DESIGNING AND DEVELOPMENT OF FLYWHEEL SUPPORTED ONBOARD BATTERY CHARGER FOR ELECTRIC VEHICLES

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Abstract

The major limitation of the electric vehicle is that Short Driving Range and Longer Recharge time. Since both problem of electric vehicle has a direct relation with the capacity and endurance of the batteries, the development of vehicle battery technology introduced Nickel–metal hydride (NiMH) and lithium ion (Li-ion) batteries. Even if the power capacity of the battery increases and it enhance the driving range those vehicles still are not applicable on the area where facing shortage of power because they need to be recharge. AFPM were selected for charging applications. Firstly, the chosen parameters of the AFPM machine were indicated, as well as the calculated variables from the analytical equations. Secondly, using Ansof Maxwell 3D electromagnetic analysis; the peak flux density analyzed and by using Ansys 16.0 static structural analysis; induced stress in different component was simulated. The prototype was constructed, investigated and lastly the experimental conducted. Experimental results were compared to the analytical ones. The comparison indicated that the experimental results confirm the analytical analysis.

2. INTRODUCTION

The aim of automotive industry is to increase energy efficiency of the vehicles; to decrease pollutants or emissions and cost of manufacturing, enhance comfort, reliability and safety. The increasing need for sustainable and alternative energy source to be used instead of gasoline powered engines has forced the researchers to know more about the gradual growth of battery technologies for electric vehicles (EVs). The need for electric power in vehicles is growing.

Specially, using electrical energy for vehicle's propulsion presents significant benefits in the achievement of reduction of fuel consumption and emissions.

3. METHODOLOGY AND MATERIALS

3.1 General Method

In this study combination of both quantitative and qualitative data has been collected in order to achieve the objective. It is proposed to gather quantitative information experimentally and theoretical designing formulas. As much as possible assumptions are minimized to reduce error.

Basically the method used in this study has 3 phases,

- 1st phase analytical (theoretical designing)
- 2nd phase modeling and simulation
- 3rd phase experiments

Before conducting experiment, analytical analysis has done. The simulation conducted on ansys 16. and Ansoft maxwell. Based on the result found on the first and second step prototype of flywheel supported charger is manufactured. The prototype is tested and results from the experiment were recorded organized in the form of charts. Finally the result from those three phases are discussed briefly and compared each other.

Since this is experimental research In order to gather experimental data this study mainly used two electric motors, one alternator, flywheel, volt meter, digital tachometer. [9] discussed a project, Proton Exchange Membrane (PEM) energy unit are progressively being refered to by governments as a conceivable pathway to the decrease of ozone depleting substance outflow. It is one of the forthcoming force hotspots for car applications, prepare machines, stationary cogeneration frameworks, and portable electronic gadgets. Be that as it may, the dryness of the film of a PEM power device diminishes the ionic conductivity, bringing about execution decrease. In this work, a two-dimensional model is utilized to examine the fundamental and collaboration impacts of five outline factors, at three levels in a proton trade layer (PEM) energy unit. Investigation is directed for working possibilities of 0.7 and 0.6V and a scope of current densities. An engine that picks up its energy from a hydrogen tank and a power device Stored in a tank. The substance vitality from the hydrogen will be changed over into electrical vitality by the power device to push the prepare at up to most extreme speed of 80km/hr. Prepare apparatuses like Fans, lighting may likewise keep running on PEM energy unit. This new hydrogen prepare is along these lines ideal for shorter, calmer extends of the system that jolt hasn't yet come to.

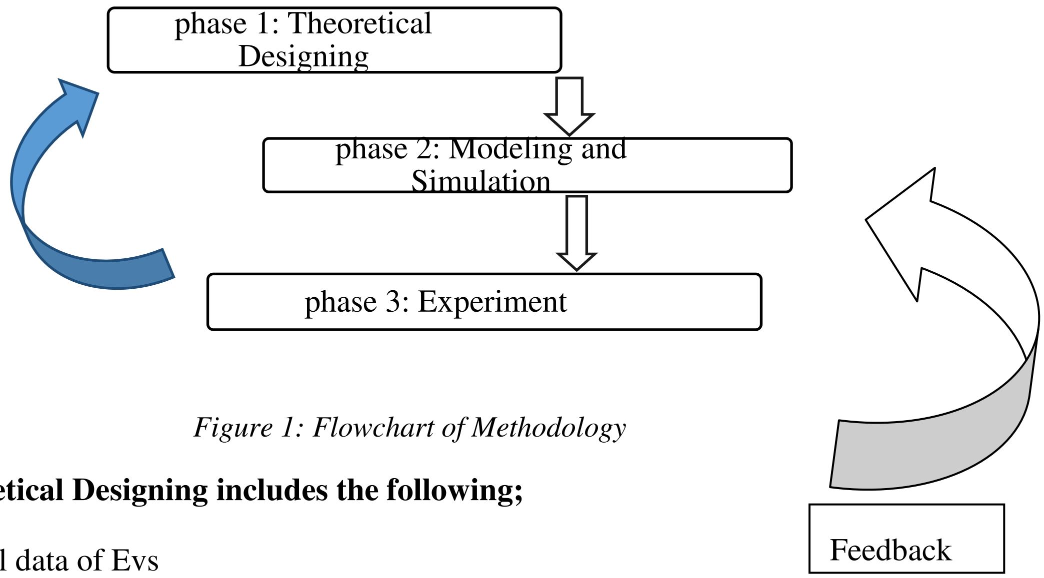


Figure 1: Flowchart of Methodology

Phase 1: Theoretical Designing includes the following;

- Technical data of Evs
- Concept generation (mechanism)
- Design of component
- Selection of components
- Losses and efficiency calculation
- Rotor dynamics

Phase 2: Modeling and Simulation

✓ peak flux density between magnets (B_{mg}) using ANSOFT MAXWELL 3D

✓ Stress induced in the shaft, flywheel, and key using ANSYS WORKBENCH 16.

Phase 3: Experiment

❖ Producing a prototype

❖ Measuring the result

4. DESIGN ANALYSIS

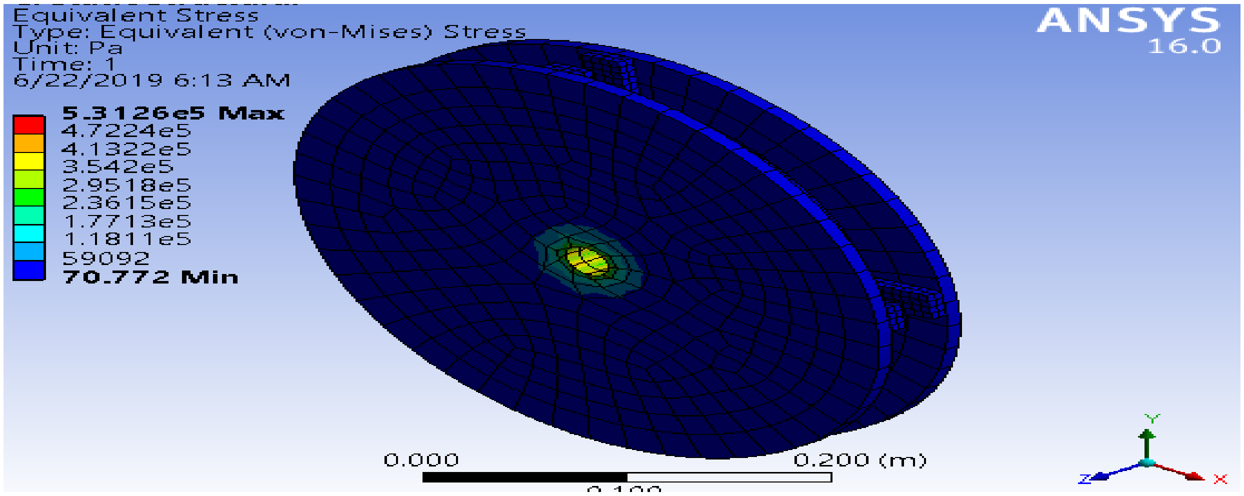
4.1 Technical data of electrical vehicle charging system

Since pure electric cars have a rechargeable electrical energy storage which is battery, therefore it needs to be charged again after the energy stored in it utilized. Before get in to the detail design analysis it is better to understand the power (watt/hour) needed to charge the average electric car. The peak current draw at different levels will vary car to car and is limited inside the vehicle itself by on-board circuitry. For level 1 charging when plugged into regular120V AC outlet, a lot of cars (like Chevy volt) will limit to 12A which is 1.4kW, and the peak allowed by the standard (and typical household wiring) is 16A which is 1.9kW. Some cars (like Chevy Volt) has a reduced power 8A option for level 1, giving 0.96kW. For level 2: 240V AC chargers, typically cars have between a 3kW (Volt, etc.) to 6.6kW (Spark EV, Focus EV, Nissan leaf, etc.) and 10kW (B-Class) on-board charger, but the standard allows up to19.2kw. The level 3 400VDC charging is nominally up to 90kw and peak charging rates vary by car. The BMW i3, for example, maxes out at 50kw.

Level	Voltage in volts	Current in Amps	Power in Kw
1	120 AC	8	0.96
		12	1.4
2	240 AC	80	10
3	400 DC	255	90[5]

Table 1: Level of charging and corresponding voltage, current and power value

This thesis basically focuses on ***level 1 charging electric vehicles***, hence the parameters on the table above regarding with level 1 charging system will be taken as an input parameters. Mean that the generator, being designed, must have 120V AC at the outlet and the power should be 1.9kw.



5. RESULT AND DISCUSSION

5.1 Simulation results

5.1.1 Simulation result of magnetic flux density between magnets

Ansoft Maxwell softwarw is powerfull software to simulate permanent magnet. The magnetic flux density between the magnet is determined analyticaly, i.e. 0.618 T. it is known that if the gap between the magnet is to small the flux density will increase and if the value of an air gap is large the value of flux density between the magnet will decrease.

In this study the air gap is taken as 18mm and property of N42 permanent magnet. The size of the magnet is also taken as 50mm×25mm×10mm.

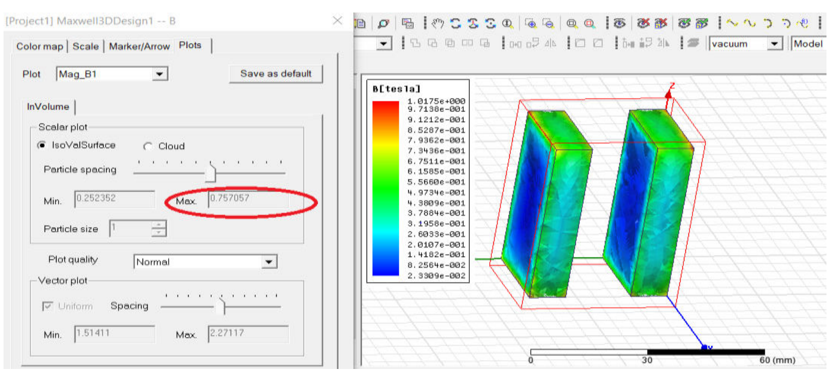


Figure1: simulation of permanent magnet in ANSOFT MAXWELL 14.0

Figure 1 shows the result of maximum magnetic flux density between two magnets carried out by ansoft Maxwell software is 0.757 T. Since the result from the software is greater than the analytical result it is safe. A little consideration shows if the value of flux density determined by simulation is lower than the analytical result then it should be redesign.

5.1.2 Flywheel simulation result

The simulation of flywheel is performed on ansys 16 software, and the result shows stress and total deformation of the flywheel due to torque. Stress induced in the flywheel is much less than the allowable stress of the material from which the flywheel is made of.

Maximum induced stress calculated from the software is 0.00053 Mpa and maximum total deformation is 0.000275 mm (shown in figure 2). This implies stress as well as deformation is almost approaches to zero and its impact on the functionality of flywheel is negligible.

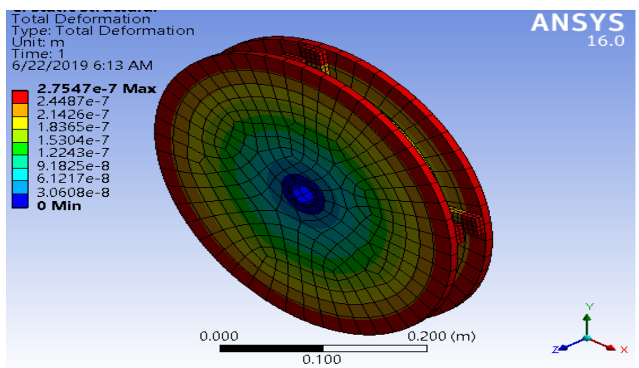


Figure2: Flywheel stress and deformation simulation result

5.2 Experiment result

Experiment setup

In the experiment 0.5hp single phase induction motor were used as a prime mover to store kinetic energy in the flywheel by means of belt drive. Between the flywheel discs there is stator winding. It is a composite material made from unsaturated polyester mix with hardener plus a fiber glass. Copper wire coils are connected in series which means there are two terminals at the end. As shown in figure 3, a multi meter is used to measure the output voltage by connecting those terminals on it. And also a digital tachometer is used to record the speed of the flywheel or rotor.

Number of a coil turn used in the stator winding is half of the number of turn used to made theoretical analysis.

Figure 3: An experiment conducting in workshop

Once the experiment set up has done, data of the output voltage and speed of the generator are recorded with respective time. The recorded data are listed in appendix H. based on the recorded data the following graphs are made in order to discuss the resul

Figure 4 shows that the speed in revolution per minuet versus time (graph). The data plotted in this chart convince during start up the speed of the flywheel is very slow but gradually increases and reach to its designed maximum speed. Time required to run the flywheel from stand to its maximum speed is 29 seconds.

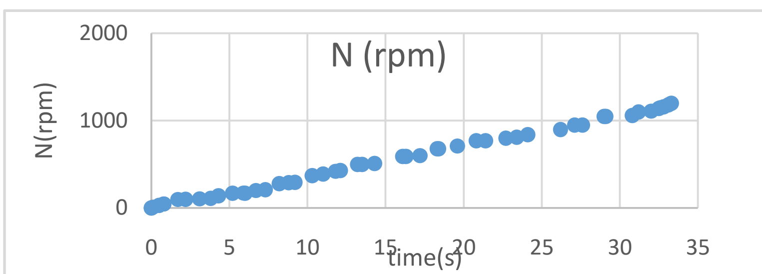


Figure 4: Revolution per minuet versus time graph

Figure 5 clearly shows the amount of induced voltage with respect to time. The time will count immediately when the motor gets power from the wall through plug. This motor keeps drawing power until the flywheel reaches to its maximum speed. Maximum value of induced voltage is obtained at maximum speed after 29 seconds. The induced voltage at maximum speed is 33.3 V. This value is obtained from the coil of single phase therefore it is possible to estimate the total voltage that will be induced from three phase by multiplying 33.3 v into $3^{0.5}$ i.e. 57.7v.

Number of turn in the coil taken to manufacture the stator was half of the analytical result, taking this in to consideration total voltage generated by the generator is twice of the result obtained from the experiment i.e. 115.4 v. since the expected output voltage from the generator is 120 v, the value obtained from the experiment differs by 4.6v. This deviation is mainly due to the manufacturing error because the air gap between the magnet and the stator coil was 1.5mm but after production the prototype the measured air gap found is 5mm. Therefore, by taking this in to consideration it is possible to say the experiment result confirms the analytical one.

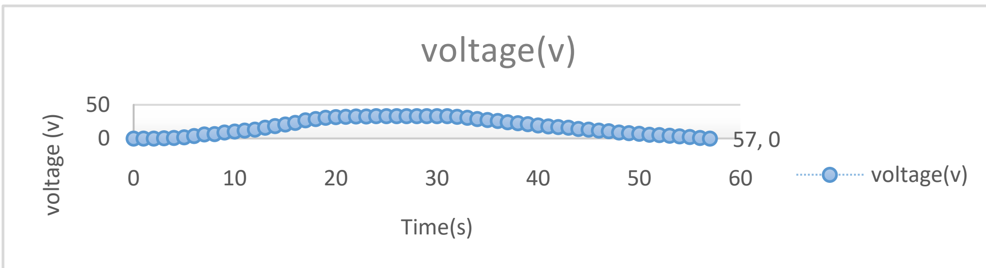


Figure5: voltage versus time graph

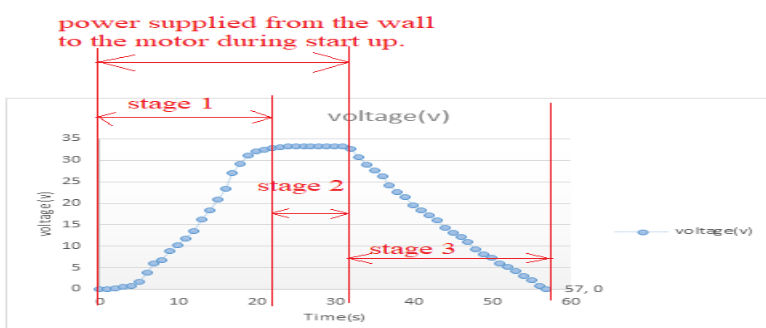


Figure 6: voltage versus time graph to show stages

Stage 1; at this stage the motor is a driving unit which draws a power from the wall. The speed of the motor increases gradually and reach 1200rpm after 29 seconds from the time at which the motor starts draw power. Once the speed of the motor reaches to its maximum revolution there is no change in output voltage.

Stage 2; at this stage the output voltage is almost constant it implies that there is no significant change in rpm but still the motor draws a power from the wall.

Stage 3; this stage clearly shows power cable of the motor has just unplugged. From the figure 6 it is observed that at the instant of power cutoff the output voltage is getting reduced but the flywheel keep driving the motor. After 25 seconds, from power cutoff, the flywheel has stopped. Therefore ratio of the time consumed to spin the flywheel from 0 up to 1200rpm to the time covered to stop spinning gives efficiency of the flywheel as 86.2%. As it calculated from analytical analysis, efficiency of the flywheel were 88.26%. When experimental result compared with that of analytical one it has a percentage error of 2.33%.

6.CONCLUSION

The objective of this paper was to design a generator to charge a set of battery pack of an electric vehicle which uses first level charging system. AFPM were selected for charging applications. Firstly, the chosen parameters of the AFPM machine were indicated, as well as the calculated variables from the analytical equations. Secondly, using Ansof Maxwell 3D electromagnetic analysis the peak flux density and by using Ansys 16.0 static structural analysis induced stress in different component was analyzed. The prototype was constructed in the university workshop, investigated and lastly the experimental results were recorded. The result obtained from the experiment is 86% flywheel efficiency and 115.4 volt. The comparison indicated, considering manufacturing error, that the experimental results confirm the analytical analysis.

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