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Numerical Analysis of Structural Influence on Heat Dissipation Performance of Eddy Current Retarder

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Abstract

This article presents an improved scheme for a type of eddy current retarder, based on the research of the electromagnetic field and temperature field of eddy current retarder, perform numerical analysis the relationship between electromagnetic field, flow field and temperature field of retarder, of before and after improvement, and discuss the influence of the mechanical structure of the eddy current retarder on its heat dissipation performance.

Keywords

Eddy current retarder, heat-dissipation capability, mechanical structure, numerical analysis.

1. Introduction

The principle of automobile friction braking lies in the conversion of kinetic energy and thermal energy[1]. If a large mass of vehicles in the braking process, continuous or frequent braking, the brake temperature will increase sharply with the reduction of vehicle speed. With the increase of brake temperature, it would result in a reduction in the friction coefficient between the brake shoes and the brake drum, so that the performance of vehicle braking would decline quickly or even failure [2]. In terms of large vehicle, such as a bus or truck, the conventional friction brake can not fully meet the requirement of brake[3].In order to solve this problem, high quality vehicles are often equipped with auxiliary braking devices in addition to friction braking[4]. The role of the retarder is to reduce the use of the main brake as much as possible in the process of deceleration or downhill, ensure the braking performance of the main brake.

2. Operation Principle of A Certain Type of Eddy Current Retarder

Vehicle retarder has eddy current retarder, hydraulic retarder and other different forms. The principle of the eddy current retarder is to transform the kinetic energy of the vehicle into heat energy through the action of electromagnetic field.

In the process of vehicle braking, after the driver issues the braking instruction through the controller, the electric eddy current retarder is connected with the power, and the coil is energized to generate a magnetic field, which forms a loop between the stator core, air gap and front and rear rotary plates.

The magnetic field strength of the current coil is proportional to the number of turns of the coil multiplied by the current. When the retarder rotates, the magnetic field lines generated by the coil are cut by the magnetic field lines in the internal closed loop, and then vortex induced current, namely eddy current, is generated. On both sides of the opposite direction of the magnetic poles, there are two kinds of eddy currents in the rotary disk, which are opposite directions. Under the action of induced eddy current, the rotating movement of the charged

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turntable is hindered by the coil magnetic field, thus achieving the braking effect (Figure 1). The direction of this resistance can be judged by Fleming's left hand rule. At the same time, the internal flow of eddy current in the rotary disc will also cause the rotor to heat up due to the thermal effect. This process causes the kinetic energy of the vehicle to be converted into heat through induced current, which is emitted by the wind through the blades on the turntable.

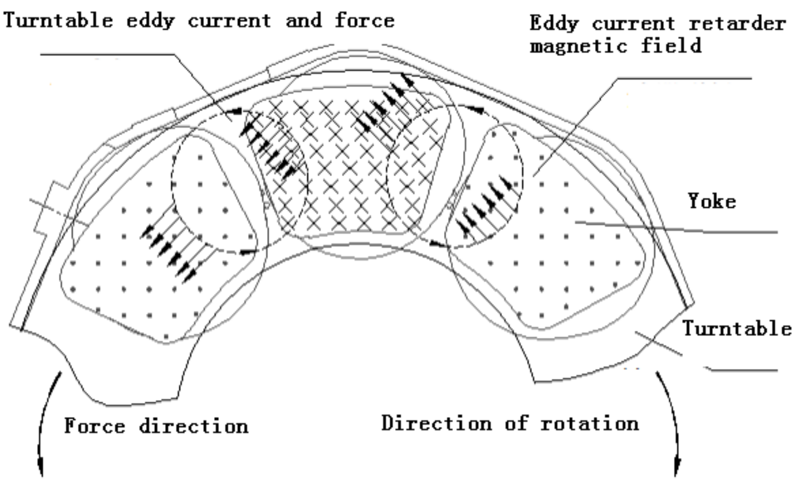

Figure 1. Braking torque of the eddy current retarder

3. Optimal Design of Eddy Current Retarder

According to the principle, an eddy current retarder is improved. The retarder without improvement is called as reference-type retarder, and the other is improved retarder.

A schematic of the reference-type retarder and the improved retarder turntable is shown below (Figure 2 and Figure 3).

The differences mainly include the following points.

1. The shape of the turntable blades is different. The reference-type retarder blade is in the shape of an involute, and the ribs connected to the inner ring are in the form of a tangent. The improved blade is in the form of a circular arc.

2. The edge of the turntable has different angles. The improved type will increase this angle.

3. The number of blades has been changed.

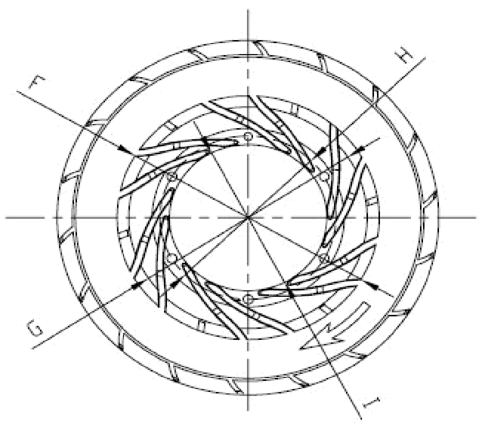

Figure 2. Schematic diagram of reference-type eddy current retarder

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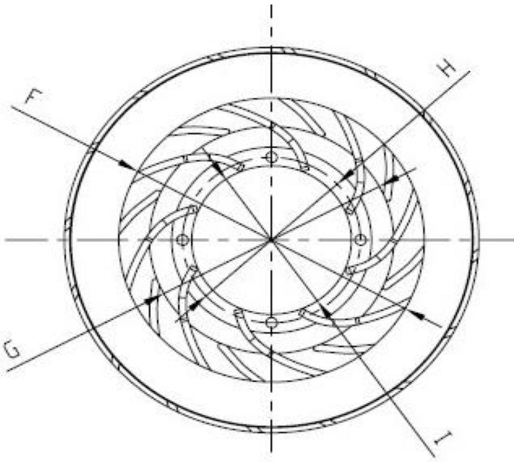
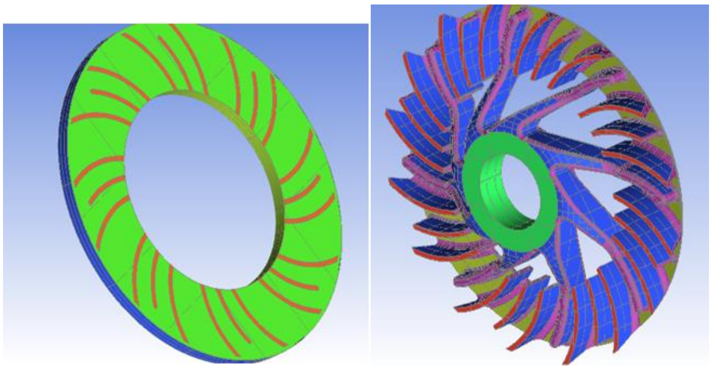


Figure 3. Schematic diagram of improved eddy current retarder

4. Finite Element Analysis

In Figure 4, the turntable geometry model consists of two parts:
Heat source: thick plate (close to the yoke)
Heat sink: heat sink fins, thin discs and connecting spokes
The fluid geometry model consists of two parts:
Rotational domain: a disk-shaped area with a radius of 0.315 m near the turntable, including the heat dissipation channel
Far field: The radius of the outer field of the turntable is 1.5 m and the axial direction is 0.5 m.



a. heat source b. heat sink

Figure 4. Computational domain geometry model

4.1. Boundary Conditions

(1) Heat generation rate： 11600000 w/m2
(2) Import and export boundaries: both choose open boundary conditions (opening);
(3) Insulation wall boundary: the surface of the thick plate close to the yoke and the wall surface connecting the flanges are adiabatic conditions;
(4) Internal interface: using GGI connection.
(5) Material:
Fluid section: ideal gas (compressible).
Solid part: Steel has a surface emissivity of 0.8 and a diffuse fraction of 1.0.

4.2. Comparison of the Analysis Results

Figure 5 shows calculated surface temperature profile of the turntable.

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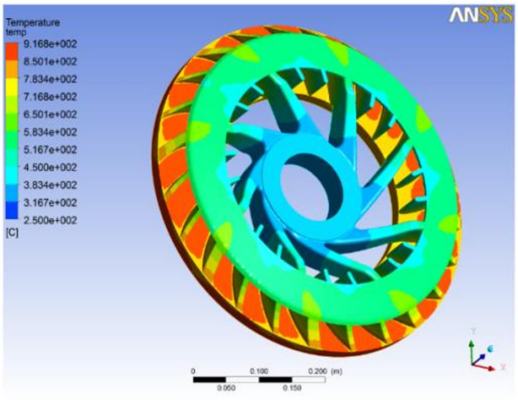
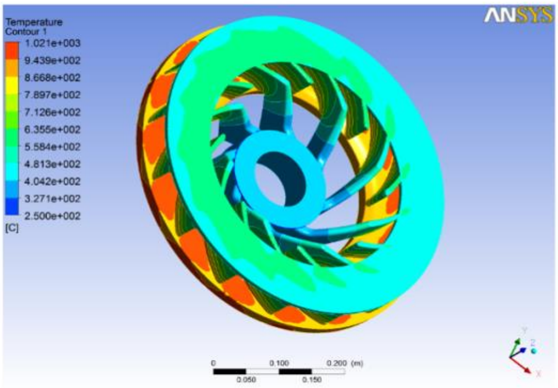


Reference-type retarder eddy current retarder turntable



Improved eddy current retarder turntable

Figure 5. Overall temperature distribution of the turntable surface

It can be seen from Fig. 39 that the maximum steady-state operating temperature of the reference-type retarder turntable and the modified turntable are 917°C and 1021°C, respectively, and the maximum temperature values on the flange surface are 368°C and 345°C, respectively. At 104°C, the maximum temperature of the flange surface is 23°C lower than the reference-type retarder. The calculated temperature value is slightly higher than the highest temperature in the actual work. This is because the insulation wall boundary set in the numerical calculation ignores the wall surface in practice. Radiant heat flux at work. Here need to indicate: the modified rotary calculation of a given heat source heating rate is not the actual measured or calculated, given value in the calculation of the same as the reference-type retarder, exist the possibility of mismatch, and improved the rotary heat dissipation fin is only 16 less than a third of the reference-type retarder, and fin thickness is small, the corresponding solid internal heat conduction heat flow is less, the two is a major cause of lead to improved turntable highest temperature is higher.

5. Conclusion

Through the heat fluid-solid coupling heat transfer simulation analysis and comparison of the rotating plate structure of an original type of eddy current retarder and its optimized and improved rotating plate.The maximum steady-state operating temperature of the reference-type retarder turntable and the improved turntable is 917°C and 1021°C respectively, and the maximum temperature of the improved turntable is 104°C higher than that of the reference-type retarder;

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Improved rotary heat dissipation fin front in 800 rpm the inlet Angle of attack is almost zero, under the condition of each cooling channel and velocity is higher, uniform pressure distribution, channel and air temperature of the whole is low, so is very conducive to the convective heat transfer, just near the cooling ribs end edge windward exists low velocity zone.

Acknowledgements

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