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Optimization of Manufacturing Process of DC Traction Motor Magnet Frames by using CNC Horizontal Machining Centre

Prabir Kumar Basak* and C. M. Sadiwala**

**Department of Mechanical Engineering,*
RKDF University, Bhopal, (Madhya Pradesh), INDIA
***Principal, Department of Mechanical Engineering,*
RKDF College of Technology and Research, Bhopal, (Madhya Pradesh), INDIA

(Corresponding author: Prabir Kumar Basak)
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ABSTRACT: In this paper traction motor based on a new electric machine technology a "permanent magnet direct current machine with reconfigurable winding control". The most significant innovations in this technology are the topologies of magnetic circuits and windings and the solid state switching and control system that replaces either the commutator and brushes or an external power converter. Basic function of a CNC machine is to provide automatic and precise motion control to its elements such work table, tool spindle etc. Drives are used to provide such kinds of controlled motion to the elements of a CNC machine tool. A drive system consists of drive motors and ball lead-screws. The control unit sends the amplified control signals to actuate drive motors which in turn rotate the ball lead-screws to position the machine table or cause rotation of the spindle.

Keywords: DC Traction Motor, permanent magnets, higher torque, CNC Horizontal Machining Centre

I. INTRODUCTION

Generally, designs that reduce torque ripple in permanent-magnet synchronous motors reduce magnetic-drive resonance in the motor by optimizing the shapes of the permanent magnets.

They also investigate the coil arrangement (including the ratio of the numbers of poles and slots), and take advantage of skew, etc. In distributed winding motors, which are used in high-speed/ high-capacity applications, torque-ripple reductions closely matching theoretical values have been archived by these design processes. However, slim motors use a concentrated winding method, in which the motor is much thinner and the diameter is larger. The effects of magnetic saturation and of manufacturing tolerances have prevented torque ripple from being reduced by the theoretical values. Torque ripple can, however, be reduced by taking magnetic saturation into account when designing the magnetic circuits, and analyzing the manufacturing tolerances and taking appropriate countermeasures to magnetic saturation in the stator teeth when an electric current is applied. This tends to give higher torque ripple than with distributed-winding stators. However, the use of magnetic-field analysis to optimize the various parameters shown in Fig., and careful consideration. Many of our motor-product lineups are leaders in their class.

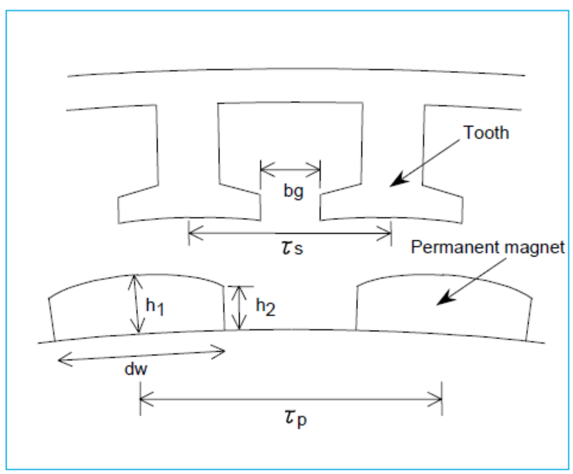

Fig. 1. Typical design parameters for concentrated winding motors.

The articles of this issue of Advance give some examples of our latest motor developments, and the technologies that made them possible. It is my earnest hope that these developments will prove to be of benefit to the reader, and that shapes and dimensions of the stator teeth and the shapes of the permanent magnets, make it possible to combine high electric loading with low torque ripple. Fig.1 shows the effect on torque ripple of changes in the slot opening. Setting the slot opening bg and the tooth pitch rs to an appropriate ratio (0.25 in the example shown in the figure) alleviates magnetic saturation due to the leakage of magnetic flux at the tips of the teeth, reducing the torque ripple over the entire driving range [12]. Analysis and Countermeasures Regarding the Impact of Manufacturing Tolerances. The manufacture of motors will always be subject to manufacturing tolerances that deviate from the ideal design values. This may cause increased torque ripple and variability. After analyzing manufacturing tolerances for the factors that cause torque ripple, the corporation used magnetic-field analysis to investigate the relationship between torque ripple and manufacturing error. Fig. shows an example of this, where the relationship between warp in the stator inner diameter and torque ripple was investigated. While a variety of different modes of warp are possible, individual investigations using magnetic-field analysis established that only certain modes of warping actually contributed to torque ripple.

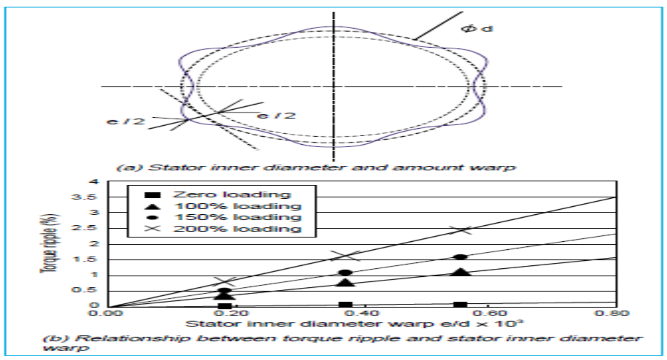

Fig.2. Effect of stator warp on torque ripple.

Given this, the relationship between torque ripple and the amount of warping in these specific modes of warping, was investigated at different load currents as shown in Fig. 2(b). The horizontal axis is specified using the d and e shown in Fig.2 (a). The figure shows that the amount of ripple is proportional to the amount of warping, and that, given a specific amount of warping, the torque ripple is essentially proportional to the load current. These indicate that reductions in torque ripple require the utmost efforts to reduce this warping. The corporation has implemented warping control measures in the manufacturing process base on the analyses described above, making it possible to achieve stable quality levels. Mitsubishi Electric has been extending the benefits of its pioneering developments in traction machine motors to an ever-wider range of elevators, and is developing theoretical and practical techniques to optimize the quality of ride for users. By identifying the critical factors affecting ride quality, both in design and in practical manufacturing, effective and efficient Measures will continue to be devised to maintain the corporation's current lead in this important area of vertical transportation. Although induction motors are used as the source of motive power in a variety of equipment used in the home because of their durability, quietness, and low cost, they are increasingly being replaced by high-efficiency brushless DC motors due to increased environmental concerns. In particular, because the power consumed by air conditioners and refrigerators accounts for some 40 percent of household power consumption, brushless DC motors are being used in both of these appliances. This article describes the efficiency-enhancing technologies in brushless DC motors for room air-conditioner compressors developed and implemented by Mitsubishi Electric Corporation. Brushless DC Motors for Room Air- Conditioner Compressors Beginning in the air-conditioner season of 2001, the corporation completely revised the structure of the 4-pole distributed-winding interior permanent magnet (IPM) motor that had been used until then, successfully improving efficiency through moving to a 6-pole concentrated-winding IPM motor with a jointed separated core structure. Motor Structures for Compressors shows the cross-section of the structure for a room air-conditioner compressor.

In the motor for the compressor, the stator is secured (though a thermal-shrinking process) to the inside of the compressor housing, and the rotor and the compressor element are linked by a shaft that transmits the driving force to the rotary compressor section. Lateral cross-sectional diagrams of the new motor for compressors and conventional motors, and the side views. Conventional motor, with a structure in which a 3-phase 4-pole 24-slot distributed winding stator is combined with an IPM rotor. The new motor, with a structure that combines a 3-phase 6-pole 9-slot concentrated winding stator with an IPM rotor. The stator uses a proprietary jointed-separated core (i.e., a joint-lapped core) invented by the corporation, and the rotor uses an IPM structure with a surface layout in which six double arc-shaped magnets are embedded.

Power drives. Drives used in an automated system or in CNC system are of different types such as electrical, hydraulic or pneumatic.

- Electrical drives. These are direct current (DC) or alternating current (AC) servo motors. They are small in size and are easy to control.

-Hydraulic drives. These drives have large power to size ratio and provide stepless motion with great accuracy. But these are difficult to maintain and are bulky. Generally they employ petroleum based hydraulic oil which may have fire hazards at upper level of working temperatures. Also hydraulic elements need special treatment to protect them against corrosion.

-Pneumatic drives. This drives use air as working medium which is available in abundant and is fire proof. They are simple in construction and are cheaper. However these drives generate low power, have less positioning accuracy and are noisy.

In CNC, usually AC, DC, servo and stepper electrical drives are used. The various drives used in CNC machines can be classified as:

a. Spindle drives to provide the main spindle power for cutting action

b. Feed drives to drive the axis.

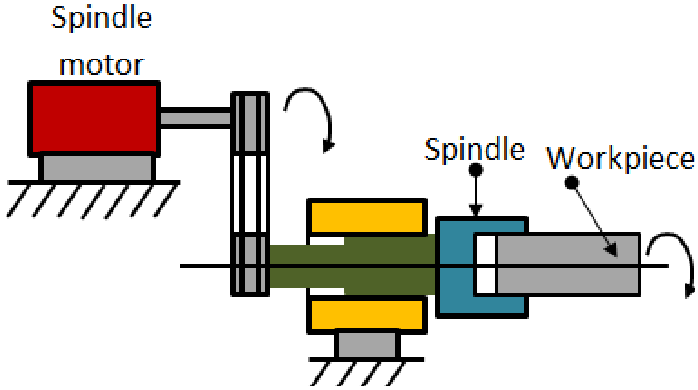

Fig. 3. Spindle drive.

The spindle drives are used to provide angular motion to the work piece or a cutting tool. Fig. 3 shows the components of a spindle drive. These drives are essentially required to maintain the speed accurately within a power band which will enable machining of a variety of materials with variations in material hardness. The speed ranges can be from 10 to 20,000 rpm. The machine tools mostly employ DC spindle drives. But as of late, the AC drives are preferred to DC drives due to the advent of microprocessor-based AC frequency inverter. High overload capacity is also needed for unintended overloads on the spindle due to an inappropriate feed. It is desirous to have a compact drive with highly smooth operation.

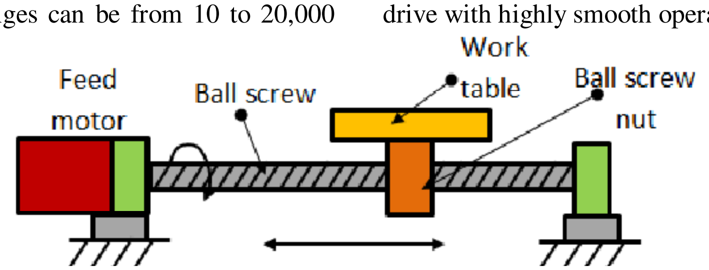

Fig. 4. Feed drive.

Generally, concentrated windings have tended to suffer from increased iron loss. To reduce iron loss, a change was made from a 4-pole to am 6-pole structure, and the rotor structure was reworked. Moving to six poles from four poles reduced the deviation in the magnetic flux-density distribution in the core, and while the electrical frequency was increased, the iron loss was successfully reduced by 11 percent from the 4- pole concentrated-winding motor under rated conditions (3,180rpm at 1.63N-m). Furthermore, a surface-layout IPM rotor structure was used in which permanent magnets are positioned near to the outer peripheral part of the rotor and electromagnetic steel plate with even lower iron losses was adopted. In addition, the shape of the permanent magnets in the layout on the rotor surface was changed from D-shaped to a double arc shape in order to increase the thickness of the magnets, thereby increasing the magnetic force. For the orientation of the magnets, a reverse- radial orientation was used to direct the central focus of the orientation towards the outer diameter. Magnetic-field analysis was used to perform optimization so as to maximize the torque constant. Switching to six poles and reworking the rotor structure made it possible to reduce the iron loss by about 20 to 30%, depending on the load conditions. Processing mechanisms of translational rotating motion are the cam and tachet mechanisms, [1], [2]. They belong to the upper bucket mechanisms and consist of a driver shaped element called cam, which is designed to transmit motion to another element of translational or oscillation motion, called tachet. Because movement can make any law by projecting properly any cam profile, these mechanisms are used in most areas of engineering (mechanical, textiles, fine mechanics, machine tools, internal combustion engines, and food engineering) which are necessary certain laws of motion technology or process required by mechanization and automation systems. It is recommended using these mechanisms because it has many advantages, such as [21] small dimensions, easy design, very good durability for complicated laws of motion, simple changes to the law of motion, relatively simple construction. of these mechanisms is that superior coupling wear accidentally causing significant changes in the law of motion, noise, and vibration.

Rod push and cam mechanisms are part of the upper joints. They consist of a driver element having a profile, called cam and a driven element called rod push. The transmission from the driver Element (cam) led to the component (rod push) is made by direct contact. This is a curve-shaped element, and it is well established and in close contact with the pusher motion. The pusher is made particularly by simple shapes: point-shaped planes, flat, circular (or roll), but may also have some curves and shapes. The laws of motion of the cam are usually those specific to the uniform movement, without acceleration. Standard laws of motion of pusher can be: linear, parabolic, co sinusoidal, and sinusoidal; but there are also more complicated laws, such as power or exponential polynomials, etc. Because these mechanisms can perform any motion, by the appropriate design of the cam profile, they can be used in all engineering fields. Relative to the nature of the movement they are different: camshafts rotating basis related to the torque, the translational cam connected to the base by translational coupling, spinning translation cams, joint with a quadrilateral articulated rod. The pushers are the same: rotating (oscillating), translation or spinning translation [1], [2]. The main components of a cam mechanism and tachet are presented in fig. These three elements are denoted by 1, 2, 3; there are also three couplings: the A-rotation, B-top rotation and translation, the C-translation, [1], [2].

Fig. 4. Machining centers turn work pieces.

The table rotates around the C axis and reaches speeds of 100 rpm for milling operations and up to 1000 rpm for turning operations. The A tilting axis can reach speeds of 50 rpm. The linear axes travel at speeds of 60 m/min. As the Ultrix multitask centres offer a number of different machining operations in one centre - turning, milling, boring and grinding - downtimes for work piece repositioning are eliminated. The vertical design of these Breton machining centres is the ideal solution for machining work pieces with diameters greater than the height of the piece. The Ultrix machining centres turn work pieces both horizontally and vertically combined with the tilting motion of axis. The turning bar with a 150mm vertical travel and positioned to the side of the vertical RAM it is possible to turn work pieces with heights greater than travel Z. This solution allows for, amongst other important features, to use very short tools instead of the conventional longer tools which are prone to abrupt jerks when machining and the use of vibration damping bars is limited just to intensive turning operations when machining very hard and resistant materials. The Ultrix range of machining centers can be fitted with a turning/milling spindle which allows varying tool positions and facilitates changeover from vertical to horizontal turning operations on the same work piece optimizing, in this way, both machining operations and tool consumption. With this range of machining centres it is possible to turn in diagonal work pieces up to 1000mm. The Ultrix range can be supplied with tool magazines for holding 30-60-150 or more tools. It is possible to choose from a wide range of turning and milling spindles. Milling spindles with S6/S1 rating, 55/48 kW (M300/14) torque 300Nm in S1, speed 14,000 rpm - 40/40 kW (M100/18) S1 torque 100Nm and speed 18,000 rpm or 28/20 kW (M38/28) S1 torque 38 Nm and speed 28,000 rpm or 55/40 kW (M16/40) S1 torque 16 Nm and speed 40,000 rpm. In S1 the milling spindles have an output power of 30 kW with a torque up to 2000 NM and speeds reaching 1000 rpm.

Fig. 5. Milling spindles automatic.

All machining operations can be run and managed in automatic guaranteeing a quality result thanks to the in-process dimensional checks. This system, in fact, detects in automatic the dimensions of the work piece and runs finishing operations in automatic satisfying the required tolerance margins. This significant and important feature further enhances the multitask potential of the Ultrix machining centres transforming them into a measuring centre. The Breton machining centres combine and incorporate in a single machine all machining operations: milling, turning, boring and when required grinding. The versatility and flexibility of the Ultrix range is more than this: the range of heads and spindles allow operators to rough mill as well as perform high-speed [4] finishing operations which require maximum precision and meticulous care. The specific machine functions of the Ultrix range substantially reduce production times: turning operations combined with the table tilting feature allow for work piece profiling in one single operation eliminating additional machining and at the same time ensuring and guaranteeing a superior quality finish.

II. CONCLUSIONS

This paper Optimization of Manufacturing Process of DC Traction Motor Magnet Frames by using CNC Horizontal Machining Centre reports the application One reason for this is that the horizontal orientation encourages chips to fall away, so they don't have to be cleared from the table. More significantly, the horizontal design allows a two-pallet work changer to be incorporated into a space-efficient machine. To save time, work can be loaded on one pallet of an horizontal machining.

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