Simulation of Output Torque of Coal Mine Permanent Magnet DC Motor for Belt Conveyor

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Abstract. With the analysis of the global coal production trend in the past ten years and the requirements of coal mine belt conveyor for drive motor, we summarized the disadvantages of coal mine belt conveyor asynchronous motor such as high loss and low operating efficiency, designed the system structure and simulation calculation model of coal mine permanent magnet DC motor, simulated the output torque of coal mine permanent magnet DC motor for 50N load condition, and realized the output characteristics of coal mine permanent magnet DC motor Calculation.

Keywords: Coal Mine; Belt Conveyor; Permanent Magnet DC Motor; Output Torque.

1. Introduction

Coal is a solid gradually formed by ancient plants buried in the ground after complex biochemistry and changes. Coal is the most abundant and widely distributed conventional energy source in the world, as well as an important strategic resource. From 2010 to 2021, global coal production rose slightly in fluctuations. After the financial crisis in 2010, the global economy recovered in an all-round way, and the coal output climbed at a high speed. According to the data released by BP, the growth rate of global coal production in 2011 was the highest in nearly seventeen years, reaching 7.3%. Since 2012, the development of the world economy has gradually slowed down, and the growth rate of coal production has declined. In 2014-2016, coal production started a negative growth for three years. In 2016, global coal production decreased to 5.217 billion tons of standard coal. Since 2017, the global economy has ushered in a new round of growth, and coal production has increased significantly again. Before the COVID-19 outbreak in 2019, the global coal production reached 5.683 billion tons of standard coal. In 2020, the global industry was hit by the COVID-19 epidemic and the economy suffered. The global coal production decreased to 5.394 billion tons of standard coal, down 5.08% year-on-year. With the improvement of the epidemic situation, the world economy is recovering rapidly, and the coal output is greatly increased. In 2021, the global coal output reached an all-time high of 5.698 billion tons of standard coal, up 5.63% year-on-year.

With the rapid development of the intelligent process of coal mine production, the safe production of coal mine is naturally inseparable from the stable operation of underground mechanical and electrical equipment. The underground environment of coal mine is very bad and complicated, with high temperature, humidity and flammable and explosive gases. The special operating environment puts forward higher requirements for the safety performance of underground mechanical and electrical equipment. Coal mine motor is the main component of underground mechanical and electrical equipment. Coal mine motor is the main underground electromechanical energy conversion device, which is widely used in scraper, belt conveyor, crusher, ventilator, winch and other equipment.

2. Belt Conveyor in Coal Mine

Belt conveyors are the main transportation equipment in coal mines. Coal mine belt conveyor is usually used for gateway transportation of fully mechanized mining, high-grade general mining or general general general mining face, and can also be used for roadway excavation transportation.

When the coal mine belt conveyor is used for gateway transportation, the tail of the machine is equipped with a bridge-type transfer machine to connect with the working face conveyor. When the coal mine belt conveyor is used for roadway excavation, the tail belt loader is connected with the roadheader. Stable operation is the basic requirement of belt conveyor for coal mine safety production. At present, coal mines generally use asynchronous motor series reducer, hydraulic coupler and other transmission mechanisms to drive belt conveyors. There are slip loss and harmonic loss in coal mine asynchronous motor, which leads to the efficiency of asynchronous motor between 0.7 and 0.9. When the asynchronous motor is used as the power source to drive the coal mine belt conveyor, the rated power of the motor should be selected according to the maximum load of the conveyor. The load of belt conveyor in coal mine is usually between 0.3 and 0.5, so the asynchronous motor in coal mine is in inefficient operation for a long time, wasting a lot of electric energy.

With the rapid development of rare earth permanent magnet industry in China, the performance of permanent magnet materials has been continuously improved, which greatly reduces the volume of permanent magnet motor and greatly improves the energy density. The permanent magnet motor has the advantages of small size, high energy density and high starting torque compared with conventional asynchronous motor. Especially, the output torque is larger at low speed, which can be used in coal mine belt conveyor to eliminate the intermediate transmission link such as reducer and realize the effective driving of belt conveyor directly, reduce the energy loss and maintenance cost of transmission link, and improve the mechanical efficiency of the whole driving system. Coal mine permanent magnet DC motor instantaneous starting output torque, high operating efficiency, suitable for coal mine belt conveyor operating conditions.

3. Coal Mine Permanent Magnet DC Motor

The coal mine permanent magnet DC motor is a type of permanent magnet synchronous motor with a rectangular air gap magnetic field compared to the traditional sinusoidal wave permanent magnet synchronous motor. However, in terms of structure and working principle, the coal mine permanent magnet DC motor is very similar to the common DC motor, and in essence, the coal mine permanent magnet DC motor can also be understood as a DC motor that uses electronic devices for phase change. The basic composition of the coal mine permanent magnet DC motor includes three parts: DC motor, controller and position sensor, and its drive control circuit is shown in Figure 1. In Figure 1, V1~V6 are the switches of the inverter. The drive control circuit determines the motor rotor position by detecting the position signal from the position sensor, generates PWM signals according to the DC motor winding conduction principle, and sends them to each electronic device of the inverter through the drive circuit processing, which makes the motor winding work according to the predetermined conduction principle and finally realizes the generation of rotating magnetic field in the air gap.

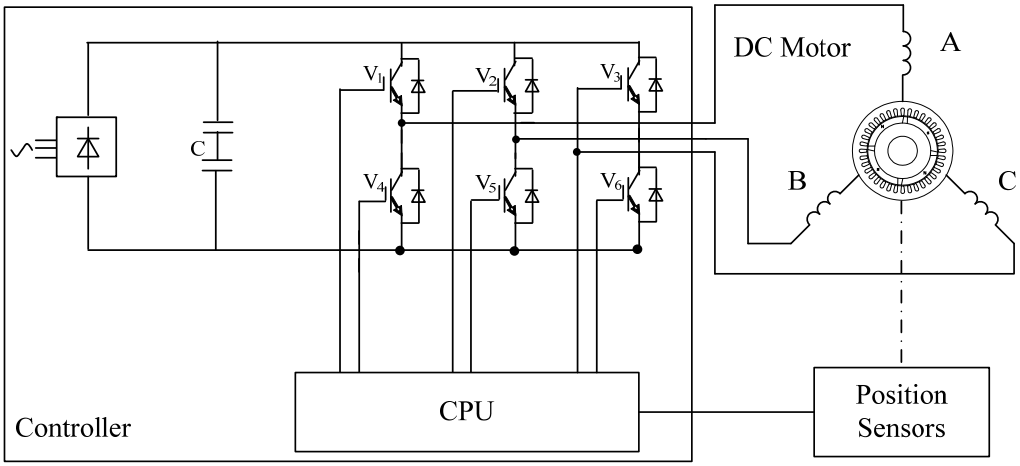


Figure 1. Structure sketch of coal mine permanent magnet DC motor

4. Simulation of Output Torque of Coal Mine Permanent Magnet DC Motor

The analysis of electromagnetic fields is actually a calculation of Maxwell's set of equations and other relevant constraints on the solution region under certain boundary conditions. In complex regions and conditions, the solution of the electromagnetic field cannot be obtained analytically, and it is necessary to apply numerical methods to solve the electromagnetic field. The numerical method for solving electromagnetic field problems covers many disciplines, including electromagnetic field theory, numerical analysis method, programming language and computer knowledge. Finite element analysis method is a common numerical method, this method will be solved for the region into many tiny areas, usually these areas are called "cells" or "finite elements", in each tiny cell, you can use the appropriate simple function instead of the complex real function, the use of computer approximation to solve these cells, the collection of all the results of cell calculations, is the entire solution to the region of the calculation results. This method of numerical analysis has both high computational accuracy and fast computing speed. The simulation calculation of coal mine permanent magnet DC motor firstly establishes the simulation model of the motor (as shown in Figure 2), and sets the profiling accuracy according to the size and importance of each structure, and the air gap and tooth slot, which are small in size and easy to produce saturation, are set with higher profiling accuracy.

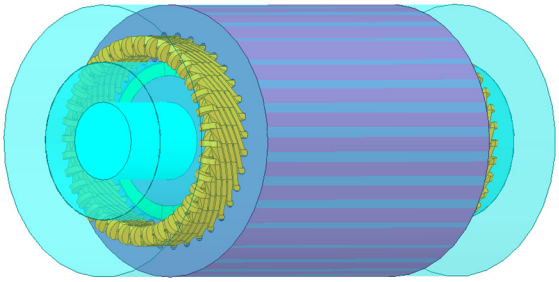


Figure 2. Simulation model of coal mine permanent magnet DC motor

During the simulation process, 50N load starting torque is applied to the coal mine PMDC motor, and the simulation time is set to 600ms, and the output torque versus time curve of the coal mine PMDC motor is obtained as shown in Figure 3. From Figure 3, we can see that the output torque of the mine PMDC motor is about 100N at the instant of starting, and the output torque is about 50N after stabilization.

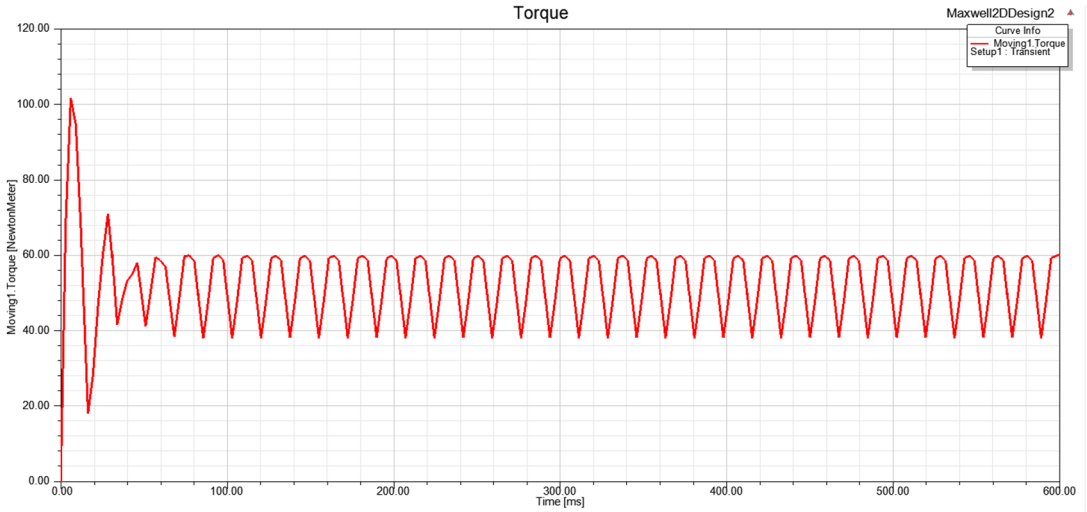


Figure 3. Output torque versus time curve of coal mine permanent magnet DC motor

5. Conclusion

In this study, the simulation model of coal mine permanent magnet DC motor is established by combining the operating environment characteristics and load conditions of coal mine belt conveyor, and the output torque characteristics of coal mine permanent magnet DC motor are simulated and analyzed, and the results show that the output torque characteristics are consistent with expectations.

Acknowledgments

This work was financially supported by Science and Technology Planning Project of Liaoning Province (2021-KF-14-03) fund.

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