JMEL 15 (1) (2026)
Journal of Mechanical Engineering Learning
https://journal.unnes.ac.id/journals/jmel
doi: https://doi.org/10.15294/jmel.v15.i1.31136

Analysis of The Effect of The Intake Manifold Curvature Angle of The KZR Engine on The Characteristic of Air Fluid Flow

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How to cite (APA Style 7th) : Fernando, A., Naryanto, R. F., Roziqin, A., & Maulana, S. (2026). Analysis of The Effect of The Intake Manifold Curvature Angle of The KZR Engine on The Characteristic of Air Fluid Flow. *JMEL : Journal of Mechanical Engineering Learning*, *15*(1), 18–22. https://doi.org/10.15294/jmel.v15.i1.31136

ARTICLE INFO

Article History:
Received: July 25, 2025
Revised: July 12, 2026
Accepted: July 12, 2026

Keywords:
Intake Manifold; Ansys Fluent; Turbulence Intensity; Turbulent Kinetic Energy; Flow Velocity

Abstract

This research is to determine the effect of variations in the intake manifold curvature angle on turbulence intensity, turbulent kinetic energy, flow velocity, and fluid flow patterns. One effort to reduce excessive fossil fuel consumption is modifying vehicles to consume fuel more efficiently through a more complete combustion process. One such method involves modifying the intake manifold of a motorized vehicle. This study used FD-based numerical study with a quantitative approach to investigate changes in the curvature angle of the intake manifold. The aim of The modification process of the intake manifold structure was conducted on a 2012 Vario 125 (KZR) motorcycle through simulation. The purpose of this simulation is to conduct a fundamental analysis before implementing changes to the intake manifold structure. The geometric definition of the intake manifold was created using SolidWorks 2020, and the simulation was performed using Ansys Workbench 2022. The curvature angle variations of the intake manifold were 110°, 120° (standard), and 130°. The simulation results showed differences in outcomes for each curvature angle. The highest turbulence intensity, turbulent kinetic energy, and flow velocity were observed at the 110° angle. This indicates that modifying the intake manifold through simulation can influence turbulence flow during the combustion process. These findings can be considered to achieve better torque and power output in vehicles in the future.

1. INTRODUCTION

Transportation involves the physical movement of people or objects over a certain period using human, animal, or machine power (Iskandar et al., 2020; Mabruwaru, 2017). In Indonesia, the number of motorized vehicles in 2015 reached 121.39 million units, dominated by motorcycles (81.5%) (Kresnanto, 2019). Every vehicle requires fossil fuel, while national oil reserves have tended to decline from 8.21 billion barrels in 2008 to approximately 7.5 billion barrels in 2018 (ESDM, 2018). Without fuel, the combustion process cannot occur (Iskandar et al., 2024; Setiyawan et al., 2024).

One solution to reduce fuel consumption is to improve combustion efficiency by modifying the intake manifold (Khan &

Hadromi, 2020; Naryanto et al., 2026). This study uses a Honda Vario Techno 125 cc motorcycle and compares the standard intake manifold with modified versions (Ardana, 2018).

Turbulence and turbulent kinetic energy are important indicators in air distribution within the combustion chamber (Kumar et al., 2018; Mahilda et al., 2016). Airflow has turbulence intensity proportional to pressure drop. The higher the turbulence intensity, the greater the pressure drop (Sunaryo et al., 2020). In flow dynamics, besides turbulent kinetic energy, velocity is also observed (Abidi & Hasan, 2021). Low-viscosity fluids such as air at high speeds are generally turbulent (Vallis, 2019).

The intake manifold design affects volumetric efficiency, engine performance, and emissions (Xu, 2017). A small bend angle with a short straight pipe results in smoother exhaust flow and more uniform exhaust velocity across the model (Aziz et al., 2021). Manufacturers design manifolds to produce a homogeneous mixture of air and fuel (Winarto & Heru, 2014). The simulation was conducted using ANSYS Fluent based on 3D CFD to obtain efficient and accurate results (Manmadhachary et al., 2017).

2. RESEARCH METHODS

This study uses a simulation method with a pre-experimental design approach, as it is conducted before actual experiments. CFD studies can be performed more quickly and reduce costs (Naryanto et al., 2024). The research stages began with a literature review to gather theories and references related to the intake manifold. Next, the intake manifold geometry was designed using SolidWorks 2019, based on the standard dimensions of the KZR engine. Three variations of the intake manifold angle were created: 110°, 120°, and 130°, with a fixed diameter of 22 mm.

Figure 1. Geometry of the 120° intake manifold

The 3D models of each design were processed in ANSYS Fluent for meshing, which involves breaking down the geometry into smaller elements to obtain accurate simulation results. The modeling was performed by defining variables such as fluid type, operating conditions, and boundary conditions. The process continued with numerical solution calculations using iterative methods.

The CFD simulation results, including flow contours and fluid distribution, were used as the basis for data analysis. Among the three designs, the best model was selected based on the simulation results showing the most optimal airflow performance to support combustion efficiency.

3. RESULTS AND DISCUSSION

Result

This study analyzed the effect of variations in the intake manifold angle (110°, 120°, and 130°) on three main parameters: turbulence intensity, turbulent kinetic energy, and flow velocity (velocity) using CFD simulation with ANSYS Fluent. The purpose of this simulation was to determine how changes in the intake manifold geometry affect fluid flow characteristics.

a. Turbulence Intensity

The simulation results showed that an increase in the intake manifold angle is inversely proportional to an decline in turbulence intensity. At 110°, the turbulence intensity value was 232,8198%, declining to 227,4689% at 120°, and reaching 227,0139% at 130°.

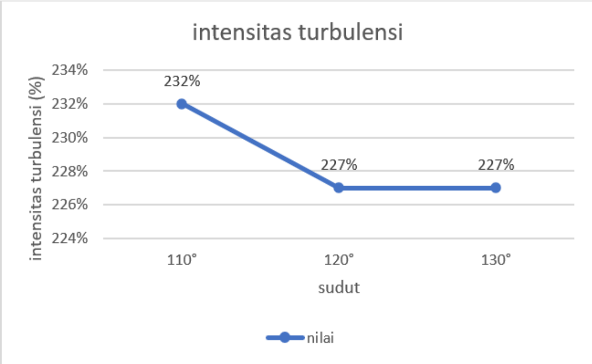

Figure 2. Turbulence Intensity Graph

This is evident from the increasingly dominant red color in the flow contours, particularly at the outlet, indicating higher turbulence. This phenomenon is caused by the increasing pressure difference in the curved angle area as the angle declines, triggering the formation of eddies and flow vortices.

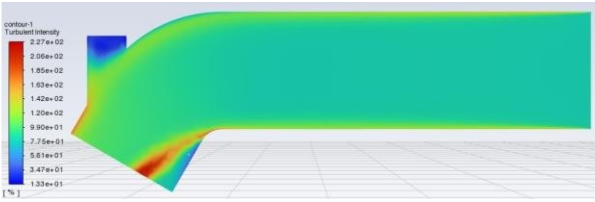

Figure 3. Turbulence Intensity at a 120° Intake Manifold Angle

b. Turbulent Kinetic Energy

A similar declining trend was observed for turbulent kinetic energy. The highest value was obtained at 110° 8,134991m²/s², increasing to 7,773845m²/s² at 120°, and reaching the lowest value of 7,729852m²/s² at 130°.

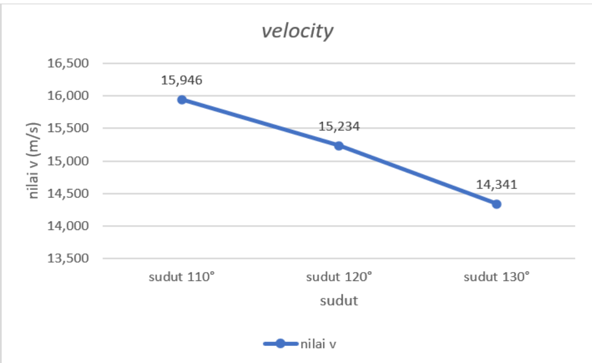

Figure 4. Turbulent Kinetic Energy Graph

The smaller the intake manifold angle, the more significant the pressure distribution and fluid flow direction changes, thereby increasing the transfer of kinetic energy in the form of turbulence. This is also visible in the contour graph, where the red color becomes more widespread, especially near the outlet area.

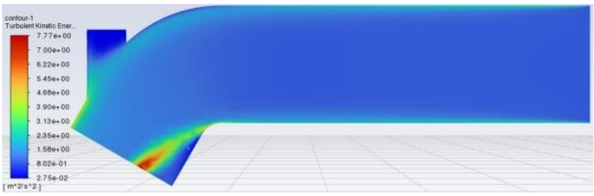

Figure 5. Turbulent Kinetic Energy Contour at a 120° Intake Manifold Angle

c. Velocity

Flow velocity also declined with the intake manifold angle. At 110°, the maximum velocity was 15,94633 m/s, increasing to 15,2342m/s at 120°, and 14,34199m/s at 130°.

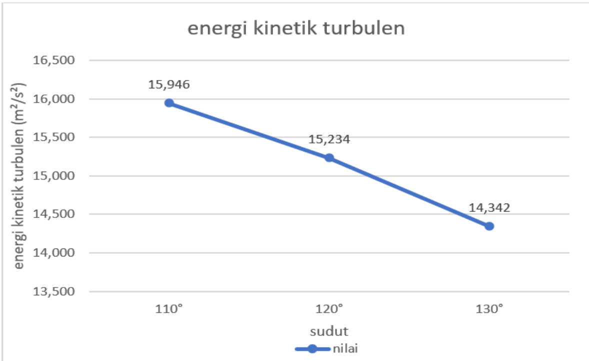

Figure 6. Flow Velocity Graph

The velocity distribution followed a similar pattern to the previous parameters, where a smaller curvature angle caused flow acceleration due to the conversion of pressure energy into kinetic energy. This is also evident from the increased red color in the velocity flow contour visualization.

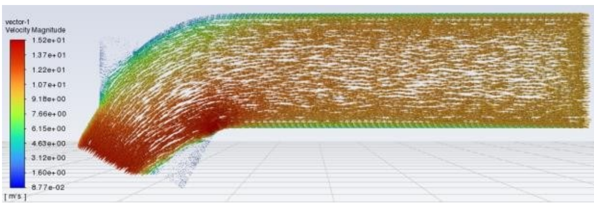

Figure 7. Velocity at a 120° Intake Manifold Angle

Discussion

Based on the simulation results of intake manifold angle variations, it can be concluded that a smaller curvature angle specifically

110° provides better flow performance compared to larger angles (120° and 130°). This is evidenced by the highest values of turbulence intensity (232.82%), turbulent kinetic energy (8.13 m^2/s^2), and flow velocity (15.95 m/s) occurring at the 110° configuration.

In contrast, increasing the intake angle tends to reduce these parameters due to changes in pressure distribution and flow geometry, which are less favorable for turbulence formation. Therefore, the 110° intake manifold angle is considered the most optimal in enhancing turbulence and air-fuel mixture quality, which are crucial for improving combustion efficiency in the engine.

4. CONCLUSION

Based on the CFD simulation results, variations in the intake manifold angle significantly affected turbulence intensity, turbulent kinetic energy, and flow velocity. The 110° intake manifold angle produced the best flow characteristics, with the highest turbulence intensity of 232.8198%, turbulent kinetic energy of 8.134991 m^2/s^2, and maximum velocity of 15.94633 m/s. As the intake manifold angle increased to 120° and 130°, all three parameters decreased, indicating that larger angles reduced turbulence formation and flow acceleration. The smaller angle generated stronger pressure differences and more intensive vortex formation, which can improve air–fuel mixture quality in the intake flow. Therefore, the 110° intake manifold angle is the most optimal configuration among the tested variations for supporting better combustion efficiency and engine performance. For further development, it is recommended to explore additional intake manifold geometries such as spiral shapes, multi-bend configurations, or variable designs to optimize flow characteristics and volumetric efficiency.

5. REFERENCES

Abidi, S. H., & Hasan, M. M. (2021). Variation of turbulent kinetic energy due to dimples in intake manifold for diesel engine. *Case Studies in Thermal Engineering*, *27*(April), 101299. https://doi.org/10.1016/j.csite.2021.101299

Ardana, I. G. N. (2018). Analisis Perbandingan Emisi Gas Buang Menggunakan Koil Standar Dengan Koil Kawahara Pada Sepeda Motor Honda Vario Techno 125 Cc Pgm-Fi Tahun 2012. *Matrix : Jurnal Manajemen Teknologi Dan Informatika*, *8*(2), 26–30.

Aziz, N. A., Rahman, M. T. A., Amin, N. A. M., Mohamad, M. S. Bin, Mohamad, A., Izham, M., & Saad, M. A. M. (2021). Flow characterisation in an exhaust manifold of a single-cylinder internal combustion engine (ICE). *Journal of Physics: Conference Series*, *2129*(1), 012077. https://doi.org/10.1088/1742-6596/2129/1/012077

ESDM. (2018). Annual Archivement of Development Report: Utilization of Natural Gas. *Kementerian Energi Dan Sumber Daya Mineral*, 120. https://migas.esdm.go.id/uploads/uploads/files/laporan-tahunan/Laptah-Migas-2018---FINAL.pdf

Iskandar, R., Arlinwibowo, J., Setiadi, R., Mujaki, A., Naryanto, R. F., Setiyawan, A., & Musyono, A. D. N. I. (2024). Impact of biodiesel blends on specific fuel consumption: A meta-analysis. *IOP Conference Series: Earth and Environmental Science*, *1381*, 012033. Retrieved from https://iopscience.iop.org/article/10.1088/1755-1315/1381/1/012033

Iskandar, R., Sukoco, Sutiman, Arifin, Z., Adkha, N. F., & Rohman, J. N. (2020). The quality of vehicle exhaust gas emission in Sleman, Indonesia in 2019. *Journal of Physics: Conference Series*, *1456*, 012030. https://doi.org/10.1088/1742-6596/1456/1/012030

Khan, M. A., & Hadromi. (2020). Automotive Science and Education Journal. *Automotive Science and Education Journal*, *9*(1), 25–30. http://journal.unnes.ac.id/sju/index.php/asej

Kresnanto, N. C. (2019). Model Pertumbuhan Sepeda Motor Berdasarkan Produk

Dosmetik Regional Bruto (PRDB) Perkapita (Studi Kasus Pulau Jawa). *Media Komunikasi Teknik Sipil*, *25*(1), 107. https://doi.org/10.14710/mkts.v25i1.18585

Kumar, N., Singh, D. B., & Sharma, S. K. (2018). *CFD Analysis of Two-phase Flow Characteristics in Horizontal Pipeline*. *1952*, 163–177.

Mabruwaru, V. A. (2017). Analisis Kinerja Angkutan Umum Penumpang Di Kota Sorong - Papua Barat (Studi Kasus Trayek a). *Uajy*, *53*(9), 8–16. *Terowongan Angin Sirkuit Terbuka*. *V*, SNF2016-CIP-147-SNF2016-CIP-150. https://doi.org/10.21009/0305020128

Manmadhachary, A., Santosh Kumar, M., & Ravi Kumar, Y. (2017). Design & manufacturing of spiral intake manifold to improve Volument efficiency of injection diesel engine byAM process. *Materials Today: Proceedings*, *4*(2), 1084–1090. https://doi.org/10.1016/j.matpr.2017.01.123

Naryanto, R. F., Pratama, D. O., Delimayanti, M. K., Karnowo, Saputro, D. D., Setiyawan, A., & Darsono, F. B. (2024). Downdraft Gasifier for Oil Palm Empty Bunches with Computational Fluid Dynamics. *IOP Conference Series: Earth and Environmental Science*, *1381*(1), 0–10. https://doi.org/10.1088/1755-1315/1381/1/012032

Naryanto, R. F., Nurudin, I. B., Kurniawan, A., Mujaki, A., & Iskandar, R. (2026). The effect of varying the number of inlet diffuser holes in the exhaust manifold on the performance of the Supra x 125 engine. *AIP Conference Proceedings*, *3319*(1), 030008. Retrieved from https://pubs.aip.org/aip/acp/article-abstract/3319/1/030008/3393832

Setiyawan, A., Faksi, S., Fitriyana, D. F., Aryadi, W., Naryanto, R. F., Darsono, F. B., Bahatmaka, A., Kriswanto, Rusiyanto, Gumelar Syafei, M. H., & Pratiwi, I. (2024). Production and Investigation of the 150 CC Engine Performance with Bioethanol from Manihot Esculenta Cassava and RON 92 Fuel Mixture. *IOP Conference Series: Earth and Environmental Science*, *1381*(1). https://doi.org/10.1088/1755-1315/1381/1/012020

Sunaryo, Irfan, A., Setiyo, M., & Amin, N. (2020). Design and simulation of mixer insulators to improve turbulence in intake manifold. *Journal of Physics: Conference Series*, *1517*(1). https://doi.org/10.1088/1742-6596/1517/1/012009

Vallis, G. K. (2019). Fluid Fundamentals. *Essentials of Atmospheric and Oceanic Dynamics*, 3–23. https://doi.org/10.1017/9781107588431.003

Winarto, E., & Heru, P. (2014). Pengaruh Modifikasi Sudut Kelengkungan Intake Manifold Terhadap Performa Mesin Pada Motor Empat Langkah. *Jurnal Teknik Mesin*, *02*(02), 196–203.

Xu, J. (2017). Flow analysis of engine intake manifold based on computational fluid dynamics. *Journal of Physics: Conference Series*, *916*(1). https://doi.org/10.1088/1742-6596/916/1/012043