Magnetic Drive Assist System: Real Time testing and its effect on Acceleration performance

Anirudh Srinivasan, Chandrasekar Sundaram, Santhosh Sivan K, Hari Krishnan R

Abstract— Due to advancement in technology, the world is moving towards electric vehicles. One reason for this is the growing shortage of fuel in the world. But the major problem with E-vehicles has been recharging on the run and the maximum speed and acceleration that these vehicles can achieve. So, people still use IC engine powered vehicles for their transportation and goods carrying purposes. One of the major periods of high fuel usage in IC engines is during acceleration. During acceleration, the engine utilizes more fuel to increase the speed and power of the road wheels. This in turn reduces the fuel efficiency of the vehicle. If the battery of the E-vehicle is completely discharged or the fuel tank of the conventional vehicle is empty, the vehicle stalls. In case of fuel run vehicles, refueling in the nearest fuel station would be good enough to make the vehicle run again, in order to reach the destination. But this is not the same with E-vehicles. Hence charging the battery on the run is the need of the hour. Using a hybrid wheel with magnets for drive assist can solve these problems. This paper aims at improving the charging of E-vehicles on the run and also assist in acceleration of both E-vehicles and IC engine powered vehicles. This can be done using magnets to induce electricity in a coil for charging a battery and also making the stationary coil rotate by increasing the flux inside the coil. Centrifugal clutch was used to provide the mechanism that would help lo increase the flux inside the coil. By this method, the endurance of the vehicle can also be increased. Based on the experimental results, it was evident that the acceleration performance increased.

Index Terms— Fuel Efficiency, Hybrid technology, E-vehicles, Acceleration, automobiles, Magnetic Field, Magnets, Power

1 Introduction

THE aim of this research is to develop a system that can boost acceleration performance using a mechatronic system. Also, the problem of charging, speed and endurance in electric vehicles has been addressed. If the acceleration performance is improved lesser fuel can be burnt for the same.

To achieve this, the wheel hub is fitted with a coil, a rotor and a semi-circular magnet. The fan coil is connected to the driveline. The rear wheel coil rotates the entire system. Electricity is generated because of the rotating magnetic field from the circular magnet. By having the magnet mounted on the centrifugal clutch, the rotating circular magnet is brought towards the inner rotor. This increases the magnetic field in the rotor and the rotors start to rotate faster. Hence, the vehicle is propelled faster.

To achieve the objectives, experiments were conducted to measure speed, time taken and acceleration achieved using a stock hub motor wheel. The magnets were fixed on the centrifugal clutch. The wheel was then fabricated with the centrifugal clutch and a coil. Experiments were conducted on the new fabricated wheel to measure the same data and compare it with the stock. An evident improvement in acceleration performance was obtained.

Upon repeated tests, a drawback was identified based on the results. During long periods of acceleration, the acceleration boost provided by the coil reduces. Thus the result of the experiments is limited to reasonable periods of acceleration.

To formulate the thesis, literature was reviewed from "Flywheel energy and Power Systems"- Björn Bolund, Hans Bernhoff and Mats Leijon in Renewable and Sustainable Energy reviews, 2007, vol. 11, issue 2, pages 235-258 and "Power storage and management system for a bicycle dynamo"- Chang Cheng Jiang, Bo Yi Jou and Mau Chi You, Taiwan Patent 093110785, April 16, 2004.

2 Experimental Set-up and Pre-requirements

2.1 Vehicle Set-up

The experiments were carried out on an 800-watt, 48-volt DC hub motor. The hub motor wheel is fixed onto an electric bike for testing. A comprehensive analysis of speed and acceleration of the DC motor powered electric bike was carried out. The magnets were attached on to the linings of the centrifugal clutch. The current generated by the coil was measured along with the current required for the coil to rotate. The coil was fixed on to the shaft of the hub motor. The shaft of me clutch was welded onto the hub motor shaft.

2.2 Speed Measurement

The speed-readings for the E-bike were taken using an accelerometer. The accelerometer can measure the direction of travel, speed and acceleration. Thus, the average time can also be obtained. The data obtained depends on the road and weather conditions since they have a direct impact on the acceleration. Thus the experiments were carried out on a flat road in dry conditions.

2.3 Experimental Study

The experimental investigations were carried out in two different phases. In the first phase, the speed, acceleration and

- *Anirudh Srinivasan is currently pursuing B.E. in Automobile Engineering in Anna University. E-mail: anirudhsrinivasan080493@gmail.com*
- *Chandraskekar Sundaram is currently pursuing B.E. in Automobile Engineering in Anna University.E-mail: chandys92@gmail.com*
- Santhosh Sivan K *is currently pursuing B.E. in Automobile Engineering in Anna University. E-mail: autosash@yahoo.com*
- Hari Krishnan R *is currently pursuing B.E. in Automobile Engineering in Anna University. Email: rharikrish93@gmail.com*

ISSN 2229-5518

the time taken to cover a given distance of the stock hub motor were found. In the second phase, the hub motor wheel was fabricated with the centrifugal clutch and the coil. This fabricated wheel was fixed onto the vehicle for testing. The speed, acceleration and the time-taken to cover a given distance by the E-bike using the fabricated wheel were found for comparison.

3 EXPERIMENTAL PROCEDURE

The rear wheel hub consists of a coil, a rotor and a semi-circular magnet. The magnet is connected to the driveline. The rear-wheel coil provides the boost and rotates the entire system. Electricity is generated because of the rotating magnetic field caused by the circular magnet. Using a centrifugal clutch, the rotating semi-circular magnet was brought closer towards the rotor (coil). This movement increases the magnetic field inside the coil. The induced magnetic field causes the rotor to rotate, thereby, driving the vehicle at a faster velocity.
The speed test and acceleration test were carried out by mounting the hub motor wheel onto an electric bike. The motor was allowed to be driven until its maximum rated speed was achieved. The distance to acquire the readings was fixed. Distances of 100m, 150m, 200m, etc. were marked on a level road. The electric bike was driven on a straight path for these distances. Maximum speed of the vehicle was found to be 28 km/hr. So, four speed points were taken: 0, 12, 20 and 28 (in km/hr) and the subsequent time taken for each speed point was noted. This data was then tabulated and the acceleration vs. time graph was plotted. Later the fabricated wheel was attached to the same electric bike. The above procedure was repeated to find the speed, acceleration and time taken to cover a given distance. Higher rates of acceleration were observed. This acceleration was because of the magnets driving the coil attached to the motor shaft.

4 THEORETICAL MODEL

MAGNETIC FIELD-

$B=(4/5)^{(3/2)}\mu_0 nI/R$ (1)

μ_0 is the permeability of free space= $4\Pi * 10^{-7}$ T m/A

n=100, I=5A, R=80mm

So, B= 56170.03 T

FORCE-

$F=BIL\sin\theta$ (2)

L=350mm

So, F=49148.8 N

ACCELERATION-

Displacement, s=18m

Initial velocity, u=12m/s

Time, t=1.4s

$a=2(s-ut)/t^2$ (3)

So, $a=1.22 m/s^2$

ACCELERATION BOOST PERCENTAGE-

$(A_1-A_1^0 + A_2-A_2^0 + A_3-A_3^0)/3 *100$ (4)
= (2.56-2.38+1.23-1.17+1.05-1.01)/3 *100
= 9.33%

5 RESULTS AND DISCUSSIONS

Speed and time tests were done on the hub motor with and without the boosting system. This was done in order to compare the efficiency of the boost system. The primary objectives of this paper were to achieve charging of batteries while the bike was running and to provide boost in acceleration or drive assist whenever the driver is cruising. Performance tests were conducted and based on these, the boost in acceleration provided by the system was determined. The graph between time taken and distance was plotted for both cases- with and without the boost system.

TABLE 1
ACCELERATION WITHOUT THE SYSTEM

Speed (km/hr)	Time (sec)	Acc. (m/s2)
0	0	0
12	1.4	2.38
20	3.3	1.17
28	5.5	1.01

TABLE 2
ACCELERATION WITH THE SYSTEM

Speed (km/hr)	Time (sec)	Acc. (m/s2)
0	0	0
12	1.3	2.56
20	3.1	1.23
28	5.2	1.05

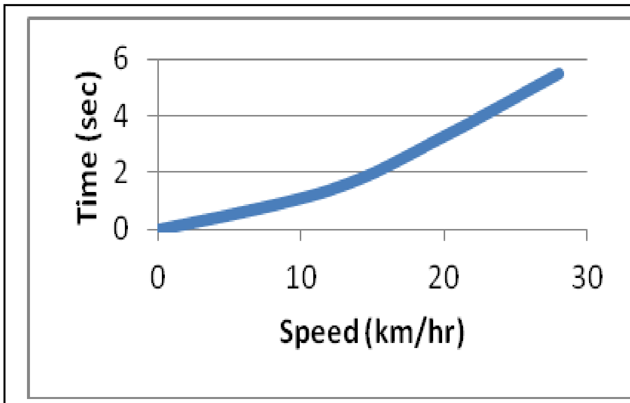

Fig. 1. Time vs. Speed without the system

ISSN 2229-5518

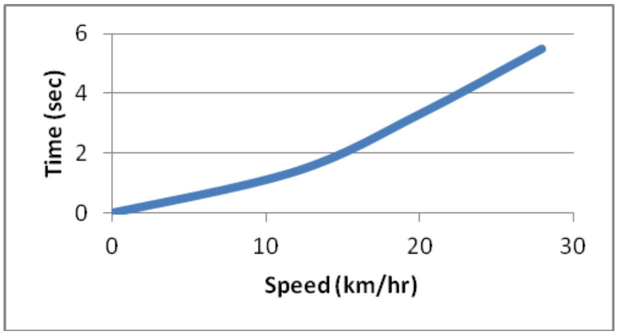

Fig. 2. Time vs. Speed with the system

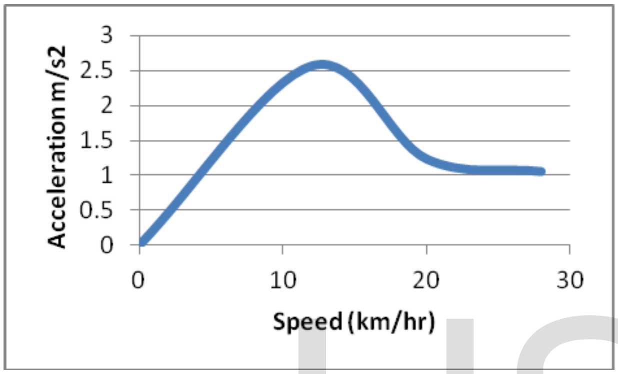

Fig. 3. Acceleration vs. Speed without the system

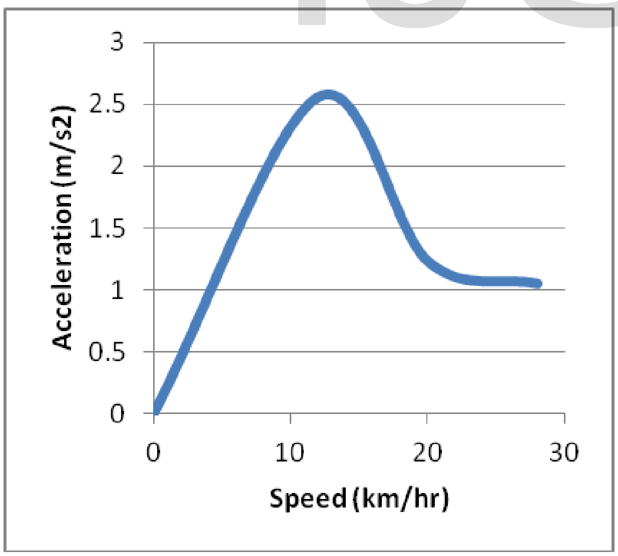

Fig. 4. Acceleration vs. Speed with the system

From the experiment findings, theoretical calculations and analysis of graphs, there is an evident acceleration boost when the proposed system is implemented. The acceleration boost percentage is approximately 9.3%.

6 CONCLUSION

The electric power generated by the system can be increased by using more high power magnets and an advanced coil like the Helmholtz coil or Maxwell coil. This would also increase the drive assist provided while acceleration by the magnets, as higher magnetic field would be subjected by the coil, thereby, increasing the force with which the coil would rotate. This in turn increases the speed of the coil and the wheel.

One of the methods to save fuel is by making the system electronically actuated and/or by incorporating electrical drives. This would mean that the batteries would have to charge and discharge simultaneously and immediately. This can be done by the magnetic assist system that has been proposed. The proposed system charges the batteries and also produces acceleration boost to save fuel in IC engine vehicles. On a mass production scale, gallons of fuel can be saved and electric vehicles can be used for longer distances without fearing much about batteries getting completely discharged.

7 ABBREVIATIONS

T- Torque (N-m)
F- Force (N)
I- Current (A)
B- Magnetic Flux (T)
Θ- Angle between current and magnetic flux (degrees)
L- Length of conductor (m)
R- Radius of conductor (m)

ACKNOWLEDGEMENT

The authors take this opportunity to thank their affiliated institution for providing them with the facilities to carry out the research. The authors also thank Dr. P. Senthil Kumar, Assistant Professor, Department of Automobile Engineering, Anna University- MIT Campus for his guidance throughout the course of the research.

REFERENCES

[1] Björn Bolund, Hans Bernhoff and Mats Leijon. "Flywheel energy and power storage systems" Renewable and Sustainable Energy Reviews, 2007, vol. 11, issue 2, pages 235-258

[2] Chang Cheng Jiang, Bo Yi Jou and Mau Chi You, "Power storage and Management system for a bicycle dynamo" Taiwan Patent 093110785, April 16, 2014

[3] Y. Arai, H. Seino, K. Yoshizawa, K. Nagashima "Development of superconducting magnetic bearing with superconducting coil and bulk superconductor for flywheel energy storage system." 25th International Symposium on Superconductiviy, Volume 494, November 15, 2013, Pages 250-254

[4] Chi Zhang and King Jet Tseng, "Design and Control of a novel flywheel energy storage system assisted by hybrid mechanical-magnetic bearings." Mechatronics, Vol. 23, Issue 3, April 2013, Pages 297-309

[5] Hansang Lee, Seungmin Jung, Yoonsung Cho, Donghee Yoon and Gilsoo Jang. "Peak power reduction and energy efficiency improvement with the superconducting flywheel energy storage in electric railway system". 25th International Symposium on Superconductivity (ISS 2012) Advances

in Super-conductivity XXV. Vol. 494, November 15, 2013, Pages 246-249