Investigation of Innovation in Carbon Black Manufacturing in the realm of Green Environment

Sunil Satav, Dr.Vivek Yakkundi, Vipul Govindrao Badhe, Archana Gaikwad

Abstract—Carbon black is major input to tyres, paint, rubber, and plastic industries. Worldwide, Carbon black production is 14 million metric ton per annum. Major inputs for manufacturing process are fossil oil (Carbon black feed stock) and water. Thermal process is used to crack oil in carbon particles in reactor at high temperature.

This paper focuses on innovative technologies used for carbon black manufacturing in the realm of reducing pollution and wastages.The focus of study is mainly on high potential contributor to environment pollution in these industries.This work also focuses on the feasible advanced technologies which substitutes the conventional manufacturing process and recycling opportunities in carbon black manufacturing process for clean environment.

Keywords— *Air pollution, Carbon black process, Noise pollution, Power plant, Water pollution*

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1] INTRODUCTION

Carbon black is a highly dispersed product of thermal or thermo oxidative decomposition of hydrocarbons which are the part of natural and industrial gases, as well as of oil and coal oils. Carbon black manufacture requires oils with a high content of aromatic hydrocarbons as a raw material for better productivity. It is produced with the thermal decomposition method or the partial combustion method using hydrocarbons such as oil or natural gas as raw material.

Carbon black is used primarily in the tyre industry to increase wear resistance, tear resistance, and strength of rubber. It is widely used in the production of high quality tread rubber for all types of vehicles, and work pieces for the restoration of the tread, agricultural machinery, conveyor belts. It is also used for the production of high-quality rubber products, cable casings operated in the complicated conditions. It is also used in the manufacture of certain alloys, special kinds of paper, and electric products (e.g. electrodes) and the galvanic elements. Carbon black is also used to produce the copy paper, and ribbons for typewriters and printers.

Emissions from carbon black manufacturing include particulate matter, carbon monoxide, sulfur compounds, polycyclic organic matter, and wastewater discharge form power plant, cleaning system and traces elements.

The source of emissions in the oil furnace process is the main process vent. The vent stream consists of the reactor effluent and the quench water vapor vented from the carbon black recovery system. Gaseous emissions may vary considerably according to the grade of carbon black being produced. Organic and CO emissions tend to be higher for small particle production, corresponding with the lower yields obtained. Sulfur compound emissions are a function of the feed sulfur content. The combined dryer vent emits carbon black from the dryer bag filter and contaminants from the use of the main process vent gas if the gas is used as a supplementary fuel for the dryer. It also emits contaminants from the combustion of impurities in the natural gas fuel for the dryer. These contaminants include sulfur oxides, nitrogen oxides, and the unburned portion of each of these pieces present in the main process vent gas the oil feedstock storage tanks are a source of organic emissions. Gaseous emissions from the main process vent may be controlled with CO boilers, incinerators, or flares. The pellet dryer combustion furnace, which is, in essence, a thermal incinerator, may also be employed in a control system. CO boilers, thermal incinerators, or combinations of these devices can achieve essentially complete oxidation of organics and can oxidize sulfur compounds in the process flue gas. Combustion efficiencies of 99.6 % for hydrogen sulfide and 99.8 % for CO have been measured for a flare on a carbon black plant. Particulate emissions may also be reduced by combustion of some of the carbon black particles, but emissions of sulfur dioxide and nitrogen oxides are thereby increased.

Water emission form De-mineralized water plant, cooling tower, boiler blow down etc. Noise pollution is also major issue due to various equipment, steam line etc.

2] PRESENT SCENARIO OF POLLUTION IN CARBON BLACK MANUFACTURING

2.1 Water pollution- Water requirement of Carbon black manufacturing process is in various areas like Quenching process, Palletizing process and Power plants. These processes generate water effluent during processing like quench tower, cooling tower blow down, De-mineralized water plant regeneration, floor washing, domestics uses etc.

Table 1: Summary of water effluent generated during Carbon black process

Area	Parameter	Quantity in Percentage
Non process Area	Oil, Grease, COD and BOD	15%
Cooling Tower Blow down	Conductivity and COD	60%
DM Plant Effluent	Conductivity, Hazardous Chemicals	24%

Boiler Blow down	Temperature and Chemicals	1%

2.2- Emissions to air-The potential source of emission to air is the 'tail gas' which comes from the reactor after product separation. It contains hydrogen, carbon dioxides, reduced sulphur compounds, sulphur oxides nitrogen compound and volatile organic matter such as ethane and acetylene.

Table 2: Summary of emissions to air

Emission Parameters	Specific emission (kg/tone carbon black)	Emission Concentration (mg/Nm^3 at 10%O2)
Particulate matters	0.2-0.4	10-30
Sulphur dioxides (as SO2)	6.5-22	400-1400
Nitrogen Oxides (as NO2)	6.0-15	400-900
Carbon Monoxide	2.0-3.0	120-200
Volatile organic compounds	Up to 0.7	Up to 50

Table 3: Sources of emissions

Emission	Origin
Carbon monoxide (CO)	• Product of incomplete combustion in the reactor • Product of incomplete combustion in dryers, boilers ,flares Etc.
Carbon dioxide (CO2)	• Product of complete combustion in the reactor • Product of in complete combustion in dryers, boilers ,flares etc.
Oxides of sulphur(Sox)	• Oxidation of feed stock sulphur compound in the reactor. • Oxidation of sulphur compound present in the tail gas.
Reduced sulphur compound (Hydrogen sulfide (H2S), carbon disulphide (CS2),carbonyl sulfide (COS)	• Decomposition and partial oxidation of feedstock sulphur compound in the reactor.
Oxides of Nitrogen (NOx)	• Oxidation of feed nitrogen compound in the reactor • Thermal NOx form the reactor • Fuel NOx form dryers, boilers, flares, etc. • Thermal NOx form dryers, boilers, flares, etc. • Oxidative post treatment of carbon black with NO2and HNO3
Hydrogen cyanide (HCN), Ammonia (NH3)	• Decomposition of feedstock nitrogen compound in the reactor
Volatile organic compounds (VOC) (e.g. methane, acetylene, ethylene)	• Incomplete decomposition of feedstock in the reactor.
Polycyclic aromatic hydrocarbons (PAH)	• Incomplete decomposition of feedstock
Particulate matters (e.g. carbon black dust)	• Slip through filter system behind reactor • Slip through deducting filter system behind dryer • Slip through thermal combustor • Fugitive emission due to storage, transportation and packing
Heavy metals	• Present as trace impurities in some feed stock

2.3 Noise pollution- Carbon Black process uses reactor with gas or oil as raw material to produce carbon black. It consists of various equipment such as blowers, compressors, pumps and dryers Etc. Due to high revolution per minute and fluid velocities high sound level is generated in various rotating equipment in pumps and centrifugal fan, blowers. Power plant and Utilities the noise level for steam turbine, gas turbine and compressor ranged from 79 – 97.5 Db(A), 84.2 – 97 Db(A) and 88.5 -100.5 Db(A) respectively .The average noise level for steam turbine, gas turbine and compressor during the period under review was 91.8 Db(A), 93.31 Db(A) and 96.55Db(A) respectively.

Table4: Summary of high sound level area / equipment in carbon black process.

Equipment	**Area**	**Sound Level dB(A)**
Packing blower	Ware House	83.30
Process Air Blower	Process	85.60
Steam Turbine	Turbine House	91.80
Gas Turbine	Turbine House	93.30
Compressor	Utilities	96.50
Boiler Daearator vent	Boiler House	98.10
Steam Line Traps	Turbine	88.50

3] INNOVATIVE METHODOLOGY ADOPTED TO REDUCE POLLUTION IN CARBON BLACK MANUFACTURING FOR CLEAN ENVIRONMENT

The pollution and their major sources are discussed in previous section. This section covers the recent methods being used in carbon black manufacturing.

3.1 Flue Gas Desulfurization or So2 Scrubbing Process

The main objective of adopting this process is to control Sulphur dioxides (as SO2) emissions.The flue gas desulfurization or So2 scrubbing process typically uses calcium or sodium based alkaline reagent. There are two types of sox scrubbing system i.e. wet and dry scrubbing system. The reagent is injected in the flue gas in a spray tower or directly in to the duct. The So2 absorbed, neutralized and /or oxidized by alkaline reagent in to solid compound, either

sodium or sodium sulfate. The solid is removed from the waste gas stream using downstream equipment.

3.2 Separation of Lean Tail Gas and collection of fine Carbon Black Particles

Carbon black and gas mixture is passed through high efficiency Bag collectors for separation of Lean Tail Gas and collection of fine carbon black particles. The filtered gas is then sent to the onsite captive power plant for combustion and generation of steam and electrical power through steam turbines. A small part of Tail gas is also utilized to generate heat for Carbon black drying process in the Tail gas fired Rotary drum dryers.
Tail Gas recycles a part of this waste tail gas and feed to Carbon Black reactors as heat source for the Thermal cracking reaction and replaces the auxiliary fuel oil being utilized. Through this process modification a substantial reduction of total plant oil requirement can be achieved and this reduction is estimated in range of 12 to 15% on continuous basis.
Prior to recycling, the Lean Tail Gas needs to be pre-conditioned in order to achieve the desired heat input to the reactors. The conditioning process of Tail gas involves dehumidification and heating operation prior to injecting into the reactor combustor. This system recycles tail gas in process and reduces emission of gases in atmosphere.

3.3 Noise controlling of equipments

Carbon black manufacturing process contain equipments such as Pump, Glob blower, Centrifugal blower, Steam turbine, Gas turbine, Steam line steam traps, Deaerators, etc . Compressor is high speed or reciprocating equipment. Compressor has been identified as major noise source and this is undesirable.Turbulence is the most important noise source in centrifugal compressors. This is really combination of two effects one is the vortex shedding and another one is upstream turbulence. The boundary layer over each blade is turbulent by the time it reaches the trailing edge. The turbulent layers on the top and bottom surface produce a fluctuation in the lift and this fluctuation has a broad frequency spectrum. The application of fluctuating force to the gas generates sound at the same frequency. Therefore, broad noise is radiated. If the flow is turbulent when it enters a blade row, the turbulence is increased and the noise is greater. Turbulence noise is radiated through the compressor casing, and it can be controlled by an acoustic enclose after the compressor has been installed as it is almost impossible to eliminate the turbulence by design.

Table 5: Noise pressure description

Description	Noise Pressure dB(A)				
Noise Pressure without Enclosure	91	93	92.5	91.8	92.4
Noise Pressure with Enclosure	78.4	79.1	78.98	78.6	78.90

The process of Deaeration is the mechanical removal of dissolved gases from the boiler feed water. There are three principles that must be met in the design of any deaerator. The feed water must be heated to the full saturation temperature corresponding to the steam pressure maintained inside the deaerator. This will lower the solubility of dissolved gases to zero. The heated water must be heated to the full saturation temperature, corresponding to the steam pressure maintained inside the deaerator. Saturated feed water steam is vent out to atmosphere to removed dissolved gases. Steam is at statured state, high velocity of steam form vent and generated high noise up to 98 Db (A).

Boiler deaerator steam vent noise control is possible byrecycle of vent steam in process such as heater, VAM etc.
Deaerator steam is at low pressure at saturated temperature with dissolved gases like oxygen and CO. Steam will be utilized in low heat process requirement to heat media such as lithium bromide, oil etc.

Table 6: Vent noise description

Description	Noise Pressure dB(A)				
Vent to atmosphere	92.00	91.5	92.4	91.8	92.04
Vent with Silencer	87.5	88.25	89.02	88.14	89.52
Vent connected to dumped condenser	74.20	72.05	73.78	72.98	74.57

Steam traps are a type of automatic valve that filters out condensate (i.e. condensed steam) and non-condensable gases such as air without letting steam escape.Thermodynamic disc steam traps have an intermittent, cyclical operating characteristic. The valve mechanism comprised of a disc and seat rings opens to discharge condensate for a few seconds; and then closes for a generally longer period until a new discharge cycle begins.
The opening and closing action of thermodynamic disc traps is caused by the difference in the forces acting on the bottom and top sides of the valve disc. These forces are essentially based on variations in kinetic and pressure energy of the typical fluids involved; air, condensate, and steam. This high-temperature, high-pressure steam discharges at high velocities produces a number of hazards to employees working near the traps. A-weighted noise levels alone can reach 100 dB (A).It generated noise 88.75 Db (A). It is higher to the WHO norms though it is not continues operation but contributing noise in plant area.

Noise levels can be reduced significantly by fitting diffuser-type silencers to each trap discharge.These silencers operated on the principle that by slowing the jet discharge velocity, the noise output would be reduced. This reduction was achieved by passing the discharge flow into a short pipe of enlarged diameter through a flow-resistive material, typically stainless steel wire wool.

Table 7: Effect of Diffuser on noise

Description	Noise Pressure in dB (A)					
Noise Pressure without Diffuser	87.5	87.5	85	87.5	90	87.5
Noise Pressure Trap with Diffuser	85	80	78	77.5	76	75

3.4 Reduction of water effluent

The major water effluent of carbon black manufacturing plant is the power plant where the effluent is generated form cooling tower and De-mineralized plant. Cooling tower generate 60% of water effluent by blow down to maintain salt level in cooling water. DM plant generates 24%of effluent form regeneration of resin beds. Non process area and Boiler blow down is small contribution of water effluent in process. Though it is small quantity it has been treated and recycled in process for zero water discharge. Cooling tower blow down and De-mineralized water plant effluent are treated in reverse water osmosis membrane and recycled as cooling water treatment. Cooling water blow down is avoided by selecting air condenser instead of surface condenser for steam turbine exhaust steam condensate. Water requirement in air cooled condenser is one time and there is no need to give the system blow down such as in cooling tower used for traditional water cooled condenser to maintain water chemistry. Water requirement for air cooled condenser is 95% less than the cooling tower.

De-mineralized water treatment plant effluent are reduced by adopting new technologies such as Ultra filter – Reverse osmosis Mix Bed DM plant, Electrode ionization (EDI) Process, Liquid-cell Membrane Contactor System. These processes reduce chemical consumption of water treatment as well as generate less water effluent.

4] CONCLUSION

The sole objective of adopting innovative methods in carbon black manufacturing is to control air emissions, pollution and reduce water effluent. The previous section indicates thatmain source of air pollution is from boiler and dryer stack, where Sox level is high even though it is not deviating Indian environment standards norms. It contributes to increase air pollution. It can be reduce to the level of 5 to 25 ppm form 350 ppm by placing flue gas desulphurization unit. Desulphurization unit byproduct has acceptance for land filling and fertilizer. There are few other sources for air pollution in plant like vents and leakages. These can be controlled by good engineering practices and preventive maintenance. This also reduces the suspended particulate in the atmosphere. Suspended particulate level changes by location, vehicle movements also, which is taken care by proper housekeeping and vehicle traffic management.

De-mineralized water plant effluent is treated in reverse osmosis and multi effect evaporator and water is recycled in plant. This gives zero water discharge (ZLD). Ion exchange bed De-mineralized water plant has new technology as reverse osmosis with mix bed or with EDI Technology. Reverse osmosis with mix bed or with EDI plant the effluent quantity is reduced up to 15-20 %. Plant floor washing water is settle down in the settling pond and willbe recycle in process for quenching purposed by putting activated carbon and sand filters .

Noise is the one of the major source of pollution in carbon black manufacturing industries. It is reduced by using noise damping technologies such as acoustic encloser for equipment, silencer for vents. Acoustic encloser helped to reduce noise level up to 25 decibel (dB).Steam line trap noise level is reduced up to 72.5 decibel (dB) by using diffuser to the out let of steam. Boiler pressurized deaerator vent noise is reduced form 98 decibel to 72 decibel (dB) by using close loop system. This also gives the heat and water recovery form vent steam.

REFERENCES

[1] I Drogin, "Carbon Black", Journal of the Air Pollution Control Association,TI-2Chemical committee informative report No.09. 16 March 2012

[2] Eric L.Crup, “Economic Impact analysis for the proposed carbon black manufacturing”,NESHAP,US Environmental Protection Agency, May 2000

[3] Howard L. Conklin,“Water requirement of the carbon black industries”, Geological survey, United state Government printing office ,Washington, 1956

[4] Report of ICBA “Carbon black users guide:safety health and environmental information”, International Carbon black Association,2004

[5] Farhad Forouharmajd, Parvin Nassiri and Mohammad Reza Monazzam, “Noise Pollution of air compressor and its noise reduction procedure by using and enclosure,” International Journal of Environmental Health Engineering” “Vol. 1 Issue 1, Feb 2012

[6] Dihel, G.M.,”Compressor Noise Control,” International Compressor Engineering Conference ,Paper 10,Purdue University,1972

[7] Brian P. Hemon , R Hilda Zonapalidou, Li Zhang, Keith J. Sims and Linda R. Siwak, “Electrodeionization in power plant application”, GE Power and water process technologies,1994

[8] Rayan Hamel, Ignao Sala, Nathan Fritz and Christropher Frampton,“Pollution Presentation inters program” Pollution Presentation Institute, Kansa State University” Page No-2, 2006

[9] Li-Shiang Liange , Lu Wang , U.S. Filter, Lo well and Massachusetts, “Continuous electrodeionised process for production of ultra pure water”, Pure water and chemical conference,2001

[10] J.O. Osarenmwinda and A. A. Onojoserio,“Noise pollution in a refining and petrochemical company in Nigeria”,International Journal of Engineering Research and Applications,Vol. 5, Issue 4, April 2015 , Page.01-05

[11] Randall F. Braoon ,Industrial Noise control and Acoustic, Louisiana Tech University , Chapter 5,2001

[12] Parag Mishra and Dr. Manoj Arrora”, “A Review of literature on air cooled steam condenser”, International Journal of Research in Aeronautical and Mechanical Engineering, Volume 1, Issue 10, October 2015