Electric Supercharger

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Abstract - *To satisfy both environmental regulations and drivability requirements, high-level control of automobile engines is currently in demand, and electrification is in progress. An electric supercharger, in which a supercharging compressor is driven by a high-speed motor instead of an exhaust turbine or belt, eliminates turbo lag by making use of the motor's high-speed response. An engine with an electric supercharger offers comparable fuel consumption to a naturally aspirated engine, and is expected to facilitate the downsizing of engines. In this paper, we introduce the electric supercharger*

Key Words: supercharger, high-speed motor, engine, fuel consumption, automobile.

1. INTRODUCTION

As India have highest no of two wheeler in the world it was asked to carry the project works in the related field. It was decided to work towards electrical super charger of two wheeler forms like petrol engine. This method can increase the boost premier to increase overall power output of the engine. Also this project can be very much cost effective. The constructional and working details of the project work and other details are discussed in the fourth coming chapter of this project work. An electric supercharger is a specific type of supercharger that uses an electrically powered forced-air system that contains an electric motor to pressurize the intake air. By pressurizing the air available to the engine intake system, the air becomes more dense, and is matched with more fuel, producing the increased horsepower to the wheels.

With the ongoing movement toward global environmental protection, regulations controlling the exhaust emissions and fuel consumption of automobiles are being enforced. Turbochargers have improved the performance of diesel engines; currently, almost all diesel vehicles are equipped with turbochargers. More and more gasoline engines are also being fitted with turbochargers to decrease weight and increase efficiency1.In recent years, engine controls have become widely diversified for the sake of both the environment and operating performance.

Variable geometry (VG) turbochargers, which can vary the turbine capacity in response to the engine load, are becoming increasingly popular. Also, electrification (and the installation of various electrical devices in automobiles) has produced the present generation of hybrid and electric vehicles, and progress continues. Batteries are also expected to improve in response to this trend. Current electrification projects impacting turbochargers include the application of electronic control actuators.

Moreover, advances in power electronics have led to the development of ultra high speed motors/generators with a capacity of100,000 rpm or higher, which are now available for use in turbochargers. In an electric supercharger the compressor is directly connected to an ultra-high speed motor, and the compressor boost pressure is controlled by the motor speed, independent of the exhaust turbine.

2. METHODOLGOY

2.1 Development concepts

To be applicable to current vehicles, the concepts are as follows:

- The electric power source is 12 V DC.
- The compressor, motor, and are integrated into one body.
- No separate fan or water-cooling device is used for cooling.

2.2 Construction and features

The electric supercharger prototype consists of a centrifugal compressor impeller and a high-speed motor rotor, supported with a ball bearing for improved response and reduced friction. Grease lubrication eliminates the need for lubrication oil piping. To improve the transient response by reducing rotor inertia, the rotor has been kept as small in diameter and as long as possible. Compressor intake air is utilized to cool the motor and inverter. Because the motor and inverter are upstream of the compressor intake, they are cooled whenever the electric supercharger rotates. The cooling airflow varies with the compressor working point and is favorable to high heat reduction in the motor and inverter when the flow volume is large. Using loss calculations based on finite element method (FEM) magnetic field analysis and circuit simulation, and using flow velocity distribution calculations in the cooling flow channel based on computational fluid dynamics (CFD) analysis, the temperature increases in the motor and inverter can be predicted, and the flow channel can be improved. Results of the CFD flow velocity distribution calculations. The cooling-channel pressure loss can also be calculated to improve the channel shape and to avoid excessive increases in the power required for the motor and inverter.

2.3 Power electronics technology

2.3.1 Ultra high speed motor

The motor is a three phase permanent magnet synchronous type. Samarium-cobalt rare-earth magnets (which are strongly magnetic and heat resistant) are used for the rotor to minimize the size of the motor. The magnets are held in place against rotor centrifugal force (which is especially important in ultra high speed motors) by surrounding them with cylindrically laminated, carbon-fiber reinforced plastic (CFRP) sheets. In carbon-cylinder manufacturing, flaking and expansion are avoided by considering the fiber direction and trimming the edge of the sheet. The rotor was spin-tested and verified at 1.2 times the rated rotational speed without breakage. A sectional view of the rotor retention ring after the increased temperature test with the motor running. The rotor appears robust, without deformation or carbon flaking. The stator coil has a single turn per phase and a star connection. A single turn per phase is the only way to realize the range of values for the back electromotive force (EMF) constant and the inductance that provides the required torque under low-voltage ultra-high speed conditions.

The rated output of the motor is 2 kW, 140,000 rpm. To achieve a high-speed response, instant double overload is permitted. By FEM magnetic-field analysis of the motor, using the electric-current waveform acquired from the inverter circuit simulation, the loss (including the eddy current in the magnet) is calculated.

3. CONSTRUCTION

In its simple construction various components are used in this project work like 4” to 3” reduction of PVC, Acrylic sheet, high rpm DC motor, 8mm MDF sheet, 2 mm aluminum sheet, hose pipe of PVC, multi stand copper wires, plastic box, variable rheostat, ILP IC, etc.

First of all as 18000 rpm PMDC motor is mounted with 4” diameter section of PVC reducer with the help of and MDF sheet mounting. A six blade axial flow fan of quarter 8cm made up of 2mm thick acrylic sheet in mounted on the output shaft of this motor. Each of these blade have area 2cm x 2.5 cm at the delivery part of the reducer that is the 4” diameter part a – conical funnel is used to form the flowing nature of outlet at the end to this funnel a hose pipe of diameter 3.5 cm is connected which in turn gets connected directly with the air filter of the vehicle. The suction part that is the 3” diameter of the reducer joint galvanize iron wire net is provided to avoid the axial flow fan from getting dogged due to any foreign material on desires while driving the vehicle.

The reducer forms the main today of the project and is mounted on the vehicle using aluminum strap.

The battery provides initial power for ruins the motor. Which is passed through a voltage regulation circuit box, this voltage regulator box consist of a TUP IC, a potentiometer, heat sinks etc. This voltage regulator drops / varies voltage as per the potentiometer setting without dropping current value.

Thus by setting potentiometer at various position the speed of motor can be adjusted there by the flow of air can be adjusted whenever the uses runs the vehicle and makes the motor ON by setting the toggle to on condition and adjust the potentiometer. The motor pumps in the extra amount of pre-minimized air in the air filter and however the engine supplied with a higher pressurized air through super charging effect takes place.

4. WORKING

4.1 Super charging

It is known fact that the potency output of an engine increases with an increase in amount of air or amalgamation in the cylinder at the commencement of compression stroke because it allows more quantity of fuel to burn. So in order to give in more air we are equipping the engines with a super charger.

1. Due to the lower volumetric displacement of supercharged engine, frictional and thermal losses are less.
2. Brake power will increase about 30-45 % because of increase in supercharged pressure as more amount of fuel will be burnt within the same period as the mass taken per stroke is increased.
3. The supercharged engine’s installation space requite is more small than that of naturally aspirated engine.
4. It is very simple for high speed engine.

4.2 Turbocharging

A turbocharged engine can be more efficient than an naturally aspirated engine because the turbine forces more intake of air, proportionately more fuel, into the combustion chamber. In turbo charging, the turbocharger is being driven by a gas turbine utilizing exhaust gases.

1. It produces more power than the same size naturally aspirated engine.
2. Better thermal efficiency than naturally aspirated and supercharged engine, because exhaust is being used to do the work which otherwise would have been wasted.
3. Better fuel economy.
4. Better volumetric efficiency.
5. High speed obtained.

The centrifugal supercharger is very similar to a turbocharger, except the centrifugal supercharger is driven by a belt off the engine, while the turbocharger is driven by the force of the exhaust gases. These type of superchargers (or turbo) run at extremely high speeds. To achieve these high speeds in the centrifugal supercharger, there is an additional internal step-up drive inside the blower. Due to the design of these units, the faster the impeller spins the more boost the blower makes. As a result, these units typically do not produce much power at low engine speeds because the impeller is not spinning fast enough to make much boost. If it were even possible to gear the blower so that it would spin fast at low engine speeds, it would then make too much boost at higher engine speeds. Turbo employ a device called a "waste gate," which bypasses exhaust gas past the turbo when a certain boost limit is reached.

The screw type blower appears somewhat similar to a Roots type blower from the outside, but the internal rotors are quite different. In a screw type blower, the rotors interleave one another and as the outside air is drawn into the blower the rotors progressively compress the air inside the blower as it passes along the rotors. These rotors require an extremely high degree of tolerance and, as a result, the screw type supercharger is more expensive than Roots.

The Roots blower is the simplest of all blowers and therefore is also the least expensive. A Roots blower does not compress the air inside the supercharger. It is actually an air pump. The compression of the inlet charge (creation of boost) actually takes place in the cylinders and the manifold. Centrifugal superchargers and screw type superchargers are called "internal compression" blowers because the air compression takes place inside the supercharger. Roots superchargers are "external compression" blowers because the air compression takes place outside of the supercharger. Roots type superchargers first appeared in automotive applications as far back as the 1930s. The basic design of a Roots supercharger has been developed over many years and has resulted in a highly refined product offered by Holley under the Wieland brand.

Roots blowers have been used on GMC diesel engines for many years. In the late 1950s, Phil Wieland was in the forefront of the development and adaptation of these superchargers for racing and performance applications. The company was active in producing manifolds and drive systems for adapting GMC diesel superchargers, such as the 4-71 and 6-71, followed by the development of its own superchargers that are completely manufactured by Wieland (including 8-71 through 14-71 models).

The EPA is tasked to develop models, which can calculate the inventory of emissions from mobile sources as well as estimate future projections. The model presently used for this purpose is MOBILE6. MOVES (Motor Vehicle Emission Simulator) is the next generation model and will eventually replace MOBILE. MOVES are designed to be a data-driven model, so that the emissions rates are derived from direct measurements. However, there are substantial portions of the fleet where data is sparse or non-existent. A separate model is needed to fill these "data holes" in MOVES. Moreover, a model is required that can capture the behavior of advanced technology vehicles, which behave very differently from conventional vehicles.

The goal of this project is to develop a model, which can capture the behavior of a variety of conventional as well as future or advanced technology vehicles for the purpose of estimating emissions inventories. The Physical Emissions Rate Estimator (or PERE) is expected to generate fuel (or energy) consumption rates for MOVES. So, in its present form, the "E" in PERE should stand for "energy" more than "emissions". The model will eventually characterize criteria pollutants [Nam, 2003], but fuel consumption is seen as the first step toward validation of the model. Modeling this "pump-to-wheel" fuel consumption also allows for a life cycle, "well to wheel", model if PERE output is combined with GREET, which models upstream ("well-topump") emissions [Wang, 2001]. The primary users of PERE are the MOVES developers and users. However, PERE will be made available to the public, when others may find it useful for modeling and comparing fuel consumption from conventional or advanced technology vehicles. The current report describes the modeling of fuel (and energy) consumption of conventional and advanced technology vehicles using physical principles. PERE is based on a number of models that exist in the literature (the references are peppered throughout this document). The model is developed for the following conventional technology types (light and heavy duty): gasoline, diesel, and motorcycle. Previous publications have already presented results for many light duty gasoline vehicles. PERE also models advanced technologies such as: advanced gasoline/diesel, "moderate" parallel hybrid, "full" parallel hybrid, hydrogen internal combustion engine, electric only, and fuel cell vehicles. Validations are presented where available. These are the technologies, which seem to have near or long term possibilities for market penetration. The number of other advanced technology combinations that could exist are enormous. Such examples are hydraulic hybrids, series hybrids, plug-in hybrids, etc. This report does not model all of the possible combinations; however the hope is to demonstrate that PERE is sufficiently robust and/or "generic" such that it can accommodate many of these technologies if the need arises.

Though the model is based on mathematical and physical principles, it is intended to be aggregate, and is not appropriate for engineering or product design. Thus it is designed to model a "typical" vehicle of technology type, rather than a specific vehicle. However, the validations are conducted on specific vehicles for a general comparison. Due to the approximations made in some of the parameters of the model, it is not expected to accurately capture fuel consumption of specific vehicles better than within 10% of measured values.

The basic mechanism of PERE involves calculating the road load energy required to move the vehicle mass along a driving trace, then distributing that energy demand to the various vehicle components (engine, electric motor, fuel cell, etc). The energy components are modeled using overall systems efficiencies. The validations in this report are conducted mainly with certification fuel economy data (though there are two modal test results presented). Where appropriate, simplifications and approximations are made using physical constraints, or based on publications in the literature. The model currently only models hot running operation. Cold start factors are handled in MOVES separately, and will only briefly be described in this report. For the purposes of modeling the future fleet, our goal is to allow as many of the significant assumptions as possible to be under the control of the user. However, default values will be presented in this paper. An attempt will be made to justify the assumptions in each case. The report begins by describing conventional vehicles, both gasoline and diesel (light and heavy duty). It then goes on to briefly examine advanced engines. Hybrid vehicles are modeled and validated, followed by fuel cell vehicles. The report caps off with a sensitivity analysis and describes how PERE rates might feed into MOVES. Each section is broken up into subsections representing the primary parts of the model: Vehicle, engine (or fuel cell), transmission, and motor.

For simplicity, PERE is currently in a spreadsheet format and should be usable for most users, who have a nominal amount of background information on hybrids and fuel cells (as well as spreadsheet skills). The final form that the model takes for the integration may be different from what is presented in this report.

5. COMPONENTS

5.1 Air filter

Fig. 5.1 Air filter

As the general idea goes, air filter plays a far more important role in a motorcycle than a car, especially due to bike's smaller engine that is more exposed to open air. The said filter is also vital for rides through rough and muddy terrains. Motorcycle air filters are mostly easy to maintain, as they are washable and reusable and are also environmentally friendly. Notably, majority of filters used in daily commutation bikes last for 15,000 to 20,000 kilometers, depending on quality of the bike as well as its running conditions.

The purpose of the air filter is to shield the engine from dust and debris in air and improve airflow. It is also designed to enhance acceleration and raise the horsepower of the motorcycle. A motorcycle requires air to fuel its fire in the engine. However, the air has a huge amount of dust and grime which can gather on the engine, in turn hindering the engine's performance. The collected dirt will decrease the power and speed of the bike and after a certain period of time the engine may just shut down. Here is where the air filter comes in as it filters the air and protects the engine from excessive dirt.
We are a renowned entity, indulged in manufacturing and supplying a quality assured Honda Bike Air Filter.

5.2 Motor

Fig5.2 Motor

A direct current (DC) Series motor is an electric machine that converts electrical energy into a mechanical energy. In normal motoring mode, most electric motors operate through the interaction between an electric motor's magnetic field and winding currents to generate force within the motor. In certain applications, such as in the transportation industry with traction motors, electric motors can operate in both motoring and generating or braking modes to also produce electrical energy from mechanical energy. In applications DC Series motors are used in fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives. DC motors can be powered by direct current (DC) sources, such as from batteries, motor vehicles or rectifiers, or by alternating current (AC) sources, such as from the power grid, inverters or generators. Small motors may be found in electric watches. General-purpose motors with highly standardized dimensions and characteristics provide convenient mechanical power for industrial use.

5.4 Battery:

In order to provide supply to the controller unit battery is used. Lead acid battery is used in this project. The lead-acid battery is a rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

Fig. 5.4 Battery

Battery is a power source of model from which power is supply to all the motors. Battery capacity is a 12 Volt and 8Ah. There are one battery are used to supply power.

5.6 Controls: Standard 5A toggle switch

Fig. 5.6 Toggle Switch

This is a heavy duty SPST toggle switch - your basic on/off toggle. Rated for 2A at 250V or 4A at 125V. Includes a face plate and two threaded nuts for mounting. Works great with our missile switch cover.

5.7 Hose: Netted GI Sheet

Hose Pipes find enormous use in every walk of our life. The Hose Pipes are manufactured in different types, shapes and sizes. Hose pipes are made of different types of materials to suit the applications they are put to. In olden days the Hose Pipes were made of Rubber and its Compounds, which were very bulky, and could not be easily moved from one place to another. They also got damaged easily and it was difficult to repair.

6. RESULT

Table 6.1 Without connecting super charger average reading

Speed	Quantity of petrol in (ml)	Distance travel by vehicle	Average (KM. per liter)
20 km/hr.	20 ml	1.1 km	55 km/lit.
30 km/hr.	20 ml	1.2 km	60 km/lit.
40 km/hr.	20 ml	1.2 km	60 km/lit.
50 km/hr.	20 ml	0.8 km	40 km/lit.
60 km/hr.	20 ml	0.7 km	35 km/lit.

6.2 Without connecting super charger power reading

Speed	**Time**
20 km/hr.	**4.25 sec.**
30 km/hr.	**5.87 sec.**
40 km/hr.	**7.85 sec.**
50 km/hr.	**11.73 sec.**
60 km/hr.	**18.21 sec.**

Table 6.3 With connecting super charger average reading

Speed	Quantity of petrol in (ml)	Distance travel by vehicle	Average (KM. per liter)
20 km/hr.	20 ml	1.2 km	60 km/lit.
30 km/hr.	20 ml	1.2 km	65 km/lit.
40 km/hr.	20 ml	1.4 km	70 km/lit.
50 km/hr.	20 ml	1.0 km	50 km/lit.
60 km/hr.	20 ml	1.1 km	55 km/lit.

Table 6.4 with connecting super charger power reading

Speed	**Time**
20 km/hr.	**2.81 sec.**
30 km/hr.	**4.57 sec.**
40 km/hr.	**7.56 sec.**
50 km/hr.	**10.24 sec.**
60 km/hr.	**13.50 sec.**

7. CONCLUSION

Considering the vehicles growth in India and the cost for this project work, it seen a lot of potential for Indian industry implement such project work.

This is not only effective for increasing the power of vehicle but also for increasing the mileage as in low rpm range no need to increase the carburetor pressure.

This project work can be of great use to Indian two wheeler industry, three wheeler and four wheeler industry.

A prototype of the electric supercharger (a promising new turbocharger technology in the face of stricter exhaust and fuel consumption regulations) was produced and tested to verify its technical possibilities. In addition to the electric supercharger, an electrically assisted turbocharger and an electric compressor for fuel cells are being developed as applications of the ultra high speed motor.

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