Simulation of Magnetorheological Finishing with COMSOL

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Abstract

In the process of magneto rheological finishing, the distribution of magnetic lines in the magnetic field is very important. The magnitude of the magnetic field strength determines whether the magneto rheological fluid can produce the rheological effect under the action of the magnetic field, thus removing the material. COMSOL is a powerful simulation software, and it can directly reflect the distribution of magnetic field by using magnetic field simulation.

Keywords

Magnetorheological Finishing; Finishing Method; Magnetic Field Simulation.

1. Introduction

The traditional optical processing methods can not meet the requirements of the processing precision and surface quality for the optical parts, both in terms of production efficiency and the stability of the precision and quality of the machining. As a new processing method of optical parts, magnetorheological finishing (MRF) is used to change the rheological properties of the magnetorheological fluid between the wheel and the surface of the workpiece through a gradient magnetic field, so that the surface material of the workpiece is removed. It provides a finishing method that can precisely control the shape of the optical parts after finishing, while ensuring the low roughness and high machining efficiency of the parts.

2. Simulation

2.1 Regional Division

The magnetic permeability of the air is set up to 1 according to the given structure size. In the iron loop, the magnetic field of the magnetorheological fluid is established by using the magnetic force line of the permanent magnet, as in Figure 1. Domain 1 is air gap, domain 2 and 4 are two symmetrical iron circuits, domain 3 is permanent magnet.

2.2 Meshing

Set the mesh density and meshing. Because this is the loop of permanent magnet, there is no current, so there is the change of magnetic field line caused by magnetic poles, and its mesh is shown in Figure 2.

2.3 Post-Processing

By analyzing the distribution of the magnetic force line in the magnetorheological finishing electromagnet model, as shown in Figure 3, it can be seen that the distribution of the magnetic force line of the permanent magnet basically follows the distribution of the physical field of the original, and the magnetic line of force forms a closed loop through the iron pipe. At the interface where the air gap is small at the top, the magnetic line will be slightly bent due to the small interface.

At the air interface, the junction of the iron pipe and the permanent magnet, and all the bending parts of the iron pipe, the magnetic flux density mode is the largest, and the magnetic induction intensity vector distribution is also denser in the air interface, slightly disorderly, and the other parts of the loop are thinner, and the magnetic induction intensity vector distribution in the space where the gap is larger is larger. It's very regular.

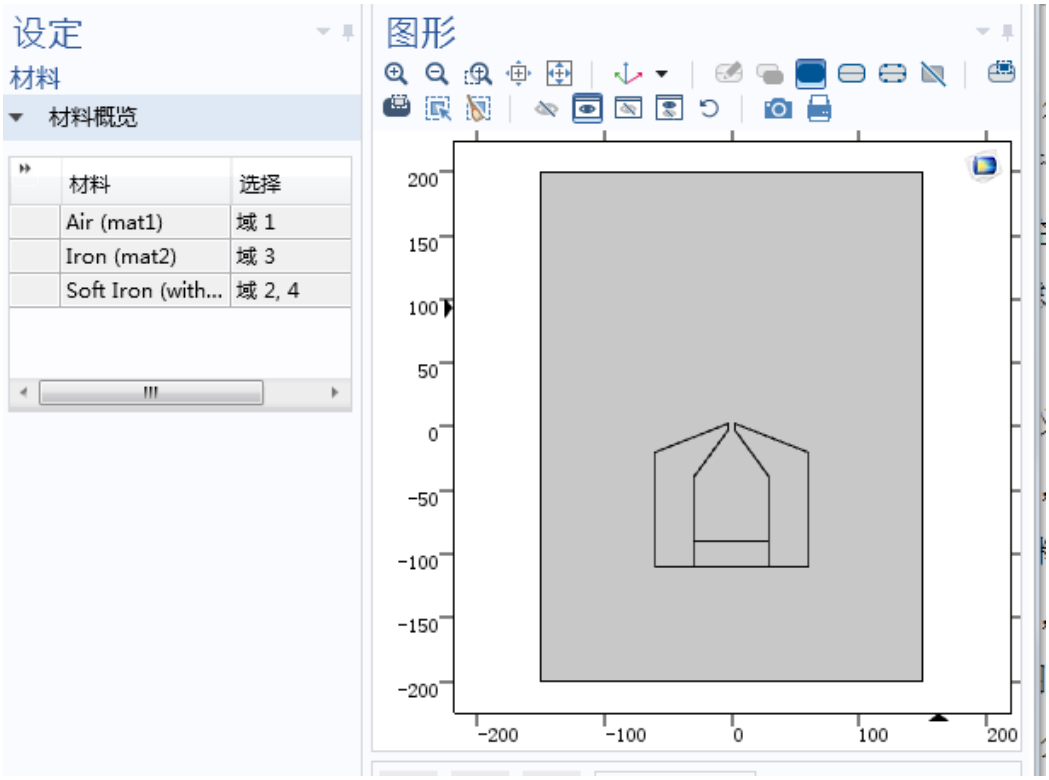

Fig 1. Electromagnetic model

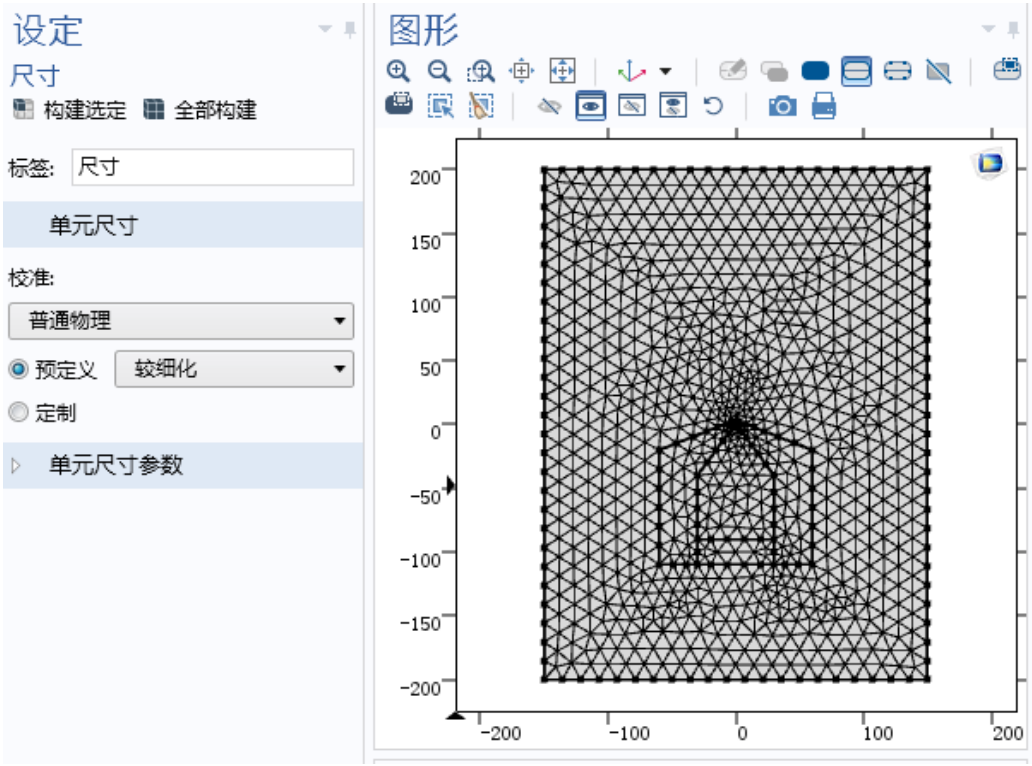

Fig 2. Meshing

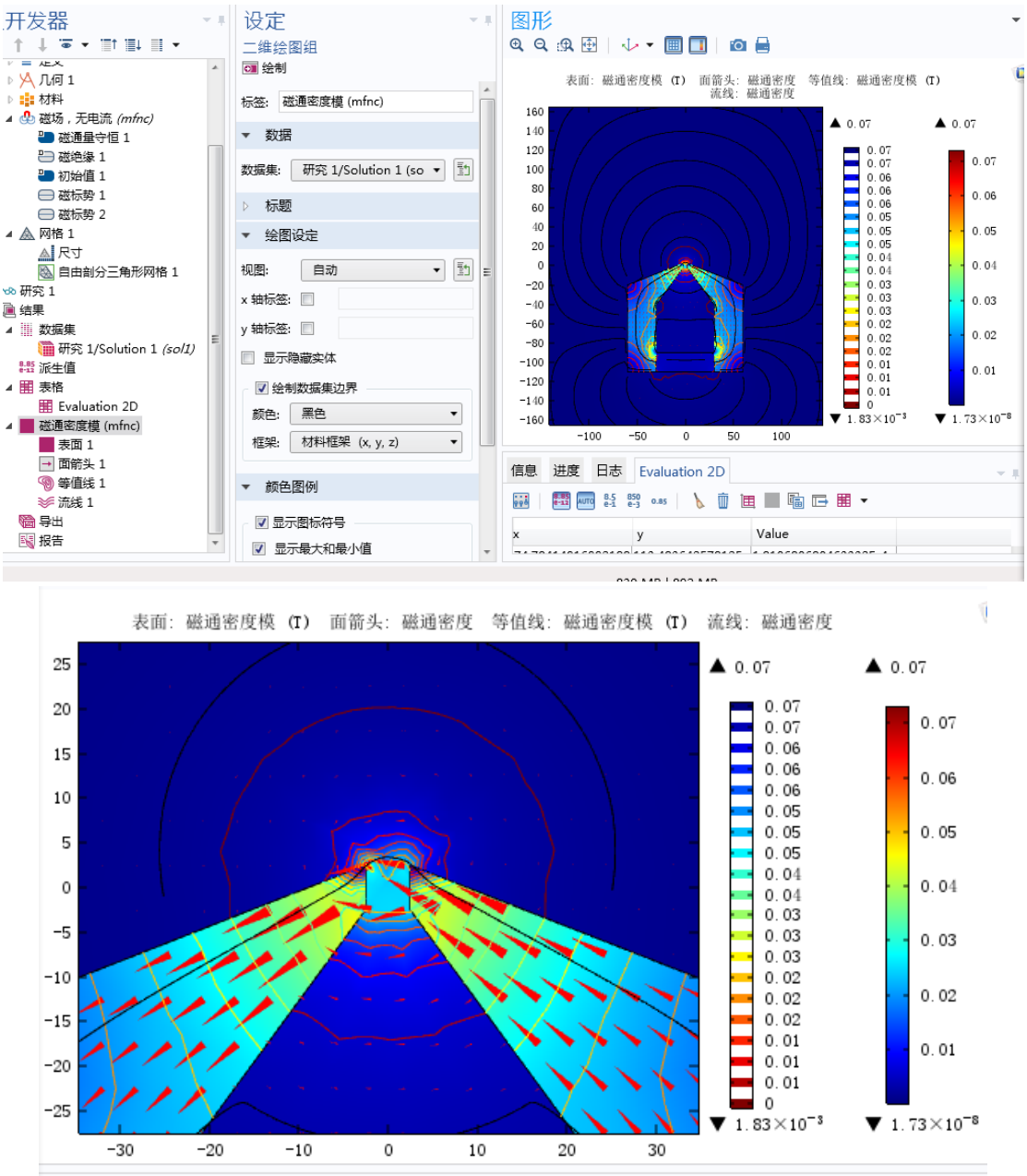

Fig 3. Post-processing

3. Conclusion

(1)Results: the median magnetic induction intensity of B is the largest in the air gap, and the gradient of B decreases along the air gap up and down. According to the mechanism of magnetorheological fluid [5], under the effect of medium magnetic field (0.2T), the magnetorheological fluid can reach a certain shear stress to be polished.

(2) Reason: the gas gap is formed between the two magnetic chokes. The finishing work area is located in the upper space of the air gap, and the gap is far greater than the width of the air gap. Therefore, the magnetic field will not change in length, and this special structure makes a part of the magnetic force line through the magnetic choke table. A gradient magnetic field perpendicular to the surface of the liquid wheel is formed on the surface, so that the gradient magnetic field can be used for finishing.

(3) Influence: a magnetic field in magnetorheological finishing region is formed, and the magnetic finishing particles suspended in the magnetorheological fluid will be arranged in a fibrous or chain structure in the direction of the magnetic field, and the magnetic moment of the solid particles will be transferred through stickiness to the base carrier, resulting in the magnetorheological fluid macros. The

change of the viscosity of the liquid increases the apparent viscosity of the liquid and exhibits a solid state property to polish it.

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