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# Analysis of Air Intake System and Filter of an Automobile Engine By Adding Aerodynamic Structured Baffle

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**ABSTRACT:***Air intake systems are the first step in the process that makes the engine to produce the power that moves your vehicle. Some cars come with factory air intakes that are well tuned to optimize power as much as possible, but for many cars you have the opportunity to increase the power. Our paper focuses on optimizing the design of an air intake system in automobile engine by adding aerodynamic structured baffles, It decrease resistance to air flow into your car's engine while still maintaining high filtration efficiency. High air flow into your engine allows more into the combustion chambers. This increased oxygen content benefits you both by giving more horsepower and torque and by increasing your fuel efficiency and economy. The basic design was designed, modified and assembled using NX Unigraphics, It is the advanced high end CAD/CAM/CAE. The CFD analysis was carried out for an existing model to understand the flow behavior and geometry. Results obtained from CFD analysis of the existing model showed good correlation with experimental data.*

*Based on existing model CFD results, the design changes like adding Aerodynamic structured baffle placement in outlet of the filter box, optimization of mesh size, intake pipe is made shot This increases the flow rate of air into your car's intake manifold which helps the engine make more power, the optimized model was again analyzed using CFD and the results showed Increased in horse power, good improvement in flow behavior, and good filteration. By using NX Unigraphics and CFD analysis, optimal design of the modified intake system for an automobile engine is achieved with considerable reduction in development time and cost.*

**KEYWORDS:***Aerodynamic structured Baffles, Air Intake system, Automobile Engine,CFD, NX Unigraphics, Optimization*

## 1. INTRODUCTION

The function of the air intake system is to allow air to reach your car engine. Oxygen in the air is one of the necessary ingredients for the engine combustion process. A good air intake system allows for clean and continuous air into the engine, thereby achieving more power and better mileage for your car. Existing model dont have any baffles inside filterbox, in our project we adding aerodynamic structured baffles inside the outlet of the plenum it made pressuredecreases constantly inside the filterbox, we made the inlet pipe shot, This increases the flow rate of air into intake manifold which helps the engine make more power, especially at higher RPM. The main disadvantage of this type of intake is that it draws heated air from under the hood of the vehicle which tends to sacrifice some power, because heated air is not as dense as cold air. Modified design brings decrease resistance to air flow into car's engine while still maintaining high filtration efficiency. High air flow into engine allows more into the combustion chambers. This increased oxygen content benefits both by giving more horsepower and torque and by increasing fuel efficiency and economy.

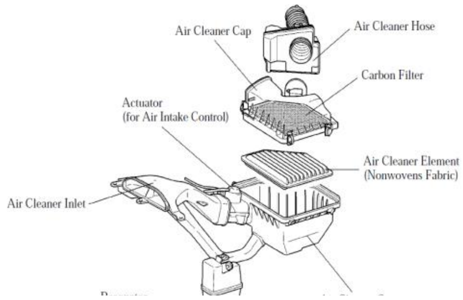



Fig 1: Air intake system of automobile

The horsepower increase will vary by application, but will average between 10

cost.

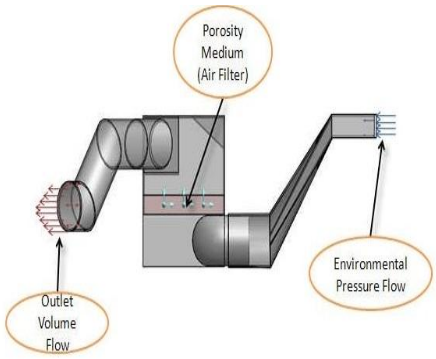
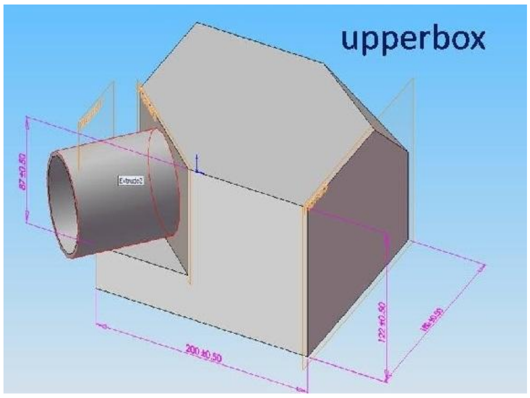



Figure2: CAD diagram of Air intake system

D.Ramasamy,Faculty of Mechanical Engineering, University Malaysia Pahang .optimized 1.6L of car engine by adding baffles in inlet plenum for ths result and 20 horsepower, the basic design was designed, modified and assembled using NX Unigraphics, It is the advanced high end CAD/CAM/CAE. The CFD analysis was carried out for an existing model to understand the flow behavior and geometry. The optimized model was again analyzed using CFD and the results showed Increased in horse power, good improvement in flow behavior, and good filtration. By using NX Unigraphics and CFD analysis, optimal design of the modified intake system for an automobile engine is achieved with considerable reduction in development time and




pressure drop is created inside the filterbox. This baffles are like ordinary one we modiffied this strucute and we place in in outlet so the pressure drop is more efficient then latter project then the shoterning the length of the inlet pipe This increases the flow rate of air into intake manifold which helps the engine make more power, especially at higher RPM

## 2. MEASUREMENTS AND NX CAD MODEL

After measure all dimension of the air intake, the model has been design by using solidwork software. Every single part of air intake has been drawn and finally all part will assemble The data of dimension for air intake system was collecting from measuring then modeling the body by NX CAD software. Data collecting of dimension as accurate as possible is very important for air intake to simulating the model in CFD.

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To measure the area, venire caliper had been used.

Inlet cross section area = 0.03756m²

Thickness of plastic = 29.5 mm

Porosity (filter) = 0.85

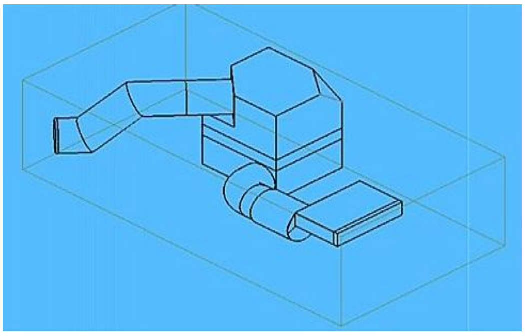

Fig 3: Assembly view of Air Intake system

Fig 4: Upper Box and Filter

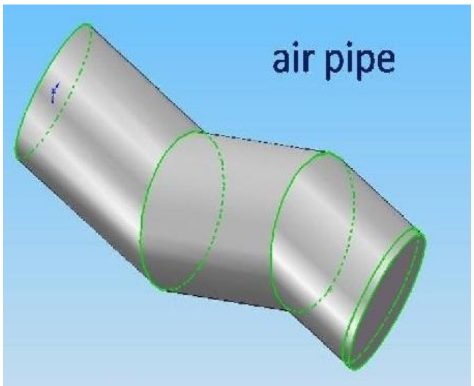


Fig 5: Air Pipe

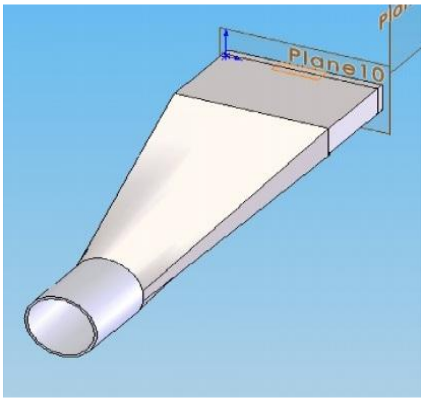


Fig 6: Resonator

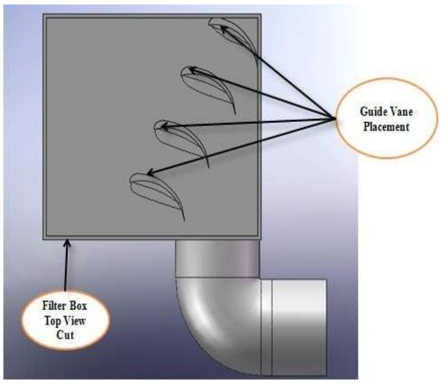


Fig 7: Placement of Aerodynamic baffles

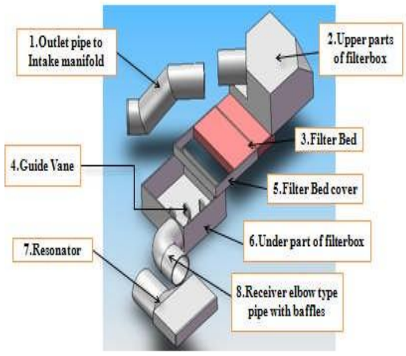


Fig 8: CADD Model with Baffles

## 3. CFD MODEL DESCRIPTION

For porous media, it is assumed that, within the volume containing the distributed resistance, there exists a local balance everywhere between pressure and resistance forces such that

$$-K_i u_i = \frac{\partial p}{\partial \xi_i} \quad (1)$$

Where ξI (i = 1, 2, 3) represents the (mutually orthogonal) orthotropic directions. Ki is the permeability ui is the superficial velocity in direction ξi The permeability Ki is assumed to be a

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quasilinear function of the superficial velocity magnitude of the form

$$K_i = \alpha_i |v| + \beta_i \quad (2)$$

Where αi and βi are user-defined coefficients. Superficial velocity at any cross section through the porous medium is defined as the volume flow rate divided by the total cross sectional area (i.e. area occupied by both fluid and solid). In this analysis, αi and βi are assumed to be same. Commercial CFD was used for this study. It is a finite volume approach based solver which is widely used in the industries. Governing equations solved by the software for this study in tensor Cartesian form are following:

Continuity:

$$\rho\left(\frac{\partial u_j}{\partial x_j}\right) = 0 \quad (3)$$

Momentum:

$$\rho \frac{\partial}{\partial x_j}\left(u_j u_i\right) = -\frac{\partial p}{\partial x_i} + \frac{\partial \tau_{ij}}{\partial x_j} + S_{cor} + S_{cfg}$$

Where ρ is density, uj is jth Cartesian velocity, p is static pressure, τij is viscous stress tensor.

For inlet, the mass flow rate was imposed using the fixed mass inlet boundary condition. The value of density (1 kg/m3), total pressure (1 atm) and turbulence intensity (5%) were specified at the inlet boundary. For outlet, outflow boundary condition was imposed with flow rate weighting of 1.

No slip boundary condition was applied on all wall surfaces.

For main filter media, porous media boundary was imposed with αi = βI = 3000. For air sensor, porous media boundary was imposed with αi = βI = 290.

Whole domain was considered at 1 atm and at 298 K as initial condition.

## 4. RESULTS AND DISCUSSION

Figure 8 shows two recirculation zones right below the filter needed to be considered for optimization as the recirculation in flow field causes energy dissipation. In order to avoid the recirculation, introducing the baffle was suggested which would guide the flow to avoid recirculation. After the baffle was introduced in the existing model, CFD analysis was again carried out to decide the location and effect of baffle.

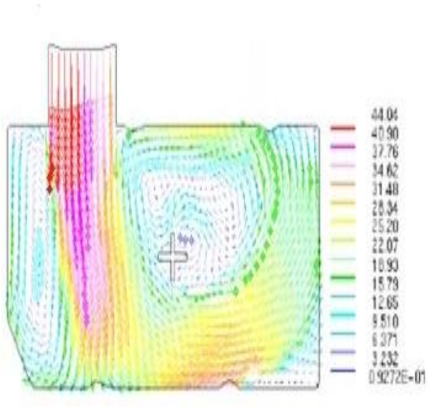



Fig 8: Two recirculation zones right below the filter considered for optimization

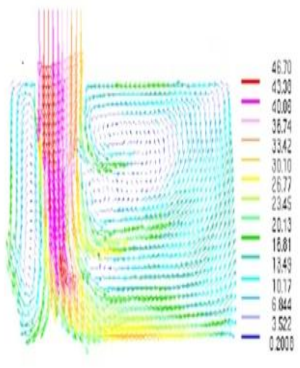



Fig 9: Velocity victor m/s plotted for the modified model

Velocity vector plot of modified model in figure (9) below gives a clear picture of less recirculating flow field. figure (10) and figure (11) show the velocity magnitude contour plot in the critical region in the flow domain. In the figure (11) it can be seen the effect of baffle as the flow is relaxed and better flow distribution

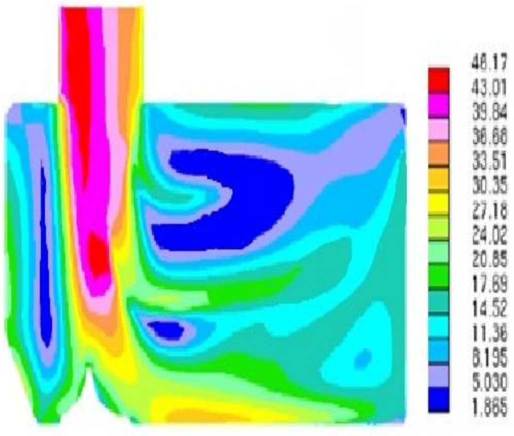
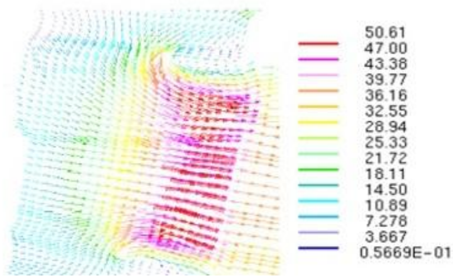



Fig 10: Velocity magnitude m/s contour plot

existing model

Fig 11: Velocity magnitude m/s contur plot for the modified model

Figure (12) shows a separation zone at one side after the first bend of clean pipe. And more concentrated velocity magnitude contours were seen at the other end which is typical phenomenon that can be seen in bends



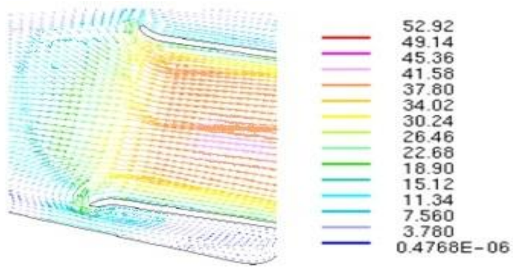




Fig 12: Velocity vectors plot near outlet after before modification modification

Fig 13: Velocity vectors plot near outlet introducing aerodynamic baffles

To overcome such phenomenon of separation, a baffle was introduced that guides the flow and make the flow uniform. This will possibly improve engine performance.

| | Percentage improvement (reduction) in total pressure drop with Aerodynamic Baffles and other modifications |
|---|---|
| Dirty pipe with mesh | 33 |
| Intake system, filter & Air sensor | 28 |

| | |
|---|---|
| Clean Pipe | 6.5 |
| Through cut the domine | 22 |

Table 1: presents percentage improvement in total pressure drop

above table 1 presents percentage improvement in total pressure drop (reduction) in the intake system with various design modifications. by changing mesh type (simplified rectangular grid) near entry to intake system and bell-mouth in dirty pipe inlet, pressure drop improved by 33%. by placement of baffles in inlet plenum before filter media the performance has improved by 28% that is significant in intake system. Bell-mouth and baffle inside the clean pipe improved the flow and pressure drop by 6.5%.

| | Pressure of air for AIS Without Guide Vane (Pa) | | Pressure drop across the AIS (Pa) | Pressure of air for AIS With guide vane (Pa) | | Pressure drop across the AIS (Pa) |
|---|---|---|---|---|---|---|
| Speed of air | Intake | Outlet | | Intake | Outlet | |
| 1000rp | 10132 | 101295 | 27 | 10132 | 101299 | 23 |
| 2000rp | 10131 | 101211 | 102 | 10131 | 101228 | 85 |
| 3000rp | 10129 | 101105 | 193 | 10129 | 101114 | 183 |
| 4000rp | 10127 | 100919 | 357 | 10127 | 100959 | 317 |
| 5000rp | 10124 | 100691 | 558 | 10124 | 100756 | 496 |
| 6000rp | 10121 | 100416 | 800 | 10121 | 100525 | 691 |
| 7000rp | 10117 | 100128 | 1049 | 10117 | 100233 | 944 |

| RP | Pressure drop between | Percentage |
|---|---|---|
| 1000 | (27-23)/27 | 14.81% |
| 2000 | (102-85)/102 | 16.67% |
| 3000 | (193 – 183)/193 | 5.181% |
| 4000 | (357-317)/357 | 11.20% |
| 5000 | (558-496) / 558 | 11.11% |
| 6000 | (800-691)/800 | 13.63% |
| 7000 | (1049-944)/1049 | 10.01% |

Table2: Pressure drop differenceTable 3: Percentage improvement

The Table 2 above shows different in pressure drop between two analyses done for existing model and optimized model. This annalist done with 1000rpm to it maximum performance exceeding itnormal rpm speed level 6000rpm to 7000rpm speed. Table is the percentage improvement calculation table to show percentage pressure drop is improved over the installation of the guide vane. The table shows the pressure inside of the AIS is improved and the loss decrease over each rpm speed varies with 1000rpm. By placement of guide vane in inlet duct filter media the pipe improved the flow and total pressure drop by 12.01% that is significant in intake system.

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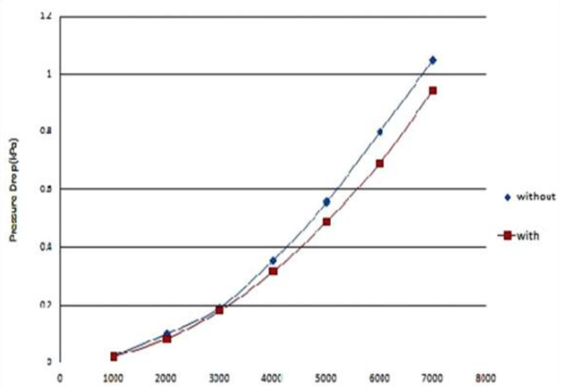


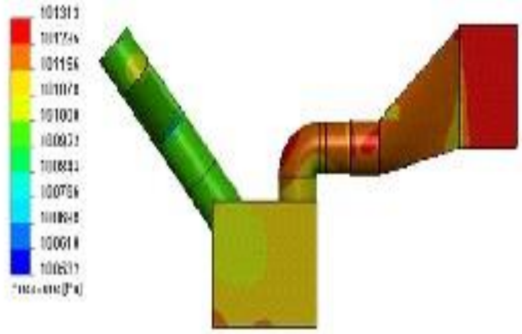
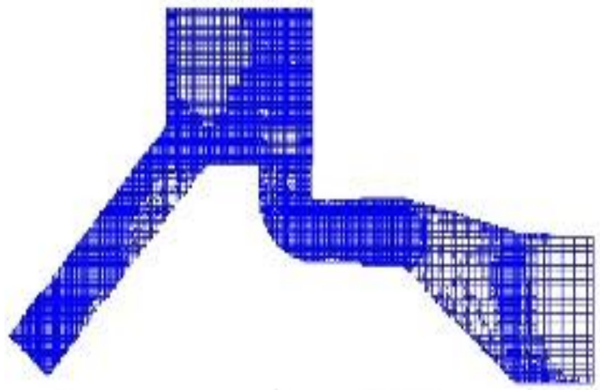



Fig 13: Pressure drop vs. rpm speedFig 14: Bottom view pressure of AIS for without guide vane

Figure 13 shows the pressure drop along the AIS is decreased and the flow is guided by the guide vane to decrease any separation flow and recirculation of the flow affected the system. For the design of the pressure-side velocity, distribution advantage of the expansion in the middle part of the cascade was taken to obtain a high pressure coefficient on the pressure side, as compared to the single airfoil case.



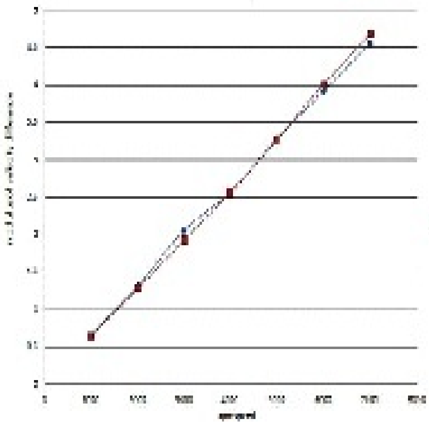


Fig 15: Mesh analysis for AIS without guide vane Fig 16: Velocity difference vs. rpm speed

Figure 14 and 15 show that analysis done with guide vane (red line) shows improvement of the pressure loss and the velocity flow guided to the outlet pipe to intake pipe to the manifold. Figure 15 that the flow is guided uniformly with the rpm speed and without (blue line) guide vane analysis in AIS. This means the flow is guided and guide vane reacts as flow guider and to avoid any separation flow and recirculation develops in the AIS filter duct media.

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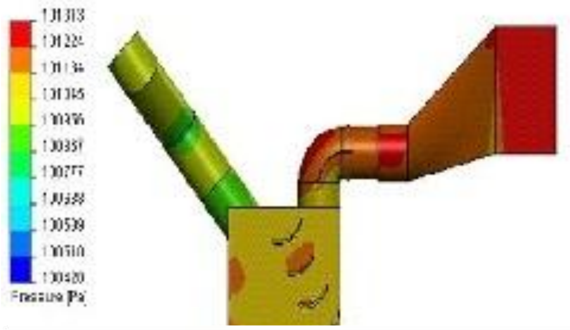

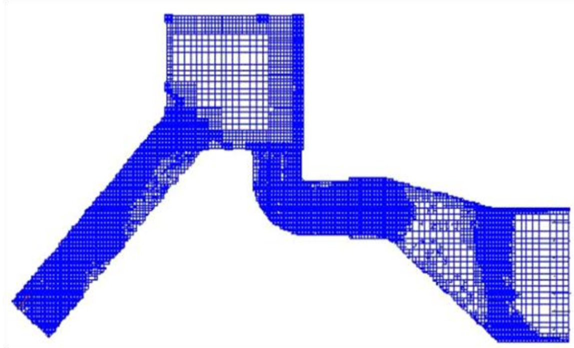

Fig 17: Bottom view pressure of AIS for with guide vane Fig 18: Mesh analysis for AIS with guide vane

Figure 16 and 17 shows the pressure drop different in AIS CFD analysis with and without guide vane. The figure shows where the pressure loss experience by AIS without guide vane along the intake elbow on the right back wall of AIS this loss resultant of the pressure drop in the model of existing model. Analysis in the AIS with guide vane shows the pressure loss experience by the AIS at back wall is decreased. The pressure experience near outlet pipe to intake pipe is increased. This pressure region near the outlet pipe is an improvement of the design that shows good correlation that will help the performance of engine.

## 5. CONCLUSION

From this analysis it can be concluded as design modifications were considered to improve the flow and pressure drop through the intake system there is a Changing of mesh type (simplified rectangular grid) in dirty pipe. Introduction of bell-mouth in dirty and clean pipe Introduction of baffles inside inlet plenum just below filter media. Introduction of baffle in clean pipe bend all the above changes incorporated in the design improved overall pressure drop by 22%.

- Objective of the project achieved when the analysis data shows improvement optimization design using guide vane improved.
- Effect of design more guide vane placement on the critical region and improve the design of AIS.
- Building duct that has more flow features that can guide the air. Introduction of bell-mouth in dirty and clean pipe.
- Effect of minimizing the length of AIS.

## AKNOWLEDGEMENT

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