Effect of Funnel Radius on Flow Restriction of Air Cleaner

Simranjeet Kaur¹, Er. Rahul Malik²

¹M.Tech. (CAD) Student & ¹Mechanical Engineering Department, PM College of Engineering, Sonipat, Haryana, India
²Head of Department (Mechanical Engineering) & ²Mechanical Engineering Department, PM College of Engineering, Sonipat, Haryana, India

Abstract—During the design optimization of air cleaner body, many factors are considered to reduce the air flow restrictions. Addition of the funnel radius improves the pressure drops and make the flow smooth. This paper focuses study on flow analysis and pressure drop through different funnel shape radius for different mass flow rate and to find the optimum funnel radius for pipe diameter used in air cleaner body.

Keywords—Funnel shape, Radius, Flow restriction, pressure drop, CFD analysis.

I. INTRODUCTION

Funnel shape is a bell mouth like shape provided radius at the intake of inlet/outlet. Funnel shape allows the flow to follow the path and prevents the mixing of flow at the entrance and flows smoothly by reducing the flow restrictions and pressure drops. Due to addition of funnel like shape the velocity of flow incoming is less at the entrance which reduce noise, turbulence, separation of flow etc. Funnel shape can be provided to rectangular duct, circular duct by adding the radius. Increase value of radius decreases pressure drop.

II. LITERATURE REVIEW

Pham Ngoc Son, Jaewon Kim and E. Y. Ahn (2011): presented the study on effect of bell mouth geometries on flow rate using CFD, it showed the strong effect of bellmouth radius on flow rate that can be varied to 5% by using different geometries for bellmouth.

Gordon P. Blair, Senior Associate, Prof Blair & Associates and W. Melvin Cahoon (2010) discussed about how to optimise the design of internal combustion engine air intake bell mouth and found considerable benefit in mass flow radius by adding simple radius. They also gave their different conclusion for different shape bell mouth as elliptical profile was much good foe aerofoil whereas the rectangular bell mouth gave the worse results.

Hidesada Kanda and Koichi Oshima (2007) gave the numerical study of flow characteristics for Reynolds number ranging from 1000 to 4000. The calculation results, however, reveal that it develops a profile somewhat towards the Poiseuille’s parabolic profile. Moreover, a feasible reason for the increase in critical Reynolds number when using bell mouths was identified, i.e., if the bell mouth region is replaced by the pipe one, it was observed that the equivalent Re decreases from the original Re value.

Vadoud Naderi, Davood Farsadizadeh, Ali Hosseinzadeh Dalir, Hadi Arvanaghi (2013) presented it study on bell mouth at intake, said strong vortices at the mouth of the intake causes reduction in discharge efficiency, reducing the curvature of bell mouth radius, coefficient of discharge rate increased.

Simranjeet Kaur, Er. Rahul Malik (2017) presented it study on design optimization of air cleaner housing for minimum pressure drop of about 30% overall reduction by changing the air cleaner geometry and application of guide vanes and funnel radius (bell mouth) at the entrance of outlet section, to reduce turbulence at AFM.

III. DETAILED PROCEDURE

To find the optimum funnel radius on designed air cleaner, Firstly, the base funnel was designed and analysis done on different diameter at different flow rates by CFD, results were thoroughly studied and same methodology was applied to designed air cleaner on behalf of study of base funnel results.
From the base funnel result study, it was concluded that the intake or any opening if not provide with funnel the flow restriction was high. It concluded that addition of funnel radius with optimum radius decrease the pressure drop.

Hence same methodology was applied to air cleaner outlet while optimizing the design for pressured drop. Air cleaner outlet is installed with Air flow measurement(AFM), which give the reading of air discharge rate, so it is necessary to make flow smooth file passing through the AFM, otherwise readings not accurate. Therefore, adding funnel shape with optimum radius made flow streamlined and reduced the pressure drop.
IV. METHODOLOGY

After analysis of initial design and the flow restriction at the outlet, the funnel radius was added. Keeping the outlet diameter constant, the values of radius were changed to reduce the flow restriction for two mass flow rates.

1. 3m$^3$/min
2. 5m$^3$/min

Using the 3D software CATIA V5 Air cleaner was designed and analysis conducted on CFD to find the optimum funnel radius for different mass flow rate.

The flow considered to be steady, incompressible.

Reynolds number = \( \frac{\text{Inertial forces}}{\text{Viscous forces}} \)

\[ \text{Re} = \frac{\nu d \rho}{\mu} \]

Mesh Generation of air cleaner body

![Funnel shape and radius R](image)

Effect of funnel radius on pressure drop.

For the mass flow rate 3 m$^3$/min and outlet diameter 56.5mm

<table>
<thead>
<tr>
<th>Radius</th>
<th>CASE</th>
<th>ELEMENT</th>
<th>COVER</th>
<th>Total Pressure drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mm</td>
<td>1.36</td>
<td>0.28</td>
<td>0.12</td>
<td>1.76</td>
</tr>
<tr>
<td>5 mm</td>
<td>1.36</td>
<td>0.28</td>
<td>0.11</td>
<td>1.75</td>
</tr>
<tr>
<td>6 mm</td>
<td>1.36</td>
<td>0.28</td>
<td>0.10</td>
<td>1.74</td>
</tr>
<tr>
<td>7 mm</td>
<td>1.36</td>
<td>0.28</td>
<td>0.09</td>
<td>1.73</td>
</tr>
</tbody>
</table>

The Results gave the pressure drop values for each component of air cleaner at different radius of 4,5,6,7 mm for outlet diameter of 56.5 mm. The cover or clean side has it outlet so pressure drop can be seen in cover side. It concluded that for the mass flow rate of 3 m$^3$/min the minimum pressure drop was studied at R 7 mm

<table>
<thead>
<tr>
<th>Radius</th>
<th>CASE</th>
<th>ELEMENT</th>
<th>COVER</th>
<th>Total Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>4_mm</td>
<td>4.04</td>
<td>0.55</td>
<td>0.29</td>
<td>4.88</td>
</tr>
<tr>
<td>5_mm</td>
<td>4.04</td>
<td>0.55</td>
<td>0.26</td>
<td>4.85</td>
</tr>
<tr>
<td>6_mm</td>
<td>4.04</td>
<td>0.55</td>
<td>0.24</td>
<td>4.83</td>
</tr>
<tr>
<td>8_mm</td>
<td>4.04</td>
<td>0.55</td>
<td>0.23</td>
<td>4.82</td>
</tr>
</tbody>
</table>

V. RESULTS & DISCUSSIONS

The Results gave the pressure drop values for each component of air cleaner at different radius of 4,5,6,7 mm for outlet diameter of 56.5 mm. For the mass flow rate of 5 m$^3$/min the minimum pressure drop was studied at R 7 mm.
VI. CONCLUSIONS

For the mass flow rate of 3 the optimum radius was R 7mm, it was observed that after increasing the value of radius more there was no change in pressure drop. The pressure drop in CS side was 0.09 improved by 25% and total pressure drop in air cleaner was improved by 1.7%.

Similarly, for mass flow rate of 5 the optimum radius was found to be R 8 mm. the pressure drop on CS side was improved by 20.6% and total pressure drop in air cleaner was improved by 1.22%.

Hence it was concluded the funnel shape radius plays important in reduction of flow restriction to improve pressure drop.

REFERENCES


