“Carbon Black Manufacturing: Challenges and Opportunities in View of Global Warming”

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1.0 Introduction

Carbon Black is well recognized as the best reinforcing material in rubber compounds. The tire industry, in particular, consumes around 80 percent of the total Carbon Black. Presently about nine million metric tons of Carbon Black are manufactured annually worldwide, resulting in the consumption of 20 million metric tons of Carbon Black oil. However, simultaneous to Carbon Black’s manufacturing process, carbon dioxide, one of the gases responsible for global warming, is also emitted.

TOKAI CARBON has been working to improve not only our production facilities to reduce carbon dioxide emissions but also to deliver a better qualified Carbon Black to the tire industry for the manufacture of energy saving tires.

2.0 What is Carbon Black?

Carbon Black is defined as an industrial raw material consisting of 95 percent or more of amorphous carbon, and its size is in the order of nanometers, produced under a well-controlled manufacturing process.

3.0 Manufacturing Process

The majority of industrial Carbon Black manufacture is based on the process of continuous imperfect combustion of Carbon Black oils, such as fluidized catalytic cracking decant oil and coal tar, using reactors. These kinds of oils are pumped up from oil storage tanks to the reactors through oil preheaters. At the same time, preheated combustion air is also supplied to the reactors. By preheating both the oil and air to a high sensible heat energy, a higher yield is obtained. The imperfect combustion reaction is stopped by the injection of quenching water at a quench zone in the reactors, whereby Carbon Black and by-product gas called tail gas are formed. This mixture of Carbon Black and tail gas exchange heat into combustion air in air preheaters and directed into main bag filters where the Carbon Black is separated from the tail gas. For handling purposes, the filtrated Carbon Black is

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then transferred to wet pelletizers which mix a constant amount of Carbon Black with approximately the same amount of water. The wet pellets are subsequently dried in dryers, which are heated by combusting the tail gas. Finally, Carbon Black is conveyed into product storage tanks and stored there until shipment to the customers.
It is very important to utilize the flammable tail gas as an alternative to fossil fuels.
Fig 1. Carbon Black Manufacturing Process

4.0 Carbon Black Oil

Carbon Black manufacture requires Carbon Black oils with a high content of aromatic hydrocarbons as a raw material for better productivity. Aromatics containing a number of condensed rings are particularly advantageous concerning the yield, since the carbon-and-hydrogen ratio increases with the number of rings. Actually, both petrochemical and carbochemical oils are used as Carbon Black oils. Fluidized catalytic cracking (FCC) decant oil and coal tar are preferable.

Table 1. Type of Carbon Black Oil

Type of Carbon Black Oil	Manufacturing Process
Petrochemical oils	
1. FCC decant oil	Fluidized catalytic cracking process
2. Ethylene Heavy End oil	Steam cracking process
Carbochemical oils	
1. Coal tar	Coke oven process
2. Creosote oil	Coal tar distillation process Delayed coking process

In classifying Carbon Black oil, density is an important parameter for the evaluation of oils, because it increases with increasing aromaticity. Also, the Bureau of Mines Correlation Index (BMCI) is used for a more detailed classification.

5.0 Heat Recovery and Tail Gas Utilization

The Carbon Black manufacturing process generates both the sensible

heat energy contained by and the chemical energy in the tail gas. Without a waste energy recovery strategy, less than 60 percent of the sensible energy and only 50 percent of the chemical energy is utilized for the Carbon Black manufacturing process. Optimizing recovery of these energies make sense in reducing carbon dioxide emissions, as well as providing additional revenue.

For reducing carbon dioxide gas, it is very important to increase the yield of Carbon Black from Carbon Black oil by using a well-controlled heat recovery process and also utilizing tail gas as a fuel for the boilers, dryers and oil preheaters. Utilization of tail gas thereby reduces the need for fossil fuels, such as petroleum oil or natural gas.

There are some energy recovery and tail gas utilization facilities in the process, such as

- Air preheaters
- Boilers including steam boilers, waste gas boilers and inline boilers
- Oil preheaters
- Dryers

5.1. Air Preheater

Reactors are equipped with air preheaters which are actually heat recovery facilities used to exchange heat from the tail gas containing Carbon Black under high temperature into combustion air for the imperfect combustion of Carbon Black oil. The simultaneously cooled Tail Gas is then directed to the next facility. An air preheater is usually constructed as a tubular heat exchanger through which combustion air counterflows to the tail gas.

Combustion air supplied by an air blower is heated up to a range of 500－800 degree C by an air preheater.

It is well known that a higher combustion air temperature results in a better yield of Carbon Black.

5.2. Tail Gas Utilization

The imperfect combustion of Carbon Black oil converts half of the hydrocarbons in oil into Carbon Black and the other half into Tail Gas.

Therefore, Tail Gas consists of some flammable components such as hydrogen, carbon monoxide and methane as shown in the Table 2 below.

Table 2. Typical Composition of Tail Gas

Compos.	H2	CO	Methane	CO2	N2	Steam
Vol. %	8.0	10.2	0.2	2.4	36.2	43.0

As the composition of tail gas indicates, it is not easy to burn tail gas with very low chemical energy. The Carbon Black Industry has developed specific tail gas combustion chambers so as to supply heat energy to boilers, dryers and oil preheaters thereby eliminating the need for petroleum oil or natural gas.

5.3. Steam Boiler

Concerning energy supply, the Carbon Black Industry installs special boilers which generate steam and/or electricity that are consumed during the manufacturing process. Generally speaking, the tail gas combustion steam boiler efficiently co-generates both steam and/or electricity that are then consumed as either heat energy to keep the Carbon Black oil warm, or as power to drive the motors for the air blowers, the air compressors and the many pumps. Furthermore, both of these energy products can be transferred to neighboring industries where possible, and can contribute to reducing carbon dioxide emissions at neighboring industries.

5.4. Other Boiler

In order to optimize process efficiency, waste gas boilers, inline boilers and oil preheaters are installed. Waste gas boilers at the dryer's stack utilize the statistic energy from burnt exhaust gas to convert water into steam for process warming. Process integrated boilers located between air preheaters and main bag filters recover the statistic energy from tail gas into steam and the cooled tail gas then protects the downstream facility from high temperatures. There are also different types of process integrated boilers that provide heat to Carbon Black oil instead of steam.

5.5. Oil Preheater

Carbon black oil is highly carbonaceous and needs to be preheated for easy transportation and atomization in reactors. The smaller the droplets, the faster they mix with the hot flame in the reactors, the quicker the reaction time and the better the carbon black yield.

5.6. Dryer

The wet pellets have to be dried after leaving the wet pelletizers. This is done by rotary-kiln dryers using an indirect heating method in order to remove the water added in wet pelletizers. The heat source for the dryers is tail gas that is separated from Carbon Black by the main bag filters. This tail gas is then directed with air into the combustion chamber of the dryer and generates burnt gas of high temperature, about 800 degree C. Then this burnt gas enters into the external drum of the dryer and indirectly heats the Carbon Black which is led to the internal drum of the dryer.

Drying efficiency and Carbon Black transport have both been improved by fitting additional components such as lifters in the dryers.

6. Energy Saving Tire

Today, some 800 million automobiles are in use worldwide. (The world's population is 6.5 billion.) These automobiles are estimated to emit five billion metric tons of carbon dioxide every year in the lifetime of automobile, accounting for 22 percent of all carbon dioxide emissions. Eighty-six percent of the automobile-derived carbon dioxide is emitted during driving. Therefore, reducing carbon dioxide emissions by reducing fuel consumption is critical. The tire industry has developed improved tires which can reduce fuel consumption by various means, such as reduced tire's weight and reduced rolling resistance.

New technologies have adopted novel material technology such as new synthetic rubbers and new filler materials including Carbon Black and Silica as well as the design technology.

The carbon black industry is very closely related to the tire industry and to this industry's continuing need for improved Carbon Black products. Recent demand from the tire industry for more energy-saving tires has made it necessary for Carbon Black to satisfy three

contradictory properties: the first is lower rolling resistance, the next is higher wet skid resistance, and the last is stronger wear resistance.

TOKAI CARBON has been engaged in new technology to satisfy these contradictions by improving Carbon Black's surface properties, which have not yet been deeply investigated.

7. Conclusion

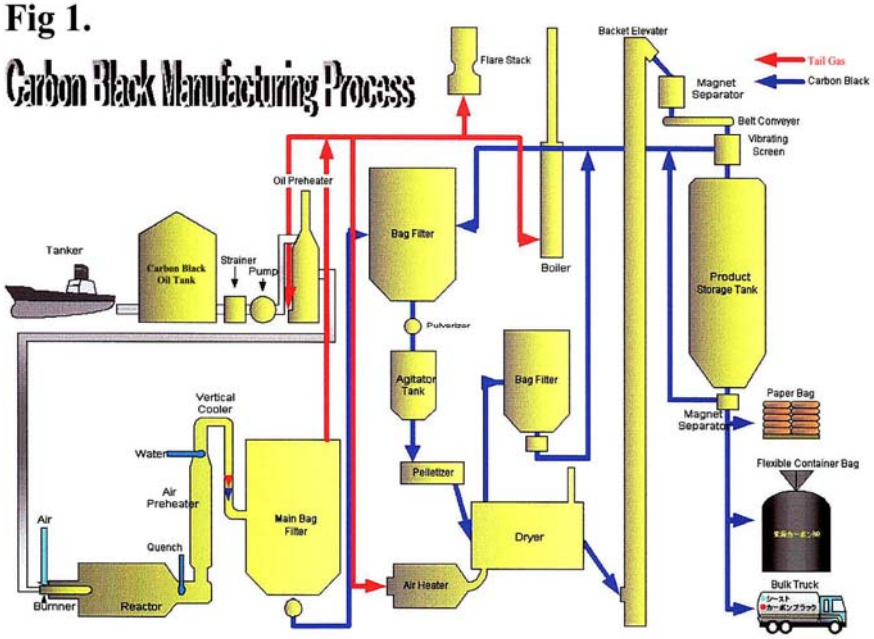
The carbon black industry, which has expanded along with automobile manufacturing, is typically energy-heavy. In its development, it faced two energy crises during the 70s. Since the 80s, the industry has endeavored to improve its production facilities to conserve energy and enhance productivity, thus addressing the energy crunch. Today, however, the industry is faced with a new need to address the problem of global warming due to the emissions of carbon dioxide, one of the gases responsible for the phenomena.

One of the goals specified in TOKAI CARBON's Corporate Philosophy is business operation in harmony with ecology. In the manufacture of Carbon Black, we are resolved to continuously operate in an eco-friendly manner by promoting heat recovery and the effective use of tail gases.

References

1 "Handbook of Carbon Black" Published by Carbon Black Association, Japan
2 "Trends in Rubber Parts for Automobiles" by T. Haraguchi, JOURNAL OF THE SOCIETY OF RUBBER INDUSTRY, Japan
3 ALSTOM

Fig 1.


Carbon Black Manufacturing Process
Flare Stack
Backet Elevater
Tail Gas
Carbon Black
Magnet Separator
Belt Conveyer
Vibrating Screen
Oil Preheater
Bag Filter
Boiler
Product Storage Tank
Tanker
Carbon Black Oil Tank
Strainer
Pump
Pulverizer
Agitator Tank
Bag Filter
Paper Bag
Magnet Separator
Vertical Cooler
Water
Air Preheater
Pelletizer
Flexible Container Bag
Air
Main Bag Filter
Dryer
Quench
Air Heater
Bulk Truck
Burnner
Reactor