Force Analysis of Orifice Plates in Magnetic Separation

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Abstract

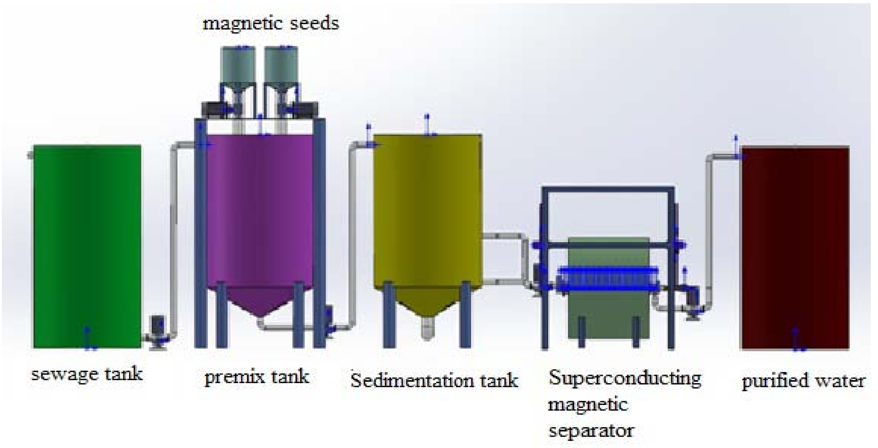
Since the 1980s, superconducting magnet has been adopted in high-gradient magnet separation (HGMS) systems. In recent years, the use of HGMS has become widespread in diverse industries ranging from waste water purification of steel production to coal desulfurization. Here, we introduce basic concepts about the magnetic separations and design parameters of the magnetic coils. An analysis of magnetic field distribution of superconducting magnets is an essential process in the HGMS systems, and high magnetic field gradient is of great benefit to efficient separation. In this work, we also analyze the influence of relevant parameters of the coils, which impact on the magnetic field distribution in key area. Finally, we discuss the force analysis of stainless steel orifice plates in room temperature bore.

Conclusion

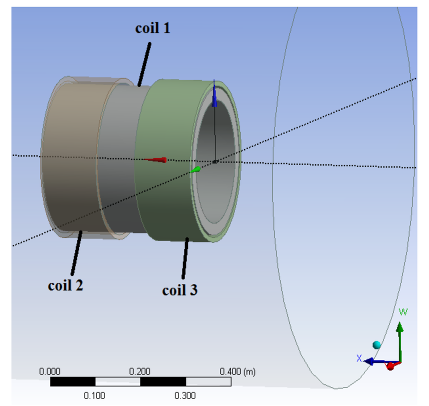
- Superconducting magnetic separation technology is expected to contribute greatly to the reduction of secondary waste produced by the concentration of harmful materials
- The inner radius of coil R_1, outer radius of the coil R_2, length of the coil H, number of turns N, running current I and diameter of NbTi/Cu wire d are relevant parameters of the magnetic field distribution in key area.
- In our system, the position we put or take the orifice plate is about 30cm from one side of the room temperature bore, and the force of take the orifice plate away is only about 158 N, which means that it is easy to operate.

Methods

Magnet Structure



The scheme of the superconducting separation system.

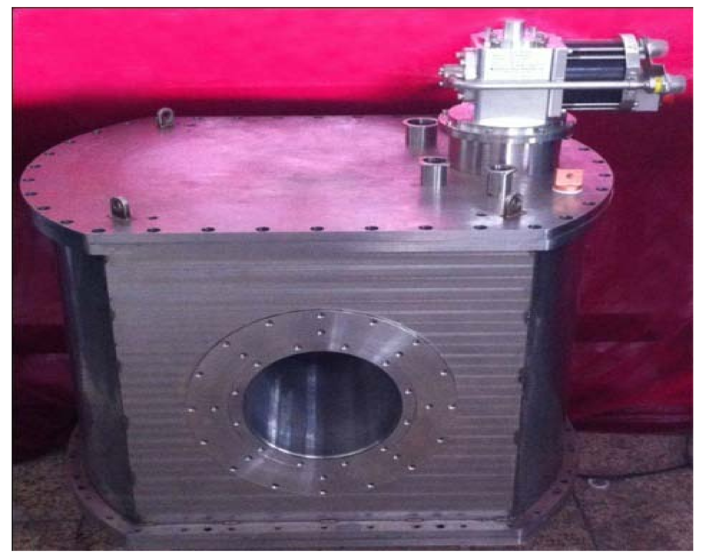


The scheme magnet structure

Orifice Plates are in superconducting magnetic separator, which is the core part in superconducting separation system.

superconducting magnet consists of three coaxial coils, Coil 1 is the main coil, and Coil 2 and 3 are compensating coils.

Procedures



ANASYS Maxwell is applied in force analysis of stainless steel orifice plates.

- Analyze the influence of relevant parameters of the magnetic field distribution
- Design magnet
- Analysis of magnetic field distribution
- Force analysis of stainless steel orifice plates

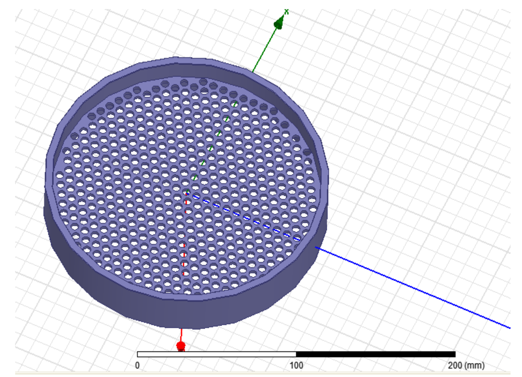
design

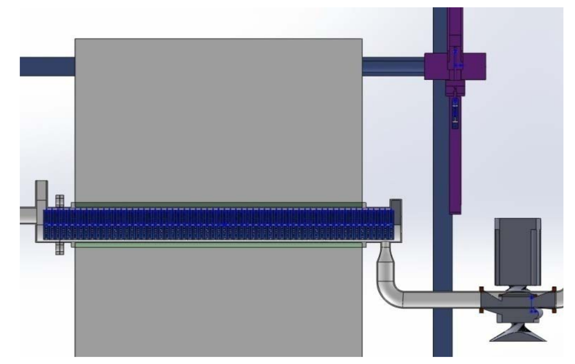
Design Parameters

Table. Geometry parameters of the magnet system. R_1, the inner radius of coil; R_2, outer radius of the coil; H, length of the coil; N, number of turns; I, running current; d, diameter of NbTi/Cu wire.

coil	R_1/mm	R_2/mm	H/mm	N	I/A	d/mm
1	128.0	147.5	370	14635	45.126	0.65
2	151.5	170.9	140	8778	45.126	0.5
3	151.5	170.9	140	8778	45.126	0.5

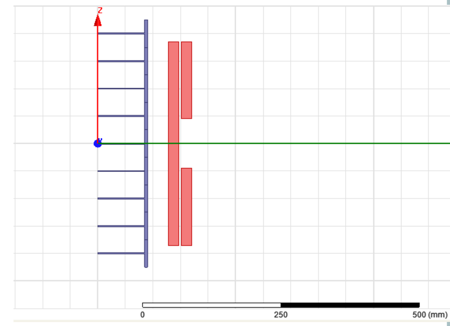
Magnetic Separator





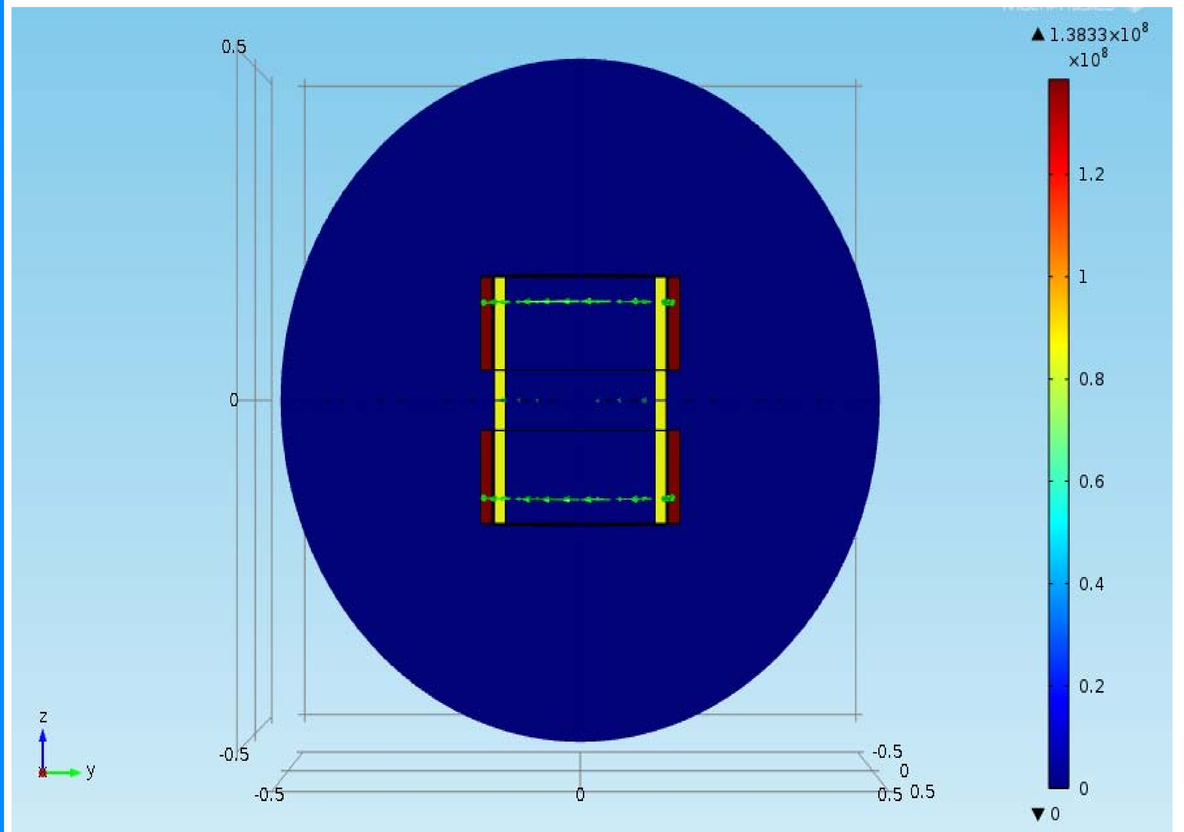
Orifice Plates are made of 304 stainless-steel.

Stainless steel orifice plates in the room temperature bore of the superconducting magnet in superconducting magnetic separator are reciprocated in and out of the magnetic field.



Results

magnetic field distribution

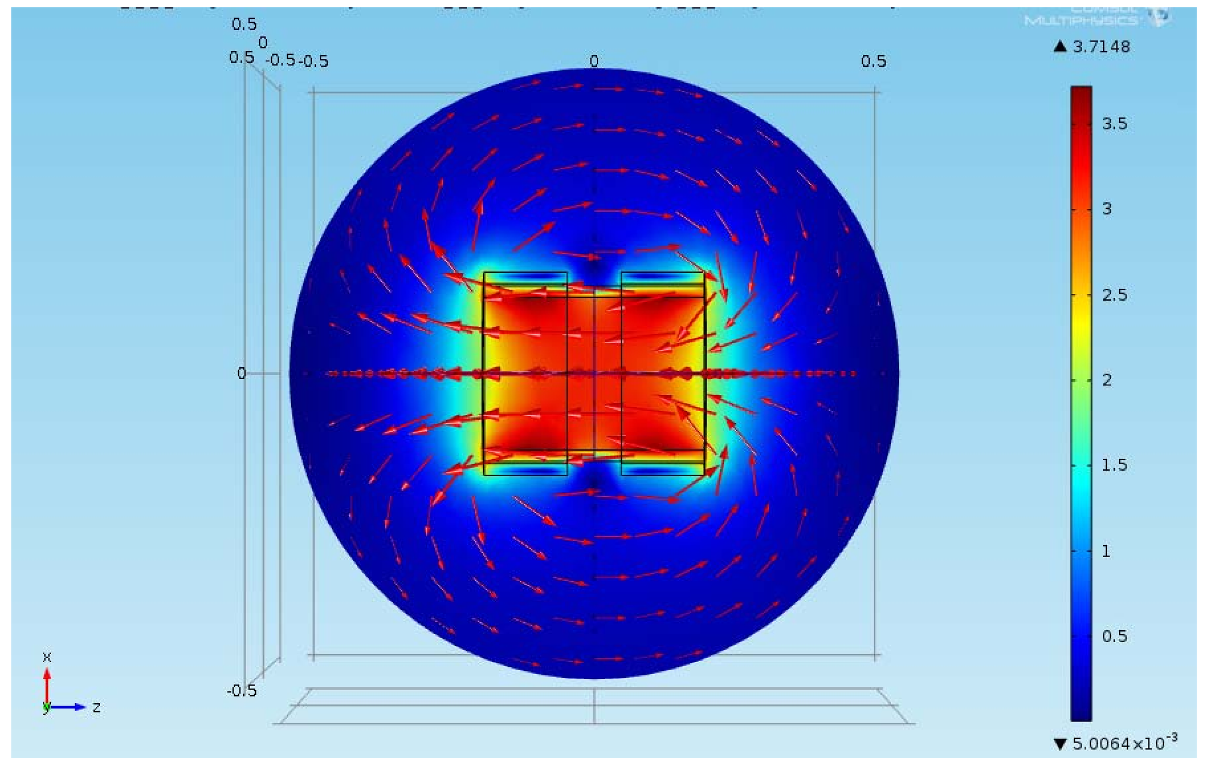


Electric current density distribution

The strong magnetic field is generated by a high current density of the superconducting coil.

The running current is 45.126A.

The current density of Coil 1 and Coil 2 is about 9.2×10^7 A/m² and 1.4×10^8 A/m², respectively.

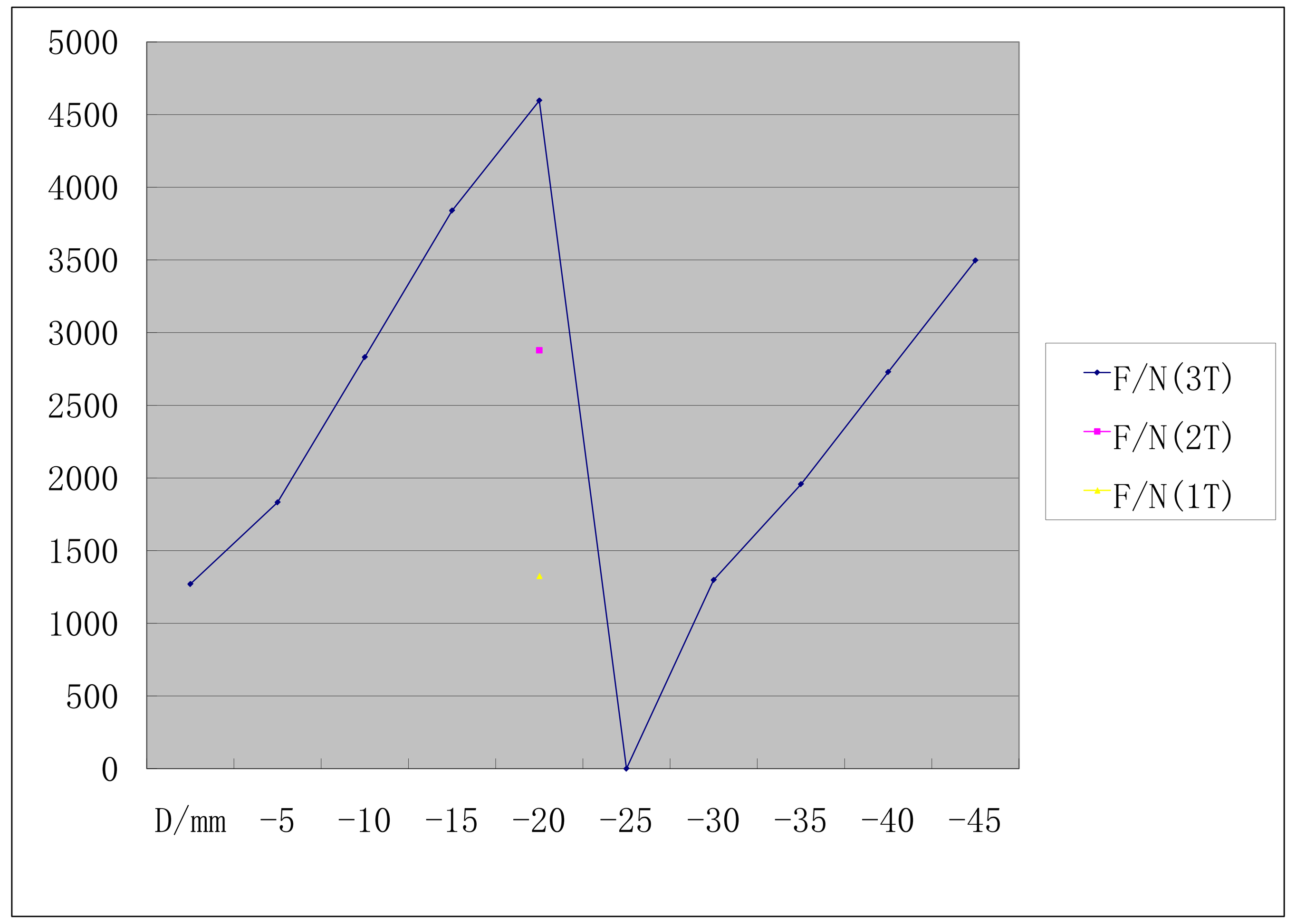


When the running current is 45.126A, the center of magnetic field can be as high as 3T, and the maximum magnetic field can reach 3.7T.

Magnetic energy storage is 168kJ.

Total inductance of magnet is about 163H.

The Force Analysis of Stainless Steel Orifice Plates



orifices on orifice plates are ignored when modeling, the result is slightly larger.

the maximum magnetic force, F_0, reaches up to 4500N, when magnetic induction intensity in key area, B_0, is 3T. Even though B_0 drop to 1T, F_0 is still over 1250N, which means that it is quite difficult to push orifice plates.

In our system, the position we put or take the orifice plate is about 30cm from one side of the room temperature bore, and the force of take the orifice plate away is only about 158 N, which means that it is easy to operate.

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