Research on Caloric Characteristic of Producing Coal Water Slurry from One of Coal Preparation Plants in Guizhou Province

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Abstract: The test for producing coal water slurry has been experimentized in the lab by using of slurry from one of coal preparation plants in Guizhou province. The conclusion indicates that by comparing coal water slurry vs slurry, there is no any advantage of caloristic value for coal water slurry, but there are too much advantages in other combustibility for coal water slurry, which based on research on curves of burning difference caloric, curves of burning caloric weight and curves of burning characteristic for coal water slurry vs slurry of different concentrate of 58%, 60% and 62%. This shows that caloric standard of industrial boiler can be gotten by burning coal water slurry from one of coal preparation plants in Guizhou provice.

Keywords: Slurry Coal water slurry Burning Caloric characteristic

1 Introduction

The characteristic of coal water slurry is the high burning efficiency, the low burning temperature and environmental pollution. Genarally ,coal water slurry includes water of 30%-35% and additive of 0.1%-1.0%. the difference of the influence for much water to burning coal water slurry and direct burning of coal dust need to research in order to know the burning characteristic.So it is a reference for applying to industry production.

Caloric analysis method is one of the most useful method for resrarching for the burning characteristic of coal. It researchs for the curve of the chang of the weght and caloric of coal because of temperoture-programmed (burning characteristic curve) in the condition of caloric balance heating-up. The estimate of burning charateristc is based on burning characteristic curve. The TG-DTG-DAT thermoanalysis technology is applied to directly determine the burning characteristic in the atmosphere of oxygen of coal dust and coal water slurry which is producted by the different condition and find that it is quickly and easily as characteristic. TG is to determine the mass varied with temperature-programmed in the temperoture heating-up. DTG is to determine tha mass varied with the rate of temperoture changing (first-order differential for TG). DTA is to deterimine the different temperoture between the mass and reference compound varied with temperoture.[1-6]

2. The Result of Burning Test Methods, Condition and Characteristic Curve of Coal Water Slurry[7]

2.1 Test Methods and Condition

The TG-DTG-DTA thermoanalysis technology carries on the thermal analysis to slurry from one of coal preparation plants in Guizhou province as well as the producted coal water slurry, through the analysis studied by the TG-DTG-DTA curve which gathers from the microcomputer researches the oxidation of the coal water slurry, burning and the thermal dynamics characteristic.,and compare the burning characteristic of coal dust with coal water slurry and contrast the different influence concentration.

Experimental apparatus adopt to the SDT2960 thermal analyzer producted by TA company, and the microcomputer collects the data in order to get the TG-DTG-DTA curve.

The determine condition: the mass of coal water slurry is about 30mg(slurry is 15mg), the atmosphere is oxygen, the flow rate of oxygen is 50ml/min, renference

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compound is $\alpha - Al_2O_3$, the rate of heating-up is 25℃/min.

2.2 Compared the Burning Characteristic of Slurry and Coal water Slurry from one of Coal Preparation Plants in Guizhou Province

The TG-DTG-DAT thermoanalysis technology is applied to study the burning chatateristic of slurry vs producted coal water slurry, the result is table 1 and figure is figure 1,figure 2, figure 3, figure 4, figure 5, figure 6, figure 7.

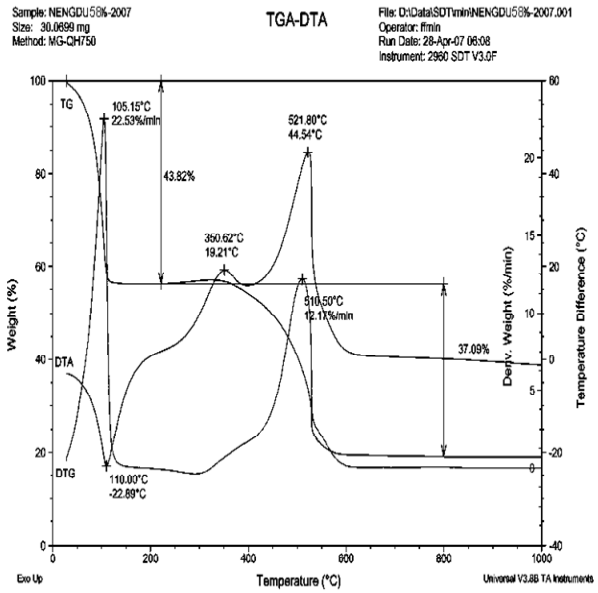

Figure 1. Buining characteristic curve of slurry

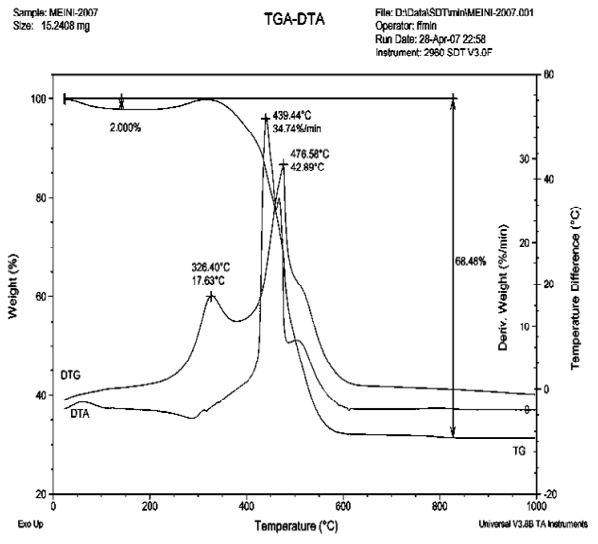

Figure 2.Burning characteristic curve of coal water slurry as concentrat of 58%

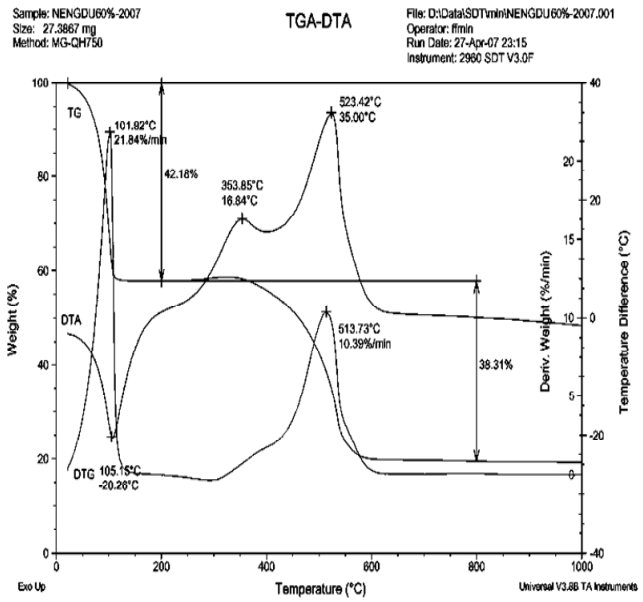

Figure 3. Burning characteristic curve of coal water slurry as concentrat of 60%

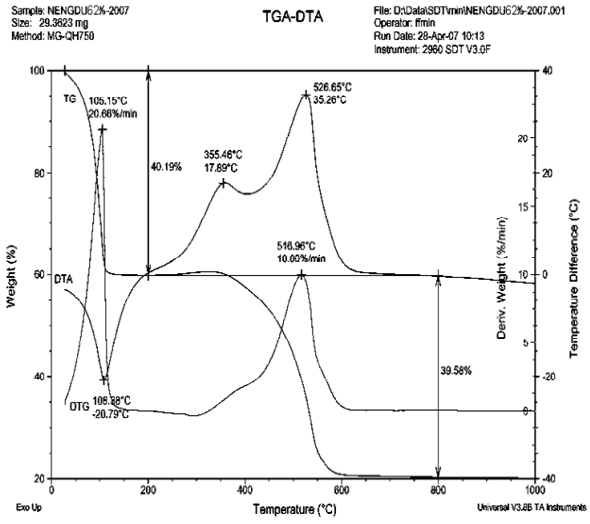

Figure 4. Burning characteristic curve of coal water slurry as concentrat of 62%

2.2.1 The Oxidation, Burning Process and Mechanism Analysis of Slurry and Coal Water Slurry[8-9]

It is seen from figure 1, figure 2, figure 3, figure 4,that the burning process of coal water slurry has two

stages, the first is dehydration,mainly included free-water, outside-waters and inside-water. There is an endothermic peak form DTA curve(figure 6). For coal dust, there is only a smoth endothermic peak from DTA curve because of a little water in it. Decalescence will end with the free-water, outside-waters and inside-water removing.

It appeared the second weightlessness from the TG curve with the temperature-programmed. Before the second weightlessness, it can be seen clearly there is a weight-gain phenomenon from the TG curve. DTA curve corresponds to start to deviate from the baseline for the exothermic phenomenon. Because coal start to absorb

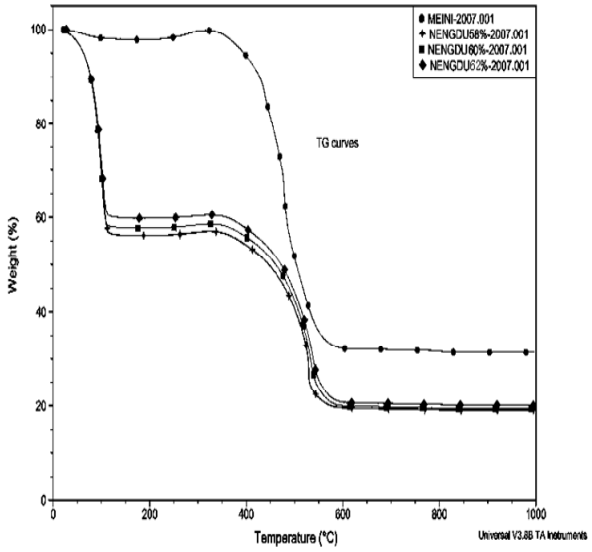

Figure 5. Burning caloric weight curve for slurry vs coal water slurry

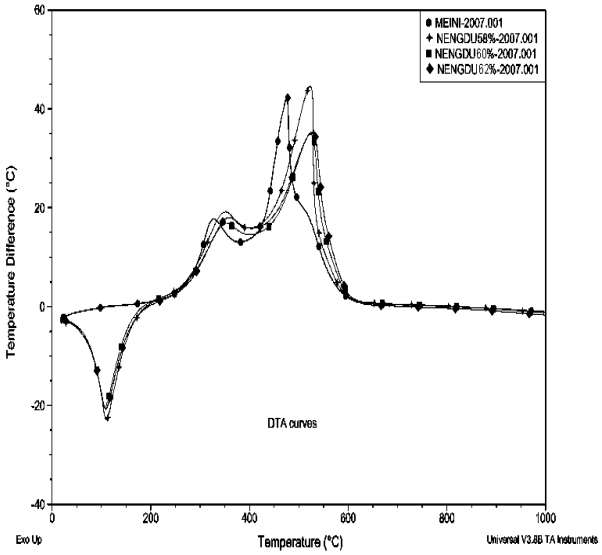

Figure 6. Burning difference caloric curve for slurry vs coal water slurry

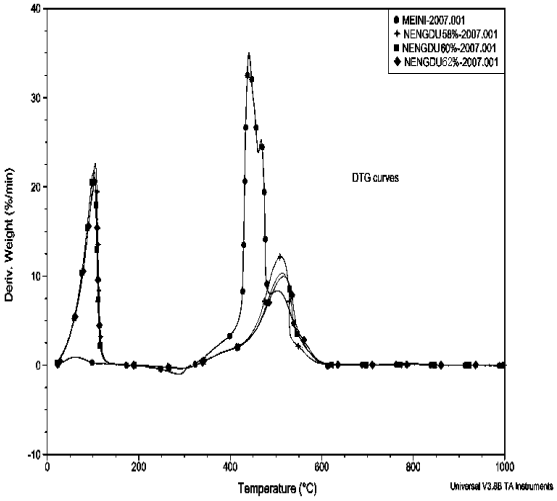

Figure 7. Burning differential caloric weight curve for slurry vs coal water slurry

Table 1. Buining characteristic result for slurry vs the different concentrat of coal water slurry

表征参数	煤泥	A 煤泥水煤浆	B 煤泥水煤浆	C 煤泥水煤浆
浓度（%）	/	58	60	62
T_1	45	28.5	21	29
T_2	/	110.00	105.15	108.38
T_3	285	282.5	280.5	285.38
T_4	326.40	350.62	353.85	355.46
T_5	430	447	442	437.5
T_6	476.58	521.80	523.42	526.65
T_7	595	605	615	619.5
V_1	/	22.53	21.84	20.66
V_2	34.74	12.17	10.39	10.00
t_1	4.8	4.66	4.36	4.24
t_2	12.4	12.9	13.38	13.36
t_3	22	23.06	23.76	23.62
S_1	/	54.6454	65.5332	61.7185
S_2	288.0518	280.1434	292.8487	338.0125
t_1/t_3	0.202	0.184	0.179	0.218
t_2/t_3	0.564	0.559	0.563	0.567
S_1/S_2	/	0.195	0.224	0.183
S_2-S_1	288.0518	225.498	227.3155	276.294

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oxygen to oxidize on the surface in the low temperoture. In the low temperature, the three processes of the oxidation exothermic dehydration and degassion of coal occurs at the same time. So it can be seen that the result of heat-absorbed and heat-release summates on the DTA curve. Only when the heat-release action of oxygen-absorbtion is more than the action of dehydration and degassing,, there will be the phonomenon of deviating from the baseline on the DTA curve. So it is defined the moment termperature as strating oxidation temperature.

With the temperature-programmed, the surface of coal occurs oxygen-absorbtion and heat-resealse all the time. At the same time, it speeds up the oxidation of coal self. So it extends to the heat-release on the DTA curve. When the quantity of oxygen-absorbtion get to a certain value, caloric decompasition reaction speeds up with the caloric oxidation. It is the temperature which occurs at the first peak on the endothermic peak from DTA curve. There exists the competition between the heat-resealse of surface of coal oxidation and the heat-abaorbtion of coal caloric decomposition. So the peak characteristic of carbon which burns before deponds on the dynamic balance of the heat-absoebtion and heat-resealse action of oxidation and caloric decompasition, and it display comperahensive action. When heat-absorbtion of caloric decompasion is lower than heat-release of oxidation, it is a slope. Otherwise, it is a lower peak. If they are equation, the peak is a line. However, they are low peak in these burning characteristic curves. They are showed that at this time the heat-absorbtion of caloric decompasion is more than heat-release of oxidation.

With the temperature-programmed, most of volatile is released and burned and there appears a high burning peak in the DTA curve. This peak is mainly the burning of fixed carbon. The temperature of burning peak is just the temperature of maximum burning speed. On the left of burning peak, Burning characteristic curve of slurry(fig1) has a shoulder peak. This is because that the pore structure of coal is different or coal granule particles inflation factor causes the change of porosity and then leads to the shoulder peak in burning peak. But after the coal-water slurry is graded, its burning characteristic curve of slurry (fig2,fig3,fig4) has no shoulder peak. This shows that after coal granule particles is graded and made into coal water slurry, its burning characteristic is improved.

With the temperature-programmed, the carbon and volatile content is over, the curves of TG(figure 5) and TA(figure 6) get to baselines, and the others weght is ash.

2.2.2 Compared the Burning Characteristic of Slurry with Coal Water Slurry

From table 1, in the process of burning coal water slurry, the temperature of water evaporation is about 20 ~ 30 ℃, the time is about 4 ~ 5 minutes, taking up 20% of the all time. The higher concentration, the less evaporation time. The caloric of evaporating moisture is 20% of the all caloric. The higher the concentration ,the higher its calorific value. The time for carbon burning is longer, about 13 minutes, and the time of different concentrations is similar. The ignition temperature T_4, the temperature T_6 of the maximum burning speed and the burning out temperature T_7 of the volatile are rising as the increasing of slurry concentration, The ignition temperature T_5 of carbon is decreasing as the increasing of slurry concentration. For burning slurry, there is only a big weightlessness process on the TG, but in the early slight weightlessness was present because of the inside moisture removal mainly, about in 5 minutes, taking up 20% of the all time. On the DTA, the exothermic peak only exists without absorption peaks.

In evaporation of water, slurry begin to loss the weight at 45℃. As lots of free moisture in coal water slurry, comparing to coal dust, temperature of water evaporated is significantly lower. The time of of water evaporation in whole time of coal water slurry burning and coal dust, are nearly equal. So evaporation that a large amount of water boil off in coal water slurry is very fast, so its existence does not extend burning time.

For the caloric, according to the theory of differential thermal analysis, the differential thermal equation that expresses the relationship between the reaction heat and the differential thermal peak area can be said,as follow[10]:

$$\Delta W = \beta \int_t^{\infty} [\Delta T - (\Delta T)_c] dt = \beta S \quad (1)$$

In the equation,

ΔW——Reaction heat(J)

β——Proportionality constant, the heat transfer coefficient between Sample and metal block and between reference compound and metal block（J/mm^2）;

ΔT——Temperature difference between Sample and reference compound（℃）;

（ΔT）$_C$——Temperature difference becanse of the baseline of differential thermal curve （℃）;

t—— Time（min）;

S——Differential thermal peak area, the area between the differential thermal curve and the baseline（mm^2）。

It can be seen that the square of different caloric S and the quantity of exithermic ΔW is derect proportion. So the square of different caloric is larger and the quantity of exithermic will be higher.

There is not a endothermic peak,but only a exothermic peak on the Buining characteristic curve of slurry. But on the starting of endothermic peak of coal water slurry, the evaported moisture consume the energy. So its calorific is lower than slurry's. It is showed from the resluts that coal water slurry is lower than slurry in the square of the whole peak. Different concentrat coal water slurry is lower than slurry on the calorific from formula 1. And the aquare of peak and the calorific of the coal water slurry are higher with the increasing concenstrat. When the concenstrat gets to 62%, the calorific between the coal water slurry and slurry is a little difference. It is showed that the existence of a large number of water in the coal water slurry has a certain influence, but only a little.

The coal slurry fixed carbon ignition temperature and burnout temperature, especially the fixed carbon ignition temperature, are a little higher than coal slime in several major uncertainty temperature. The fixed carbon ignition temperature decreased with the increase of slurry concentration and tends to close to the fixed carbon ignition temperature. This is mainly because the coal is preheated by the evaporation processes of coal inside water [11]. The differences between volatile ignition temperature T4 of coal slime and coal slurry, both below 400℃, are not so significant. It shows that the ignition temperature is close between the two.

In a word, the existence of a large number of water in the coal water slurry don't extend the whole burning time,because the moisture in the air flow can quickly evaporate, and the quantity of heat of the evaporation are about 20% of heat-release of coal water slurry burning process. This part of the loss makes the coal water slurry calorfic value lower than pulverized coal dust calorific value.The coal water slurry that the concentration is 62% is under the optimum distribution in the calorific value are higher than other concentration, and in evaporation heat loss ratio are lower than other concentration.

2.2.3 The Advantage of Coal Water Slurry Burning in Industrial Boiler

The burning temperature of coal water slurry is a little low because its heat productivity is low than coal ash. Compared to fire coal and oil burning boiler, it has several advantages bellow:

(1)Its thermal efficiency is high and it can save mach coal, so its economic benefit is quite considerable. The coal water slurry can burn efficiently, stably, completely. Its burning efficiency is greater than 95% and same to powdered coal. Its burnout efficiency is high to 98%, close to oil burning boiler. Its thermal efficiency is 84%, close to oil burning boiler, too. The carbon content of furnace clinker in coal water slurry boiler is low which is about 0.60%. But the carbon content of furnace clinker in coal burning is about 13.7%. So the quantity of furnace clinker is reduced obviously. Under the condition of same calorific value, coal water slurry boiler reduces a large number of fuel, so its effect in saving is better.

(2)Its emission concentration of smoke dust and SO_2 is lower than national standard, so it has a good environmental benefit. In the process of using coal water slurry boiler, the sulfur can be reduced to about 600mg/Nm^3 through adding sulfur fixing agent or adopting desulfurized precipitator. The smoke dust emission concentration of coal water slurry can be controlled to about 60mg/m^3 when using the corresponding dusting equipment. The blackness of emission smoke is Lingeman grade 1 which is agreed with national standard. The environmental benefit of coal

burning boiler is poor and it can't be compared to coal water slurry boiler[12].

(3)The heat absorption of gasified water in coal water slurry when burning makes the furnace's temperature reduce 100-200℃ which would obviously reduce the generation of NO_x, so the pollution to environment is reduced too.

(4)The presence of water in the slurry can help coal slurry well-distributed which is good for carbon's burning rapidly and completely. In the same time, the presence of vapor in gas can add the flame's radiation intensity and improve the heat transfer performance.

(5)Its control and adjust is automation which is similar to oil burning boiler and better to powdered coal boiler. Its store and transport way is similar to oil burning boiler and better to powdered coal boiler too.

3.Conlusions

Panbei slurry is under distribution, though its thermal properties, compared with dry slurry, doesn't show advantage in caloric but in others. Therefore, coal water slurry is feasible in industrial application. Especially as a more efficient and cleaner energy. It provides a new way to deal with deserted slurry, improves the overall the utilization of coal and greatly develops coal application, as higher efficient and cleaner energy.

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