Study On Magnetic Seal Technology of Ash Unloading Device with Impeller of EPS

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Abstract: The seal problems of ash unloading device with impeller under hopper are very common and important to the successful operation of an electrostatic precipitator. Hoppers become plugged and air ingress causes collected ash to re-entrain resulting in increased emissions, and these rigid seals are subjected to excessive wear and need frequent replacement.

This paper discusses an advanced powder magnetic seal design that installs permanent magnets at the top of vane and utilizes the magnetism in the Fe_3O_4 in fly ash to seal the space between the vanes and the walls. The device does not wear and does not need frequent replacement, and the pressure of air seal can be 50kpa.

1. The Analysis of The Element of Fe and The Magnetic Particles in Fly Ash

1.1 The Contain of Fe and The Form of The Mineral

The main chemical complement in fly ash can be classified into two categories. One is SiO_2 and Al_2O_3, the other is iron oxide, free carbon, MgO and K_2O. And because of the different burning coal, coal texture, the types of the boiler, burning rule and dedusting way in the different power plant, in fly ash there is different content of the elemental complement. In China, the content of Fe in fly ash ranges from 1.5% to 15.4%, it exists in the form of the mineral Fe mostly. This is because that the main Fe mineral, carbon and carbon monoxide play reactions during the course of the boiler burning, it forms Fe_3O_4 and Fe_2O_3, these newly oxidation of Fe and the newly formed beaded glass link together, form the pearl riched Fe whose shape like sphericity. In fly ash the mineral contained Fe mainly consists of magnetite, pyrite, hematite, siderite and limonite, which form solid fusing particles. These fine particles in minerals contained Fe almost have the magnetic property. The categories of minerals in fly ash mainly are beaded glass, quartz powder, carbon powder and magnetic pearl, whose content are more than 90%. In fly ash the content of magnetite pearl is to 7%, the others like troilite, chileite and some of iron or hematite have the characteristic of paramagnetism. It is interpreted that the specific weight of magnetic particles in fly ash is available for seal using magnetic field. And the content of Fe, mineral composition and Fe's states in fly ash of some power plants in China are shown in the followed two tables.

Table1. The Content of the Fe in Fly Ash in Some Power Plants of China

Plant name	Coal	Content of Fe in fly ash ashes(computed in Fe_2O_3)(%)

Liaoning power plant	Pingzhuang coal	10.0—14.0
Qinghe power plant	Tiefa coal	11.83
Datong power plant	Datong coal	8.81～16.5
Wulashan power plant	Wuda coal	19.04
Xuzhou power plant	Ganlin coal	17.80
Jinzhushan power plant	Anthracite	20.04
Jixi power plant	Jixi coal	15.00
Jinin power plant	Zaozhuang coal	20.40
Baoding power plant	Xishan coal	5.19
Tangshan power plant	Kailuan coal	7.82
Hushi power plant	Zhunger coal	5.12
Taiyuan No. 2 power plant	Datong coal	6.92

Table2. The Mineral Composition and Fe's States in Fly Ash of Some Power Plants in China

Mineral name	Content%	Mineral name	Content%
beaded glass	45～55	Fe element	0.07~0.21
quartz powder	16～22	Cu element	trace
carbon powder	10~15	galenite	trace
magnetic pearl	6~7	zinc blende	trace
magnetic powder	0.3~1.2	brucite	3~4
troilite	0.8~1.0	iron pyrite	0.7
Chileite, hematite	0.2	ampelite	trace
ferrosilicon oxide	0.5	rutile	trace

1.2 The Characteristics of Magnetic Powder in Fly Ash

Fe is deoxidized to roemerite in part, and the other is deoxidized to magnet by carbon and carbon monoxide although it is un-magnetite under the condition of existing C and CO and the temperature is about 1400 □ when the coal is burned in boiler . The magnetic powder, **which is the beaded glass richened Fe**, which owns the darker appearance, heavier density, and it is paramagnetic so that it can be separated from the close-grained beaded glass by magnetic choice. The magnetic powder supplies the seal probability through magnetic force for powder, and the content and the magnetization rate effect the seal.

1.2.1 The Element Composition and Form of Magnetic Powder

The element composition of magnetic powder lies in the mineral composition of the coal. More than 60% content in it is Fe_2O_3 and Fe_3O_4, about 30% SiO_2 and Al_2O_3□ and about 3%--5% CaO and MgO.

The magnetic powder in fly ash is constitute of magnetite, aerosiderite meteoric iron and chileite. The magnetite, that is Fe_3O_4, belongs to ferrous magnetic mineral. While the

hematite, that is Fe_2O_3, has two kinds of transform: one isα—Fe_2O_3, which is un-magnetic, and the other isγ—Fe_2O_3, which is magnetic. And the content of α—Fe_2O_3 andγ—Fe_2O_3 in hematite lies in the burnt temperature of boiler. α—Fe_2O_3 is half-baked diamagnetic mineral whileγ—Fe_2O_3 is ferrous magnetic mineral. The categories and content of Fe element in fly ash of different power plates are different with the variety of flame's temperature in boiler. At first, Fe_3O_4 is oxidized toγ—Fe_2O_3, or eutectic mixture containedγ—Fe_2O_3 and Fe_3O_4, then it transformsα—Fe_2O_3. And after the temperature exceeds 1400□, Fe_2O_3 transforms Fe_3O_4.

1.2.2 The Physical Characteristics of Magnetic Powder

Table 3 shows the physical characteristic of magnetic powder in some power plants in China. From the table a conclusion can be drawn that true density and heaped density of magnetic powder are greater than those of fly ash. This is due to the abundant Fe element in magnetic powder. In this table, it can be seen that the number of particles whose granularity are less than 75μm is more than 50%. It shows that the particle diameters of magnetite are finer and the particles are close-grained. The content of Fe element is more than 95% in fine magnetic powder, and it owns the high specific magnetization rate(about 59.70□ 72.30cm^3/g, which is close to the specific magnetization rate of magnetite.) As a result, the characteristic of magnetic powder is available to seal in magnetic field.

Table3. The Physical Characteristics of Magnetic Powder in Some Power Plants in China

Plant name	True density (g/cm^3)	Heaped density (g/cm^3)	Contain of magnetic matter(%)	Specific magnetization rate (cm^3/g)	Contain of matter whose granularity is less than 75μm (%)
Jixi Power Plant	3.50	1.80	97.2	5.40×10^{-2}	59.70
Fushun Power Plant	3.70	1.86	97.5	7.85×10^{-2}	60.04
Zouxian Power Plant	3.62	1.77	97.0	6.30×10^{-2}	70.21
Shiliquan Power Plant	3.45	1.70	96.0	6.44×10^{-2}	66.40
Tangshan Power Plant	3.64	1.83	95.3	5.60×10^{-2}	72.30
Zhuzhou Power Plant	4.02	1.86	96.7	6.50×10^{-2}	63.50
Baoding Power Plant	3.60	1.75	96.6	7.00×10^{-2}	70.05

Fly ash is divided into several categories through a sieve according to granularity in order to

investigate the material content of Fe element under different granularity. The result is that the content of Fe heightens when the granularity of fly ash minishes, that is, the magnetic matter is primary in the fine magnetic powder, while other elements are abundant in the coarse fly ash. For the magnetic seal, the finer the granularity of powder , the better the seal layer . The fine magnetic powder is easy to collect the finer power in the operation of magnetic force and it can reduce the airvoid ratio of the whole seal layer, so it's useful for seal.

1.3 The Magnetic Domain Analyse of Magnetic Particles

The magnetic powder, as a kind of ferrous magnetic mineral, owns greater coercive force and remanence. The magnetism of matter roots in atom's magnetism. There is an exchanging function that is rooted in the static between the electrons bordered on the same atom in microstructure, which is called spontaneity magnetization, and it can force every atom's magnetic torque to parallel or un-parallel. The effect of function makes every atom's magnetic torque attain magnetic saturation in the same direction within little district. This district is called the magnetic domain and this is the essential reason that the magnetic matter produces the magnetism. Magnetite belongs to cubic system and un-spinelle type structure and its magnetic torque is permanent. Synchronously, there is the characteristic of ferrous magnetic mineral.

1.3.1 The Connection between Coercive Force of Magnetic Particles and Granularity

Figure 1 shows the connection between coercive force of magnetic particles and granularity. From the figure, a conclusion can be drawn that the remanent coercive force of the magnetite (Hc) increases with the granularity's reduction. The coercive force raises rapidly when the granularity becomes great finer because there is magnetic domain structure inside the magnetite, and it is very important to move the magnetic domain's rampart when magnetizing. But the rotation of the magnetic domain improves with the granularity's reduction. Synchronously, the energy that the rotation of domain needs is more than the one that the moving of the magnetic domain's rampart needs. The result is that the coercive force increases, even rapidly with the granularity's reduction.

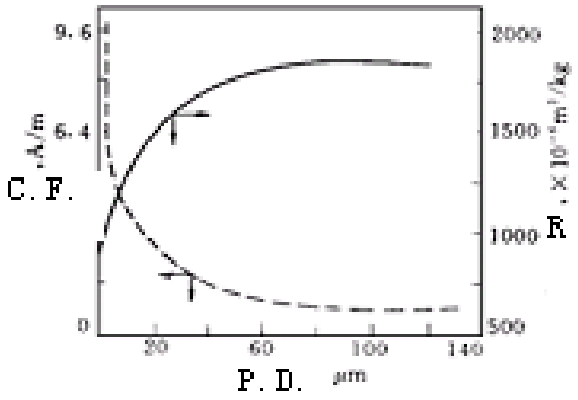


Figure1. The Connection between Coercive Force of Magnetite and Granularity

1.3.2 The Study on Distributing Formula about The Field of Magnetite Particles

The magnetite particles can polymerize based on the field founded by the magnetite particles around them after they are magnetized. So it's necessary to study this field.

A magnetite particle and its field created are investigated. This particle is considered spherical, the radius as R_0, which is put into another field whose intensity is H_0. This particle is magnetized equably and the intensity of magnetization（M） is fixed on H_0. Figure 2 shows the connection.

The magnetic potential can describe the inner and outer field of magnetic particles and Laplace equation is:

$$\nabla^2\varphi_1=0,\ \nabla^2\varphi_2=0 \qquad (1)$$

(φ_1 and φ_2 are the inner and outer magnetic potential of the particle respectively)

There is a connection on the spherical surface($r=R_0$)：

$$H_1\theta = H_2\theta \text{(or } \varphi_1=\varphi_2) \qquad B_{1r}=B_{2r} \qquad (2)$$

We know the outer intensity of magnetic field of magnetite particle is:

$$\vec{H} = \vec{H}_r + \vec{H}_\theta \qquad (3)$$

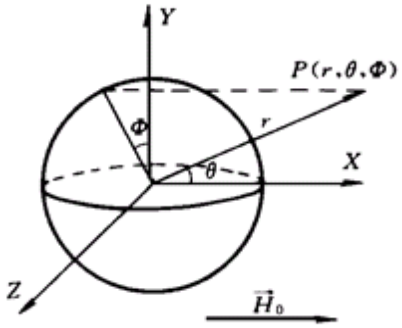


Figure2. The Connection between Coordinates of The Particles and Outer Magnetic Field

$$H_r = -\frac{\partial\varphi_1}{\partial r} = H_0\cos\theta + \frac{2MR_0^3}{3r^3} + \frac{2MR_0^3}{3r^3}\cos\theta \quad \frac{\partial H_r}{\partial r} = -2M\frac{R_0^3}{r^4}\cos\theta \qquad (4)$$

$$H_\theta = -\frac{1}{r}\frac{\partial\varphi_1}{\partial r} = -H_0\sin\theta + \frac{MR_0^3}{3r^3}\sin\theta \qquad \frac{\partial H_\theta}{\partial r} = -M\frac{R_0^3}{r^4}\sin\theta \qquad (5)$$

We can only consider the point $P_0(r,0,\varphi)$ which is in a specific direction ($\theta=0$) and draw the conclusion based on (2)、(4)：

$$H = H_0 + \frac{2MR_0^3}{3r^3} \quad , \quad \text{gradH} = -2\text{M}\frac{\text{R}_0^3}{\text{r}^4} \qquad (6)$$

When there is no outer magnetic field, the magnetite particles create the field depended on remanence and the intensity of magnetic field is:

$$H_r = -\frac{\partial\varphi_{(r)}}{\partial r} = \frac{2}{3r^3}M_rR_0^3\cos\theta \quad , \quad \frac{\partial H_r}{\partial r} = -2M_r\frac{R_0^3}{r^4}\cos\theta \qquad (7)$$

$$H_\theta = -\frac{1}{r}\frac{\partial \varphi_{1(r)}}{\partial \theta} = \frac{1}{3} M_r \frac{R_0^3}{r^3}\sin\theta \quad , \quad \frac{\partial H_\theta}{\partial r} = 0 \tag{8}$$

There is the connection in the spot of the point Po(r,0,φ):

$$H_r = \frac{2}{3r^3} M_r R_0^3 \quad , \quad \mathrm{gradH_r} = -\frac{2}{r^4} M_r R_0^3 \tag{9}$$

From the deductive formula, it can be concluded that there exists the linear proportion relation between granule's exterior magnetic field intensity and magnetization intensity (direct ratio to the granule's radial cube, inverse ratio to the distance cubed to the surface of granule). The magnetic field of granule has inverse ratio to the fourth power of the distance and the others are the similar.

Through the analysis of the magnetic domain of magnetic powder, it's suggested that the particles owed lesser granularity have bigger coercive force and endure greater magnetic field force. They can form close-grained trees structure in magnetic seal equipment that can absorb smaller granule. With the time going, there comes into being a close-grained rampart in the magnetic seal clearance that can work for seal effectively.

2.The Configurable Theory about The Ash Unloading Device For Magnetic Seal

At present, the electrical lock-gas device is sealed at the end of the impeller by installing end pressure plates and seal strips（such as the felt strip） which can be dismantled and exchanged at the top of the impeller of the rotor in mostly power plants at international range. When the impeller is running, the felt strip can contact with the shell of machine at the state of friction in order to prevent leaking air. But the felt strip is easy to be worn out, so other materials such as polytetrafluoroethylene or rubber which is able to endure abrasion were used to replace it. But, this method of seal has connatural shortcoming:

(1)because the seal ring or the felt strip directly contact with the cliff of the lock-gas device， so the abrasion is relatively serious and the resistance is great. After a period of time, the seal ring will be worn out, and the capability of seal will become weak. In the end, the air leaked will influence the normal operation.

(2)Because the natural life of the lip seal ring made of rubber and the felt strip is not long, the work-load of backout and replacing is very great which bring great discommodity to the industrial automation. Therefore, the settlement of problem about the seal of electrical lock-gas device has important practically meaning in the industry.

2.1 The Designing Principle of The Ash Unloading Device for Magnetic seal

Take the ash from firepower plant as an example, and fly ash has its own features as follows.

- It is dry, so the oil or water seal cannot be used.
- Because a strong friction between the ash and the shell makes a severe abrasion, it is unsuitable to adopt mechanical seal.
- For the presence of "reverse pressure", gas seal is also unsuitable.

For the reasons mentioned above, the present sealing methods couldn't satisfy the need of equipment running. The fly ash contains some magnetic mineral that could be adsorbed into the sealing clearance under the magnetic field force, so the sealing function could be fulfilled by a permanent magnet that is installed on the end of impellers.

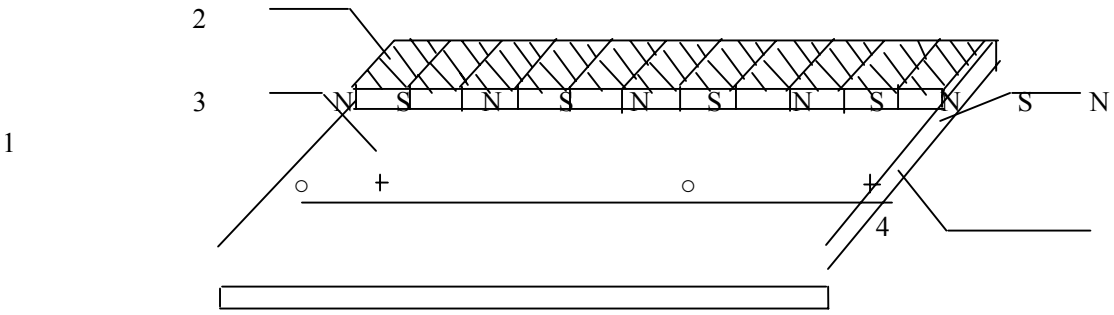
The coal-burning fly ash in good fluidization distributes its stocks granularity at the

range of 10～100μm, most importantly, the fly ash contains iron mineral that will form magnetic powder with other minerals and the powder has strong paramagnetism. Simultaneously, other metal oxide with the spinel structure has some extent of magnetic performance. So the magnetic field could be used to seal impellers of the electric lock-gas device.

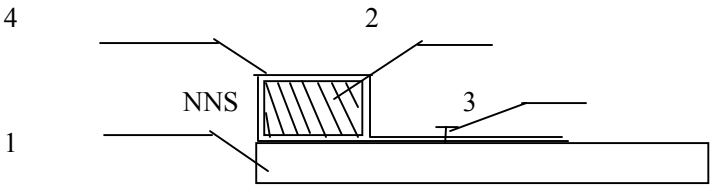
2.2 The Structure Principle about The Ash Unloading Device for Magnetic Seal

The ash-unloading device for magnetic seal is modified on the basis of the conventional electric lock-gas device. The sealing is fulfilled by a permanent magnet installed on the end of impeller. The permanent magnet is arrange by a certain compound mode, and fixed on the end of impeller by bolts and metal clamp. Meanwhile, the metal clamp encloses the permanent magnet. This structure also has the function to protect the permanent magnet from abrasion and other solid matter that may damage the magnet during operation.

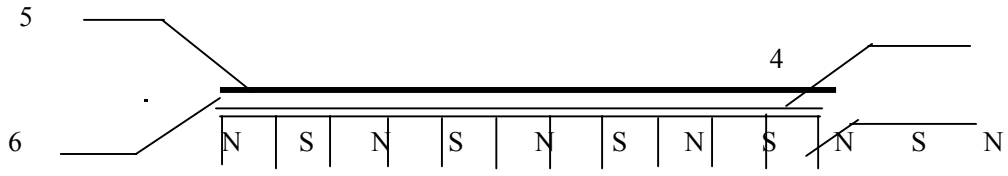
The row material of metal clamp could be the stainless steel sheet, copper sheet or aluminum plat with good resistance to abrasion. These metals belong to non-magnetic substance, so the magnetic circuit couldn't be influenced. The rotor impeller is driven by motor, and the permanent magnet on the end of impeller absorb the magnetic particle from the fly ash and form a seal course that could be self-repaired during the rotation to make sure the leak tightness of the device. See the assembly method of permanent magnet from the figure 3 .



The Assembly Over Look View of Permanent Magnet Material



The Assembly Side View of Permanent Magnet Material (1)



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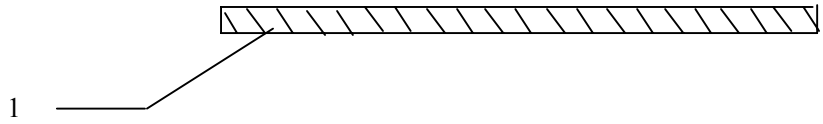


The Assembly Side View of Permanent Magnet Material (2)

Figure3. The Assembly Figure of Permanent Magnet Material

1 The impeller of electric lock-gas device 2 Permanent Magnet Material

3 The fixed bolts 4 The fixed metal clamps

5 the inner shell of lock-gas device 6 the ash layer locked

When being installed, the N pole and S pole of permanent magnet are arranged in the alternate way, and form an opening magnetic system with parallel arrangement, see figure 3-3.Magnetic lines of flux start from N pole to S pole to form a close circuit. Due to the lock-gas device is made up of casting iron, it also induces magnetic pole under the effect of magnetic field force. Magnetic lines of flux mainly concentrate in the magnetic pole and the sealing clearance, so the intensity of magnetic field is relatively uniform. This arrangement of permanent magnet makes it uneasy to form air chambers in the seal course, and it is advantageous for sealing because the seal course bears uniformly under the action of pressure force.

3.The Experiments of The Seal Capacity of Ash Unloading Device

3.1 The Experimental Facility

As the figure 4 shows, the experimental facility consists of the revamped electric lock-gas device and pneumatic conveyer equipment. The impellers of the electric lock-gas device are machined and the clearance distance is 5 mm between the impellers and the inner shell. The top of the impellers is equipped with the permanent magnets, so the clearance distance can be adjusted. The fly ash can be fitted into the facility through the hole of rubber plug(6) on the top self-made ash bucket. During the course of experiments, we can seal up this facility by rubber plug in case of gas leakage. The exhaust pipe can pick positive or negative pressure pneumatic conveyer equipment up. The numerical reading of the manometer can proof the seal effect.

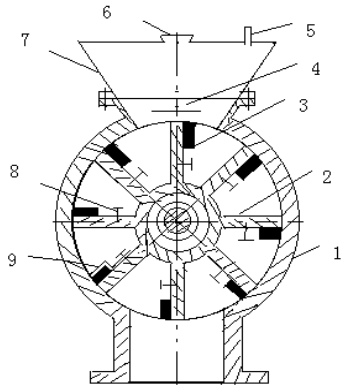


Figure4. The Design Drawing of The Seal Device Used Magnetic Powder

1.The outer shell 2. The impeller 3. Permanent magnet 4. The feed inlet
5. The exhaust pipe (connect with the conveyer equipment) 6 .Rubber plug
7.Ash bucket 8.The fixed blot 9.The fixed metal clamps

3.2 The Method of Experiments

The sealing pressure under the static conditions is measured under the laboratory condition. The methods are as follows:

1) Figure 3—1,3—2: according to the experiment demands for clearance distance, we fit the permanent magnet, adjust the position of the fixed blots, and make the proper distance between the electric lock-gas device's shell and the permanent magnet. Connect the gas circuit devices.

2) Cover the feed outlet with the clamps. Inject the fly ash from the feed inlet. Running the rotating shaft some times, make the permanent magnets absorb the magnetic powder in the fly ash and then form the seal course. Use the rubber plugs plug the feed outlet, and use the lock ring and flange seal the rotor shaft to prevent the air from leaking.

3) Switch-in the air compressing machine EC51, store some pressured air, and connect the gas circuit.

4) Open the gas circuit valve, adjust the air input, inject the pressured air into the device slowly, and write down the reading of the manometer when fly ash ejects from the feed outlet. Because the seal course will be destroyed when the pressure in the device is greater than this reading, so this numerical reading is the maximum that the seal course can be borne.

5) Open the rubber plug, inject the fly ash again and continue to experiments under other conditions.

The fly ash used in this experiments is collected from the ash bucket of ESP in a power plant of China. The physical-chemical characteristic as follow:

Table4. The Chemical Constitution of Experimental Fly Ash of Power Plant

Constitution	C	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Aggregation
Content（%）	6.5	53.85	29.44	5.19	2.24	1.05	95.98

heaped density： 0.75g/cm^3 true density： 2.0 g/cm^3

the content of magnetic powder： 7% magnetic susceptibility： 7.00×10^{-2}cm^3/g

The parameters of permanent magnets made of Nd-Fe-B:

permanent-magnet1： 13×9×7 (mm) surface magnetic flux： 4650Gs

permanent-magnet 2： 5×4×13 (mm) surface magnetic flux： 3000Gs

permanent-magnet 3： 8×8×16(mm) surface magnetic flux： 2700 Gs

Adopting the fly ash and permanent-magnets as above, we had the different experiments under the different seal interval and height of fly ash.

3.3 The Result of Sealing Experiments

Table5. Sealing Pressures of Different Height of Fly Ash When Sealing Clearance Is 1 mm

Magnet	Uninstalled	Magnet 1	Magnet 2	Magnet 3

Height of fly ash (cm)	（Mpa）	（Mpa）	（Mpa）	（Mpa）
0	Non-pressure output	0.015	0.005	0.008
5	Non-pressure output	0.020	0.008	0.010
8	0.002	0.025	0.012	0.015

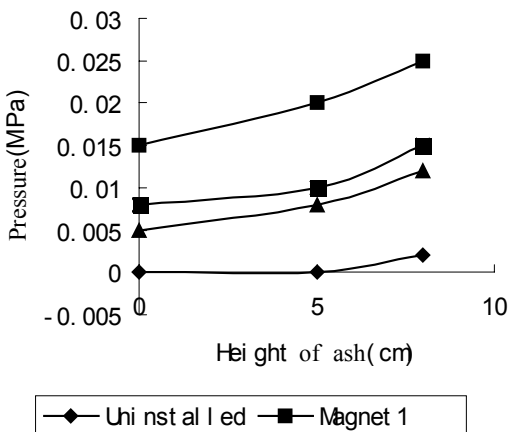
Table6. Sealing Pressures of Different Height of Fly Ash When Sealing Clearance Is 2mm

Magnet / Height of fly ash (cm)	Uninstalled （Mpa）	Magnet 1 （Mpa）	Magnet 2 （Mpa）	Magnet 3 （Mpa）
0	Non-pressure output	0.010	0.003	0.006
5	Non-pressure output	0.015	0.005	0.008
8	0.001	0.022	0.011	0.013

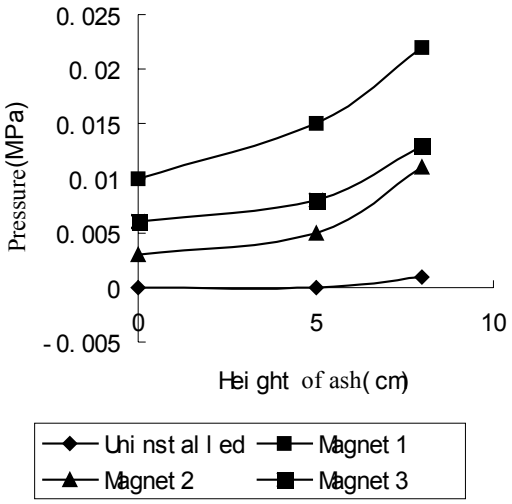
Table7. Sealing Pressures of Different Height of Fly Ash When Sealing Clearance Is 3mm

Magnet / Height of fly ash (cm)	Uninstalled （Mpa）	Magnet 1 （Mpa）	Magnet 2 （Mpa）	Magnet 3 （Mpa）
0	Non-pressure output	0.008	0.002	0.005
5	Non-pressure output	0.012	0.004	0.010
8	Non-pressure output	0.018	0.008	0.015

The Tendency of Airproof Pressure When Sealing Clearance Is 1mm



The Tendency of Airproof Pressure When Sealing Clearance Is 2mm


0. 025
0. 02
0. 015
0. 01
0. 005
0
- 0. 005
Pressure(MPa)
0
5
10
Hei ght of ash(cm)
Uni nst al l ed
Magnet 1
Magnet 2
Magnet 3

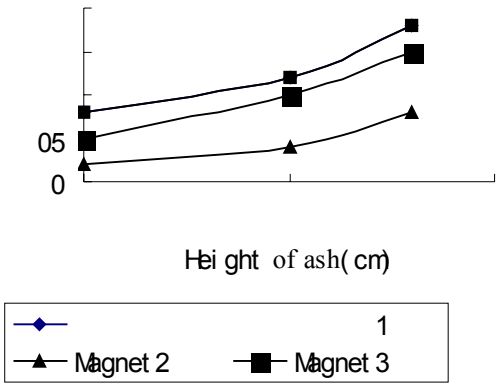


Figure5. Sealing Pressure of Different Sealing Clearance and Different Height of Fly Ash

According to the data and figure above, although there is some powder on the vane, the airflow will still penetrate the sealing layer through the edge of airframe or the bubbles inside the powder because of the powder fluidization. Therefore, the sealing layer will be destroyed, and there will be no reading of pressure for manometer to determine when magnet is uninstalled. Once magnet is installed, the sealing layer will be formed and sealing function will work. The data on the manometer will increase when the thickness of sealing layer increases. There are two factors to bring the pressure:

- The sealing layer formed by magnet has sealing function, which can endure some pressure.
- The thickness of layer also has some effect on the sealing pressure, obviously, the thicker the lay is, the bigger pressure is, which show an linear proportion relation between them.

When there are some particles above the ash bucket, some particles owning weak magnetism will fall off under the force of air current, while others owning strong magnetism will be absorbed to the pole of magnet under the magnetic force, which makes the ability of self-repairing of the sealing layer increase and the magnet can exert its function fully. When the thickness of layer is zero, the pressure measured will be very little because the sealing layer does not develop fully, but the computational value through theory is adjacent to the measured one when the thickness of layer is 5cm. Though the particle layer can give birth to pressure, yet thickness of layer is not the important factor that produce sealing pressure, because the particles can be fluidized and the pressure endured is very little. From the experiment without magnet, it is concluded that the thickness of lay merely makes the capacity of self-repairing of the sealing layer increase, and it is the magnetic force imposed on the particles by the magnet that plays an very important role on the seal.

3.4 The Comparison of Sealing Performance of Fly Ash Contained Different Content of Magnetic Powder

Powder magnetic sealing technology has a premise that there must be some magnetic powder in the sealing medium. The content of magnetic matter in different powder is various and it has some influence on the sealing performance. we made sealing experiments about Magnet 1,2 and 3 with different content of magnetic powder. Powder is made by fly ash of Baoding heat power plant and magnetic material(Fe_3O_4).There are four kinds of powder whose content of magnetic powder is 7%,9%,12% and 15% respectively. The sealing clearance is 1mm and the thickness of layer is 5cm.The experimental data is shown in the figure 6 below.

Table 8 Sealing Experiment with Different Content of Magnetic Powder in Powder

Content of magnetic powder / Sealing type	7% （Mpa）	9% （Mpa）	12% （Mpa）	15% （Mpa）
Magnet 1	0.020	0.025	0.028	0.030
Magnet 2	0.008	0.012	0.015	0.017
Magnet 3	0.010	0.015	0.018	0.020

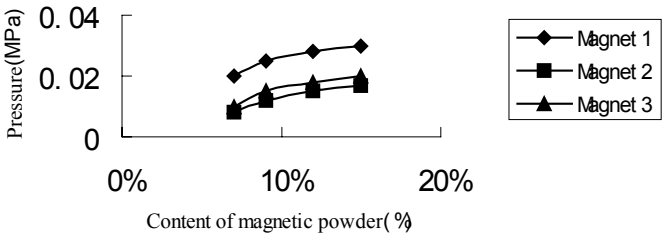


Figure6. Sealing Experiments with Different Content of Magnetic Powder

According to the experimental data and the tendency of sealing pressure, the sealing pressure measured increases with the content of magnetic material in powder increase, but when the content of magnet powder increases to a certain value, the increasing tendency will slow down. It is because sealing layer becomes saturated under certain magnetism when the content of magnet powder increases to a certain value. And then, the increase of the content of magnet powder has a little effect on the sealing performance and the curve becomes smooth. If there is a relative stronger magnetic force, the powder layer absorbed may become thicken, which increases more resistance to the equipments and causes an increase of cost of magnet and also may impose adverse effects on the equipments. Therefore, to minimize the equipment expenses and maximize the profits under the condition of settling the sealing requirement, it is necessary to confirm all the parameters about magnet though theoretical analysis and experiments.

3.5 The Adaptability of Magnetic Sealing of Ash Unloading Device

As a new powder sealing technology, powder magnetic sealing has an overwhelming advantage over others. Besides application to the seal of coal powder, there are also many other

applications about the transportation of powder in industries, such as cement and chemical etc. These powders contain magnetic materials in different degree. For example, coal powder and cement contain some magnetic powder, and the magnetic powder has the small granularity and some magnetic intensity simultaneity. So we could make the magnetic powder filled in the clearance between impellers and airframe under the magnetic force and solve the problem of seal of the whole equipment though magnetic method.

4. Conclusion

Experiment prove, in the operation of magnetic force, the powder contained magnetic matter is small, such as fly ash, and the gap among particles is also little, so the gas compact capability is very good. The magnetic powder has strong capability of automatic recovery. The magnetic body can attract magnetic particles continually from fly ash, even if a part of the powder block drop out when the equipment operating. So, the powder magnetic seal design that installs permanent magnets at the top of vane and utilizes the magnetism in the Fe_3O_4 in fly ash to seal the space between the vanes and the walls. And the device does not wear and does not need frequent replacement.