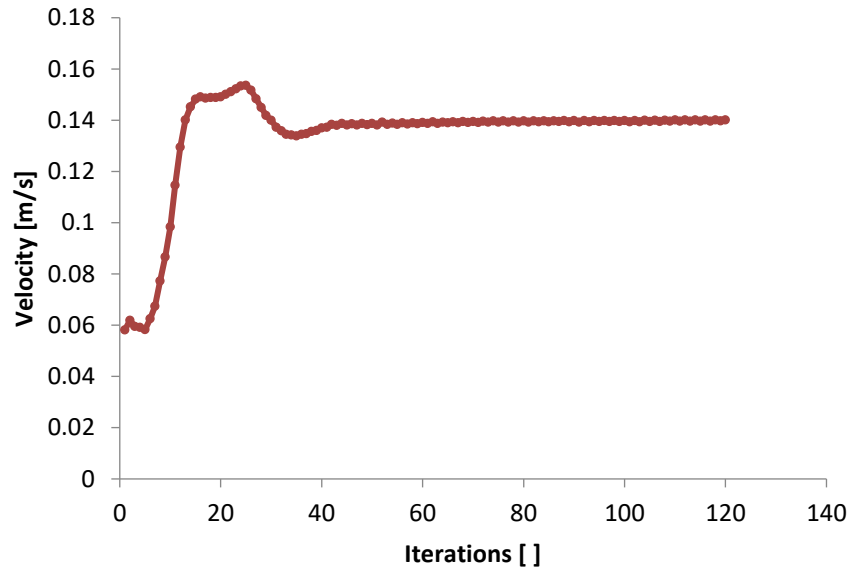
**Figure 8.** Change in turbulence intensity of 3-blade turbo cyclone

Airflow profile result can be shown in contour image after iteration of calculation computational. Based on **Figure 9**, airflow velocity showed a significant change in direction from input velocity to output velocity. significant airflow velocity showed that airflow swirling in 4-blade turbo cyclone. Pressure distribution of 4-blade turbo cyclones showed more different output pressure.



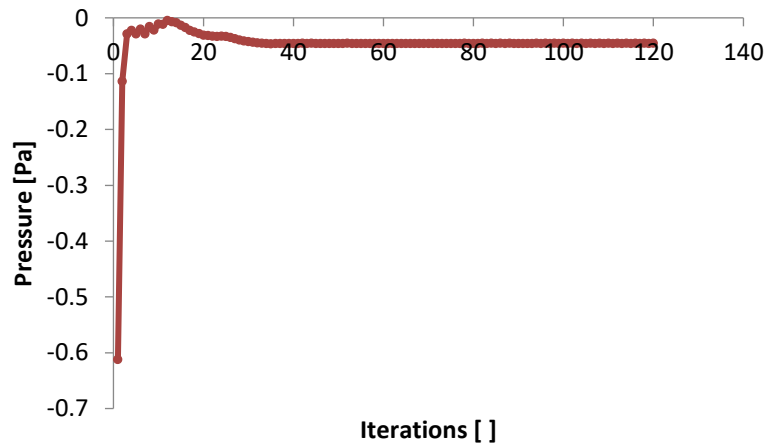
**Figure 9.** Velocity distribution and pressure distribution of 4-blade turbo cyclone

4-blade turbo cyclone change in velocity can be determined after 120 iterations of simulation and the value of change in velocity take from average velocity from all iterations. From **Figure 10**, the minimum value of velocity in a 4-blade turbo cyclone is 0.13925 m/s with the maximum value of velocity being 0.41974 m/s. So, the change in velocity of 4-blade turbo is 0.14009 m/s.



**Figure 10.** Change in velocity of 4-blade turbo cyclone

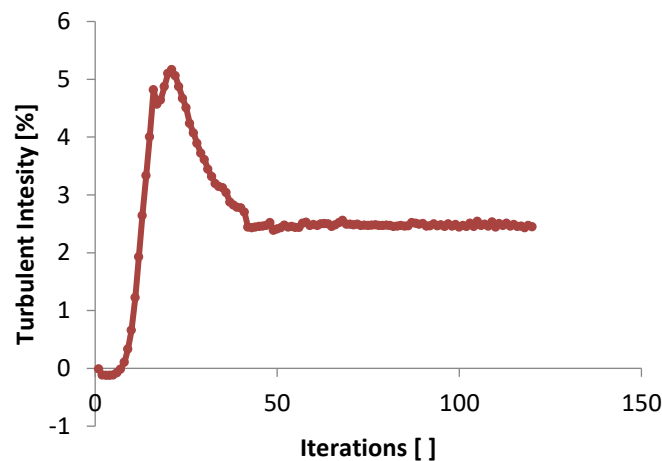
4-blade turbo cyclone change in pressure can be determined after 120 iterations of simulation and the value of change in pressure take from average pressure from all iterations. From **Figure 11**, the minimum value of pressure in a 4-blade turbo cyclone being -0.04621 Pa with the maximum value of pressure is -0.04581 Pa. So, the change in pressure of 4-blade turbo cyclone is -0.04582 Pa.



**Figure 11.** Change in pressure of 4-blade turbo cyclone

4-blade turbo cyclone change in turbulence intensity can be determined after 120 iterations of simulation and the value of change in turbulence intensity has been taken from average turbulence from all iterations. From **Figure 12**, the minimum value of turbulence intensity of a 4-blade turbo cyclone is 2.43246 % with the maximum value of turbulence intensity 2.54162 %. So, the change in turbulence intensity of 4-blade turbo cyclone is 2.44536% which means is a medium-turbulence case.





**Figure 12.** Change in turbulence intensity of 4-blade turbo cyclone

## 5. CONCLUSION

Based on the research and analysis that has been done previously about the effect of variations of the turbo cyclone blade, intake manifold spacer, and variations of the combined performance generated on the Honda Supra Fit 125CC combustion engine. The combustion engine's performance showed the combination of turbo cyclone 4-blade and intake manifold spacer that applied in Honda Supra fit 125CC increased due to the impact of change turbulence intensity value. All application of variations turbo cyclone and intake manifold spacer in Honda Supra Fit 125CC showed the changes in flow profile results by simulated computational fluid dynamics. The best airflow turbulence profile shown in 4-blade turbo cyclone with change in turbulence intensity is 2.44536% mean medium-turbulence case. 4-blade turbo cyclone had a change in velocity value of 0.14009 m/s with a change in pressure value is -0.04582 Pa. The smallest change in turbulence intensity is the intake manifold spacer. The value of the change in the intensity of the intake manifold spacer turbulence is only 0.41247% or below 1%, which means that the turbulent conditions are classified as low-turbulent cases. The condition of the intake manifold spacer shows a speed change value of 0.26269 m/s, a pressure change value of only -0.00673 Pa. There is no change in turbulent flow when a large velocity change with a small pressure drop occurs. The addition of turbo cyclone and intake manifold spacer variations is proven to change the linear flow to turbulent flow due to the rotating airflow. In future research, it is hoped that the application of turbo cyclones and intake manifold spacers can be carried out on injection motorcycles.

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