Fabrication and Development of Turbocharger for Two Stroke Engine

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ABSTRACT:
In general, Turbochargers are used throughout the automotive industry as they can enhance the output of an internal combustion engine without the need to increase its capacity. A study on the effect of turbocharger on a single cylinder two wheeler engine is made in this work. Also, the fabrication and installation of turbocharger in a single cylinder is available in this literature. We have fabricated a prototype model of turbocharger and implemented on a two-stroke petrol engine by which, the fuel efficiency and mileage of the engine can be increased. Thus, our aim in selecting this paper is to highlight the effectiveness of turbo-charging.

Keywords: Turbo-charger, IC Engine, Efficiency, Fuel Consumption, Two Stroke Engine.

I. INTRODUCTION
An attempt has been made in this work by which the exhaust gas is re-utilized with the help of turbocharger arrangement. The output of the engine exhaust gas is given to the input of the turbine blades which results in driving of the compressor and the pressurized air is produced. This compressed air is then supplied to the input of the engine. This setup is implemented in two wheeler engine having a low velocity of exhaust gas.

The fuel inside the two stroke engine do not burn properly due to cycle limitations. By considering this drawback, we decided to build a structure which will help in increasing the performance of a two stroke engine. In actual practice, the air fuel ratio of two stroke engine is less compared to the theoretical value (14:1 or 16:1) because of insufficient amount of air in air-fuel mixture. Thus, we decided to increase the actual air fuel ratio by implementing this new concept of turbo-charging to a two stroke engine.

The exhaust gas coming from the engine contains pressure as well as heat energy. Due to availability of these two energies, the exhaust manifold gets preheated and the vapour thus contains high power. This power is wasted by passing the exhaust gas to the surrounding. This energy of the exhaust gas can be utilized. This is done by a system called turbo-charger. Turbo-charging is basically providing pressurized air to the engine without mounting any component. It is a fan assembled unit that rotates on the power of air. This power is supplied by the exhaust manifold. Turbo-charging is the system that gives pressurized air to the carburettor. The carburettor adjusts the regulator valve according to the air need and the use of fuel is decreased. This also increases the mileage by minimizing the fuel to be supplied by increasing the air fuel ratio. [1] [2]

Fig. 1.1 shows the inside view of turbocharger. The compressor wheel and turbine are mounted on the same shaft. The exhaust gas coming from the engine strikes turbine blades and rotates the turbine. As the turbine rotates, the compressor wheel starts rotating with the same speed as that of turbine. The fresh air from the atmosphere gets sucked inside the compressor and it gets compressed. This compressed air is then supplied to the carburettor and thus increasing air-fuel ratio.

Figure 1. Working of turbocharger
II. WORKING PRINCIPLE

The exhaust gas coming from silencer rotates the turbine blades. The rotation of the blades causes the rotation of blower inside the compressor as the two are mounted on the same shaft. Due to the rotation of the compressor fan, fresh air enters the compressor. This fresh air flows through the turbocharger in following manner. The fresh air sucked by the compressor fan is then compressed in the compressor. This increases the pressure of the air and the density increases. This air is then supplied to the carburettor. [4]

![Diagram](image)

III. COMPONENTS AND DESCRIPTION

The major components involved in the fabrication of the turbocharger are as follows.

- **IC engine:**
  
  We have used a two-stroke single cylinder Suzuki engine with specifications as follows:
  
  - Type of fuel used: Petrol
  - Cooling system: Air cooled
  - Number of cylinder: Single
  - Number of stroke: Two stroke
  - Arrangement: Vertical
  - Cubic Capacity: 100 cc. [5]

- **Bearing:**
  
  Ball and roller bearings are used widely in instruments and machines in order to minimize friction and power loss. It is an important component in turbocharger. The bearing used in this project is of SKF Company. [6]
  
  - Material: Carbon steel
  - Bearing Number: SKF 6202
  - Type of bearing: Ball bearing
  - Size: 35mm OD, 15mm ID

- **Frame:**
  
  We have constructed an L-angled frame of dimensions 25×25×3 mm for mounting components. Material used for the fabrication of frame is Mild Steel.

- **Turbine:**
  
  The main parts of the efficient turbine are:
  
  - **Nozzle with regulating needle:**
    
    The exhaust pipe is jointed to the 1” pipe and this end is shaped to sharp to act as a nozzle. This pipe is provided with a bend near the turbine. This is done to accommodate regulating needle. The pipe at the end is provided with guide cross to ensure parallel flow. The nozzle is made of mild steel for small wheels and of cast steel for large turbines.
  
  - **Runner with blades:**
    
    Normally the runner wheels are mild steel in one piece with the blades and boss of special steel. The blade is the most important part of this project. It subjected to erosion due to impact of sandy air or chemically unsuitable gas. Depending upon head, stresses and quality of gas it is made of mild steel, cast steel or stainless steel. Cast iron is generally avoided, except for very small runners, due to its unsatisfactory welding characteristic. We have fabricated runner with 32 blades at an angle of 15°. The material used is Aluminium.
Casing:
The casing of a turbine has to carry housing for the bearing and it has also to support the nozzle and pipe bend. It is reinforced at this point to withstand reaction of jet. It is made of mild steel or cast iron and is generally made in two parts so that ejection and assembling is easy. The upper portion should fit tightly to prevent the air leading to runner and the lower portion has to be wide enough to prevent the water from reaching the runner again. We have fabricated the casing using Mild Steel material and thickness of the casing is 1.25 mm.

Blower:
The fan (impeller) rotates inside the shell. The shell is so designed that the air is rushed out forcefully. The blower consists of two main parts. They are

- Casing
- Impeller Blades (Fan)

The turbine is directly coupled with Impeller blades through bearings. The gas is used to strike the turbine and the blower is rotated so that the air is rushed out force. We have fabricated centrifugal blower with 32 blades at an angle of 15°. The material used is Aluminium.

The summary of all components used for the fabrication is shown in the table below.

<table>
<thead>
<tr>
<th>SR NO</th>
<th>NAME OF THE PARTS</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frame Stand</td>
<td>Mild Steel</td>
</tr>
<tr>
<td>2</td>
<td>Turbine</td>
<td>M.S.</td>
</tr>
<tr>
<td>3</td>
<td>Blower</td>
<td>Aluminium</td>
</tr>
<tr>
<td>4</td>
<td>Bearing with Bearing Cap</td>
<td>M.S</td>
</tr>
<tr>
<td>5</td>
<td>Engine (Suzuki 100cc)</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Chain with Sprocket</td>
<td>M.S</td>
</tr>
<tr>
<td>7</td>
<td>Connecting Tube</td>
<td>Plastic</td>
</tr>
<tr>
<td>8</td>
<td>Bolt and Nut</td>
<td>M.S</td>
</tr>
<tr>
<td>9</td>
<td>Wheel Arrangement</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1: Components

IV. OBSERVATIONS AND TESTING:

For this work, the existing silencer of a motorcycle is modified with the assembly of turbocharger. The turbine is mounted exactly above the silencer. The turbine is then connected to a mild steel shaft of diameter 15 mm. On the other side of the shaft, the compressor is fitted. The casing of the compressor is gradually decreasing in area from one end to another to compress the air sucked by the blower. The compressed air is then passed to the inlet of the carburettor with the help of connecting tube. The setup of the project work is shown in the fig 2.
V. OBSERVATIONS AND TESTING:

The effect of mounting a turbocharger to a two-stroke two-wheeler engine is very much same as that of four-wheeler turbocharged engine. When the pressurized air is supplied to the carburettor, the adjustment of throttle valve changes due to change in speed of the engine. When the throttle valve adjusts, the required pressure air and fuel flow through the carburettor will be less. Due to this, the O₂ content in the combustion chamber increases and thus the fuel burns efficiently. This ultimately increases the power and fuel efficiency of the engine. The experimental setup is as shown in fig. 3.

![Experimental setup](image)

**Figure 3. Experimental setup**

Testing of the engine:

The testing process is carried out by taking different quantities of fuel at steady state conditions. The timing for burning of a particular amount of fuel is noted for both the cases (without using a turbocharger & using a turbocharger). The readings of performance are obtained and are shown in the table below. From the table 2, it is clear that fuel consumption decreases with the usage of turbocharger as the engine runs for a greater amount of time period by using a turbocharger.

![Fuel consumption table](image)

**Table 2. Fuel Consumption Testing**

Mileage Testing:

The engine was also tested to calculate the increase in mileage of the engine due to addition of turbocharger. The testing is carried out by calculating the mileage of the engine running at different speeds. The readings of performance obtained are shown in the table below. Table 3 shows that the mileage of the engine is increased by 10% to 11% approximately with the implementation of the turbocharger.
Table 3 Mileage Testing

<table>
<thead>
<tr>
<th></th>
<th>RPM</th>
<th>Fuel Quantity (lit.)</th>
<th>Distance Travelled (km)</th>
<th>Increase in mileage (KMPL)</th>
<th>Percentage increase in mileage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without Turbocharger</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Turbocharger</td>
<td>312.80</td>
<td>0.02</td>
<td>0.578</td>
<td>2.78</td>
<td>9.29</td>
</tr>
<tr>
<td>Using Turbocharger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Turbocharger</td>
<td>375.36</td>
<td>0.02</td>
<td>0.7016</td>
<td>3.76</td>
<td>10.71</td>
</tr>
<tr>
<td>Using Turbocharger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without Turbocharger</td>
<td>500.85</td>
<td>0.02</td>
<td>0.9735</td>
<td>5.04</td>
<td>10.35</td>
</tr>
<tr>
<td>Using Turbocharger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Emission Testing

Emission Testing:

Emission testing of the exhaust gases coming out from the engine for both cases (without turbocharger & with turbocharger) was done. It was found that percentages of CO (carbon monoxide) and HC (hydrocarbon) were reduced after implementing the turbocharger. Also, amount of oxygen was increased considerably. Figure 4 shows the emission testing performed on the engine. [12]
VI. RESULTS:

- The trial and testing shows that the fuel efficiency is increased by introducing a turbocharger to the engine about 10% to 12%.
- Additionally, the mileage of the engine has increased by 10%-11% approximately.
- Percentages of CO (carbon monoxide) and HC (hydrocarbon) were reduced after implementing the turbocharger thus decreasing the emissions of harmful gases. Also amount of oxygen was increased considerably.

![Graph: Comparison of fuel efficiency](image)

VII. LIMITATIONS:

1. Limited compression ratio lowers efficiency, because the fuel is already mixed with the air during compression, it will auto-ignite if the compression ratio is high.
2. Additional cost and space is required to install this arrangement in the engine.
3. In lower speeds turbocharger is unable to compress and hence, the engine is constantly fighting to draw air past the throttle.
4. Also, the time gap can be formed between the throttle being actuated and turbocharging responding, called as 'Turbo-Lag'.

VIII. CONCLUSION:

The designed and fabricated setup of the turbocharger was implemented in two-stroke engine, which increased the fuel efficiency of the engine by 10% to 12% and mileage by 10% to 11%. The experimental setup is also favourable with regard to economic considerations and engine efficiency.

IX. REFERENCES:

[2] Internal combustion Engine by V. Ganesan