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PRODUCTION OF CARBON BLACK FROM SHALE OIL IN CHINA

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This paper describes the production of carbon black from shale oil in China by the spray method. The carbon black obtained is of high quality and meets the specification. It is shown that this process is economically feasible.

Introduction

Using shale oil as feedstock, carbon black is produced by the spray method under strictly controlled conditions of partial combustion and high-temperature pyrolysis of shale oil. Carbon black obtained consists mainly of elementary carbon, with little amounts of hydrogen, nitrogen, sulphur, oxygen, etc. Such kind of carbon black has suitable size, unique structure, and high enhancing ability. As it may be used in the rubber products industry for improving the rubber elasticity, pressure-oil-cooling resistance and permanent deformation of rubber commodities, such carbon black has a prospective market. In addition, the installation of the production is not complicated, the technology has been fully elaborated and is easy to operate. In 1994, annual production of carbon black amounted to 600 tons.

Mechanism of the Formation of Carbon Black

Carbon black is produced at partial combustion and high-temperature pyrolysis of shale oil. Both the combustion and pyrolysis processes proceed simultaneously.

The pyrolysis process may be described as follows:

$$C_nH_m(\text{shale oil}) \xrightarrow{\text{pyrolysis}} n\ C(\text{carbon black}) + m/2\ H_2$$

This is an endothermic reaction, the heat required for the pyrolysis of a part of shale oil is evolved from the combustion of another part of it due to the limited quantity of air introduced.

Formation of carbon black involves three stages: initial reaction, formation and growing of nuclei, aggregation of carbon black. These three stages proceed very quickly at high temperature.

At the initial reaction stage, hydrocarbons in shale oil are pyrolyzed and polymerized, thus producing polycondensed aromatics.

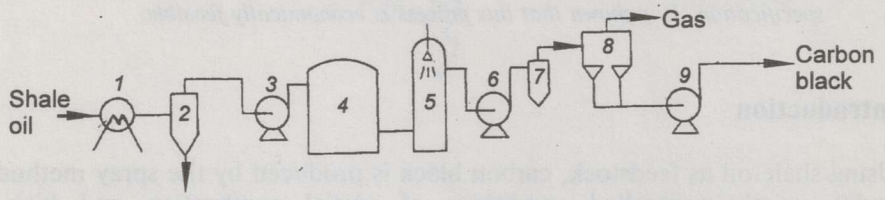
At the nuclei formation stage, the polyaromatics coagulate to form the nuclei with active conjugated valence bonds, thus promoting the growth of nuclei.

At the third stage, the nuclei react with each other, forming the aggregates of carbon black.

Production of Carbon Black

1. Technology of Production of Carbon Black

The flow sheet of production of carbon black is shown in Figure:



Flow sheet of carbon black production: *1* - preheater; *2* - sludge removal tank; *3* - oil pump; *4* - reactor; *5* - cooling tower; *6* - exhauster; *7* - cyclone; *8* - bag filter; *9* - fan

Feedstock shale oil heated in preheater (*1*) passes through the tank for sludge removal (*2*) and is pumped by oil pump (*3*) to the reactor (*4*) where partial combustion and pyrolysis take place resulting in the formation of carbon black powder. Combustion and pyrolysis products are cooled in a cooling tower (*5*), and by an exhauster (*6*) directed to cyclone (*7*). After passing cyclone and bag filter (*8*) carbon black powder is obtained. The product is pneumatically transported by fan (*9*).

2. Operation Parameters

Temperature of shale oil entering the reactor: 80-90 °C

Pressure of shale oil entering the reactor: 0.1-0.12 MPa

Combustion temperature: 1100-1300 °C

Reaction temperature: 650-800 °C

Temperature in the collecting system: 250-300 °C

Pressure in the collecting system: from -150 to -250 mm H_2O

Properties of Carbon Black

The physical and chemical properties of the carbon black are compared with the specification, as shown in Table.

Quality of Carbon Black Obtained as Compared with Specification

Characteristics	Specification requirements	Quality tested
Iodine value, g/kg	10-20	18
Oil value, $cm^3/100$ g	90-130	98
pH value	7.0-10.0	9.4
Diphenyl guanidine consumption, %	0.5-3.0	0.8
Ash, %	≤0.3	0.15
100 mesh residue, %	0.00	0.00
Elongation, %	≥570	572
Breakdown strength, MPa	≥19.6	21.1
Elongation resistance, MPa	6.7-7.8	7.5
Permanent deformation, %	≤27	22
Hardness, Shao method	56-60	57

Consumption of Feed and Utilities for 1 ton Carbon Black

Shale Oil: 2.54 tons
Electricity: 200 kWh
Water: 18.7 m^3
Coal: 1.3 tons

Technico-Economic Costs for Producing 1 ton Carbon Black

1. Production Costs:

Shale Oil:	819 yuan/t • 2.54 tons	= 2080 yuan
Electricity:	0.38 yuan/kWh • 200 kWh	= 76 yuan
Water:	0.5 yuan/m^3 • 18.7 m^3	= 9.4 yuan
Coal:	200 yuan/t • 1.3 t	= 260 yuan
Package	50 yuan • 4	= 200 yuan
Maintenance	and Depreciation	200 yuan
Wages		250 yuan
Management		375 yuan
Total		3450.4 yuan

2. Selling Costs 5000.0 yuan

3. Taxes 687.8 yuan

4. Profit after Taxes 861.8 yuan

Conclusions

1. Carbon Black powder has been produced using shale oil as feed. The spraying technique is fully elaborated, and the equipment is rather simple.
2. The factory for producing carbon black makes profit, therefore this process is prospective.

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