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A Comparative Analysis of Waste Tyre Pyrolysis, Gasifiction and Liquification Processes

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***Abstract* - This research analysised the corrective waste tyre technologies as well as use for energy and material recovery. To address the emergent waste tyre trouble the Waste minimization and utilization technologies are used. Waste tyres cause a range of environmental and health disputes as they are bulkiness and non-degradable. For this pyrolysis, gasification and liquefaction (PGL) processes are the probable solution to tackle these problems. In this paper the process conditions and potential products for each process are discussed. An ecological impact consideration of PGL processes and probable corrective solutions are also presented. PGL processes have enormous possible for commerce. Though the achievement of every process depends on some financial and ecological factors such as resources and working costs, supply accessibility, permitting process and discharge from these operations.**

***Keywords*—Economic, Energy, Environmental, Gasification, Liquefaction, Pyrolysis, Minimization, Waste**

INTRODUCTION

WASTE tyres are a important division of the city waste stream that is growing in quantity [1]. Waste tyres are non-degradable due to the vulcanization procedure they feel throughout their manufacture. The vulcanized rubber is cross-linked with sulphur bonds and is additional secluded by antioxidants and antiozonants [2]. In 1998, the globe manufacture and sales of tyres were predictable to have approved the one billion mark, with 2007 guess reported at 1.25 billion tyres [1]. In India, 55 to 120 million waste tyres are predictable to be deserted deceitful crossways the country. one more 10 million or so are additional to the store every year as vehicle owners by new ones. A lot of of these scrap tyres end up in landfills while others are blistered for heat up or left in the open. Combustion of tyres creates poisonous gases, which hold carcinogenic and mutagenic chemicals [3], [4]. Therefore waste tyre burning requires luxurious air emissions organize systems and there is also worry about the levels of ash produced. Efforts on waste tyre use again as solid fuel are largely recognized. Waste tyres have been used as main or minor fuel sources in the manufacture of electricity, cement, steam, paper, steel, lime and keen on the burning of trash; though these skills have been harshly incomplete by the little souk insist and the overall operational costs of these plants [5]. It is well known that tyres have high volatile and low ash contents with a heating value better than that of biomass and coal. These possessions create them perfect resources used for thermal procedure like pyrolysis, gasification and liquefaction [6]-[8]. Though India is creation important role, a massive

advertise for waste tyres is necessary to tackle this rising ecological dispute. Pyrolysis, gasification, and liquefaction are technologies that could be used to redirect a important part of the scrap tyres at present being landfilled.

TABLE I

Composition Of Whole Tyres

Ingredient	**Passenger car tyre**	**Lorry tyre**	**OTR tyre**
Rubber/Elastomers	47%	45%	47%
Carbon Black	21.5%	22%	22%
Metal	16.5%	25%	12%
Textile	5.5%	---	10%
Zinc oxide	1%	2%	2%
Sulphur	1%	1%	1%
Additives	7.5%	5%	6%
Carbon-based materials	7.4%	67%	76%

Moisture	2.00 (by weight)
Volatile	15.07 (by weight)
Fixed carbon	76.16 (by weight)
Ash	6.77 (by weight)
Elemental analysis[a]	
N	0.14 (by weight)
C	85.80 (by weight)
H	1.12 (by weight)
O	6.17 (by difference)

Fig I: Proximate Analysis Of Waste Tyre

II. PYROLYSIS, GASIFICATION AND LIQUEFACTION (PGL) PROCESSES

PGL procedure here option way for the removal of scrap tyres. They are at present second-hand for the change of carbonaceous resources to fuels and additional precious products, and their role may become important as the provide of usual wealth obtain exhausted.

i. Pyrolysis

Pyrolysis procedure takes place with no air or in anaerobic ambiance characteristically at a temperature of 400-700°C. Throughout this procedure, in the case of tire pyrolysis, sulfide bonds happening in the rubber turn out to be out of order and after that carbon chains are bursting and lastly gaseous, liquid and solid products are produced, which then can be subjected to additional dispensation. The major mechanisms are: methane gas , hydrogen, hydrogen sulfide and carbon monoxide. Oil stand for around 44%, and part of solids about 46% [9]. The liquid stage consists of a combination of aliphatic and scented hydrocarbons, such as benzene, toluene and others. The division of this mechanism from the fluid division can be attained by cleansing and refining. The solid portion consists of char, remnants of steel, silica, ZnO, ZnS, and any remains of catalysts, which were old [10]. Char can be old as a stuffing for rubber compounds, or might be focus to creation. The work of the products created, equally qualitative and quantitative, is needy on the pyrolysis process parameters such as temperature, the duration of the process, the conditions of pressure, inert gas and catalyst presence. Present are technologies in which the process occurs in an inert atmosphere, mostly nitrogen, or in the presence of catalysts accelerating the process and facilitate the distribution of multi-particle compounds. It is also likely to take out the procedure at the hydrogen flow through, so-called, hydrocracking. Vacuum pyrolysis process was bring in in the behind nineties, developed by Pyrovac International Iac. from Canada. The reactor is heated by the molten salts, pyrolysis occurs at a pressure of 20 kPa at a temperature of 480-520°C [8]. Present are also waste tires removal technique base on plasma pyrolysis and pyrolysis with water and CO2 in supercritical circumstances. in Israel Plasma pyrolysis of tires is used by Plasma Recycling Ltd, which produces synthesis gas [8]. Pyrolysis, as well as gasification, is a multifaceted process consisting of more than a few phase.

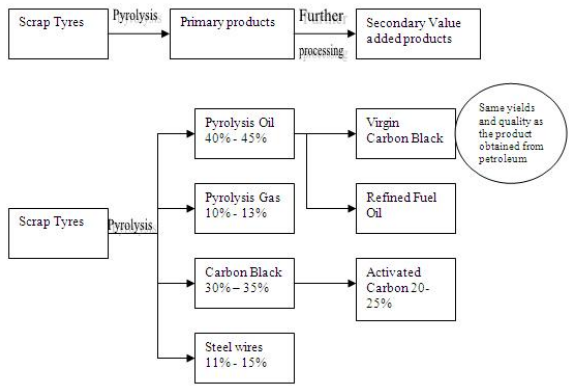

Fig II. Pyrolysis process pathway

ii. Gasification

Gasification is the thermal conversion of an organic substance into a combustible gas in the presence of an oxidant (air, steam) is shown in fig III .The oxidant (gasification agent) is supplied to the feedstock (e.g. shredered tires) where a series of heterogeneous reactions takes place [11]. Equations below shows gasification reactions for carbonaceous char.

$C + CO_2 = 2CO$	$\Delta H° = +172$ kJ
$C + H_2O\ (g) = CO + H_2$	$\Delta H° = +130$ kJ
$C + 2H_2O\ (g) = CO_2 + 2H_2$	$\Delta H° = +88$ kJ
$C + 2H_2 = CH_4$	$\Delta H° = -71$ kJ
$CO + H_2O\ (g) = CO_2 + H_2$	$\Delta H° = -42$ kJ
$CO + 3H_2 = CH_4 + H_2O\ (g)$	$\Delta H° = -205$ kJ
$C + 1/2\ O_2 = CO$	$\Delta H° = -109$ kJ
$C + O_2 = CO_2$	$\Delta H° = -390$ kJ

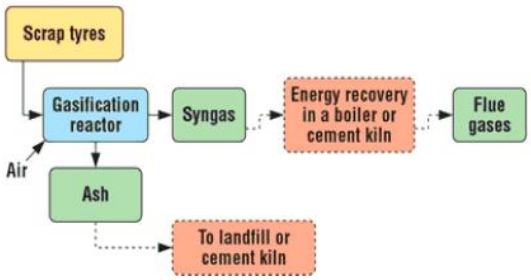

Fig III. Gasification process layout

C.Liquefaction

Liquefaction is the thermo chemical change of an natural solid into petroleum like liquid. Liquefaction characteristically engages the manufacture of a liquid calm of serious molecular compounds with possessions alike, other than not the same, to those of petroleum based fuels. The mechanism concerned in waste tyre liquefaction process are dispersal of solvent into the rubber; rubber swelling; rubber degradation; rubber dissolution; product separation from insoluble [12]. The gases and condensates are look upon as significant byproducts of waste tyre liquefaction. The gases create to develop at around 200^oC. The rate of gas generation reaches utmost at what time the combination is at best response temperature. Condensate generation follows a alike prototype to gases and is composed of hydrocarbons variety from C_6 to C_{20} [13]. An oil yield of up to 90.2% is likely [13]. Tyres might be liquefied individually, or in mixture with other waste materials and/or coal in co-processing schemes, in one or two stage processes. Liquefaction give an effectual move toward for change the organic content into oils.

III. ENVIRONMENTAL IMPACT ASSESSMENT

This part there an assessment of the ecological crash of waste tyre pyrolysis with potential alleviation measures. These crash comprise air emissions, liquid wastes, and solid residues. Usually, the green impact is alike in all three PGL technologies. When compared to operations that utilize combustion of waste tyres, it is generally accepted that PGL technologies yield equal or lower environmental risks in most cases. Though, the information obtainable is incomplete, owing to the little number of full-scale PGL facilities [14]. Exhaust gas clean-up of PGL processes is fewer compared to burning; Though, good design and operation of the process and emissions control systems are necessary to ensure that all health and safety requirements are met. The control of air emissions is made less costly and complex for PGL processes compared to incineration because (a) subsequent combustion of low-molecular-

weight gases from pyrolysis and gasification processes produces much cleaner air compared to the combustion of raw feed stocks (b) pyrolysis and gasification processes use zero or minimum air or oxygen. (c) Pyrolytic gases are typically in a reducing environment, and can be treated or utilized unlike the fully combusted (oxidative) exhaust.

A. Air Emissions

Air emissions might be the most ecological anxiety in PGL operations by waste tyres. The gases from pyrolysis and gasification processes (and following combustion processes, if appropriate) can hold a diversity of air pollutants that must be forbidden prior to discharge into the ambient air. These include particulate matter (PM), oxides of nitrogen (NOx), oxides of sulphur (SOx), dioxins and furans, hydrocarbon (HC) gases, metals, carbon dioxide (CO2), and carbon monoxide (CO) [15].

B. Liquid Residues

The main liquid products from tyre PGL processes are pyrolysis oils and any residual scrubber solutions from the air pollution control equipment. Pyrolysis oils from tyres and other products are multifaceted mixtures of hydrocarbons. The liquid fraction can hold a range of species counting acids, alcohols, aldehydes, aromatics, ketones, esters, heterocyclic derivatives, and phenols, along with unreliable amounts of water [16].

C. Solid Residues

The solid residue residual from PGL processes is characteristically an lifeless ash or char. The lifeless ash is the remains from the 3 to 5% of inorganic material in the tyre that cannot be rehabilitated to energy or products through PGL [14].

V. CONCLUSION

PGL procedure can be functional in the conduct of waste tyres for energy and material revival. The achievement of each ability is prejudiced by the economics, feedstock requirements and availability, and the permitting processes. The paper also assessed the environmental impacts of waste tyre pyrolysis and the potential alleviation actions.

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