Crude Oil Generation By Waste Tyre Pyrolysis

Bhushan Vyas[1], Dr. Sarita Sharma[2], Dr. Ashok Sharma[3], Dr. Sanjay Verma[4]
[1, 2] Dept of Chemical engineering
[2, 3]Professor,Dept of Chemical engineering
[4]Associate professor, Dept of Chemical engineering
[1, 2, 3, 4] Ujjain engineering college Ujjain,(M.P.),India

Abstract- *Tonns of waste tyres are dumped each and every year in the landfills. This not simply generates a nuisance yet it is also harmful for that environment. A great deal of chemicals can be used as making tyres in addition to the rubber. When these waste tyres lie within the landfills, you will discover a probability of these harmful chemicals leeching in the groundwater below and pollute this type of water supply. This is that the usage of waste tyre pyrolysis recycling method is gaining a lot of popularity for recycling the waste tyres.Pyrolysis is the simple thermochemical conversion of biomass into more useful fuels and also producing electricity. One of the greatest features of this product is with the aid of pyrolysis technology, it can be easy to get fuel oil from waste tyres and also plastics. The raw materials needed for operating this plant is quite cheap as these raw materials are useless to individuals. Pyrolysis is the processing of transforming certain product from the present form to newer form using heat. This method is today used in recycling tyre, plastics, and rubber that have been a problematic waste within our environment. Batch type waste tyre recycling plant utilize green technology in converting old scrap tyres into pyrolysis oil, carbon black, and metal wires. This technology is essential because of increasing non-biodegradable products which have filled the planet earth surface in present. In this experiment we can show smaller feed size particles provide more reaction surface, giving high heating rate and rapid decomposition of rubber and also increase the reaction time.*

Keywords- waste tyre pyrolysis, waste treatment, sustainable waste treatment process, ecofriendly waste to fuel process

I. INTRODUCTION

Pyrolysis has been proposed as a viable recycling technology to treat the very large tonnages of used tyres generated each year throughout the world. [1]Estimated that 1.5 billion tyres are produced globally per year and majority of these eventually end up as waste tyres contributing a significant portion of the solid waste stream. It was reported that the European Community generated an estimated 4.5 million tons of new tyres in 2010, with 289 million tyres being replaced per year. In the United States, approximately 500 million waste tyres were generated in 2007, with about 128 million used tyres already stockpiled. In Australia, around 52.5 million tyres reached their end of life between 2007 and 2008. Approximately 64% of these tyres went to landfill, or were illegally dumped or stockpiled, while only 13% were recycled [3] ,for the solution of the problem we adopt pyrolysis method Pyrolysis is the thermal degradation of the tyre in the absence of oxygen, generates oil, char, gas and residual steel wires, all of them having strong recycling potential. The process has the advantages of producing gaseous molecules with high calorific value that can be used to provide the energy requirements of the process plant. The steel wires may be readily recycled back into the steel industry the oil may be burned as a substitute furnace or boiler fuel.[1]
The prices of the petro fuels are increasing at a high rate so it has become necessary to develop the alternate renewable fuels. Use of renewable fuels not only save environment but also contribute to economy of the country.[2]Industrial sector in India is developing and the need for fuels are also increasing as the industry is mainly depended on fossil fuels, the price fluctuation make their planning difficult and their cost of production will also increase. As this difficulty exists, they are searching for alternative fuels which can be a substitute for the present fuel with an economical benefit too. Waste to energy is the recent trend in the selection of alternate fuels. Studies are made before on the subject Tyre pyrolysis oil as an alternative fuel.[4]As waste tyre disposal is also a major problem tyre pyrolysis can be adopted as a method through which pyrolytic oil generated. Pyrolytic oil has similar calorific value like diesel fuel and fuel which has comparable features with diesel.the extracted oil quality are also improve through the desulphurization process.

II. MATERIALS USED IN EXPERIMENT

In this process we used rubber tyre as a raw material for the experiment. Waste tyre were cleaned with detergent and water to remove contained foreign materials such as mud and oil. Washed out waste tyre were dried and cut into different size small pieces in the range of 2", 5" and 10"(inches) by using Shredder. The most commonly used catalyst in the waste tyre pyrolysis includes activated alumina, natural zeolite. Gas burner is used for primary heating of the reactor. After pyrolytic gas generation started it can pass through the condenser unit and uncondensed gas are used for heating of the reactor.

III. EXPERIMENTAL SETUP

The Activity is performed in a small scale externally heated fixed bed pyrolysis batch reactor was used for production of oil from Rubber Tyre. Figure 1 shows the schematic diagram of pyrolysis setup. Basic instruments of the pyrolysis method are shredder, Pyrolysis reactor, burner, temperature controller, condenser, gas for heating, insulator, temperature sensor, storage tank, valve, and blower. High quality double shaft shredder is used for crushing the waste tyre. Average rotating speed 10-30 RPM and 40 HP motor is used. The effective length and diameter of the stainless steel made insulated reactor are 850 X 2500 (mm) respectively. The reactor with tyre was heated by burner up to 450- 500°C. Here it is necessary to mention that the sensor was used through the wall of the stainless steel pyrolysis chamber to measure the temperature. Therefore, the temperature mention may have appeared small in amount as compared to conventional system. Besides, a nitrogen hole was used in the pyrolysis chamber to provide uniform heating across the cross-section of the reactor chamber and to create inert environment in the pyrolysis chamber.as well as pressure of the reactor is 0.3-0.35 Kg/cm^{2}maintain through the pressure controller.

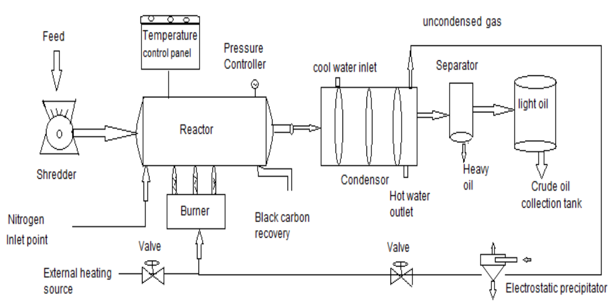

Figure 1: Schematic representation of experimental setup

There was no output at low temperature range and the process was carried out between the temperature ranges of 450°C and 500°C in the reactor for about around three hours and fifty minutes. The vapor products of pyrolysis were carried out through condensers. The condensers were cooled by water and the condensed pyrolytic-oil was collected into collectors. The non-condensed gas was flared to the burner for heating purpose and the char was collected from the reactor after completion of pyrolysis cycle.

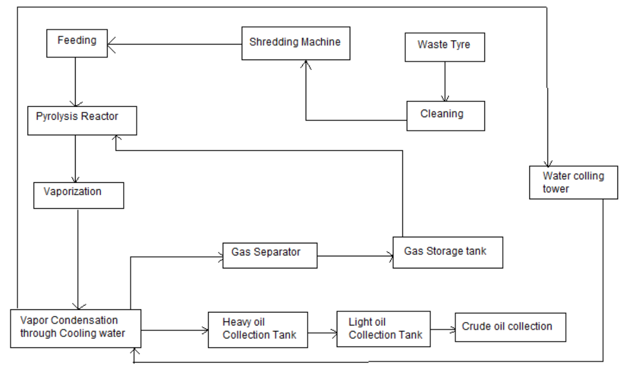

Figure 2: Schematic representation of Pyrolysis process.

PYROLYSIS PROCESS DESCRIPTION:-

Cleaning –For this experiment we use most commonly available domestic vehicle tyre. First step of this experiment is cleaning, waste tyre were cleaned with detergent and water to remove contained foreign materials such as mud and oil.

Shredding- After dust removal we use industrial shredder for cutting it into small pieces, shredder is size reduction equipment use in industrial application for reduce the size of material. It is the key machine in the process of the waste tyre recycling. The tyre shredding equipment can be used as pre-treatment device. Which can not only save cost and energy for the whole production, but only can improve efficiency greatly.

Loading- For this experiment we use batch type pyrolysis reactor in which we feed Shredded waste tyreas a raw material. Average 100Kg of sample tyre with the catalyst powder feed in the reactor and make reactor rotate slowly through rotating mechanism. Once the feeding is completed, the feeding hole is sealed and nitrogen is purged to evacuate oxygen from the reactor.

PreHeating- The pyrolysis reactor temperature is increased by external heating by using through gas burner.it takes around 3 to 4 hr. for vapors generation started, The reactor starts thermal decomposition of tyre once its temperature reached to around 450°C, and pressure of 0.3-0.35 Kg/cm^2. At this operating condition pyrolysis gas production started.

Heating to Gas generation- This period takes 6 to 8½ an hour to initiate vapors generation. The Pyrolysis gas comes out from the reactor is passed through the condensing system to liquefy and recover the liquid product of various grades. The gas which can't be liquefied under across the condensing unit is taken back to burner of the reactor for maintaining its temperature.

Cooling-The cooling cycle starts when thermal cracking of the tyre is completed. It normally takes 8 to 10 Hrs. (according to the weather condition). Cooling time can be reduce by using industrial blower.

Black Carbon and Steel Recovery-The carbon black and scrap steel is recovered from the reactor when its temperature falls down to 30°C after the whole process, around 4 - 7Hour time (according to the weather) is required for recovery of both the end products. After the removal of black carbon and ash maintenance related work startedon an average each batch takes place 22-24 hours to complete one cycle of operation.

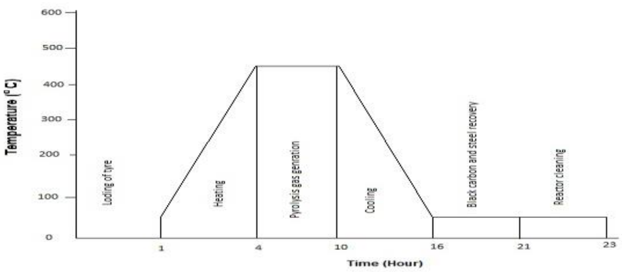

Figure 3: Temperature Cycleof the process

IV. PRODUCT FROM PYROLYSIS

A. **Pyrolysis Gas**- The approximate yield of gas from waste tyre pyrolysis is about to 10-30% by weight and it increases with increasing pyrolysis temperature. The pyrolysis derived gas has a calorific value of approximately 30-40 MJ N/m^{3}and can be sufficient to provide the energy required for a small scale process plant. The carbon oxide components (CO and CO_2) are mostly derived from the oxygenated organic compounds in tyres, such as stearic acid and extender oils. H_2S is a product of the Sulphur links vulcanized rubber structure decomposition and its concentration is low. C_4 and >C_4 gases are the most predominant products and these result from the Depolymerisation of Styrene-Butadiene-Rubber (SBR), usually the main constituent of automotive tyres. The components of the gas obtained from tyre pyrolysis at 400, 500, 600 and 700°C. The gaseous product mixture is made of shorter aliphatic chains than SBR due to rubber cracking and subsequent reactions to form lighter gases.

B. **Pyrolysis Oil-**There is need for greener fuel alternatives due to fossil fuel depletion, increasing crude oil prices and emission challenges. Tyre pyrolysis liquids production pathways with their wide range of potential applications. The waste tyre pyrolytic liquid is an oily organic compound, dark brown in colour and with a strong acrid smell. This oil should be handled carefully as it reacts easily with human skin, leaving permanent yellowish brown marks and an acrid smell for a few days, and this is difficult to remove by detergents. The tyre derived oil is composed mainly of alkylated benzenes, naphthalenes, phenanthrenes, n-alkanes from C11 to C24, and alkenes from C8 to C15, with small quantities of nitrogen, Sulphur and oxygenated compounds. The pyrolysis oil has a high calorific value of about 44 MJ/kg compared to that of waste tyres, 33 MJ/kg. The calorific value of the oil is also higher than that of bituminous coal, 28 MJ/kg and wood charcoal, 30 MJ/kg. Pyrolytic oils can be used as liquid fuels for industrial furnaces, power plants and boilers. The oil has a relatively low ash content and residual carbon. The liquids are very complex mixtures, containing aliphatic and aromatic compounds with their total concentration of 49.54% and 16.65%, respectively. The aliphatic compounds mainly consist of alkanes and alkenes with alkenes being the predominant group 43.23%. The aromatic compounds are mainly single ring alkyl aromatics. The aromatic nature of the waste tyre pyrolytic oils is due to aryl chain fragments from SBR aromatic rings splitting and cyclation of olefin structures through dehydrogenation reaction. The thermal degradation of accelerators used in tyre compounding and these are usually sulphur and/or nitrogen based organic compounds. The oils have higher carbon content, leading to the production of high value carbon materials for various applications. They are also contaminated with little metallic elements. The olefinic composition of the waste tyre pyrolytic oil is similar to that of condensates from petroleum residues cracking and thermal steam cracking of gasoline. Hence, pyrolytic oil may be blended with these condensates and subjected to the same thermal treatment. Monoterpene [1-methyl-4-(1 methylethenyl) cyclohexene], also known as limonene constitutes about 30% of pyrolytic liquids. dl-Limonene(dipentene) is produced from the thermal decomposition of poly-isoprene or natural rubber. It has extremely fast growing and vast industrial applications including formulation of resins and adhesives; dispersing agent for pigments; fragrance in cleaning products and an environmentally acceptable solvent. It also has applications in the cosmetic industry.

C. **Activated Carbon**- Activated carbon from pyrolytic char can be used for water purification and air purification and also used as a filler in photocopy machine tuner, as well as in batteries and fuel cells. Pyrolytic char has a calorific value comparable to high-grade coal and may therefore be used as fuel either in pulverized or briquetted form. The application of pyrolytic char as low grade carbon black for the manufacturing of thermoplastics and a low cost adsorbents for the treatment of industrial effluents has also been suggested. The potential of the tyre carbon black product as possible adsorbents for various pollutants has been assessed and found to be successful, thus stimulating a huge research interest. Active carbon can be used to adsorb phenols, basic dyes, metals, p-chlorophenols, butane and natural gas. The production, characterization and uses of carbon black as printing inks bases and recycled tyre fillers have been studied. To enhance the commercial value of waste tyre pyrolytic carbon black and increase its potential application as activated carbon, further treatment such as chemical activation is required. This allows both pyrolysis and activation to be integrated into a single, relatively lower temperature process in the absence of oxygen. Demineralization of carbon black with acid (sulphuric and hydrochloric acid) followed by activation at high temperature, normally 900^0C, in a furnace is common. Commercial activation of carbon black is usually conducted at temperatures above 800^0C in a mixture of steam and carbon dioxide. There is general agreement that steam is a more reactive agent than carbon dioxide Activation increases the surface area while decreasing the concentration of contaminants or non-carbon material. Steam-activated carbon black present greater capacities for the adsorption of small and medium size species such as phenol and methylene blue, while carbon dioxide-activated adsorb larger molecular size compounds such as textile dye Procion Red more effectively. Carbon black characteristics are influenced by the nature of activation and process temperature to a lesser extent.

Activated carbon has been used in the removal of both organic and inorganic species from industrial effluents. Due to the high surface area, 164 to 1260 m^2/g and pore volumes of up to 1.62 cm^3/g, tyre carbon black is considered to be a potential adsorbent in water treatment particularly for the removal of organic pollutants such as phenol and p-chlorophenol. Potassium hydroxide (KOH) activated waste tyre pyrolytic carbon black can be used to remove halogenated hydrocarbons and pesticides from drinking water. Tyre-derived carbon may also be used to remove chromium, lead, copper, dyes and phenol from industrial waste waters.

Activated carbon from waste tyres provides an effective means for gas-phase applications such as the separation, storage and catalysis of gaseous species. One example is the storage of natural gas for automobiles in which natural gas is adsorbed on tyre carbons under high pressure. It can also be used for the transportation of flammable gases such as acetylene. Pyrolytic carbon black may be used in the treatment of industrial gaseous effluents.

D. **Steel Wires** - The pyrolysis derived steel wire marketing depends on the cleanliness, quantity, and packaging of the product. The cleanliness of recovered is measured by the degree of rubber contamination. Steel with less than 10% rubber is considered acceptable in the market. Thermal processing of scrap tyres can be used to recover steel with minimum or zero rubber contamination. The quality is also influenced by the pyrolytic process. For a batch process, the separation of steel and carbon black from pyrolytic oil is fairly simple. This is complex for continuous pyrolysis, gasification and liquefaction process where tyres are usually ground into chips. In addition, the recycling of the recovered steel in the manufacturing of steel products is hindered by the burning of residual sulphur. The waste tyre market is influenced by the business cycle. During off peak, the processors may give away the steel for free or pay markets for collection. Bailing is difficult for steel recovered from shredded tyres. The added cost of transportation and storage reduces the income from this waste stream. However, this may be cheaper than paying a tipping fee for disposal.[5]

V. INFLUENCE OF OPERATING PARAMETERS ON YIELD

The pyrolysis process yields a gaseous fraction of mainly non-condensable gases, a solid fraction mainly composed of carbon, metal and others inert material as well as an oily fraction mainly composed of organic substances condensable at ambient temperature and pressure. The composition of the pyrolysis products is influenced by the process operating conditions such as feed size, operating temperature and residence time, heating rate and as well as the presence of catalytic medium.

A. **Feed Size**

Smaller feed size particles provide more reaction surface, giving high heating rate and rapid decomposition of rubber. The oil product vapors comparatively get enough time for secondary reactions in the reactor and this consequently increases gas yield and reduces liquid and char yields. On the other hand, the heating rate in whole tyre feed is low due to its lower thermal conductivity, in addition heat can flow only to a certain depth in the available pyrolysis time compared to almost complete thermal decomposition of the smaller pieces. Thus, the rubber core of the larger pieces becomes carbonized and cannot be decomposed completely resulting in increased char yield and decreased liquid and gas yield. The use of tyre chips instead of whole tyres may also increase the efficiency of the process by 20-30%

B. **Temperature**

The increase in gas yield with a corresponding reduction in liquid yield with increase in temperature is due to vapour decomposing into permanent gases, and secondary re-polymerization as well as carbonization reactions of oil hydrocarbons into char. It is also a result of char loss and thermal cracking. Thus, gas yields dominate at higher temperatures. Higher pyrolysis temperature and longer reaction times increase the gas yield and decrease char production. Highly volatile products are obtained at low temperature.[6]

C. **Residence time**

An increase in vapor residence time decreases liquid and char yields while the gas yield increases slightly. This is due to the decomposition of some oil vapor into secondary permanent gases. Primary vapors are first produced from tyre pyrolysis at optimum temperature, the primary oil vapors then degrade into secondary gases. [5]

VI. RESULT&DISCUSSION

Table 1: Feed size and oil production

Feed size(Inch)	> 10 inch.	> 5 inch	> 2 inch
vapor extraction starting time(Hour)	4:45 hr.	4.10 hr.	3:50 hr.
Amount oftotal crude oil extraction in (lit.)	48 liter	52 liter	55 liter
At constant temp.	450-500˚C	450-500˚C	450-500˚C

In Table-1 show that the oil production rate at450˚C to 500˚C of 100 kg sample tested in Batch type Pyrolysis reactorThis experiment has been performed in batch type pyrolysis reactor.Inthis experiment different size of shredded tyre where put into the reactorand reading were measured. Under this experiment it has been proved that small shredded tyreproduce more oil.'Smaller the tyre size more oil will be extracted' and it has been also observed that small tyre piece took less time to produce oil, this experiment proved that size of the tyre use in reactor has a great impact in the oil extraction processes.

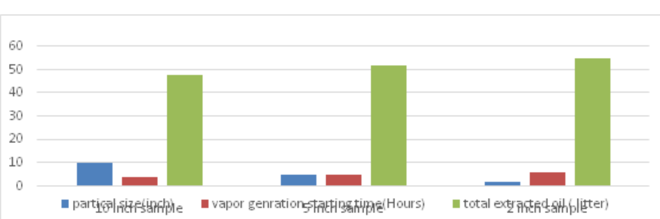

Figure 4: feed size vs oil production

In Figure 4 is showing that the graphical representation of Pyrolysis oil extraction rate at different size of shredded tyre which has been feed in the reactor, how much quantity of oil is extracted from the reactor is depend on the size of tyre which is feeded into the reactor. The process is also show that the more we shredded the tyre the more oil will be generated and our time will also be saved it means efficient and effective both will be achieved.

Table 2: Characteristics of Waste tyre pyrolysis oil

PARAMETER	RESULT MEASURED
Color	Dark Brown
Viscosity (cSt)	1.82
Density(g/cc)	0.78
Flash Point	18.5 ºC
Fire Point	- 17 ºC
Calorific Value	41.8MJ/ kg

Table 2 is shows that there is a pyrolysis Crude oil has Calorific value is 41.8 MJ/kg . The oil derived from pyrolysis of rubber has been known as a material with excellent and consistent fuel properties with a high calorific value.

VII. CONCLUSION

Recycling of tyres by the pyrolysis has resulted in ecofriendly process technique. Pyrolysis offers a great hope in generating fuel oils, which are heavily priced now. This reduces the economical burden on developing countries. So, this technology may be an initiative to solve fuel crisis and the problems due to disposal of Waste tyre.Solid, liquid and gases are products of tyres pyrolysis. Solid product of pyrolysis is 30 to 45%. Pyrolysis solid waste composed of black carbon char and different minerals constituents. These solid waste materials can be used again in different industries specially rubber industries as activated carbon and most commonly used as a row material for photocopy machine ink. The liquid product is 45 to 65%. Liquid products are organic compounds. This pyrolysis liquid can be used as a fuel for many useful applications and also a source of renewable source of energy. It has good calorific value similar to diesel fuel. Its gaseous products are 10 to 25% of Unsaturated Pyrolytic gases are mainly the mixture of CO, CO_2, H_2, H_2S, and CH_4 etc. Pyrolytic gaseous mixture is also a source of fuel which can be used in many industrial applications for heating purpose. The capital cost required to invest on Pyrolysis plant is low compared to other technologies.

REFERENCES

[1] "Sana Kordoghli'', Using Oxides of Alkaline-Earth Metals as Catalysts in Used Tyres Pyrolysis, International Journal of ChemTech Research, Vol.9,2016

[2] ''Ratnakiran D Wankhade and TK Bhattacharya'', ''Pyrolysis oil an emerging alternate fuel for future'', Journal of Pharmacognosy and Phytochemistry , 2017;VOL 6(6): 239-243

[3] JefreyPilusa "Economic Assessment of Waste Tyres Pyrolysis Technology: A Case study for Gauteng Province, South Africa", Journal of Research in Chemical, Metallurgical and Civil Engg., Vol. 1, Issue 1(2014) page 41-49

[4] Binoy C N , "Cost Reduction Using Alternative Fuel in a Forging Industry", International Journal of Scientific and Research Publications 1, vol. ISSN 2250-3153

[5] Nhlanhla, "A review and discussion of waste tyre pyrolysis and derived product", Proceedings of the World Congress on Engineering, Vol II, WCE 2014, July 2 - 4, 2014, London, U.K.

[6] M. Z. H. Khan, Journal of Environmental and Public Health Volume 2016, Article ID 7869080, 6 pages http://dx.doi.org/10.1155/2016/7869080 ,Research Article ,Pyrolytic Waste Plastic Oil and Its Diesel Blend: Fuel Characterization ,Department of Chemical Engineering, Jessore Science and Technology University, Jessore 7408, Bangladesh

[7] Ishfaq Abdullah, Pyrolysis of Scrap Tyres and Waste Lube Oil by Using Catalytic Agent , Int. Journal of Engineering Research and Applications, Vol. 4, ISSN : 2248-9622, Chemical Engg.Dept, Sharif College of Engineering & Technology Lahore, Pakistan

[8] Trimurti production PVT.Ltd, Sanwer road indore .