Reduction of Cogging Torque in Brushless DC Motor

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Abstract- Brushless DC motor is a motor with a high output and high torque density that is used for electric vehicles and for industry purposes. It's a Brushless DC engine with a long service life. The main aim of this investigation is to reduce torque for cogging and to reduce torque for cogging by different methods. Cogging torque is caused by reticence between stator teeth and rotor magnets. There are various approaches to reduce the cogging torque. The torque can be decreased by this process. The torques abruptly influence the engine's output by causing torque wriggles, vibration, velocity changes and acoustic noise.

Indexed Terms- BLDC, EV, PMFSM, FEA

I. INTRODUCTION

The brushless DC (BLDC) motor is becoming increasingly popular in some sectors such as automotive (particularly electric vehicles (EV)), HVAC, white goods, and industrial because it does away with the mechanical commutator used in traditional motors, replacing it with an electronic device that improves the reliability and durability of the unit. A brushless DC motor is an electronically commutated dc motor that does not have brushes and it is also a PERMANENT MAGNET DC motor. It has both windings and magnets and it is a combination of the switched reluctance motor. Another advantage of a BLDC motor is that it can be made smaller and lighter than a brush type with the same power output, making the former suitable for applications where space is tight. The downside is that BLDC motors do need electronic management to run. These motors are highly efficient in producing a high torque over a vast speed range.

II. CONSTRUCTION OF BLDC MOTOR

A brushless dc engine with rotor position feedback is known as a permanent machine synchronously. In a different configuration, BLDC motors are mounted. It is based on the winding of the stator. The three motors are available: single, two and three-phase. They are available in three configurations. A brushless dc motor is known as a continuous sync machine with feedback on the rotor position. Generally speaking, brushless motors are operated via a three-phase power bridge. In order to start the control devices on the inverter bridge, the engine needs a sensor for the rotor location and for the proper switching sequence. The power devices are sequentially switched every 60 degrees based on their rotor location. The electronic switch is an electronic motor instead of switching the armature current with brushes. This removes issues with the brush and the switch arrangement, such as sparkle and wear off the switch brush system, thus making the BLDC more robust than the DC motor.

Fig 1: Construction of BLDC Motor

A stator is a static system in which the twist is a fixed component and the stator arrangement is identical to the induction engine. It is manufactured from axially cut steel laminations for winding.
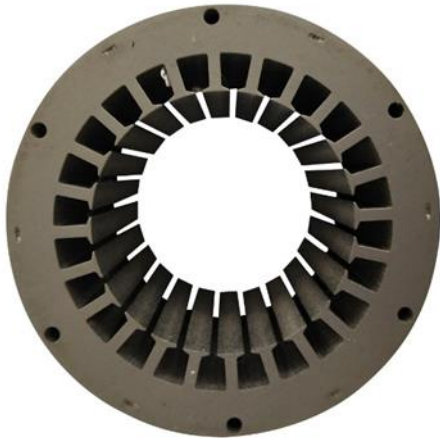
Fig 2: Stator of BLDC Motor

Two brushless DC motors are available
They are:

2.1 Internal rotor design:

the rotor is placed at its middle in the inner rotor design and the rotor is adjacent to the stator winding. As the rotor is located in the center, insulating thermal insulation is not necessary and the warmth is easily dissipated. Because of this reason, the internal rotor engine generates a high torque and uses Widely.
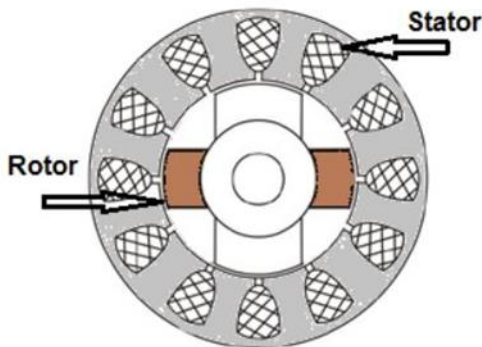

Fig 3: Internal Rotor Design

2.2 Outer rotor design

In the exterior design of the rotor, the rotor next to the Centre of the engine. Inside the rotor, the magnets chop the engine's heat and prevent it from disappearing from the engine. This engine form, which is similarly built, works at a lower rating and has low torque.
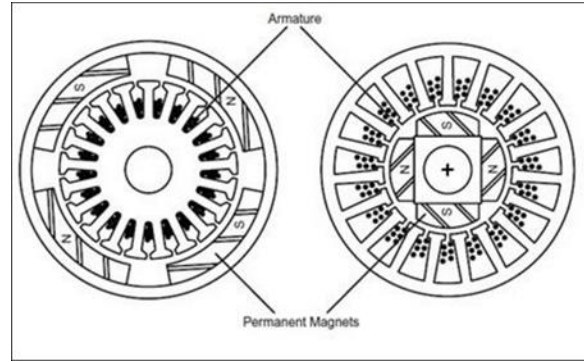

Fig 4: Outer Rotor Design

III. WORKING PRINCIPLE AND OPERATION OF BRUSHLESS DC MOTOR

In BLDC, the motor operates by the traditional DC motor theory, i.e., Lorentia force legislation, which stipulates that it has some force if an existing driver is put in a magnetic field. The BLDC engine is primarily based on a brushed DC engine i.e., input on the inner shaft position. The BLDC engine's operating theory is the same as the DC engine. Conductors facing a certain magnet pole (say N poles) carry current in one direction while they carry current in the opposite direction faced with the other pole. The magnet and reinforcement fields are thus always orthogonal to each other, as seen in the following Fig underneath. Note the "direct axis" and "square axis" naming convention. N S direct axis square axis frame spiral bobbin Illustration 1: DC computer orthogonal fields Suppose a double-pole rotor under an armature rotates. If the N pole crosses a conductor completely, a certain mechanism is required to alter the current path of the conductor. Otherwise, the force direction on the driver is reversed A switch segment is changing in the supply direction as it shifts from one brush to the other.
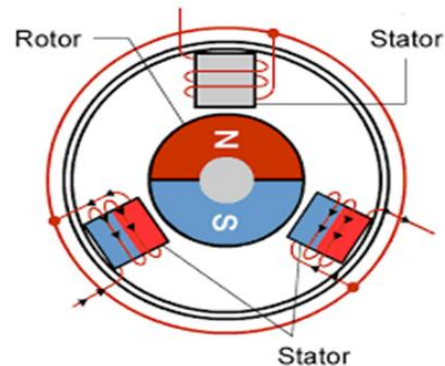

Fig 5: Working Principle

3.1 Rotor position is sensed in different ways that are

3.1.1 Hall Sensors

A Hall Effect Sensor is a commonly used sensor which provides feedback from a rotor location on a motor controller. Let's understand what this sensor means in an automotive engine control system. BLDC is a complicated circuit, in which various components work together in the desired way to drive the motor. The attributes that most affect engineers during the design of a device, are efficiency, durability and performance. Though electrical aspect is taken by the magnets and bobbins, a microcontroller serves as the motor's brain. However, even the sharper brain needs sensory inputs. Speed and position are the two sensory inputs of great significance. In the sense of motor switching, let us understand them. Edwin Hall found this in 1879.
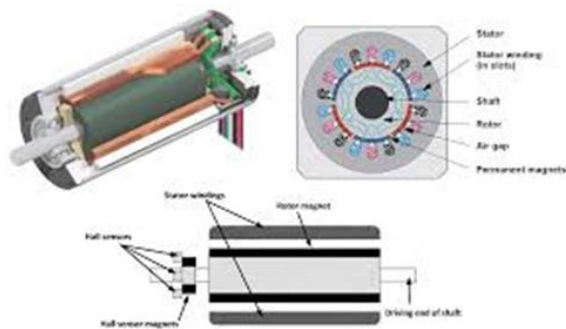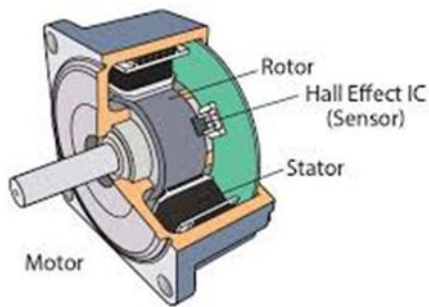
Fig 6: Hall sensor

Fig 7: Hall sensor location

3.1.2 Optical Encoders

In innumerable applications, Brushless Dc (BLDC) motors are used. Today, many engineers are aiming at improving the efficiency of their BLDC driven systems and a new trend is emerging: more BLDC engines with more rotor poles and stator stages are being designed. Engines with this design have great torque and stability. However, as we explore these new engines, using them with optical encoders is needed. The most important thing.

Resolver   Optical Encoder

Fig 8: optical Encoder

3.2 Methods of Reducing Cogging Torque

There are some different methods for reducing cogging torque.

They are

3.2.1 Notching of the rotor tooth

The fringing flux is triggered before the stator teeth and the rotor teeth begin to overlap, due to the significant partial saturation. The distribution of the flux of the initial structure is shown in Figure 4a. This part offers a new knotted teeth shape to minimise fringing flow. The V-form markers on both sides of the rotor teeth differs from the knotted teeth on the top of a stator or rotor teeth in the proposed knotted teeth shape. Changes were done to achieve better torque characteristics by adjusting the shape and location of the v-form notch. In Figure 5 you can see the ranks of key sizes (i.e., the height of the V-form notch vertex H1, the profound V-form notch L and the width of the V-form notch h2). Given that the teeth top has an important effect on the torque, the torque should not be too far from the tooth surface, and thus parameter h1 is selected between 0 mm and 3,0 mm. Moreover, given the size and depth of the V-form notch on the sides of the teeth, 7 8062 magnetic reluctance directly influence Energies 2014. Therefore, the depth L and width h2 of the notch in the form of V should be low for the average torque to be increased. L from 0.1 mm to 0.8 mm is chosen in this paper and h2 is chosen from 0.04 mm to 0.36 mm.

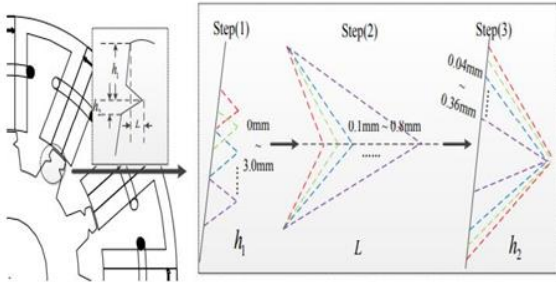Fig 9: Notching of the Rotor Tooth

3.2.2 Chamfering for rotor tooth

The blow job teeth of a rotor. Only permitting the work, this. It ensures a very smooth flow in the air gap. The correct angle cutting of any radius of our arc will significantly reduce the torque.
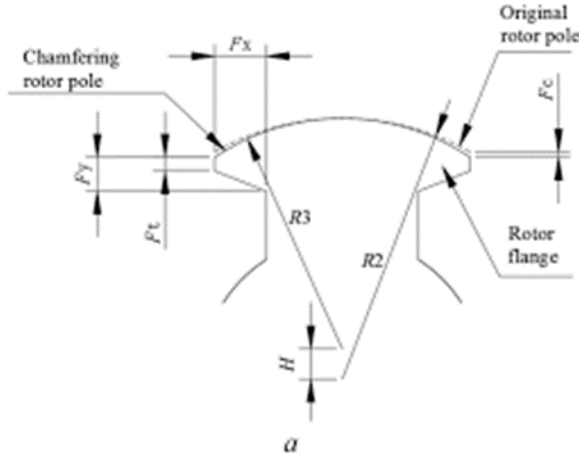

Fig 10: Chamfering for Rotor Tooth

3.2.3 skewing of the rotor

The most common method for reducing trapping torque in PM machines is skewing. The stator of the PMFSM is as a magnet while the rotor contains laminations. In PMFSM, the skewing rotor is much easier. The rotor is twisted by a spinning half-cycle torque of six mechanical degrees. The rotor FEA will cut the torque of cogging by 95%. The engine sound is reduced and back emf is reduced and the electromagnetic torque decreases.
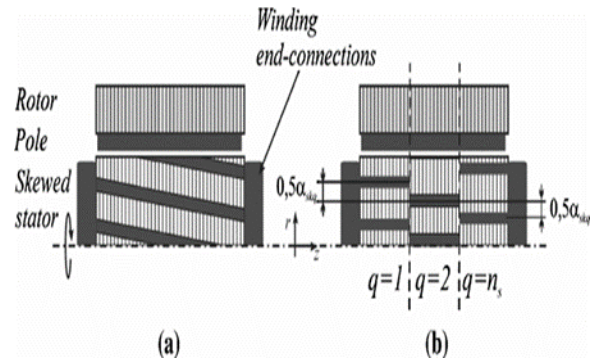

Fig 11: Skewing of the Rotor

3.2.4 Optimisation of magnet thickness

The thickness of the magnet should be identical to the stator teeth. The FEA therefore shows that the magnet's thickness can be optimised to reduce the torque. In general, the configuration of the thinner magnets leads to low torque and low airgap and a low electromagnetic field.
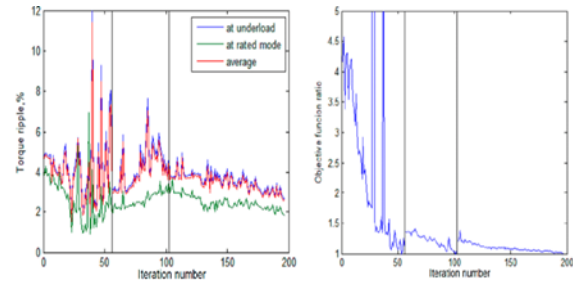

Fig 12: Optimization of Magnet Thickness

3.3 Merits, Demerits and Applications of Brushless DC Motor

3.3.1 Merits of Brushless DC motor

- There is no carbon burning engine that eliminates regular replacement needs for brushes and maintenance costs.
- Brushless DC engine can cause high sparks which can result in a limited lifetime or the full brushed DC motor burnout.
- Brushless DC engines are available in small, lightweight sizes and also have a large torque-to-weight ratio making them ideal for many robot and medical applications involving robotic arms and robot legs. • Brushless DC engines are available with a high weight-to-weight ratio.
- A brushless DC engine has a low load current, so it can run low to no load.

- This produces a very lightweight and small brushless DC engine, which is very high in torque rating.
- The DC Brushless engines can adjust and track the speed and couple, ensuring precise torque and speed control, greater performance and lower energy usage, while also providing long battery life when the engine is operated by those batteries.
- Brushed DC motors have a heating problem, and due to the electromagnet in the middle of the motor, they don't cool easily. On the other hand, there is no electromagnetic in the centre of the brushless DC motor which reduces the heating issue.

3.3.2 Demerits of Brushless DC motor

- The cost of a brushless DC engine is relative to that of a brushed DC engine and also raises the total cost of the electronic controller as is the case for a conventional mechanical low-cost switching motor with brushes.
- Low speed vibration occurs during low-speed rotation if a brushless DC motor is worked. However, at high-speed vibrations are reduced.
- This natural frequency can often match or be closer to a body's or plastic part's vibration frequency which results in the appearance of the resonance phenomenon because of the inherently natural vibration frequency of the brushless DC engine. However, this resonance can be reduced by modification, and in most brushless DC motorised devices it is normal to observe the resonance phenomenon.

3.3.3 Applications of Brushless DC motors

- DVD and CD players on computers.
- Diesel, hybrid and electric cars.
- Industrial robots, CNC machine tools and plain belts.
- Washers, compressors and dryers.
- Blowers, blowers and fans.

CONCLUSION

The five methods of design are to minimise the torque in the BLDC motor. The rotor skewing technique has proven that it is most effective in reducing the gripping torque of the BLDC engine. There will be no improvement in the EMF electromagnetic torque and back. The rotor too reduces the cogging torque by a

tooth pairing technique. Both are the preferred approaches.

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