Senior Design / BS / MS Project
May- 2020

Compressed Air Supercharging Unit

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SENIOR DESIGN EXPO

Abstract

With the design of engines for automobile use, engineers are constantly searching for new methods to improve the performance of engines. While improving the performance, the two outcomes that are primarily desired are increasing the engine's power output or increasing efficiency by reducing its size while maintaining the same power output. This project develops a compressed air supercharging system for use in an automobile engine. With preliminary testing, a 35% increase in air flow of the engine was achieved. This was done by injecting 18.7 CFM of compressed air which resulted in a flow of 41.9 CFM through the test orifice, and a total airflow of 60.6 CFM through the prototype.

Introduction

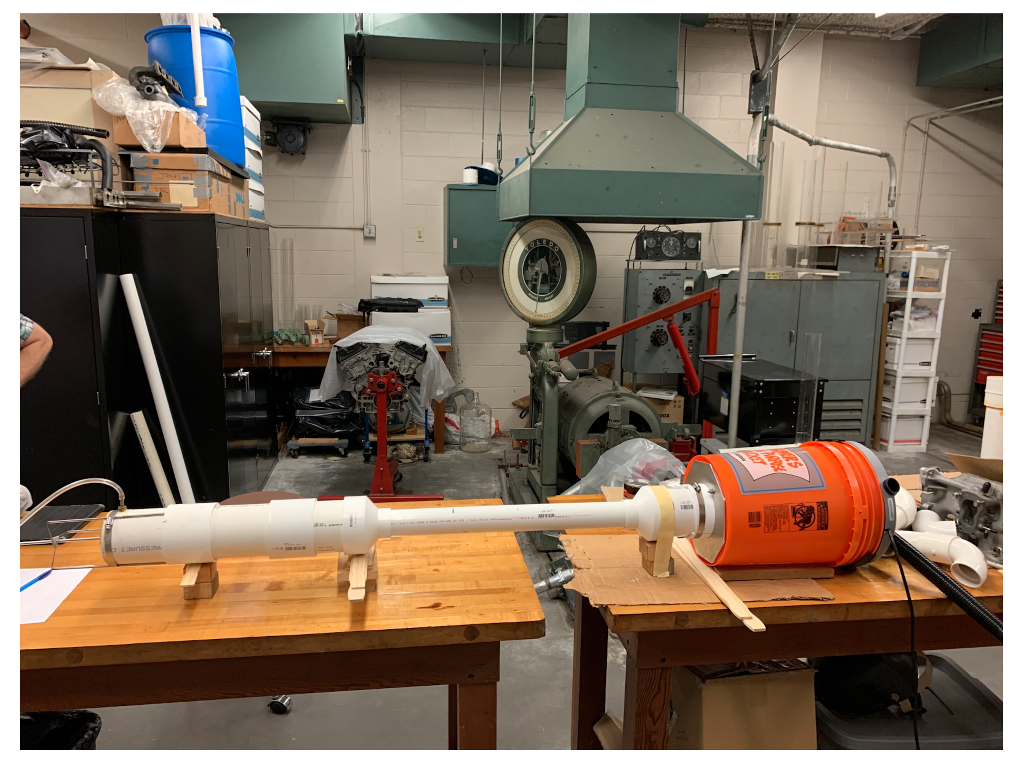
The engine cycle is a combination of the intake of air, the fuel in the chamber and the ignition of the mixture. In this cycle, the air is most often the limiting factor in creating the most power or best efficiency. To improve performance, the system of forced induction was created. Forced induction, often referred to as supercharging or turbocharging, is defined as the introduction of air into an engine cylinder at a density greater than ambient. This introduction of high-density air has previously been done through turbocharging, which is a method that extracts energy from the engine's exhaust gasses to power a turbine to compress air into the intake of the engine. A second common method is the process of supercharging, which is essentially the same as turbocharging, but the turbine is powered by a belt off of the engine instead of the exhaust gasses.

Forced induction systems allow for improvement in either the power output of the engine or the efficiency of the engine. When a turbocharger or supercharger is used, the increased airflow through the cylinders can result in a higher power output. The same increase in airflow also makes it possible to achieve the same power output from an engine that is smaller in displacement. The smaller engine inherently results in a higher fuel efficiency due to the lower amount of friction with the smaller piston size. Fewer cylinders also favor lower hydrocarbon emissions, which have gained increasing scrutiny in recent years

Methods I Design I Analysis

The majority of the prototype was constructed using PVC pipe and couplers. A ¼" diameter stainless steel pipe was connected to a shop air source and used to inject compressed air into the PVC pipes. Three stabilizers were constructed out of welding rod and epoxy to ensure the steel pipe was in the center of the PVC pipe.

- The orifice was used to create a pressure drop in the pipe that could be measured when connected to an inclined manometer
- Changes in this measurable pressure drop indicated changes in velocity, and therefore changes in volumetric flow rate
- Compressed air at 15 psi was injected at various locations starting at 5" before the diameter reduction



Results

Injector Depth (in. before diam. Reduc.)	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9
Pressure Drop (in. H2O)	1.58	1.51	1.45	1.33	1.3	1.3	1.27	1.25	1.22	1.2	1.14	1.02	0.92	0.77	0.61

The above table shows injecting after the reduction in diameter had no appreciable effect. Moving it further away, however, was beneficial. The results showed that 18.7 CFM of injected compressed air resulted in a flow of 41.9 CFM through the test orifice. The 41.9 CFM of ambient air was measured independent of the injected compressed air, therefore the total air flow into the system was 60.6 CFM. This represents a 35% increase in airflow.

Conclusion

The goal of this project was to create a method of forced induction that utilized compressed air. A proof of concept experiment to validate the proposed method of forced induction was done. This experiment was conducted with a prototype system constructed of PVC and stainless-steel pipes, a venturi, and a shop air injection line. The results showed that 18.7 CFM of injected compressed air resulted in a flow of 41.9 CFM through the test orifice. The 41.9 CFM of ambient air was measured independent of the compressed air, therefore the total flow into the system was 60.6 CFM. This represents a 35% increase in airflow, which would result in a significant increase in power output. The next step is to integrate our findings into the prototype from the proof of concept experiment and test it on an engine. This testing would be conducted on the Toyota 2TC cylinder head with a diameter reducer directly on the flow bench to get accurate results. If this step yielded promising results, the final step would be to build a functioning prototype to be placed in a car for road testing. Unfortunately, these final steps with the Toyota 2TC cylinder head were not able to be completed due to the outbreak of COVID-19.

Acknowledgments

We would like to give a big thanks to our advisor, Michael Swain, and Matthew Swain for additional help. We would also like to thank the University of Miami College of Engineering faculty for their guidance.

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