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Study on the action law of key influencing factors of magnetic field strength of magnetic filter material

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Abstract. In recent years, the application of magnetic field technology in the field of water treatment has been relatively mature. The common ways of adding magnetic field are external magnetic field and internal magnetic powder. In order to solve the problem of uneven distribution of magnetic field caused by external mode and easy loss of magnetic powder caused by internal injection mode, this paper studied a preparation method of magnetic filter material used in biological filter tank, and studied the key influencing factors such as composition, particle size, magnetization time and times that affect magnetic field strength of filter material. The results show that the nanometer Fe_3O_4 content has a great influence on the magnetic field strength of the magnetic filter material. When the content is 16.6%, the magnetic field strength of the filter material is the best. The larger the particle size of the filter material is, the less the magnetic structure of the surface magnetization vector is not collinear, and the higher the internal coercivity is, the higher the magnetic field strength of the filter material is. The magnetic field intensity of the filter material increased gradually with the extension of magnetization time, and basically became saturated after 60min. Repeated magnetization can improve the initial magnetic field strength of the filter material, but has little effect on the stable magnetic field strength after magnetic recession.

1. Introduction

In recent years, studies have shown that magnetic fields affect the activity of enzymes in biological populations, which in turn affect the metabolic responses of organisms. Therefore, the application of magnetic field strengthening technology in water treatment can help solve the efficiency problem of water treatment, and the combination with magnetic field technology can achieve the purpose of reducing energy consumption, energy conservation and emission reduction. Some studies on biological effects of magnetic field in the field of water treatment are as follows. Geng shuying et al. [1] found that external magnetic field could effectively improve dehydrogenase activity. Niu chuan et al. [2] found that the magnetic field could shorten the start-up time of the bio-anaerobic reactor, and in addition, the magnetic field of shan jun et al. [3] could induce the enrichment of biological population, thus improving the effect of sewage treatment. Therefore, it is necessary to study the magnetic field technology in water treatment.

In the research literature, there are two common ways of adding magnetic field: external magnetic field and internal magnetic powder. However, it is found in the test operation that the distribution of internal magnetic field in the external magnetic field is uneven and the abundance of biological population is not good. There are some problems in the way of internal magnetic powder, such as easy loss of magnetic powder. In order to further improve the processing efficiency, it is necessary to



optimize the magnetic field in the reactor. The use of a fixed bed to load a magnetic material on the filter material to prepare a magnetic filter material is expected to achieve a uniform distribution of the magnetic field on the basis of reducing the loss of the magnetic powder, and the magnetic filter material can simultaneously serve as a biological carrier to increase the biomass and thereby improve the water treatment efficiency. At present, it is found that increasing the intensity of magnetic field is helpful to increase the abundance of biological population in the reactor, so as to improve the efficiency of sewage treatment. In order to improve the magnetic strength of filter materials, the composition and types of magnetic materials are studied as follows. Li zhanfu et al. [4] found that the addition of active metal elements such as Ca, Al and Cu could protect the magnetic phase in the firing process, thus improving the magnetic strength of the material. Sun Shaowu [5] study, such as adding nanometer Cu fire protect α -Fe and tempering process, so as to improve the magnetic orientation degree. Liu weiqiang et al. [6] added Cu content of 0.25wt%, the remanence and maximum magnetic product energy reached the maximum. To sum up, we added 0.25wt% of nanometer copper into the magnetic material, which is conducive to the protection of magnetic properties, so as to achieve the best magnetic field strength of the filter material. In addition, it has been found that strong magnetic materials, such as neodymium iron boron magnetic powder, can make compounds have high saturation magnetization [7-10]; while magnetic nano Fe_3O_4 has better superparamagnetism and larger specific surface area and its Metal ions, phosphorus, ammonia nitrogen and humic acid have good adsorption properties [11]. It can be seen that the above two materials are beneficial to increase the magnetic field strength of the filter material, so it is proposed to use NdFeB magnetic powder and nano Fe_3O_4 as main components. Wei ding et al. [12] studied the static magnetic properties of iron, silicon and aluminum powder with different particle sizes. Wang zhiwei et al. [13] studied the magnetic effects of different particle sizes and Fe_3O_4 contents on magnetic adriamycin verapamil protein nanoparticles. Zhang dong et al. [14] studied the influence of different magnetization times on residual magnetic field intensity. Li jiawei et al. [15] studied the effect of magnetization times on the magnetic field captured by YBCO superconductor.

It can be seen from the above that magnetic nano- Fe_3O_4 content, particle size, magnetization time, magnetization times and other factors are several key factors affecting the magnetic field strength of magnetic filter materials. However, the above literature does not simultaneously analyze how the four key factors affect the magnetic strength of the filter material. Therefore, this paper intends to explore the magnetic law of four key factors and study the best method for preparing a new magnetic filter.

2. Materials and methods

2.1. Test materials and equipment

Materials: 49.8g-59.8g LW-N bonded NdFeB magnetic powder (accounting for 49.8%-59.8% of the total composition), 6.6 g - 16.6 g of nano- Fe_3O_4 magnetic powder (accounting for 6.6% - 16.6% of total composition), 33 g of type 425 - ordinary Portland cement, 0.2 g of 20 nm copper powder and 0.4 g of pore former NaCl. The processing flow of high score data and its application, and makes evaluation and analysis.

Equipment: 1mm, 2mm, 3mm, 4mm, 5mm hole mesh, GZX-9140MBE electric blast drying oven, KSY-12D-18 muffle furnace, BSA124S electronic weighing balance, ELE-P80/38 electric suction cup, 17D3005D12007 DC power supply and CH-HALL multi-dimensional magnetic field testing system.

2.2. Preparation and magnetization of filter materials

2.2.1. Preparation Process. First, nano- Fe_3O_4 magnetic powder with a content of 6.6%-16.6%, 49.8%-59.8% NdFeB magnetic powder, 33% model 425-silicate cement, 0.2% nano copper powder, 0.4% NaCl were mixed evenly. It is dried at 105° C and hand-sprayed into pellets. Next, use 1mm, 2mm, 3mm, 4mm, 5mm perforated mesh mesh to separate spherical filter materials with different particle sizes. Then, the filter material is placed in the alumina ark and fired at high temperature in a

muffle furnace. The first stage is heating and the second stage is tempering process to fire filter material at high temperature. Finally, it is raised to 1000°C by the first-stage heating process, and after natural cooling, it is heated again to 900°C through the secondary tempering process, cooled down to room temperature. The whole process is finished.

2.2.2. Method and process of magnetization. The 12V, 1A electromagnet is connected to a DC current and is tested by the CH-HALL multi-dimensional magnetic field test system. The surface of the electric chuck produces a magnetic field strength of approximately 50mT. The fired magnetic filter material is placed on the electric chuck for magnetization. The magnetization time gradient ranges from 20min to 40min, 60min to 80min. Magnetization frequency range: 0, 1, 2, 3.

3. Results and discussion

3.1. Effect of nano- Fe_3O_4 content on magnetic field strength of magnetic filter

The nanometer ferroferric oxide with different gradient contents was added by the above preparation method. After the magnetization time was 60 min under different particle size conditions, the magnetic field strength of the single magnetic filter material was tested by CH-HALL multi-dimensional magnetic field test system. The results are shown in figure 1.

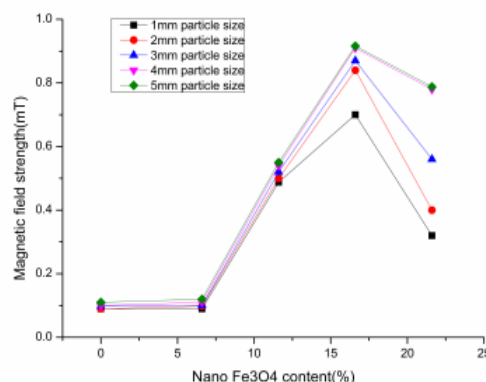


Figure 1. Effect of the content ratio of nano- Fe_3O_4 on the magnetic properties of the filter material (the content of other materials is fixed, the magnetization time is 60min)

The figure above shows the effect of nano- Fe_3O_4 on the magnetic field strength of magnetic filter materials under different particle size conditions. When the content of nano- Fe_3O_4 is 0 or 6.6%, there is no significant increase in the magnetic field strength. However, when the content of nano- Fe_3O_4 was increased to 11.6%, the magnetic field strength was significantly increased compared with 6.6%. The content was increased again, and when it reached 16.6%, the magnetic field strength at each particle size reached the optimum state. Once again, the magnetic field strength begins to decrease. When the content of nano- Fe_3O_4 is increased to 16.6%, the nano-scale Fe_3O_4 magnetic powder can be filled with micron-sized NdFeB magnetic powder, so that the filter material becomes very dense. During the firing process, the demagnetization of the NdFeB is more obvious than that of the nano- Fe_3O_4 .

Therefore, the magnetic strength is optimal. The tempering process can protect the partial magnetic properties of the two magnetic materials, and the maximum magnetic product energy and remanence of the nano- Fe_3O_4 are much lower than that of the NdFeB magnetic powder. If the content of nano- Fe_3O_4 is increased again, reaching 21.6%, the magnetic field strength of the filter material will decrease as shown in the figure above. Therefore, when the content of nano- Fe_3O_4 is 16.6%, the magnetic field strength is optimal. At the same time, in the longitudinal observation, with the addition of the same amount of nano- Fe_3O_4 , the magnetic field strength tends to increase with the increase of the particle size, so it is necessary to further explore the law of the change of the magnetic field strength with the particle size.

3.2. Effect of particle size on magnetic strength of magnetic biological filter

The above preparation process and magnetization method were used to test the surface magnetic field intensity of a single magnetic filter material after firing under different magnetization times and particle size gradients with the ch-hall multi-dimensional magnetic field testing system. The test results are shown in figure 2 below.

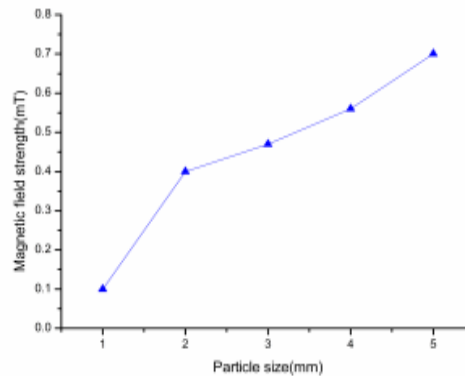


Figure 2. Effect of particle size on magnetic field strength of magnetic filter (content of nano- Fe_3O_4 is 16.6%, magnetization time is 45min)

As can be seen from the above figure, the magnetic field strength increases as the particle size increases. The particle size varies from 1-5 mm and the magnetic field strength increases from 0.1 mT to 0.7 mT. The larger the particle size is, the smaller the specific surface area is, the less the surface magnetization vector is less collinear, the internal coercive force is higher than that of the small particle size magnetic filter, and the residual magnetization is higher than the filter material with small particle size. Moreover, the filter material of the biological filter has a particle size ranging from 3-5 mm. In summary, it is known that the filter material has a particle size of 5 mm, which satisfies the requirements. However, it is clear that in Figure 1, the content of nano- Fe_3O_4 is 16.6%, and when the magnetization time is 60 min, the magnetic field strength reaches 0.91 mT when the particle size is 5 mm, which is significantly higher than the magnetic field strength of 45 min. To this end, we need to further explore the effect of magnetization time on the magnetic field strength of the magnetic filter material when the content of Fe_3O_4 and the particle size are fixed.

3.3. Effect of magnetization time on magnetic field strength

A constant magnetic field is generated when a direct current is applied to the electric chuck for a certain period of time. At the same time, the magnetic powder again acquires magnetism, which has a maximum saturation magnetic field strength. After reaching this limit, the magnetic field strength does not change. Therefore, we need to explore how long it takes to reach the saturation magnetic field strength. Using the above magnetization method, the magnetic field strength of the magnetic filter material after firing was tested by the CH-HALL multi-dimensional magnetic field test system under different magnetization time. The test results are shown in figure 3 below.

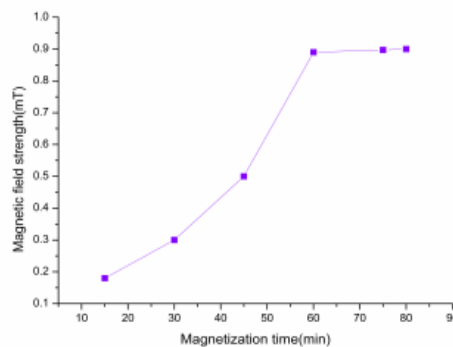


Figure 3. Effect of different magnetization time on the magnetic field strength of the filter material (nano Fe_3O_4 content is 16.6%, particle size is 5mm)

It can be seen from the above figure that the magnetic field strength increases with the increase of the magnetization time when the magnetization time is between 15-60 min. When the time is 60min, the magnetic field strength reaches 0.8mT. After further magnetization for 15min, the magnetic field strength only increases by 0.1mT. At this time, the magnetization time is increased and the magnetic field strength is no longer changed. Obviously, it is because when the magnetic powder is magnetized for 75min, it will be magnetized to reach the saturation state, and at a certain time, when the internal alignment of the magnetic material is finally completely consistent with the external magnetic field, it will be magnetized again and the orientation remains unchanged, so the magnetic field intensity does not change. Considering comprehensively, the magnetic charging time of magnetic biological filter material is 60min.

3.4. The variation of magnetic field intensity of magnetic filter after repeated magnetization

After magnetization, the magnetic powder inside the magnetic filter material will increase with time, and the magnetic field intensity will decrease, resulting in demagnetization. After remagnetization, magnetization and demagnetization also occur. Therefore, we need to study and clarify the law of the residual magnetic field strength of the magnetic filter with time. After the filter material is placed for 2h,4h,6h,8h and 10h in different magnetization times, the ch-hall multi-dimensional magnetic field testing system is used to test the residual magnetic field strength of the filter material at different time points. The results are shown in figure 4 below.

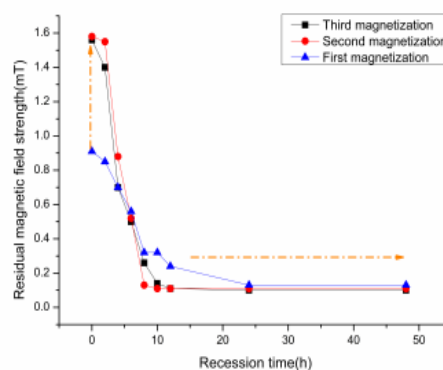


Figure 4. The decay of the magnetic field strength of the filter material after three times of magnetization (nano Fe_3O_4 content is 16.6%, particle size is 5mm, magnetization time is 1h)

After the above repeated magnetization, the curve of each decline in magnetic field intensity is statistically analyzed, and it is found that the magnetic field intensity reached 0.91mT for the first magnetization. But then as time begins to decay, after 24h, the attenuation reaches a steady state, and

the magnetic field strength reaches about 0.13mT. However, after the second magnetization, the magnetic field strength of the filter material suddenly increased, which basically reached 1.58mT, and then gradually declined, and the magnetic field strength eventually attenuated to around 0.1mT. After the third magnetization, the magnetic field curve is basically the same as the second time. Longitudinal comparison, the first, second and third magnetization, the difference in residual magnetic field strength under the same decay time as indicated by the arrow in the figure. In the 0-6h decay time range, the residual magnetic field strength after the second magnetization is basically higher than the first magnetic strength. Magnetization is to place the magnetic material in a strong magnetic field so that the magnetic domains inside the ferromagnetic material are sequentially arranged in a certain direction. When the external magnetic field is removed, the magnetic domains of these substances can maintain the arrangement and have magnetic properties. Because the magnetic filter material is basically demagnetized before the first magnetization under the conditions of high temperature and tempering, the internal coercive force is still present, so the magnetic field strength after magnetization reaches 0.91 mT. Second and third magnetization, because according to the magnetization curve of the magnetic powder inside the filter material, when the magnetization magnetic induction intensity reaches saturated B_m , H_m of the magnetic powder reaches the maximum value, which is in the critical magnetization state and the magnetic field intensity reaches the optimal state.

4. Conclusion

The results show that the nanometer Fe_3O_4 content has a great influence on the magnetic field strength of the magnetic filter material. When the content is 16.6%, the magnetic field strength of the filter material is the best. The larger the particle size of the filter material, the less magnetic structure of the surface magnetization vector is not common, the higher the internal coercivity, the higher the magnetic field strength of the filter material; the increase of the magnetic field strength of the filter material increases gradually with the extension of the magnetic time, and the magnetization is basically saturated after 60min. Repeated magnetization can improve the initial magnetic field strength of the filter material, but it has little effect on the stable magnetic field strength after magnetic decline.

Acknowledgement

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