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ADVANTAGE OF USING BLDC MOTORS IN ELECTRIC TRACTION

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ABSTRACT
In these modern days, the consumption of electrical energy is increasing day by day, we need to use the power frugally and efficiently as much as we can. With a combination of simple energy changes, we could potentially save hundreds of dollars on our energy bills. In this literature, we will get to know how much energy is wasting by using the brushed DC motors in railways, and how we can save energy by using brushless dc motors in electrical locomotives.

Index terms: simple energy changes, brushed DC motors, locomotives, frugally.

INTRODUCTION:

Startingwith the steam locomotive, railway advancement is continuously going with the up-gradation of Technology. DC motors are used on trains is because of good speed control and their high torque. Trains are an extensive application, for that reason, a DC motor can productively and safely move the heavy load forward. Differentiate from AC motors, DC motors can give industry applications with a fine balance of strong starting torque and controllable speed for seamless yet precise performance. DC motors are also a tremendous choice for train windscreen wipers, a challenging application that must be able to manage in several situations.

An alternative to the DC system is the AC series motor, known as the universal motor, which is essentially the identical device that runs on alternating current. Since both the armature and field current reverse at the alike time, the behavior of the motor is alike to that when actuating with direct current. To attain better-operating conditions, AC railways are frequently supplied with current at a lower frequency than the commercial supply used for common lighting and power. The AC mode allows standardized distribution of power down the length of a rail line and also permits speed control with switchgear on the vehicle. In India, the most typical means of transportation is the railway. Most of the railway line is electrified, which enlarges the electricity demand. Indian Railway system makes use of only two phases from three-phase electric power supply to fed locomotive. Arrivals of locomotive at substation are dynamic load. Due to this voltage drop take place at overhead equipment (OHE) will be an inefficient operation of the motor in locomotives.

The brushless DC (BLDC) motor is becomingmore popular in sectors such as automotiveespecially electric vehicles (EV) and industrial applications. since the commutator is used in conventional DC motors, replacing it with an electronic device improves the robustness and durability of the unit.

One more advantage of a BLDC motor is that it can be made compact and lighter than a brush type with the same power output. The brushes of an ordinary DC motor transfer power to the rotor windings. In addition, power can be lost due to impoverished brush to metal contact and arcing.

II.THE PRINCIPAL OF WORKING & CONSTRUCTION OF BLDC MOTOR

BLDC motor works on the principle which is similar to that of a Brushed DC motor.Since there are no brushes in a BLDC Motor, the commutation is controlled by electronic sensors. The sensors used are hall sensors and optical encoders. The brushless motor contains no sliding elements on the collector so this completely solves the problem of maintenance and replacement of brushes and other electrical contacts. The main design distinction between brushed and brushless motors is replacinga mechanical commutator with an electric switch circuit. Considering that, a BLDC motor is a kind of synchronous motor in the sense that the magnetic field generated by the stator and the rotor revolve at the same frequency.

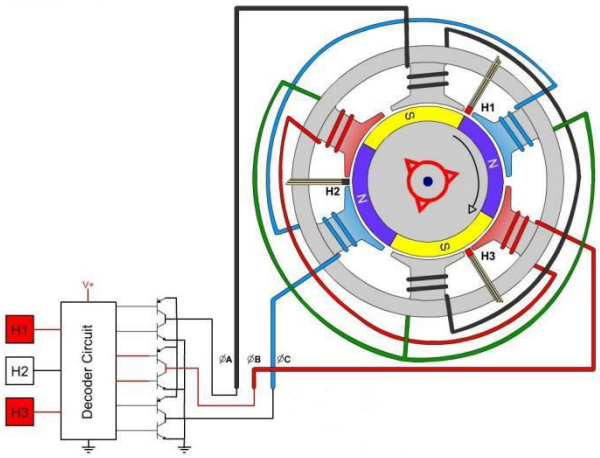

Fig.1 construction overview

BLDC motors are similar to AC induction motors and brushed DC motors in terms of construction and working principle. Like all other machines(motors), these BLDC motors also have a statorand a rotor.

Stator

Similar to an Induction motor, the stator of the BLDC motor is made up of stacked laminated steel. The winding in BLDC is a bit different than that of the traditional induction motor. The stator is constructed with stacked steel laminationsAs shown in figure 2.1

Fig.2.1 Stator of BLDC motor

Steel laminations in the stator can be slotted as shown in Figure. Because of the unavailability of teeth in the lamination stack, requirements for the cogging torque also go down, thus making them an ideal fit for low speeds too. Majority of the BLDC motors made of three stator windings that are connected in star or 'Y' (without a neutral point). because, in the Δ configuration, fifty percent of the voltage is applied across the winding that is not driven, thus increasing losses, in turn, efficiency and torque.The disadvantage of a slotless core is the higher cost because it requires supplementary winding to compensate for the huge air gap.3

Rotor

The rotor of a BLDC motor is made out of permanent magnets. (typically, rare earth alloy magnets like Samarium Cobalt (SmCo) and alloy of Neodymium, Neodymium (Nd),Ferrite, and Boron (NdFeB)).

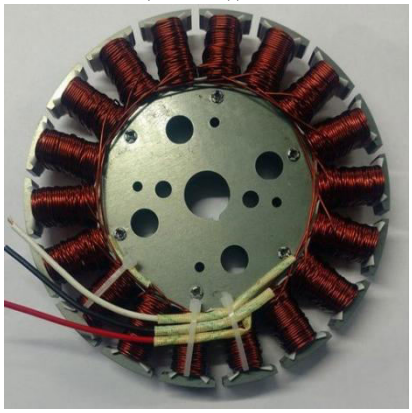

Fig 2.2 Rotor of BLDC motor

Based on the application, the number of poles can vary with North (N) and South (S) poles placed alternately. An additional rotor criterion that impacts the maximum torque is the material used for the construction of a permanent magnet; the higher the flux density of the material, the higher the torque.

although, brushless motors are not without their disadvantages. The main drawback is, a separate speed controller with much-compounded electronics is needed. These speed controllers can often be as heavy and expensive as the motors themselves, which can be restrictive for micro-air vehicle applications where weight is at a premium.

III.PerformanceCharacteristics:(compared with brushed DC motor)

The efficiency of the BLDC motor depends on the stages given below. There will be losses in the:

- AC to DC conversion(mainsrectification)
- DC to AC conversion (H-bridge)
- Motor windings for a little motor

Mathematically we would say efficiency:

$$\eta = \frac{\text{Poweroutmechanical}}{\text{Power inelectrical}}$$

Figure 3.1 shows that as voltage increases the resulting output power increases. The gross power and efficiency of the motor, at a given voltage input, differ with the position on the torque/RPM curve. The maximum efficiency will not take place at maximum power. The utmost power takes place at a low RPM, higher torque condition than the maximum efficiency.

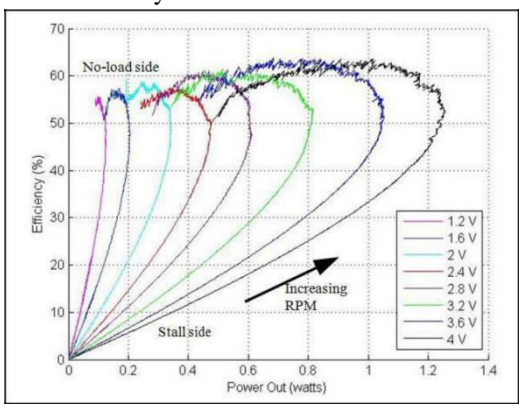

Fig3.1 Efficiency vs. motor power output for the brushed motor.

Dissimilar to the brushed motors, brushless motors have an extra standard control restriction that affects their performance, the PWM signal which throttles the motor. Therefore, both voltage and throttle setting have effects on the motor's power output as shown in fig 3.2 below.

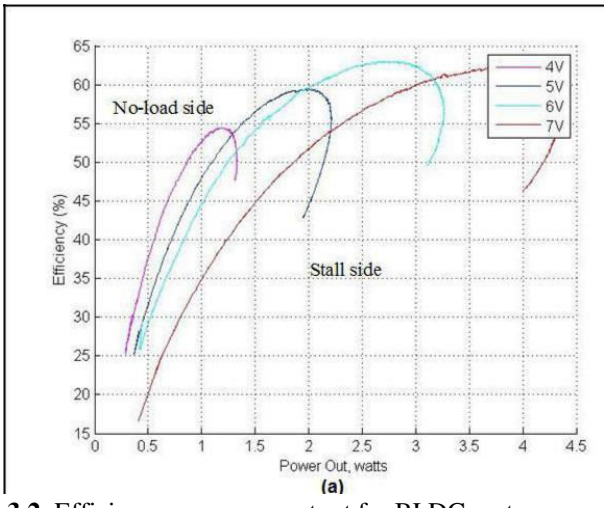

Fig3.2 Efficiency vs. power output for BLDC motor (100% throttle and varying voltage).

Scrutinizing the efficiency vs motor power output, it can also be observed that the brushless motor acts differently than the brushed DC motor. Brushless motors can attain higher rotational speeds than brushed motors due to their reduced friction which means no brushes.

IV. The advantages of BLDC motors:

- Brushless DC motor can achieve higher efficiency than theconventional induction motor due to the elimination of secondary loss. Current brushless DC motor technology for **train applications** possesses a high efficiency of 97%.
- It is less costly because of concentrated windings which shorten the end windings compared to three-phase permanent magnet synchronous motor (PMSM).
- Eradication of ionizing sparks from the commutator (ESD).
- Increased efficiency producing more torque per watt.
- Increased reliability.
- Reduced noise.
- longer lifetime by eliminating brush and commutator abrasion.

IN COMPARISON WITH INDUCTION MOTORS:

- Compared to induction motors, BLDC motors are expensive to manufacture butthey are very efficient.
- Lighter in weight.
- Compact in size.
- Simpler to control the speed.
- The speed/torque characteristics are flat. It permits operations at all speeds with rated load.
- Output power/Frame size is high.
- Due to the permanent magnets on the rotor, the smaller size can be achieved for given output power.
- The rotor inertia is low.
- This enables better dynamic characteristics.
- The starting current of BLDC motors is rated, No special startersare required.

V.CONCLUSION

As there is a large load on the electric traction system, hence power requirement is more. The resistance of the brush and commutator causes a voltage drop called the**brush drop**. This may be several volts, but it can cause large power losses inhigh current machines. The switching action of the commutator causes sparking at the contacts, causes a fire threat in explosive atmospheres, and generating electromagnetic intervention. so using brushless DC motors in an electric traction system is much more efficient.

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