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Yields from Pyrolysis of Refinery Residue Using a Batch Process

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Abstract

Batch pyrolysis was a valuable process of assessing the potential of recovering and characterising products from hazardous waste materials. This research explored the pyrolysis of hydrocarbon-rich refinery residue, from crude oil processes, in a 1200 liter electrically-heated batch retort. Furthermore, the off-gases produced were easily processed in compliance with existing regulatory emission standards. The methodology offers a novel, cost-effective and environmentally compliant method of assessing recovery potential of valuable products. The pyrolysis experiments yielded significant oil *(70%)* with high calorific value *(40 MJ/kg)*, char *(14%)* with carbon content over *80%* and non-condensable gas *(6%)* with significant calorific value *(240 kJ/mol)*. The final gas stream was subjected to an oxidative clean-up process with continuous on-line monitoring demonstrating compliance with South African emission standards. The gas treatment was overall economically optimal as only a smaller portion of the original residue was subjected to emission-controlling steps.

Keywords: batch pyrolysis, retort, residue, volatiles, oil yields, char, emissions, oil recovery

1. Introduction

The inherent disadvantage to the petrochemical industry has been the pursuit of greater production yields due to the increase in fuel and chemical demands [1]. This has, inevitably, led to an increased generation of non-distillable crude residue/hydrocarbon- rich waste sludge [2]. Various high quality fuel and chemical products derived from crude were subjected to several processing and refining stages prior to being regarded as commercially viable or premium grade products. These various processing stages are well documented in the literature and include: catalytic cracking [3–5], catalyzed and uncatalyzed reforming [6–9], hydrogenation [10–12], de-sulphurization [13–16], distillation [17], etc.

The dynamics and characteristics of distillation processes are based primarily on the feasibility of their operating potential, and do not possess the capability of elevated operating temperature, typically greater than 415°C [2]. This has led to the generation of large quantities of non-distillable residues, containing entrained "hydrocarbon values", that have not been liberated in the thermal conversion process from liquid crude to gaseous phase distillable and condensable products. The work conducted by Ngan [2] aimed at extending the capability of an ethylene furnace for flash pyrolysis of heavy crude fractions containing pitch. Here, pyrolysis was performed in order to recover a higher hydrocarbon fraction in vapor form for cracking purposes. Subsequently, the validation of pyrolysis as an effective means of recovering a higher hydrocarbon fraction was confirmed. But more importantly, this objective is not readily achievable in atmospheric or vacuum distillation columns. This further proved the need for the present work, as material exhibiting characteristics similar to that of hydrocarbon-rich residues, which may be generated in future by any fuel manufacturing industry, would thus require an efficient and investigative method to evaluate the yield potential of the waste hydrocarbon feedstock. The feasibility of utilizing a pilot scale continuous pyrolysis unit becomes an issue of

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