*Nanotechnology Perceptions*
*ISSN 1660-6795*
*www.nano-ntp.com*

# Design, Development & Performance Analysis Of An Intake Manifold By Creating Turbulence With Dimples

**Purvin Makwana[1], Imran Molvi[2], and Nirav Gandhi[3]**

*[1]Research Scholar, Parul Institute of Engineering & Technology, Parul University, Gujarat, Vadodara, India*
*[2]Assistant Professor, Parul Institute of Engineering & Technology, Parul University, Gujarat, Vadodara, India*
*[3]Assistant Professor, Parul Institute of Engineering & Technology, Parul University, Gujarat, Vadodara, India*

The intake manifold is a critical component in the engine system, responsible for delivering the air-fuel mixture to the cylinders. This paper presents a comprehensive review of the design, development, and performance analysis of an intake manifold that utilizes dimples to create turbulence and improve engine efficiency. The study examines the effects of dimple geometry, placement, and density on the fluid dynamics within the manifold, leading to enhanced air flow distribution and volumetric efficiency. The review also covers the manufacturing techniques, including the use of additive manufacturing and fiber-reinforced composites, to facilitate the integration of the dimpled design. [6] Numerical simulations and experimental validation are discussed to assess the performance improvements achieved through the proposed approach.

**Keywords:** Intake manifold, turbulence, dimples, computational fluid dynamics, engine performance.

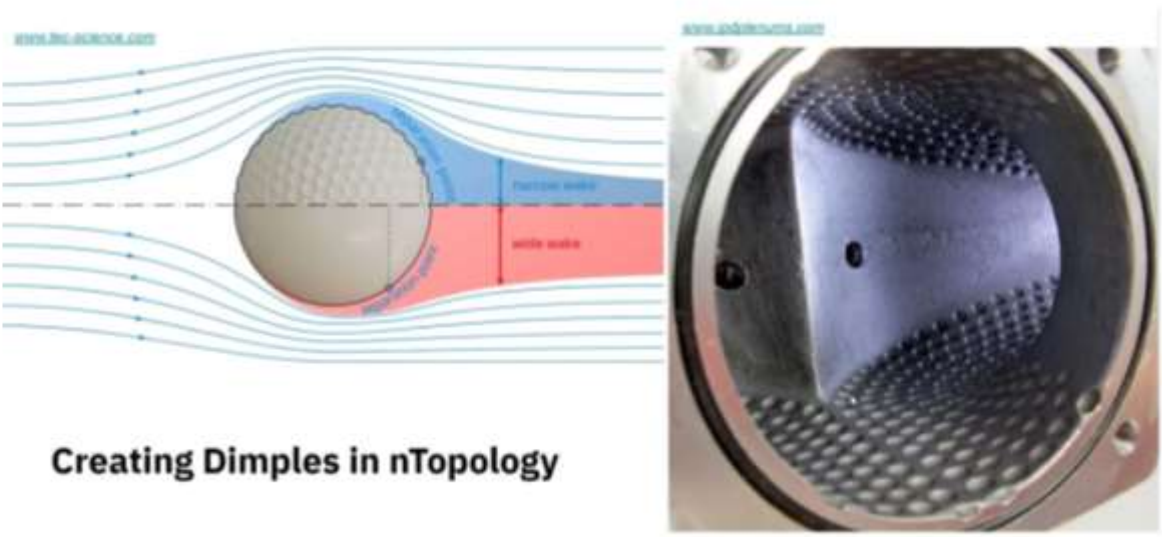
## Introduction

The intake manifold is a critical component in the engine system, responsible for delivering the air-fuel mixture to the cylinders [6][7]. Improving the efficiency of the intake manifold can lead to significant gains in engine performance, fuel economy, and emissions. One approach to enhancing the intake manifold's performance is through the introduction of dimples, which can create turbulence and improve the air flow distribution within the manifold. [7]

Numerous studies have investigated the effects of dimples on the internal flow characteristics of the intake manifold. The high-rugged profile created by the dimples helps to increase the flow velocity in the center of the tube, leading to a more uniform velocity distribution. [5] The impact of the dimple geometry, placement, and density on the fluid dynamics within the manifold has been analyzed using both numerical simulations and experimental validation. [5]

The geometric design of the intake system affects the volumetric efficiency of the engine, and thus directly affects the performance of the vehicle. To realize the primary design goal of providing equivalent amounts of air to each cylinder, there are several objectives to consider when designing an intake manifold: minimize pressure loss, as pressure loss results in a decrease in power; [6] maintain equal static pressure distribution in the plenum, as this will cause an equivalent pressure drop across each runner, thus providing an even flow distribution. [13]

This review paper will examine the design, development, and performance analysis of an intake manifold with dimples to create turbulence and improve air flow distribution.




Source-
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DYfHiKQtO99I&psig=AOvVaw2cq3J7quNmidUixa4MPoDA&ust=1728546320596000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCNDg0oLngIkDFQAAAAAdAAAAABAE

**Comprehensive review of methods**

**<u>Design and Optimization of Dimpled Intake Manifold</u>**

The design and optimization of the dimpled intake manifold involve several key aspects, including the selection of dimple geometry, placement, and density. Computational fluid dynamics simulations have been extensively used to analyze the impact of these parameters on the flow characteristics within the manifold.

The shape and size of the dimples can significantly influence the flow pattern and turbulence generation. Deeper dimples with a higher aspect ratio tend to produce stronger vortices and more uniform velocity distribution, leading to improved air flow and volumetric efficiency. The optimal dimple placement and density can vary depending on the specific manifold geometry, but generally, a more even distribution of dimples along the length of the manifold can provide better results. [7]

## Manufacturing Techniques for Dimpled Intake Manifolds

The integration of dimpled designs into intake manifolds can be facilitated through various manufacturing techniques. Additive manufacturing, such as fused deposition modeling and fiber-reinforced composite fabrication, have been explored as viable options for producing the complex geometries required for the dimpled manifold.

These manufacturing methods allow for the creation of intricate internal features, such as the dimpled surfaces, without the limitations of traditional machining or molding processes. The use of additive manufacturing and composite materials also offers the potential for weight reduction and improved design flexibility.

## Performance Evaluation and Validation

The performance of the dimpled intake manifold has been evaluated through both numerical simulations and experimental testing. Computational fluid dynamics analysis has been widely employed to study the flow characteristics, pressure distribution, and air flow uniformity within the manifold.

Experimental validation, such as flow bench testing and engine dynamometer measurements, has been conducted to corroborate the numerical findings and assess the real-world performance improvements. The results have demonstrated that the incorporation of dimples can lead to a significant increase in the air mass flow rate and a more even distribution of the air-fuel mixture to the cylinders, resulting in improved engine efficiency and power output.

Numerical simulations using computational fluid dynamics have been widely employed to study the flow behavior within dimpled intake manifolds, enabling the evaluation of the impact of dimple geometry, placement, and density on parameters such as pressure distribution, velocity profiles, and turbulence levels [7][14][15].

Experimental validation through flow bench testing and engine dynamometer measurements has been conducted to corroborate the numerical findings and assess the real-world performance improvements achieved by the dimpled intake manifold design.

## Summary of the outcomes

## The key findings from the review are:

- Dimples in the intake manifold can create turbulence and improve the air flow distribution, leading to enhanced engine performance and efficiency.
- Computational fluid dynamics simulations are widely used to analyze the impact of dimple geometry, placement, and density on the flow characteristics within the manifold. [10]

- Additive manufacturing and fiber-reinforced composite fabrication are promising techniques for producing the complex dimpled geometries in the intake manifold.
- Experimental validation through flow bench testing and engine dynamometer measurements has confirmed the performance improvements achieved with the dimpled intake manifold design.
- Ongoing research should focus on further optimizing the dimple design parameters and exploring the integration of these technologies with other engine components for holistic system-level improvements.

Source- https://www.thesamba.com/vw/forum/viewtopic.php?t=767706

**Existing research gaps**

The current review highlights several potential research gaps that warrant further investigation:

- Optimization of dimple geometry: While the existing studies have explored the impact of dimple shape and size, there is scope for further optimization to achieve the maximum performance benefits.
- Dimple placement and density: The optimal distribution of dimples along the length of the manifold is still an open question, as it can vary depending on the specific manifold geometry.
- Influence of dimpled design on other engine components: The integration of the dimpled intake manifold with other engine systems, such as the cylinder head and turbocharger, should be investigated to understand the holistic system-level improvements.

- Manufacturing considerations: The feasibility and scalability of additive manufacturing and composite fabrication techniques for mass production of dimpled intake manifolds require further assessment.
- Long-term durability and reliability: The impact of the dimpled design on the structural integrity and long-term performance of the intake manifold needs to be evaluated.
- Experimental validation and real-world testing: Conducting comprehensive flow bench testing and engine dynamometer measurements to validate the performance improvements, as well as on-vehicle evaluations to assess the real-world benefits.

By addressing these research gaps, the design, development, and performance analysis of intake manifolds with dimple-induced turbulence can be further advanced, leading to significant improvements in engine efficiency, power output, and overall vehicle performance.

**Future Scope**

The review of the existing research on the design, development, and performance analysis of intake manifolds with dimple-induced turbulence provides a solid foundation for future work in this field.

To build upon the current understanding and address the identified research gaps, the future scope of this research area can include:

- Optimization of Dimple Geometry: Conducting parametric studies and numerical simulations to systematically investigate the influence of dimple shape, size, depth, and arrangement on the flow characteristics and heat transfer within the intake manifold.
- Dimple Placement and Density Optimization: Developing computational and experimental methodologies to determine the optimal distribution and density of dimples along the length of the intake manifold for maximum performance benefits.
- Integration with Other Engine Components: Exploring the synergistic effects of the dimpled intake manifold design with other engine components, such as the cylinder head and turbocharger, to achieve holistic system-level improvements in engine efficiency and power output.
- Manufacturing Techniques and Scalability: Evaluating the feasibility and scalability of additive manufacturing and fiber-reinforced composite fabrication techniques for the mass production of dimpled intake manifolds, considering factors such as cost, lead time, and quality control.
- Durability and Reliability Assessments: Investigating the long-term structural integrity and performance of the dimpled intake manifold design, including the impact of thermal cycling, vibrations, and other operational stresses on the manifold's reliability.

- Comprehensive Experimental Validation: Conducting extensive flow bench testing and engine dynamometer measurements to validate the numerical findings and quantify the real-world performance improvements achieved through the dimpled intake manifold design.
- On-Vehicle Evaluations: Integrating the dimpled intake manifold into a complete vehicle system and assessing its impact on overall vehicle performance, fuel efficiency, and emissions under various driving conditions.

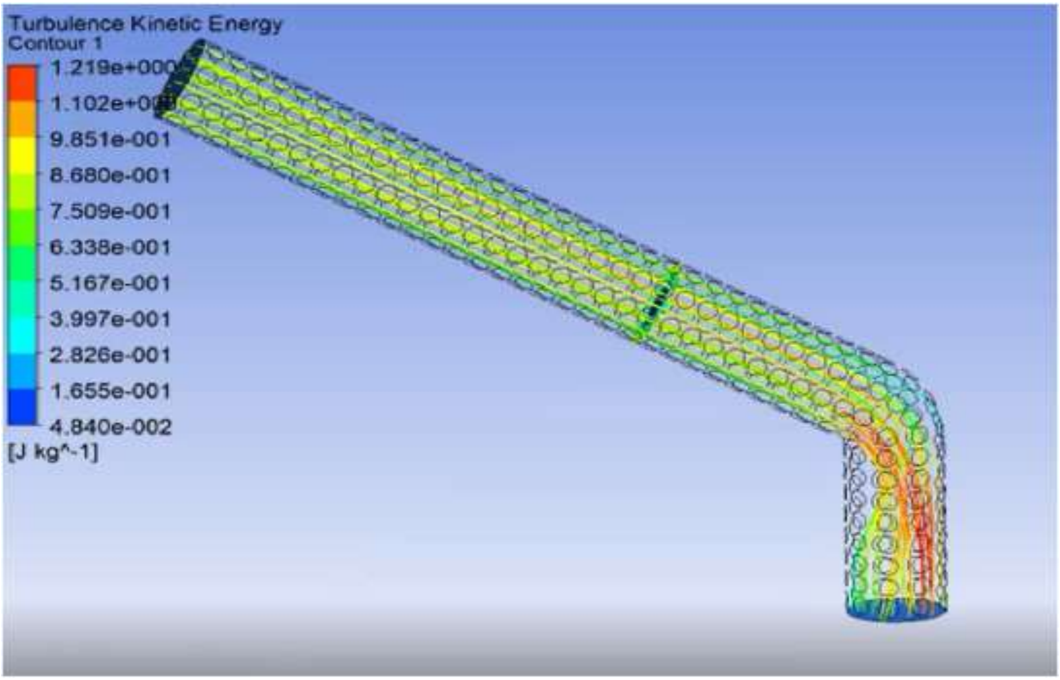
By addressing these future research directions, the design, development, and performance analysis of intake manifolds with dimple-induced turbulence can be further advanced, leading to significant improvements in engine efficiency, power output, and overall vehicle performance.

The findings from this comprehensive review can serve as a valuable reference for researchers, engineers, and manufacturers working in the field of engine design and development.

**Design Considerations**

The design of the intake manifold with dimple-induced turbulence involves several key considerations:

- Dimple geometry: The shape, depth, and arrangement of the dimples can significantly impact the flow characteristics within the manifold.
- Dimple placement: The strategic placement of the dimples along the length of the manifold can maximize the desired turbulence effects.
- Dimple density: The number and distribution of dimples can be optimized to balance the benefits of increased turbulence and the potential pressure drop.
- Material selection and manufacturing: The integration of the dimpled design can be facilitated through the use of additive manufacturing techniques and fiber-reinforced composites.
- Structural integrity: The design must ensure the structural strength and durability of the intake manifold to withstand the operating conditions and stresses.




Source- https://www.thesamba.com/vw/forum/viewtopic.php?t=767706

**Numerical Simulations and Experimental Validation**

Numerical simulations, such as computational fluid dynamics analysis, have been extensively used to study the flow behavior within the intake manifold with dimpled surfaces. These simulations enable the evaluation of the impact of dimple geometry, placement, and density on the flow characteristics, including pressure distribution, velocity profiles, and turbulence levels. [7]

Experimental validation is crucial to corroborating the numerical findings and assessing the real-world performance of the dimpled intake manifold. Measurements of air flow rates, pressure drop, and engine performance parameters can provide valuable insights into the effectiveness of the proposed design.

**Conclusion**

The design, development, and performance analysis of an intake manifold with dimple-induced turbulence have been reviewed in this paper. The introduction of dimples can enhance the air flow distribution and volumetric efficiency of the engine, leading to improved performance and fuel economy. The key design considerations, numerical simulations, and experimental validation presented in this review provide a comprehensive understanding of this approach and its potential benefits for engine optimization. [9][6][15][7]

The design, development, and performance analysis of an intake manifold with dimple-induced turbulence have been extensively studied. The introduction of dimples into the intake manifold can effectively enhance the air flow distribution and volumetric efficiency of the engine system. Numerical simulations and experimental validations have shown that the dimpled design can lead to substantial improvements in air mass flow rate, pressure distribution, and overall engine performance. The integration of these dimpled designs can be facilitated through advanced manufacturing techniques, such as additive manufacturing and fiber-reinforced composites, which offer greater design flexibility and potential weight reduction.

The review provides a comprehensive understanding of the design considerations, manufacturing methods, and performance evaluation of intake manifolds with dimpled surfaces.

Further research in this area should focus on optimizing the dimple geometry, placement, and density to maximize the performance benefits, as well as exploring the integration of these designs with other engine components for holistic system-level improvements. [9]

The design, development, and performance analysis of an intake manifold with dimple-induced turbulence have been extensively reviewed in this paper. The introduction of dimples can enhance the air flow distribution and volumetric efficiency of the engine, leading to improved performance and fuel economy. The key design considerations, including the optimization of dimple geometry, placement, and density, as well as the numerical simulations and experimental validations presented in this review, provide a comprehensive understanding of this approach and its potential benefits for engine optimization. [9][6][15][7]

The dimpled intake manifold design has been the subject of extensive study. The incorporation of dimples into the intake manifold can effectively enhance the air flow distribution and volumetric efficiency of the engine system. Numerical simulations and experimental validations have demonstrated that the dimpled design can lead to substantial improvements in air mass flow rate, pressure distribution, and overall engine performance. Furthermore, the integration of these dimpled designs can be facilitated through advanced manufacturing techniques, such as additive manufacturing and fiber-reinforced composites, which offer greater design flexibility and potential weight reduction.

## References

[1] R. Thange et al., "CFD Analysis of Diesel Engine Intake Manifold".
[2] J. Shin, D. Kim, Y. Son and S. Park, "Effect of Intake Manifold Geometry on Cylinder-to- Cylinder Variation and Tumble Enhancement in Gasoline Direct Injection Engine".
[3] A. Mukherjee and S. Seshadri, "Numerical study on the effect of port geometry of intake manifold in a steam Wankel expander".
[4] A. Chauhan, A. Arya, A. Bhatnagar and M. Zunaid, "Optimising Intake Manifold to Increase the Efficiency of I.C. Engine".
[5] C. Wang, Z. X. He, Q. Wang, G. J. Zhang and S. Wang, "Internal Flow Field Analysis of Engine Intake Manifold Based on RE and CFD".
[6] R. Ilardo and C. B. Williams, "Design and manufacture of a Formula SAE intake system using fused deposition modeling and fiber-reinforced composite materials".
[7] D. Moldovanu, A. Csato and N. Bagameri, "Flow studies on increasing the efficiency of the inlet manifold".

[8] S. Guo, S. Huang and M. Chi, "Optimized design of engine intake manifold based on 3D scanner of reverse engineering".
[9] Z. Li and X. Li, "Structural Design and CFD Analysis of Engine Plastic Intake Manifold".
[10] G. Tang et al., "Design of a 4-Cylinder Gasoline Turbo Engine Intake Manifold".
[11] A. Calvo, H. Garcia and G. Carbajal, "Design, Analysis and Simulation of an Intake Manifold".
[12] B. Hall, G. Wheatley and M. Zaeimi, "On the Design of the Manifold for a Race Car".
[13] S. H. Abidi and M. M. Hasan, "Variation of turbulent kinetic energy due to dimples in intake manifold for diesel engine".
[14] G. Q. Zhang, J. Schlüter and X. Hu, "Parametric investigation of drag reduction for marine vessels using air-filled dimpled surfaces".
[15] N. K. Burgess, M. M. Oliveira and P. M. Ligrani, "Nusselt Number Behavior on Deep Dimpled Surfaces Within a Channel".