Study on Preparation and Stability of Coal Water Slurry

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Abstract. The preparation of coal water slurry (CWS) as a new substitute for oil and the factors affecting the stability of CWS were studied in this paper. Dry method was used to prepare CWS. Dry coal water slurry refers to the preparation of CWS by grinding coal into powder, then adding water and additives, mixing and stirring. Preparation process is simple and convenient, and has low technical requirements. There are many factors affecting the stability of CWS. In this paper, the coal-water ratio, mixing time and coal particle size are selected to study, and the effects of various variables on the stability of CWS in a certain range are determined. The final experimental results show that the CWS prepared by mixing for 15 minutes with 65% water, 34% coal and 1% additive is the most stable.

1. Introduction
Coal is widely distributed in North China and Northwest China. Coal resources account for more than 60% of China's energy consumption. However, when coal is used, it is polluted heavily, has a lot of ash and slag, and its heating rate is not high. In view of the above shortcomings of coal, coal water slurry technology came into being. Coal water slurry (CWS), as a new substitute for oil and environmental protection fuel, is being recognized by more and more enterprises. The application of CWS technology can further improve the product structure of coal enterprises and improve the economic benefits of coal enterprises. Coal water slurry technology can also solve the problems of environmental protection and process regulation in some coal-fired enterprises. Therefore, coal water slurry technology is more realistic at present, and it is also the most marketable clean coal technology in the 21st century [1-3].

Coal water slurry is a kind of slurry fuel which can burn stably. It is made of 60% - 70% coal, 40% - 30% water and a small amount of chemical additives through certain processing technology. It can flow like oil. It is a kind of high efficient clean fuel, which is a good substitute for solid coal, oil and natural gas [4-5].

Coal water slurry stability refers to the uniformity of coal slurry during storage and transportation. CWS is a solid-liquid two-phase mixture prepared by physical processing, which belongs to coarse dispersion system. Therefore, solid-liquid separation is easy to occur under the action of gravity or other external forces. During the storage and transportation of coal water slurry, if the slurry does not produce hard precipitation, it is considered that the slurry is stable [6]. Because coal water slurry belongs to coarse dispersion system, when the concentration is low, the pulverized coal particles will settle freely according to Stokes formula. When the concentration is high, the interaction between particles makes the settlement very complex, which makes the study of static stability of CWS very complex. According to the state of particles in solid-liquid dispersion system, CWS can be divided into two types. One is accumulating solidly suspension (hard precipitation) and the particles do not attract each other. The other is flocculating suspension (soft precipitation), and there is only a weak interaction between particles [7].
This paper mainly studies the preparation method and stability of coal water slurry.

2. Experimental part

2.1 Experimental scheme
In this experiment, sodium lignosulfonate was selected as dispersant. In the variables of coal-water ratio, mixing time and coal particle size, the stability of coal water slurry was studied by controlling two variables and changing one of them to determine the optimal value of each variable in the most stable state. The coal with 100 mesh, 120 mesh, 140 mesh, 160 mesh and 180 mesh; stirring time 5min, 10min, 15min, 20min, 25min; coal-water ratio is selected 57% coal, 42% water, 1g additive; 61% coal, 38% water, 1g additive; 65% coal, 34% water, 1g additive; 69% coal, 30% water, 1g additive; 73% coal, 26% water, 1g additive.

2.2 Determination of coal water slurry stability
The method of determination is to place a certain amount of uniform coal slurry sample in disposable paper cup, and keep it in the laboratory for three days. After the coal water slurry is completely stabilized, the disposable paper cup and the quality of the coal water slurry are weighed. The static stability of the coal water slurry is expressed by the percentage of the stable quality of the coal water slurry to the total quality of the fresh coal water slurry.

2.3 Experimental reagents
Sodium lignosulfonate (analytical purity)
Coal of Yang Jia Gou coal mine in Ningxia

2.4 Experimental steps

2.4.1 Preparation of coal water slurry
(1) Put the coal into the crusher, break it into small coal blocks about 0.5 cm by electricity, then put the small coal blocks about 100 g into the rotary pulverizer, grind them into powder by electricity, screen out the corresponding coal particles with 100 mesh, 120 mesh, 140 mesh, 160 mesh and 180 mesh respectively, and put them into the electric blast drying box for a period of time.
(2) Take a certain amount of distilled water in corundum bottle, add 1 g sodium lignosulfonate, stir with glass rod, add a certain amount of prepared coal sample to the stirred solution, and then stir fully for a certain time until the solution is pulped.

2.4.2 Determination of mass fraction
Take a dry and clean disposable cups and call its mass M1. Then take the finished product of coal water slurry into the disposable paper cup and call its mass M2. Put it in a static position for three days until it is completely stable, pour out the product of coal water slurry (removing residue) and call its mass M3.

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\text{Mass fraction formula: } W = \frac{M3}{M2-M1} \times 100\%
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M1: quality of disposable paper cups
M2: the total quality of disposable clean paper cups and coal water slurry
M3: quality of the product after the stabilization of coal water slurry

2.5 Experimental data

2.5.1 The relationship between mixing time and the stability of CWS
The results of the experiment are shown in Table 1 and Figure 1.
Table 1 Influence of stirring time on the stability of CWS

| Stirring time (min) | Raw coal particle size (mesh) | Coal-water ratio (% coal) | Viscosity (mPa·s) | M1 (g) | M2 (g) | M3 (g) | Mass fraction (%) |
|---------------------|-------------------------------|---------------------------|-------------------|--------|--------|--------|------------------|
| 5                   | 120                           | 65                        | 576               | 5.1    | 93.4   | 77.3   | 87.5             |
| 10                  | 120                           | 65                        | 650               | 4.8    | 92.8   | 82.4   | 93.6             |
| 15                  | 120                           | 65                        | 706               | 4.9    | 94.6   | 88.0   | 98.1             |
| 20                  | 120                           | 65                        | 585               | 5.9    | 94.3   | 85.3   | 96.5             |
| 25                  | 120                           | 65                        | 563               | 5.2    | 91.6   | 79.3   | 91.8             |

Figure 1 The relationship between mixing time and the stability of CWS

From Table 1 and Figure 1, it can be seen that the stability of CWS in these five groups of experiments is larger when the stirring time is 15 minutes, which indicates that the 15 minutes stirring time is the most suitable time for CWS production. When pulverized coal is put into aqueous solution, the wetting process of solid particle surface first occurs, followed by the dispersal of particle aggregates by hydrodynamic forces. Short stirring time will result in the formation of solid settlement of coal particle aggregates, which will reduce the stability of coal water slurry; while long stirring time will increase the water evolution rate of coal powder, and the stability of coal water slurry will be affected by the agglomeration of the produced coal water slurry [9].

2.5.2 The relationship between the size of coal particles and the stability of CWS

The results of the experiment are shown in Table 2 and figure 2.

Table 2 The relationship between the size of coal and the stability of CWS

| Raw coal particle size (mesh) | Stirring time (min) | Coal-water ratio (% coal) | Viscosity (mPa·s) | M1 (g) | M2 (g) | M3 (g) | Mass fraction (%) |
|------------------------------|---------------------|---------------------------|-------------------|--------|--------|--------|------------------|
| 100                          | 15                  | 65                        | 963               | 5.1    | 93.6   | 85.8   | 97.0             |
| 120                          | 15                  | 65                        | 915               | 4.6    | 91.5   | 84.1   | 96.8             |
| 140                          | 15                  | 65                        | 907               | 4.9    | 92.8   | 84.8   | 96.5             |
| 160                          | 15                  | 65                        | 876               | 5.2    | 89.4   | 80.7   | 95.9             |
| 180                          | 15                  | 65                        | 824               | 5.3    | 90.7   | 81.0   | 94.8             |
Figure 2 The relationship between the size of coal and the stability of CWS

From Table 2, the stability of CWS in these five groups of experiments is the largest when the mesh number of pulverized coal is 100 mesh, which shows that the mesh number of pulverized coal with 100 mesh is the most suitable for CWS production. As can be seen from Figure 2, the stability of CWS decreases with the increase of the mesh number of pulverized coal. This is because as the particle size of pulverized coal gradually decreases, the density of pulverized coal particles will gradually increase, the hydrophilicity of pulverized coal particles will gradually decrease, the settling speed of the prepared coal water slurry will gradually increase, and the stability of coal water slurry will decrease; when the pulverized coal particles are larger, the gravity of the pulverized coal particles will be greater than the buoyancy and surface tension of water and can't form uniform suspension, which affects the CWS stability [10].

2.5.3 Relationship between coal-water ratio and stability of CWS

The results of the experiment are shown in Table 3 and Figure 3.

| Coal-water ratio (% coal) | Stirring time (min) | Raw coal particle size (mesh) | Viscosity (mPa s) | M1 (g) | M2 (g) | M3 (g) | Mass fraction (%) |
|--------------------------|--------------------|-----------------------------|------------------|--------|-------|-------|-----------------|
| 57                       | 15                 | 120                         | 637              | 5.3    | 87.5  | 71.0  | 86.4            |
| 61                       | 15                 | 120                         | 893              | 5.0    | 90.9  | 81.3  | 94.7            |
| 65                       | 15                 | 120                         | 915              | 4.8    | 89.6  | 83.3  | 98.2            |
| 69                       | 15                 | 120                         | 907              | 5.1    | 91.4  | 83.3  | 96.5            |
| 73                       | 15                 | 120                         | 729              | 5.2    | 88.7  | 68.1  | 81.5            |
From Table 3 and Figure 3, it can be seen that the stability of CWS is the highest when 65% coal, 34% water and 1% additives are used, and the viscosity is closest to 1200 mPa·s [11]. It shows that 65% coal, 34% water and 1% additives are most suitable for CWS. This is because the slurry formed by excessive pulverized coal has high viscosity and is not easy to flow. The slurry produced by excessive pulverized coal is very easy to precipitate water and the conductive viscosity is too low. Too high or too low viscosity will affect the stability of CWS. So CWS prepared with 65% coal, 34% water and 1% additive is the most stable.

3. Conclusion

(1) In the relationship between the stability of CWS and mixing time, it is found that the best stability is obtained when the mixing time of CWS is 15 minutes in the range of 5 to 25 minutes, and the viscosity of CWS is 706 mPa·s at 15 minutes of mixing time, which is the closest to the requirement of industrial CWS.

(2) In the relationship between the stability of CWS and the mesh number of pulverized coal, it is found that the stability of CWS is the best when the mesh number of pulverized coal is 100 mesh in the range of 100 mesh to 180 mesh, and the viscosity of CWS is 963 mPa·s at 15 minutes of mixing time.

(3) In the relationship between the stability of CWS and the coal-water ratio, it is found that the stability of 65% coal, 34% water and 1% additives is the best in the range of 57% to 73% coal.

(4) Coal water slurry is the most stable when the mixing time is 15 minutes, the mesh number of coal particles is 100 mesh, the coal-water ratio is 65% coal, 34% water and 1% additive.

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