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Seminar



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Research Methods & Project

Technical Abstract

Within this report lays the details of a Comparative based research project. The foundations of the project are; a comparison between an Original Manufactures Intake parts vs Aftermarket performance parts, using various methods to scrutinise both. It's the objective of the report to find which of the parts is superior and why.

This Report has been created with the intentions to research whether investigations in similar areas can help the outcome of the project. Using references and research, this investigation will be formulated using both original ideas and existing research findings.

Methods that can be used to enhance the project have been outlined in this report; making sure the project has viability within the engineering sector is focused in this report.

This report suggests using Flowbench Analysis of both parts to gain raw data will allow stepping stone to view their efficiencies/deficiencies. Using computer aided design software to implement the parts in the simulations where all theoretical situations can be analysed. Computational Fluid dynamics is one of the main talking points within this report.

A plan how to continue forward with the project is also proposed. Outlining that learning how to master techniques and software could be key to the success of this project. Ultimately explaining time can be saved if research and inquiry is carried out thoroughly first.

Abstract

This report will propose an investigation to try and compare 2 engine components to see which is best. Standard “factory” parts will be tested against performance parts. This report outlines techniques to try and find which is best, and why

This Report has been created with the intentions to research whether investigations in similar areas can help the outcome of the project. Using references and research, this investigation will be made using both original ideas and existing research findings.

Methods that can be used to improve the project have been found in this report; making sure the project is useful within the engineering sector.

The report will use specialized equipment that will show how airflows through the components. This can be reviewed, then data can be collected on the pros/cons. Also using specialist computer software to draw the parts on a computer, and also using software to do airflow simulations.

A plan how to continue forward with the project is also proposed. Outlining that learning how to master techniques and software could be key to the success of this project. Ultimately explaining time can be saved if research and inquiry is carried out thoroughly first.

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1.0 Introduction

This report focuses on the research footing of analysis for an air intake system. Air must travel from atmosphere, into the engine cylinder chambers. Before the air reaches the cylinder, it must path through several channels before it can reach that point.

The vehicle being used as an example is a 1997-2004 Volkswagen Golf Hatchback Gti 1.8T. As this car is pressure charged, the intake has 2 intakes; before the turbo, and after the turbo. Project will focus on the part before the turbo. These parts are the snorkel, the airbox and the turbo inlet pipe.

This report will look at the reason this project is needed, existing research in the field and how the project will progress from this point.

“In engines, the configuration of the inlet and exhaust flow networks employed plays an important role in determining the volumetric efficiency” Ferguson, Kirkpatrick (2001)

2.0 Project Proposal

The proposal of the Project is the evaluation of induction, specific to a Turbo Charged vehicles intake. The vehicle in question is a 1997-2004 Volkswagen Golf Hatchback Gti 1.8T. The intake is exclusive to all components pre-Turbo Charger. The aim of the evaluation is to find deficiencies in the original equipment manufactured for the vehicle.

Secondly, the same type of analysis will be under taken on after-market “performance” parts. These parts are intended to improve overall performance of the intake. This analysis will scrutinise whether these parts increase or decrease efficiency.

The efficiency in question is Volumetric Efficiency. Pesic (2013) states “The volumetric efficiency significantly influences engine output. Both design and dimensions of an intake and exhaust system have large impact on volumetric efficiency”

Analysis of the parts will be carried using varying methods, such as:

- **Computer Fluid-Dynamics (CFD)** – Simulation software. This will be achieved by measuring and creating 3D model equivalents of the parts, and then using simulation testing.
- **Flowbench testing** – A practical testing method, which can create airflow/suction through the assembly built from the physical intake parts. Data can be gathered, and comparisons can be drawn between parts
- **Computer Aided Design** software will be used to create the models for the Computational Fluid Dynamic analysis. Computer Aided Design software will also be used in the process of designing a possible alteration to an existing part, or an entirely new design.

3.0 Problem Identification

One of the areas to be investigated will be the actual construction of the Airbox, as well as the piping to and from it.

“The geometrical design of the airbox for an internal combustion engine has a significant effect on the pressure loss in the entire inlet tract. Due to the location of the airbox, its size and shape is usually limited as a result of the proximity to other under-bonnet features. The shape is also limited by manufacturing, assembly and Noise Vibration and Harshness considerations” (Branney et al. 2006, SAE Technical Paper 2006-32-0114).

As discussed in “Development of Optimization Techniques for the Design of an Internal Combustion Engine Airbox”, the actual design of the original airbox could be a limiting factor. The authors instigate a limitation is due to the engine construction, including all its parts. Limitations to manufacturers in terms of design are factors such as noise from induction and space that’s available to install engine parts.

Arnault, Baudet and Becker (2015) suggest, that noise is one of the key features which manufacturers try to disguise. They imply manufacturers employ tactics and devices which could prove to be “bulky” and can generate drawbacks on performance.

Here lies some of the potential problems that can be evaluated in the future. Removal of the considered intake parts can be carried out and inspected. An inspection could identify potential problems created by the manufacture such as noise reduction methods, and space limitations.

4.0 Analysis Methods

- 4.1 Physical Inspection - An initial analysis can be carried out by taking the required parts off the vehicle, then inspecting them for limiting factors. Arnault., Baudet, and Becker (2012) suggest that devices called “resonators” can be bulky and generate “drawbacks on performance”. A comparison can be made between the Standard parts and the aftermarket parts for said draw backs.
- 4.2 Flow Bench Analysis – Data can be gathered using a flow bench. The manufacture and after-market parts will be able to be tested on the flow bench, resulting in a flow value. There are similar existing studies compare flow bench data to CFD simulations. This is the case in ‘Use of Computational Fluid Dynamics (CFD) Tools for High-Performance Engine Tuning’. Within this report Guy, Teipel and Stanglmaier (2006) study ‘Steady flow and dynamic analysis comparison of an air intake breathing capacity’. Using methods found in this report could help aid the optimization of time management. I could help to reduce time experimenting with the apparatus, in favour of gathering solid data faster. As seen in Fig 1. above, an airbox can be positioned on a flow bench with all its components attached together. Analysis techniques such as ‘



Figure 1: An airbox setup for flow bench analysis (amsnow.com)

- 4.3 Computational Fluid Dynamics (CFD) Analysis –

Computational fluid Dynamics is a simulation software that is used to analyse the fluid flow through pipes and orifices. It enables the user to see how air or “fluid”

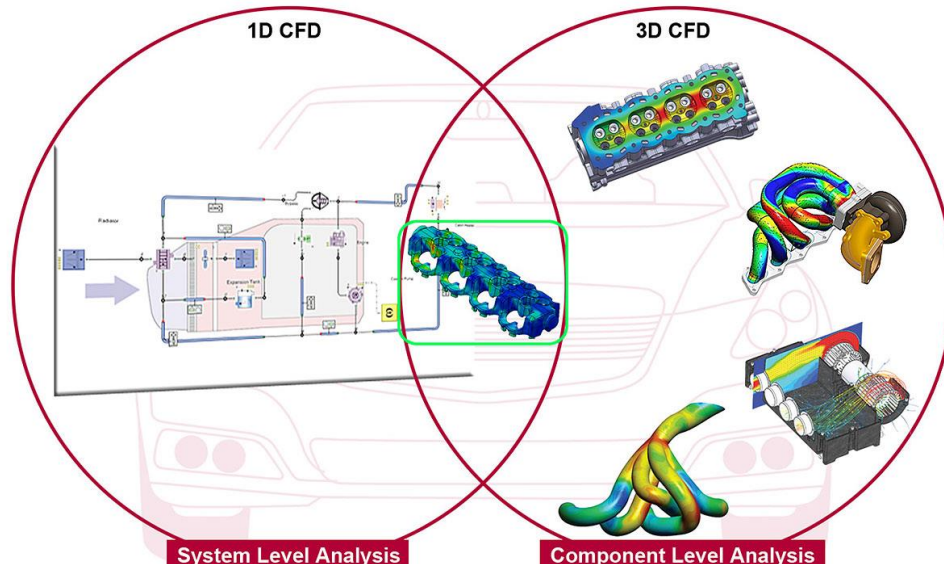


Figure 2: Representation of 1D-CFD and 3D-CFD(mentor.com)

reacts and flows through the subject of simulation. When doing background research, it was found that Computational Fluid Dynamics comes in various forms. The methods found which apply to this subject of this report are “1D-CFD” and “3D-CFD” analysis. Enginsoft.com (No date) state 1D-CFD focuses on: “the entire system rather than on the details of the flow inside a specific component of that system”. It helps with “system balancing and component sizing”. This would prove to be an asset when it comes to development on a new potential new part. On the other hand, Itb.ingenieure.de (No date) proclaim “3D-CFD delivers pressures, velocities and temperatures from which others factors like force and turbulence can be deduced”.

- 4.4 Further Research – Further research is to be carried out, this is possibly to find any existing research which corresponds with the subject of this paper. **Smith 1977** suggests that technology from other types of engines can be utilized for the use of automotive purposes. He states that high pressure air supply that is used on ramjet engines can be adapted to use in automotive engines.

5.0 Proposed Future project development

Going forward with the project, a structure of planning will need to be followed. This is to ensure that objectives and milestones will be achieved. Planning for a project like this could prove to be difficult some aspects can change during the investigation. The following is proposed path to follow for the progression of this project:

- 5.1 Continued Research throughout the project - This could prove to be one of the factors that can alter the path of the project, as existing theories and experiments could provide an alternative source of analysis; whether that's positive or negative.
- 5.2 Flow bench Test Session(s) – An initial test must be held on the flow bench to ensure that the components are able to be fully integrated for testing. Then subsequent testing will need to be held in order to gain raw data.
- 5.3 Implementation on Computer aided software. The sooner this stage is completed the better for the project. Manual measurements can be made, and then used to make components. A Coordinate Measuring Machine (CMM) could also be used to plot exact points. Avon-Dynamic (2016) explain:

“A coordinate measuring machine (CMM) is a device used in the measurement of the physical geometrical characteristics of an object. These machines can be manually controlled by an operator or they may be computer controlled. Measurements are defined by a probe attached to the third moving axis of this machine. A coordinate measuring machine (CMM) is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the object”.

- 5.4 Computational Fluid Dynamics – It is key that this software is utilized to its full potential. It could prove to have a diverse effect on the course of the project. Becoming comfortable with the software is key, with tutorials available with Solid works software. Available at: <https://blogs.solidworks.com/teacher/2011/08/cfd-tutorial-inlet-flow-air-over-a-wing-and-more-solidworks-flow-tutorials-part-i.html>

6.0 Conclusion of Development

Having outlined a potential plan to follow, the project should accomplish the following:

1. Comparing the physical parts for difference in their construction.
2. Raw data successfully collected from both the Manufacture original equipment parts, and the after markets parts (Using the flow bench).
3. All components that have been flow benched will be accurately re-creating in computer aided design software.
4. Successful analysis of all parts using Computational Fluid Dynamics software (1D CFD & 3D-CFD). Using Steady State and transient simulations.

If the above objectives are met the project will be provide an evaluation on whether aftermarket parts are an improvement. Pending the results of the investigation, this could lead to the creation of a new component completely.

7.0 Reference List

Branney, C., Cunningham, G., Spence, S., and McCullough, G., "Development of Optimization Techniques for the Design of an Internal Combustion Engine Airbox," SAE Technical Paper 2006-32-0114, 2006, <https://doi-org.ezproxy.uwtsd.ac.uk/10.4271/2006-32-0114>.

Arnault, N., Baudet, A., and Becker, N., "New Low Packaging Acoustic Solution for Air Intake Line," SAE Technical Paper 2015-01-1665, 2015

Ferguson, C. and Kirkpatrick, A. (2001). *Internal combustion engines*. 2nd ed. New York: John Wiley & Sons, p.176.

Smith, P. (1977). *The design and tuning of competition engines*. 6th ed. Cambridge: Robert Bentley, pp.311,312.

Enginesoft.com, Available at : <https://www.enginsoft.com/technologies/computational-fluid-dynamics/1-d-system-level/> (accessed 12/11/2018)

Itb-ingenieure.de, Available at: <http://www.itb-ingenieure.de/en/methods/3d-computational-fluid-dynamics-cfd> (accessed 11/11/18)

Avon-dynamic.co.uk, Available at: <https://avon-dynamic.co.uk/what-is-cmm/> (accessed 14/11/18)

Pesic, R., Davinic, A., Petkovic, S., Taranovic, D. and Miloradovic, D. (2013). Aspects of volumetric efficiency measurement for reciprocating engines. *Thermal Science*, [online] 17(1), pp.35-48. Available at: <http://www.doiserbia.nb.rs/img/doi/0354-9836/2013/0354-98361200153P.pdf> [Accessed 10 Nov. 2018].

8.0 Figure List

Figure 1: An airbox setup for flow bench analysis

Available at : <http://www.amsnow.com/reviews/product-reviews/2008/11/other-products-custom-ski-doo-800r-air-box> 8

Figure 2: Representation of 1D-CFD and 3D-CFD Available at:

<https://www.mentor.com/products/mechanical/flomaster/1d-3d-cfd/>
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