

# TREATMENT FOR HARMFUL GAS EMISSION OUT OF RANKINE CYCLE

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**Abstract:** Every Rankine cycle works in process starting from boiler, turbine, condenser, and then pump. The boiler area, where all of the solid waste is burned, emits the most of the hazardous gas. The traditional Rankine cycle employs all types of waste, such as wood, coal, and solid waste, to generate extremely high temperatures. As a result, several hazardous pollutants, such as Sulphur, COx, and NOx, are generated. As a result, adequate treatment is required to protect the release of dangerous gases into the atmosphere [1]. To create a purifying system, we are merging the smog tower concept, sprinkling water concept, and water disposal concept. We have also developed the CAD model of Spark Arrester; Smog tube and chemical separation tank and the phenomenon is been widely explained in this paper.

The Rankine cycle is increasingly being used in power producing plants. The thermodynamic notion of converting thermal energy into electric energy is used in the Rankine cycle. A substantial volume of municipal solid waste is used to boil the water in the boiler section. The gases emitted by the burned MAW are extremely hazardous to the respiratory system as well as the environment cycle. To obtain cleansed air, we created a cost-effective approach by combining the phenomena of smog towers, water churning, and filtering systems. In gaseous form, the contaminants are extremely difficult to capture or remediate. The technologies are available on the market; however, they are highly expensive. So, if we can dissolve the contaminants in water, the treatment process will be much easier. As a result, we developed a computer-aided design (CAD) model that converts gaseous dissolved pollutants to water dissolved pollutants before treating them.

## Introduction

For the functional definition of impact categories, the ORC environmental impacts (EIs) have been revealed comprehensively from working fluid and heat domain aspects. The impact of ORC refrigerant leakage, which has been largely ignored in earlier ORC research, is important in determining environmental performance and is particularly important for working fluids with a high global warming potential (GWP). When compared to high-GWP fluids, using lower-GWP fluids can result in a 50–84 percent reduction in emissions, while adding the annual leakage rate from 2 to 8% for high-GWP fluids results in a 60–124 percent increase in total emissions [2]. Increasing the efficiency of a pump or turbine from 75% to 90% can result in a 10–16% reduction in emissions. Other inventory EIs have also been briefly examined. The amount of ash generated ranges from 15-25 percent (by weight) and from 5-15 percent (by volume) of the MSW processed from remaining of the smoke (Wt% is) Carbon: 55.57, Hydrogen: 5.38, Oxygen :34.88, Nitrogen :2.09, Sulphur :0.31, Chlorine :0.04, Phosphorous :0.10

According to the Greenpeace Southeast Asia Analysis of IQAir data, over 120,000 persons died in India in 2020 as a result of air pollution and related diseases (at least 12,000 in Bengaluru alone). According to the report, air pollution has cost India \$2 lakh crore in economic damages [3].

Components	Mass (%)		Moisture Content (%)		Density (kg/m)	
	Range	Typical	Range	Typical	Range	Typical
Food Waste	6-26	147	50-80	70	120-480	290
Paper	15-45	34	4-10	6	30-130	85
Card Board	3-15	7	4-8	5	30-80	50
Plastic	2-8	5	1-4	2	30-130	65
Textile	0-4	2	6-15	10	30-100	65
Rubber	0-1	0.5	1-4	2	90-200	130
Leather	0-2	0.5	8-12	10	90-260	160
Garden Trimmings	0-20	12	30-80	60	66-225	105

To overcome the challenges due to HS- /H<sub>2</sub>S, several technologies for Sulphur pollution remediation have been developed and practiced over the past decades including conventional physicochemical-based processes such as Alkanolamine. The physicochemical procedures were designed to treat gaseous sulphide streams or huge quantities of polluted water streams with high sulphide concentrations (Tang et al., 2009). However, most physicochemical approaches require large chemical doses and consume a lot of energy [3], resulting in substantial operating costs, especially for small-scale applications (sulphide loading less than 100 t/day) (Gabriel and Deshusses 2003; Syed et al., 2006; 75 Klok et al., 2013) [4]. Biological techniques, on the other hand, have proven appealing features such as the absence of catalysts, minimal sludge output, and the potential recovery of elemental Sulphur. Activated carbon has a high absorptivity and a great adsorption capacity due to its huge specific surface area and well-developed micropores. The physical adsorption properties of activated carbon are mainly related to the pore structure and specific surface area of activated carbon.

## Literature Review

When compared to other adsorption materials, activated carbon pore walls have a total surface area of 500-1700 m<sup>2</sup>/g and small micropores. Hu Zian discovered that the adsorption process of activated carbon is very complicated and involves the interaction of many forces (van der Waals' force, electrostatic action, complexation reaction, etc.). The surface of activated carbon contains primarily carbonyl, carboxyl, lactone, and phenolic hydroxyl groups, and the adsorption performance of activated carbon is determined by the interaction of many oxygen-containing functional groups [5].

There are three main modes of action: The first is to give electrons-to be impacted by electrons, the second is electrostatic action, and the third is coordination reaction. According to Huang Xishou et al's research, a water bath oscillating reaction was carried out at ambient temperature utilizing 0.25 g carbon-sodium dodecylbenzene sulfonate (SDBS) as an adsorbent to adsorb lead (10 mg/L) in simulated wastewater of 100 ml. The pH is 7, and the lead adsorption rate could be as high as 98.0 percent. Adsorption of 200 mL with 0.02 g carbon **SDBS** wastewater with 100 g/L nickel ion concentration, water bath oscillation at room temperature, pH = 7, and nickel adsorption rate is up to 96.3 percent According to Wu Y. et AL's research, copper-loaded activated carbon is more than 90% effective at treating phenol-containing wastewater. In the last process we are going to use the sand filtering method will be used in the last step; this procedure was previously examined by Peter A Clarke in June 2012, and they used fine sand, coarse sand, and pebbles in the same way we did.

## Objectives of the work

The MSW (municipal solid waste) will be burned in the boiler section, and the heated smoke will next enter the spark arrester section. The heat from a flame front travelling at subsonic velocities is absorbed by a spark arrester, which lowers the temperature of the burning gas/air mixture below its auto-ignition temperature, preventing the flame from surviving. Heat is absorbed through channels (passages) built into an element. The MESH (maximum experimental safe gap) of the gas for a particular installation is chosen and measured using these channels. These passages can be regular, like crimped metal ribbon or wire mesh or a sheet metal plate with punched holes, or irregular, such as those in random packing. Purpose of spark arrester is Stopping the spread of an open fire, Limiting the spread of an already occurred explosion, preventing potentially explosive mixtures from igniting, confining fire within a controlled location, Stopping the propagation of a flame traveling at subsonic velocities. Then the comparatively low temperature air will enter in smog tube where it will go through bi-filtration process Pre- filter and Activated carbon filter(sheet).

It will then enter in the CST (chemical separation tank). To enforce the low velocity low temperature air to flow inside the CST we will use one turbine/blades in one outlet of the of the CST which will gradually lower the pressure inside the CST cavity. Inside the CST we will attach the water sprinkler mechanism which will be continuously sprinkled on the coming polluted air, and the clean air will go out, and the polluted water will be drained out to the filtration system. The filtration system will be as follows:

1) CARBON MONOXIDE TREATMENT PLANT

2) Manganese Greensand Filter

3) Sand Filtration Plant.

## METHODOLOGY AND EXPERIMENTAL WORK

Steps of Filtration:

- Air Filtration:

- Spark Arrester
- Smog Tube
  - i. Prefilter
  - ii. Activated Carbon Filter
- Chemical Separation Tank
- Water Filtration:
  - HPCA layer
  - Carbon Filtration System
  - Sulphur Filtration System
    - Manganese Greensand Filter
  - Sand Filter
  - EDTA Method

### Step 1

Spark Arrester: A **Spark arrester** (also spelled **arrestor**), **deflagration arrester**, or **flame trap** is a device that stops fuel combustion by extinguishing the flame.

Purpose of this spark arrester will be

- Stopping the spread of an open fire
- Limiting the spread of an already occurred explosion
- Preventing potentially explosive mixtures from igniting
- Confining fire within a controlled location
- Stopping the propagation of a flame traveling at subsonic velocities

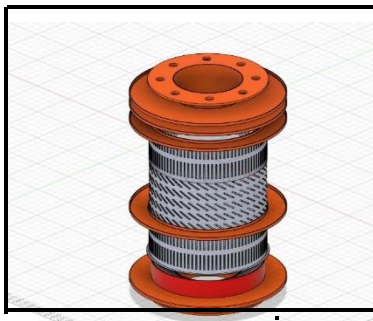


Figure 1 Spark Arrester Outer Body

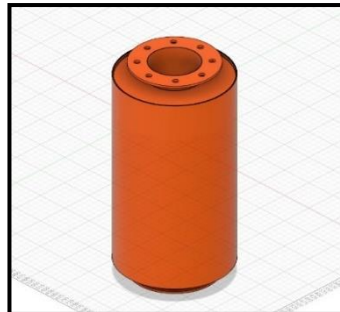


Figure 2 Spark Arrester Inner Body

### Step 2

Smog collecting tube: -

It will have prefilters and activated carbon filters.

- Pre-filters in your smog tower are a wonderful feature to have. It also prolongs the life of the HEPA and activated carbon filters that come after the pre-filter. In a cylindrical tank, the pre-filter is the first line of defence, capturing the biggest particles that the primary filter can't generally handle. Pre-filters are a useful element that improves air filtration technology by preventing particles from entering the primary filter.
- Activated carbon filters are unique in that they tend to remove dust and dirt from the air more effectively than regular filters. As they use chemically developed carbon, they can eliminate smaller particles and even odor.

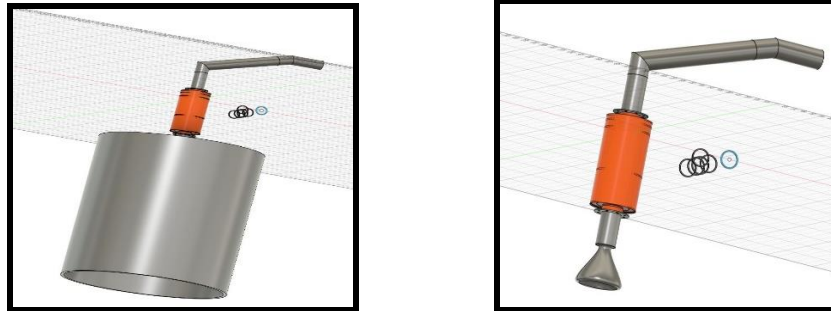


Figure 3 Spark Arrester with Smog Tube

### Step 3

Chemical separation tank (CST) consists of Turbine, Motor, Water sprinkler system, Air inlet and outlet, Water drainage outlet and cylindrical cavity. The Process is:

- Air will come out of the smog pipe where all the minute particles, dust particles are collected.
- We will create a suction i.e. pressure drop inside the cylindrical cavity of CST due to which air will continue to come in from smog pipe.
- The water will be sprinkled across the upper half of the CST, which will take all the AIR impurity inside the water, the Impure water will then go out through drainage outlet to filtration plant.
- The Air will go out through the OUTLET.

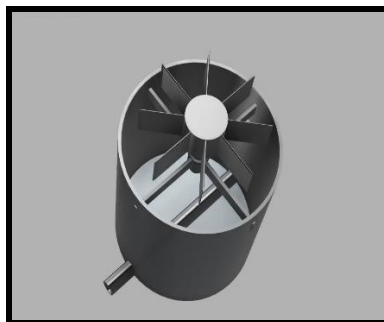


Figure 2 Chemical Separation Tank



Figure 3 Nozzle

### Step 4

Carbon filter

Carbon filtering works by adsorption pollutants in the treated fluid are trapped inside the pore structure of a carbon substrate. The substrate is made up of many carbon granules, each of which is highly porous. As a result, the substrate has a huge surface area, which could trap pollutants [6]. Filters commonly use activated carbon, which has been processed to have a substantially larger surface area than untreated carbon. The surface area of one gramme of activated carbon is almost 3,000 m<sup>2</sup> (32,000 sq ft).

## Manganese Greensand Filter

The ion exchange characteristics of greensand are used to create a manganese base material, which is then oxidized using potassium permanganate to produce manganese oxides. Because of the well-defined manganese oxide coating, the material has a strong buffering or oxidation-reduction capacity. Over 300 grains of manganese per cubic ft can be oxidized, and over 1 oz. of potassium permanganate per cubic ft can be reduced by the manganese greensand. Manganese greensand grains have the right size and shape to catch fine iron and manganese precipitates that pass through the upper coarse anthracite layer during normal service circumstances. There is no detention period, no filter medium, no high chlorine concentration, and no Sulphur dioxide in a real manganese greensand process. Manganese greensand is non-soluble and catalytic by nature. The total dissolved solids of the treated water do not grow, and backwashing manganese greensand is not required every time the well pump starts up. Since the 1950s, the manganese greensand technique has been employed in the United States. Hungerford & Terry, Inc. of Clayton, New Jersey, worked to refine the process throughout its early years of use, eventually developing the Ferro sand CR Process, which was patented in 1965. [7] The Ferro sand Filter has been used since then by thousands of municipalities and industrial customers worldwide. Ferro sand Filter Media is made to precise specifications to assure complete oxidation of soluble iron, manganese, and arsenic using stoichiometric quantities of oxidizing agents without the use of long reaction durations or high pH levels. (A ferric chloride pre-feed may be necessary for arsenic removal.) It works as a filter media which operates the oxidation and reduction chemical principles, as well as the well-known catalytic effects of manganese oxides. Due to its chemical composition, Ferro sand has a number of advantages, including the ability to be used in two different ways. This allows for flexibility in the design of the water treating equipment, with specific features tailored to the raw water characteristics.

### Step 5

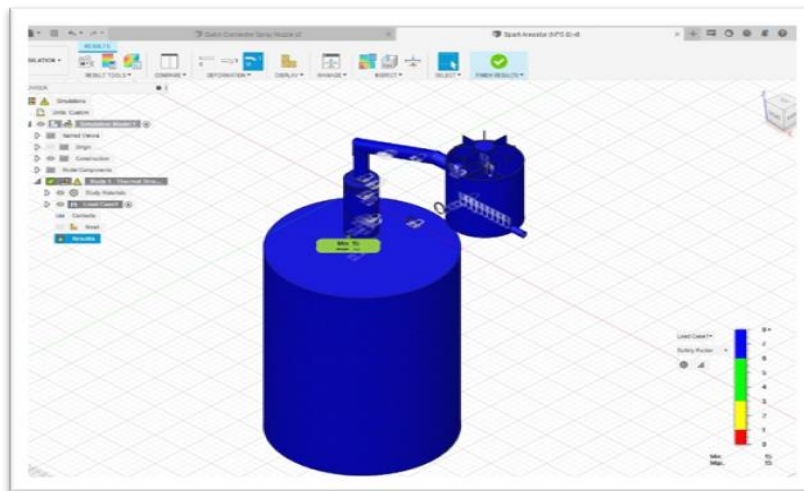
Addition layer of HPCA filter layer on the top of the chemical separation Tank.

- HEPA filters are composed of a mat of randomly arranged fibers.
- Polypropylene or fiberglass fibers with sizes ranging from 0.5 to 2.0 micrometers are commonly used. These filters are usually made up of tangled bundles of tiny fibers. Air flows along a small, convoluted channel created by these fibers. When the biggest particles pass through this channel, they act like a kitchen sieve that is physically preventing them from flowing through. When smaller particles flow through air, however, as the air twists and turns, the smaller particles are unable to maintain the same air velocity and are crushed by the fibers. [8]
- The tiny particles have extremely little inertia and are constantly moving around the air molecules as if they are being blasted by them (Brownian motion). They collide with the fibres because of their mobility.
- Key factors affecting its functions are fiber diameter, filter thickness, and face velocity.
- The air space between HEPA filter fibres is often significantly greater than 0.3 m, which influences its functions. For tiny particles, HEPA filters are set to a very high level.

### Result

The CAD model was designed in Fusion 360 [9]. It was rendered using specific materials. The simulation was performed using 44 contracts and 100N surface force was given along with the thermal temperature at 120 degrees Celsius. The simulation was performed and the results were

- The deformation of the whole body is negligible.
- The stress and impact are sufficient for the kind of structure made in CAD design.
- There is no edges or curves where the permeant deformation is carrying.



### Conclusion: -

- Due to combining the smog tube, Chemical separation tank and spark arrester the total value is reduced by 30% as compared to if we buy it separately.
- The harmful gases [Carbon: 55.57, Hydrogen: 5.38, Oxygen :34.88, Nitrogen :2.09, Sulphur :0.31, Chlorine :0.04, Phosphorous :0.10] can be successfully treated with water purity of less than 20 ppm.
- The CAD design is made in such a way that there is no effect of stress corrosion at any point so it increases durability of our system.
- 8 filtration system is successfully determined to segregate air from small particles, harmful gas emission and water treatment.
- One plant has all three solutions
  - i. Gas filtration.
  - ii. Solid waste management for power generation.
  - iii. Water treatment.

### Future Scope: -

- India is a developing country. The urbanization is happening at very prime speed in India. Municipal solid waste treatment is one of the major headaches of 21<sup>st</sup> century. This plan offers the three-way solution of power generation, harmful gas purification and waste disposal so this can be implemented in lot of cities in upcoming years.
- India has large demand of elements like Sulphur, nitrogen compound in Research and development field for research, so may be in future if technology becomes cheaper these trapped compounds can be given in various chemical laboratories.

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