FABRICATION AND TESTING OF SINGLE CYLINDER FUEL INJECTION PETROL ENGINE COUPLED WITH TURBO CHARGER

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ABSTRACT

This project aims to improve the performance and efficiency of a 100cc single-cylinder, four-stroke petrol engine by integrating a turbocharger specifically designed for small displacement engines. In the context of rising fuel costs and stringent emission norms, the study explores a low-cost, practical solution to enhance two-wheeler engine output without major structural modifications.

The methodology involved selecting a compatible turbocharger and mechanically coupling it with the engine. Key parameters such as engine speed, power output and exhaust emissions were recorded before and after the turbocharger installation. Testing was conducted under controlled conditions to analyze the impact of forced induction on combustion efficiency and overall engine behavior.

The results demonstrated a notable increase in engine power and efficiency, along with a reduction in specific fuel consumption. The successful integration of the turbocharger confirms the potential of this approach in improving the performance of small engines used in two-wheelers, making it a viable upgrade for better fuel economy and environmental compliance.

Keywords- Turbocharger, Kawasaki boxer AR100cc, Fabrication, Testing, Power Increase’s, Fuel economy, Mechanical efficiency, Brake power, Indicated power, Frictional power, Mass of fuel, Specific fuel consumption.

1. Introduction

In an era where fuel efficiency and performance are critical factors in automotive design, the exploration of turbocharging technologies has gained significant momentum — not just in cars, but increasingly in smaller vehicles as well. Traditionally, turbochargers have been employed in high-performance and commercial vehicles to enhance power output and fuel economy by utilizing exhaust gases to increase air intake into the engine. However, their application in small-displacement two-wheelers remains largely unexplored due to perceived challenges such as space constraints, thermal management, and cost-effectiveness.

This project investigates the feasibility and benefits of implementing a turbocharging system on a Kawasaki Boxer AR 100cc motorcycle — a vehicle typically associated with economy, simplicity, and reliability rather than high performance. By integrating a compact turbocharger with the existing engine configuration, the project aims to enhance both fuel mileage and speed performance without altering the internal architecture of the engine or significantly increasing overall vehicle weight.

With rising fuel prices and growing environmental concerns, improving the efficiency of small-displacement motorcycles can have a profound impact, especially in developing countries where two-wheelers are the primary mode of transportation. The goal of this project is not just to demonstrate technical feasibility, but to present a practical, cost-effective solution that can be replicated and scaled for broader use.

This report outlines the fabrication, and testing of a turbocharger system tailored for a 100cc engine, discussing the challenges, innovations, and expected performance improvements. It builds on existing research and technological advancements while paving the way for a new frontier in small-engine optimization through forced induction.

2. Literature Review

1) Paper Title: Turbo Charger in Two-Wheeler Engine

Authors: S. Vanangamudi, S. Prabhakar, C. Thamotharan, R. Anbazhagan

Summary: This paper explores how a turbocharger can be installed in two-wheeler engines to utilize exhaust gases, increasing the intake air pressure and thus enhancing combustion efficiency. The authors show that turbocharging leads to significant improvements in engine power and overall performance without increasing the engine size.

2) Paper Title: Mechanism of Turbo Charger for 2 Stroke Engine to Improve Efficiency

Authors: Mohit A. Bagul, Akhilesh M. Wadme, Vishal D. Shewale, Minal S. Borse

Summary: The study focuses on how turbocharging a two-stroke engine can improve combustion efficiency, engine performance, and fuel economy. The authors discuss the

challenges in turbocharging two-stroke engines and propose solutions for better air-fuel mixture management.

3) Paper Title: Performance Evaluation of Single Cylinder Four-Stroke S.I. Engine Using Turbocharging System
   Authors: Prashant S. Jadhav, S. U. Patel
   Summary: The authors experiment with turbocharging a single-cylinder engine and find noticeable gains in power and fuel economy without increasing the physical size of the engine, proving the potential of turbocharging small-displacement engines.
4) Paper Title: “Fabrication and Implementation of Turbo Charger in Two-Wheeler.”

Authors: Amalorpava Dass. J, Mr. Sankarlal. P

Summary: This paper presents the design and implementation of a turbocharger in a two-wheeler engine to improve power and efficiency. By redirecting exhaust gases to drive a turbine, the system compresses intake air, resulting in better combustion. The study highlights the potential for fuel savings, reduced emissions, and enhanced engine performance, especially in small-capacity bikes. The authors demonstrate that turbocharging can be a practical solution for improving two-wheeler efficiency with minimal environmental impact.

5) Paper Title: Turbocharged Single Cylinder Si Engine

Authors: Abhishek Saini, Prakash Shakti, Himanshu Kulshrestha

Summary: This paper focuses on enhancing the performance of a 125cc single-cylinder spark ignition (SI) engine by installing a turbocharger. Using a Honda Stunner CBF as the test vehicle, the study demonstrates how exhaust gases can drive a turbine to compress intake air, improving volumetric efficiency and power output. The results show that turbocharging boosts engine performance without increasing fuel consumption or engine size.

6) Paper Title: Fabrication And Performance Test of Turbocharger for Two-Wheeler

Authors: B Jnana Deepak, N Krishna Priya, B Revanth K S Jaya Prakash and B Hemanth Kumar

Summary: This paper focuses on utilizing the exhaust gas from a two-wheeler engine to drive a turbocharger, thereby increasing the power output and efficiency. The authors installed a turbine-compressor setup where the turbine is driven by exhaust gases and the resulting compressed air is supplied to the carburetor, improving the air–fuel mixture. The study aimed to increase volumetric efficiency, reduce fuel consumption, and control emissions. The turbocharger system was coupled with an intercooler for improved performance. The final prototype showed enhanced engine output and a reduction in harmful emissions, confirming the effectiveness of turbocharging in small engine vehicles

7) Paper Title: Turbo Charger for Two-wheeler

Authors: Mr. M Mohamed Ariffuddeen M.E, Arun T, Gopi S, Jayaram A.S, Jeevagan M

Summary: This paper discusses the design, fabrication, and implementation of a turbocharger in a two-wheeler to improve engine performance. By reusing exhaust gas energy to drive a turbine, the turbocharger helps boost volumetric efficiency and reduces fuel consumption. The project targets improvements for both commercial and racing motorcycles. Emphasis is placed on producing more power without increasing engine size, aligning with goals of fuel economy and lower emissions. The authors created a prototype setup using components like a K&N air filter, flanges, nozzles, and a turbine-compressor pair to enhance airflow and combustion in the engine

8) Paper Title: Turbo Charger in Two Wheelers

Authors: K M Arunraja, R. V Naveen Kumar, V. Raj Kumar, T Tamil selvan, S.Vikesh

Summary: This paper focuses on the design, effect, and installation of a turbocharger in a spark-ignition (SI) engine for two-wheelers. It explains how turbochargers use exhaust gas energy to compress intake air, enhancing the volumetric efficiency and power of the engine without increasing its size. The paper contrasts turbochargers with superchargers and emphasizes their growing relevance in building more economical and environmentally friendly vehicles. The research outlines the working principle of a turbocharger, highlighting how compressed air increases combustion efficiency, and presents a basic design of a turbine fan suitable for two-wheeler applications

9) Paper Title: Performance Analysis on A Turbocharged Two-Wheeler Engine

Authors: P Balashanmugam, E Elakiya and Sunayana Sharma

Summary: This paper investigates the use of exhaust gas to drive a turbocharger in a 100cc Suzuki gasoline engine. The main objective is to enhance engine performance and fuel economy while keeping emissions within national standards. The authors used a MEXA-584L gas analyzer to measure exhaust components such as CO, HC, CO_2, and NOx. The study showed that a well-designed turbocharger improves volumetric efficiency and reduces pollution. During half-throttle testing, over 90% of scooters and motorcycles emitted hydrocarbons within acceptable limits, indicating the system's environmental benefits and efficiency gains

10) Paper Title: Performance characteristics of modified turbocharger for a two-wheeler engine

Authors: B Gowtham Rajana, B. Manindra Reddyb, N Emerald Rayb, J Saharshab, K.G.D. Sri Harshac Mallineni Chandra Babu Naidu

Summary: This paper focuses on improving the performance of a 420cc single-cylinder SI engine by integrating a modified VZ21 turbocharger. It reports a 10–15% increase in indicated power, brake power, and torque after turbocharging. Fuel efficiency improved from 32 kmpl to 45 kmpl. However, initial emissions exceeded BS-IV norms, but were later controlled by optimizing ignition timing. The study confirms the viability of turbocharging for engine downsizing while maintaining high performance, and highlights the potential for use in high-altitude conditions as future work

11) Paper Title: Fabrication and Development of Turbocharger for Two Stroke Engine

Authors: Krishna Dwivedi, Omkar Kunte, Amit Verma, Avinash Kadam

Summary: This paper explores the development and installation of a turbocharger on a two-stroke petrol engine to improve fuel efficiency and mileage. The authors fabricated a prototype turbocharger system using the engine's exhaust gas to power a turbine, which then compresses intake air. By increasing the actual air-fuel ratio, the setup helps achieve better combustion and performance. The paper emphasizes the reuse of exhaust energy, minimizing wastage, and enhancing engine output through an economical and efficient turbocharging method.

12) Paper Title: Engine Performance Improvement Through Turbocharger Matching And Turbine Design

Authors: Shaolin Chen, Chaochen Ma, Hong Zhang, Cheng Xu, Fen Lei, Tao Feng, Gang Cao, Hanqin Yang, Chongfan Wei.

Summary: This paper explores the role of turbine design and appropriate matching of the turbocharger to the engine for enhancing performance. It demonstrates that selecting the right turbine size and blade configuration significantly improves engine efficiency, reduces turbo lag, and increases power output.

13) Paper Title: Performance Enhancement of Engine Using Turbocharger

Authors: Mayur Ingale, Harshal Kawale, Aniket Thakre, Nikhi Shrikhande

Summary: This study focuses on how turbocharging boosts the performance of internal combustion engines. It presents comparative data showing improved brake thermal efficiency, increased power, and reduced specific fuel consumption when a turbocharger is used, especially under high-load conditions.

14) Paper Title: Fabrication of Turbocharger for Two-Wheeler

Authors: Sandeepshekar.G, Raghupathi.S, Umesh Waddar, Praveen chauhan, Manjunath.c

Summary: This paper describes the design and fabrication of a low-cost turbocharger suitable for two-wheelers. It outlines material selection, turbocharger sizing, and integration challenges, concluding that such retrofitting can lead to better fuel efficiency and power without significant engine modifications.

15) Paper Title: Turbo Charging of Two Stroke S.I Engine

Authors: Mane P.R, Ghadge H.S, Dombale G.A, Bhagwat V.M, Ankush R.D

Summary: The research examines the feasibility of turbocharging a two-stroke spark ignition (S.I.) engine. Due to the scavenging process and lack of exhaust valves, turbocharging is complex, but the study proposes solutions like tuned exhausts and bypass valves. Results show a notable improvement in power and torque when implemented correctly.

3. Methodology

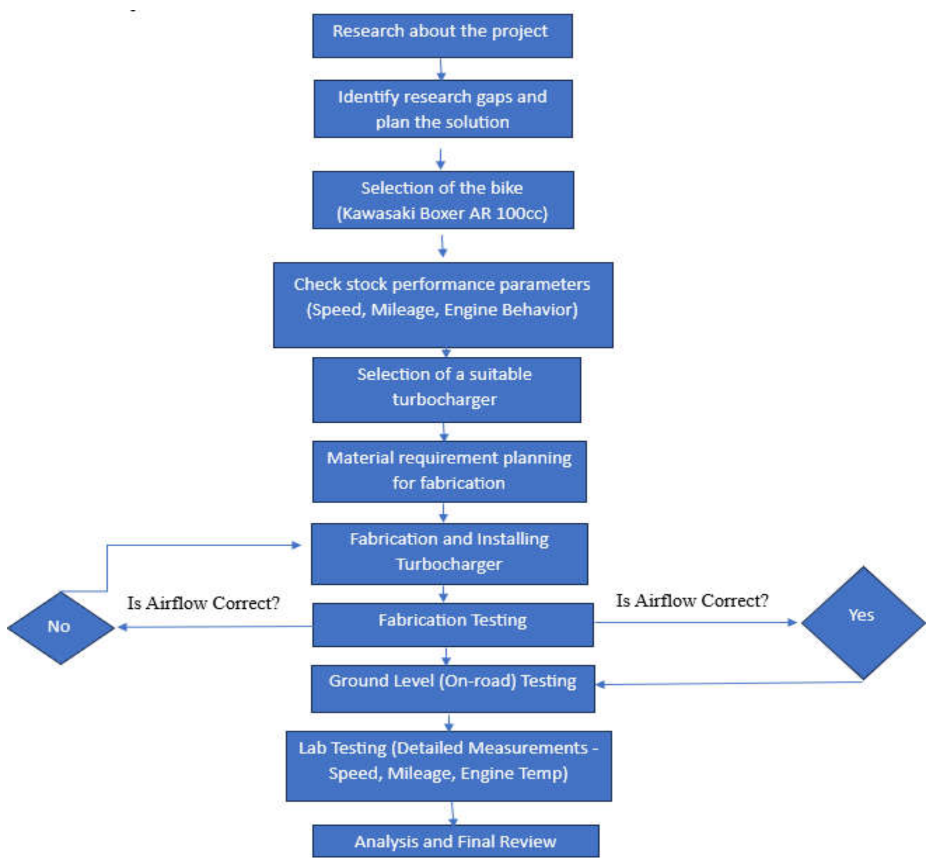

Figure 1: Methodology Flow Chart

4. Performance readings Before and After Turbocharger

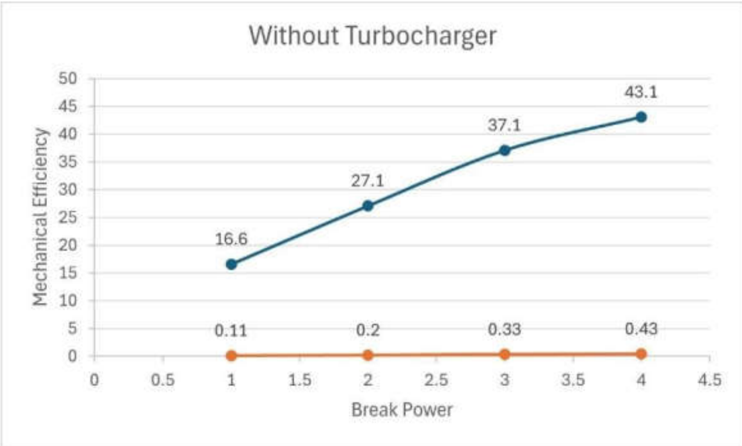

Figure 2: Mechanical Efficiency vs. Brake Power (Without Turbocharger)

Torque (Nm)	Brake Power (BP) (kW)	Fuel Mass (mf) (kg)	SFC (kg/kWh)	Friction Power (FP) (kW)	Indicated Power (IP) (kW)	Mechanical Efficiency (η_{me}) (%)
2.25	0.11	7.69×10^{-5}	2.3	0.6	0.72	16.60%
4.28	0.2	8.53×10^{-5}	1.33	0.6	0.83	27%
6.31	0.33	10×10^{-5}	1	0.6	0.96	37%
8.57	0.43	11.8×10^{-5}	0.9	0.6	1.07	43%

Table 1: Performance Parameters without Turbocharger

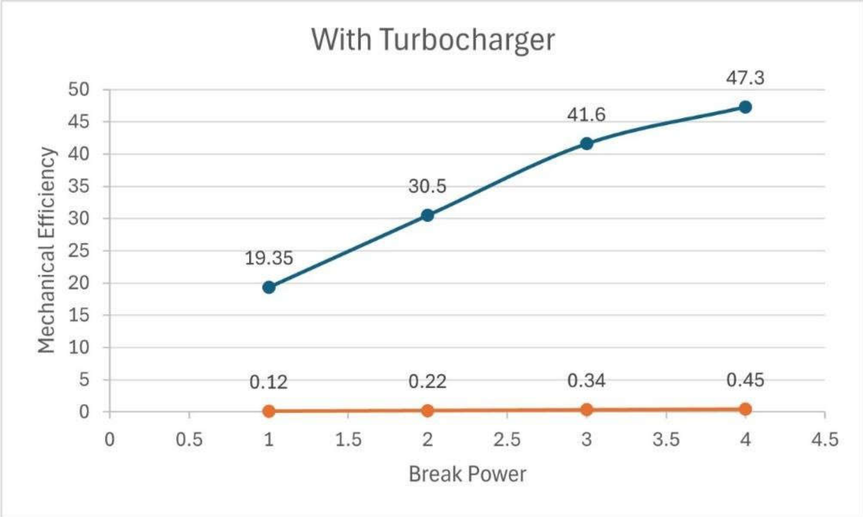

Figure: 3 Mechanical Efficiency vs. Brake Power (With Turbocharger)

S. No	Torque (T) (Nm)	Brake Power (BP) (kW)	Fuel Flow Rate (ṁf) (kg/s)	Specific Fuel Consumption (SFC) (kg/kWh)	Friction Power (FP) (kW)	Indicated Power (IP = BP + FP) (kW)	Mechanical Efficiency (ηmech %)
1	2.25	0.12	7.69×10^{-5}	2.3	0.5	0.62	19.35%
2	4.28	0.22	8.53×10^{-5}	1.39	0.5	0.72	30.50%
3	6.31	0.34	1.00×10^{-4}	1.06	0.5	0.84	41.60%
4	8.57	0.45	1.18×10^{-4}	0.94	0.5	0.95	47.30%

Table 2: Performance parameters with Turbocharger

5. Working

The working of the turbocharger system integrated into a two-wheeler engine, can be understood through the cyclic flow of gases and air that enhances engine performance. The process begins with the operation of the engine, which during combustion produces high-temperature exhaust gases as a byproduct. Instead of releasing these gases directly into the atmosphere, they are redirected toward the turbocharger. The turbocharger harnesses the kinetic and thermal energy of these exhaust gases to drive a turbine, which in turn compresses the incoming ambient air. This compressed air is then passed through the bike's air filter, which ensures that any particulates or impurities are removed, maintaining the quality and cleanliness of the intake air. Once filtered, the high-pressure air is delivered to the carburetor. In the carburetor, this compressed air is mixed with fuel in a precise ratio to form a dense and energy-rich air-fuel mixture. This mixture is then sent back into the engine's combustion chamber, where it ignites to produce more powerful combustion strokes compared to naturally aspirated systems. The cycle repeats as the engine continues to generate exhaust gases, which are again utilized by the turbocharger. This closed-loop system significantly improves the engine power output, better fuel economy. By recovering waste energy and enhancing air intake, this setup ensures the engine operates with greater efficiency and performance than conventional designs.

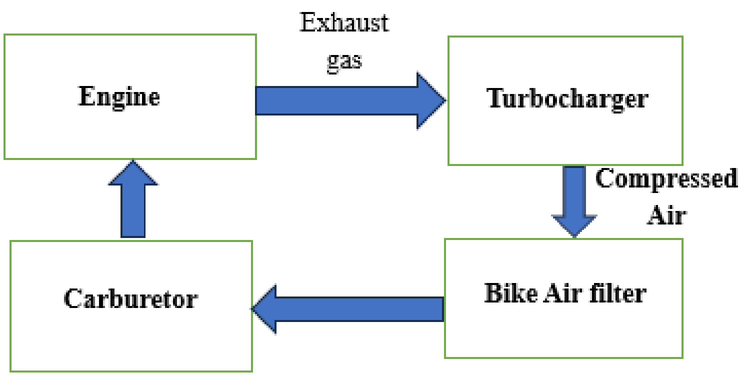

Figure 4: Work flow

6. Comparative analysis

Torque (Nm)	Brake Power (kW)		SFC (kg/kWh)		Indicated Power (kW)		Mechanical Efficiency (%)	
	Without	With	Without	With	Without	With	Without	With
2.25	0.11	0.12	2.30	2.30	0.72	0.62	16.6%	19.35%
4.28	0.20	0.22	1.33	1.39	0.83	0.72	27.1%	30.5%
6.31	0.33	0.34	1.00	1.06	0.96	0.84	37.1%	41.6%
8.57	0.43	0.45	0.90	0.94	1.07	0.95	43.1%	47.3%

Table:3 Comparison Table

Figure 5: Final appearance of the bike

7. Conclusion

The comprehensive analysis of engine performance with and without the integration of a turbocharger leads to a clear and consistent conclusion turbocharging significantly enhances the mechanical efficiency and overall effectiveness of an internal combustion engine. The comparative data show that at every level of torque tested, engines equipped with a turbocharger outperform naturally aspirated engines in terms of brake power and indicated power. This results in higher mechanical efficiency values across the board, with improvements ranging from approximately 3% to 4.2%. For example, mechanical efficiency increased from 16.6% to 19.35% at 2.25 Nm torque and from 43.1% to 47.3% at 8.57 Nm torque, demonstrating the consistent advantage provided by turbocharging.

Although a marginal rise in specific fuel consumption was observed (such as from 1.33 kg/kWh to 1.39 kg/kWh at 4.28 Nm torque), this increase is minimal when compared to the significant gains in power output and efficiency. The presence of the turbocharger enables the engine to recover and utilize the energy that would otherwise be lost through exhaust gases, thereby increasing the amount of mechanical energy extracted from the combustion process. This more effective energy utilization means that the engine can deliver higher performance without a proportionate increase in fuel consumption, making turbocharging a highly efficient solution for boosting engine capabilities.

From a practical standpoint, the implementation of a turbocharger not only increases the engine's power-to-weight ratio but also contributes to better fuel economy over time due to the improved efficiency. This makes turbochargers especially valuable in applications where engine performance and fuel efficiency are both crucial—such as in automotive, marine, and industrial machinery. Ultimately, the use of a turbocharger transforms the performance characteristics of an engine, offering a more efficient, powerful, and sustainable solution for modern engineering needs. The results of this study strongly support the adoption of turbocharging technology as a means to enhance mechanical efficiency and optimize engine performance

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