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Effect of Feed Composition and Product Quantity of Co-Processing Refined Bleached Deodorized Palm Oil (RBDPO)

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ABSTRACT

The research on Co-Processing Refined Bleached Deodorized Palm Oil (RBDPO) was conducted to examine the Effect of Feed Composition and Product Quantity. It is to provide the competitive renewable fuels in accordance with the government programs to promote Renewable Energy (RE) by utilizing the processing unit, infrastructure, transportation, and storage at existing refineries in Indoesia. The product is hydrocarbon fuel with existing specifications from previous petroleum feed. This research was carried out using a reactor temperature of 500-505 oC, feed flow rate of 2800T/D, ratio of RBDPO and VGO feed composition based on% wt, as well as RBDPO composition of 5%, 10%, 12.5%, 15% and 20%, respectively. This was followed by the addition of 15%, 20%, and 5% long residue to the feed component to determine the optimal composition of the product ratio. The result showed that the conversion ratio of valuable products between the base condition (77.7%) and the composition of RBDPO/VGO Co-processing (20/80) produced an optimum yield point for valuable products with a conversion result of 79.3%.

Keywords: *Co-processing, Renewable Energy, FCC unit; RBDPO, VGO*

1. INTRODUCTION

Indonesia is the largest consumer of energy in the Southeast Asia region and fifth in the Asia Pacific, after China, India, Japan, and South Korea. In 2016, the country's final energy consumption without firewood was dominated by fuel at 47%, with the largest share of 42% allocated to the transportation, and 36% to the industrial sector. Furthermore, the use of Fossil energy, such as petroleum, in fulfilling the consumption rate of energy is still relatively high at 96% with 48% petroleum, 18% gas, and 30% coal [1].

The cracking of oil from plants into fuel, such as diesel and gasoline, has become an interesting topic of discussion because it is an alternative fuel source that supports the policy [2]. It is also a renewable and environmentally friendly fuel source due to the presence of free nitrogen and sulfur [3].

Furthermore, renewable energy can also be produces by using co-processing RBDPO at the existing refinery industry. It is a combination process of biomass raw materials (RBDPO) and crude oil which consists of vacuum Gas Oil (VGO) [4] [14].

Recently, co-processing received attention for its potential ability to provide renewable fuels using the existing unit process, infrastructure, transportation, and storage units. The process produced hydrocarbon fuel from the previous petroleum feed, with existing specifications [4] [15].

The trial laboratory-scale test using the ACE (Advanced Cracking Evaluation) will confirm that the Co-Processing showed good result by producing renewable energy products. The initial data was also confirmed by the process licensor (IFP Axens, France) and the catalyst manufacturer (BASF, USA). It is also showed that the process did not have a negative impact on the entire Unit refinery operation [5] [16] [17].

Furthermore, temperature is an important parameter used to obtain the optimal results in this trial process [6]. Therefore, comparing the quality and quantity of the products before the trial period are benchmarks used to operationally observed and determine the margin [7] [17].

In this research integrating the optimization process and the right composition increases the percentage of the research [8].

2. MATERIAL AND METHODS

2.1. Materials

Refined, Bleached, Deodorized Palm Oil (RBDPO) is a CPO's derivative product, which has been physically and chemically treated. Its main advantage is associated with the low content of impurities such as sulfur and metal. Conversely, it has organic compounds, and its impact needs to be mitigated on the operating process [20]. The RBDPO used as feed-in the co-processing process was purchased from SAP Ltd. (Wilmar) with the occurrence of all processes on a commercial scale unit, as shown in Table 1 [9]. The research was conducted at the FCC Unit of PT Pertamina Persero RU III Plaju Palembang South Sumatra, Indonesia.

In general, RBDPO acceptance activities refer to the accepted crude or intermediate oil documents required which include RBDPO COQ (Certificate of Quality), RBDPO PDS (Product Data Sheet), RBDPO MSDS (Material Safety Data Sheet), Q88, Last Vetting, Ship Particular, Pertamina Safety Approval (PSA), Ship Inspection Report (SIRE). The implementation process is described at the acceptance stage, and the parts are in accordance with the respective functions and responsibilities [10].

Table 1. Properties of the RBDPO

Analytical Item	Metode Analisa	CoA	Spec RKS
Free Fatty Acid, (%)	AOCS (Ca 5a-40)	0.097	0.1 max
Color	Lovibond 5 ¼"	2.9	3.0 max
Melting Point, SMP, °C	AOCS (Cc 1-25)	36.6	35-39 °C
Iodine Value, Wijs	AOCS (Cd 1d-92)	52.18	50 – 55
Moisture & Impurities, %	AOCS (Ca 2b-38)	0.051	0.1% v max
Analisa Parameter lain		Analysis Results	
Specific Gravity at 60/60 °F	ASTM D-1298	0.9109	
API Gravity		23.84	
Distillation	ASTM D-86		
Initial Boiling Point, °C		226	
Water Content, %vol	ASTM D-6034	Traces	
Sulfur Content, %wt	ASTM D-4294	0.004	
Metal Content:	UOP -391		
V, ppm		0.08	
Ni, ppm		0.28	
Na, ppm		6.56	
Nitrogen Content, ppm	ASTM D-3238	*)	
Iodine Value,	AOCS (Cd 1d-92)	*)	
Condranson Carbon Residue, % wt	ASTM D-189	1.24	
Pour Point, °C	ASTM D-97	9	

*) There are no facilities

The existing feed or base in the form of VGO is the middle fraction of the product from the HVU II refinery of Pertamina RU III Plaju, In Indonesia. The VGO feed characteristics are shown in Table 2.

The catalyst used in the co-processing process is a product from Grace Davision company, designed for existing feeds [21]. The unit used for co-processing has a feed quality design as shown in Table 2.

Table 2. Reference for Feed Quality Design of FCC Unit properties

Parameter	Test Method	VGO	L. Res	Design
Specific Gravity at 60/60 °F	ASTM D-1298 or	0.878	0.931	0.888
API Gravity	D-287	29.66	20.49	27.85
Metal Content	UOP -391			
V, ppm	UOP -391	0.1	1	0.3
Ni, ppm	UOP -391	1	10	0.8
Na, ppm	UOP -391	-	-	2.0
Sulfur Content, %wt	ASTM D-4294	0.08	0.2	0.1
Nitrogen Content, %wt	ASTM D-3238	-	0.11	0.1
Hydrogen Content, %wt	Griffin		12.6	13
Carbon Cond Residue, % wt	ASTM D-189	0.05	4.92	1.05
Viskositas, Cst	ASTM D-445			
At 50 °C		-	122	-
At 60 °C		12.25	-	-
At 77 °C		8.27	-	-
Pour Point	ASTM D-97			
°C		49	-	-
°F		120	-	-
Distillation	ASTM D-1160			
IBP °C		248	323	248
10 % vol °C		380	368	378
30 % vol °C		419	415	418
50 % vol °C		440	435	440
70 % vol °C		456	501	465
90 % vol °C		503	-	-
FBP °C		536	-	-
Feed Capacity Design	T/D (20500BPSD)	2300	590	80%/20%

2.2. Experimental setup

A research was carried out in 2 stages. The initial stage includes observation by comparing the feedstock composition between RBDPO and VGO, starting from 5% wt and 10% wt on feed. Further stage was carried out with RBDPO feedstock composition at a ratio of 10% wt, 12.5% wt, 15% wt, and 20% wt. The next combination for a ratio of 15% wt and 20% wt was added with L. Res 5% wt to the feed at the target capacity, and with a total of 2800-2820 T/D. The feedstock composition between VGO and RBDPO is also used to maintain the heat balance of the Rg-Rx system.

The determination ratio of RBDPO and VGO is intended to mitigate the possibilities that occur in operating conditions during co-processing. The next step is used to determine the optimal composition towards the product ratio obtained [11].

Generally, RBDPO revenue activities refer to the crude oil or intermediate receipt documents applicable in RU III. The needed documents include RBDPO COQ (Certificate of Quality), RBDPO PDS (Product Data Sheet), RBDPO MSDS (Material Safety Data Sheet), Q88, Last Vetting, Ship Particular, Pertamina Safety Approval (PSA), and Ship Inspection Report (SIRE).

The implementation process is described at the acceptance stage, and the parts are in accordance with the respective functions and responsibilities [12].

The handling stage of RBDPO in the tank comprises of several parts, which includes settling the object for a minimum of 4 hours or in accordance with the target, operating the steam coil in the tank as needed, maintaining the RBDPO temperature at a target of 50 ºC, ensuring tank safety equipment such as PSV, sample holes, etc. It also ensures the operation position is ready, with the tank drained to remove free water and oil/RBDPO samples for analysis. The handling stage of RBDPO in the tank comprises of several parts, which includes settling the object for a minimum of 4 hours or in accordance with the target, operating the steam coil in the tank as needed, maintaining the RBDPO temperature at a target of 50 ºC, ensuring tank safety equipment such as PSV, sample holes, etc. It also ensures the operation position is ready, with the tank drained to remove free water and oil/RBDPO samples for analysis.

Alternatively, the handling process of the Co-processing RBDPO products includes allocating a dedicated product tank during the process, taking samples, analyzing the process using predetermined parameters, increasing the sampling frequency, analyzing dry gas samples, and carrying out hazard monitoring in the operational area during Co-processing.

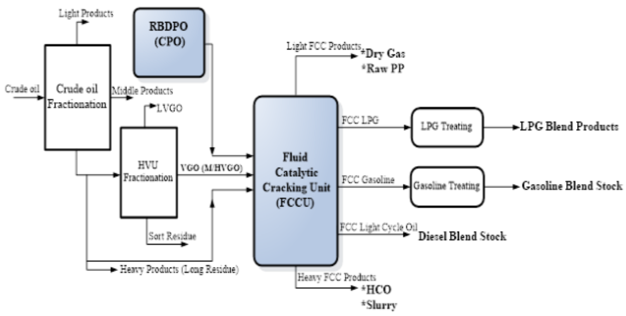

Figure 1 Refining scheme RBDPO is directly co-feed into the FCCU Unit

2.3. Analysis and characterization

The estimated Co-Processing composition is the ratio between RBDPO and VGO feed, which is estimated at a certain ratio, and capable of reducing the yield of the product. According to existing studies and the results of the trial, the hypothesis made on the feed composition ratio is limited to a maximum of 20% RBDPO, and this is seen or mitigated by the trial possibility with a larger scale feed ratio [22].

3. RESULTS AND DISCUSSION

A product data was obtained by analyzing and processing data from the DCS (Distributed Control System) with other instrumentations in the Central Control Room FCC Unit during the trial stage. **Table 3.** FCC shift in dry gas, raw propane propylene (Raw PP), LPG, Gasoline, Light cycle gasoil, HCGO/slurry oil, and coke yields when Co-processing RBDPO with vacuum gas oil (VGO).

Research group	Dry gas	Raw PP	LPG	Gasoline	LCO	HCO/Slurry	Coke
Base Feed VGO (100)	3.2	9.3	10.4	51.6	15.8	6.4	3.2
RBDPO/VGO (5/95)	+0.3	-0.6	+0.1	0	+0.7	-0.6	+0.1
RBDPO/VGO (10/90)	+0.6	-0.3	0	+0.2	-0.7	+0.2	-0.1
RBDPO/VGO (12.5/87.5)	+0.6	-0.4	0	-0.5	+0.8	-0.5	+0.2
RBDPO/VGO (15/85)	+0.5	-0.4	-0.3	-0.4	+0.4	+0.1	+0.2
RBDPO/VGO (20/80)	+0.5	-0.8	+0.1	+1.5	-1.1	-0.4	+0.3
RBDPO/VGO/LongRes(15/80/4.96)	+0.5	-0.5	-0.8	+0.2	0	+0.6	+0.2
RBDPO/VGO/LongR(20/74.9/5.31)	+0.4	-0.8	-0.2	-0.6	+0.5	+0.4	+0.3

*) Total feed (2803-2826 T/D), Temp reactor (503-505^{0}C), Yield product and feed composition in (%wt)

The product data in Table 3 is obtained and summarized in the form of weight percent yield, which is calculated based on the total feed percentage, with an increase or decrease in product yield, as shown in Figures 2 and 3.

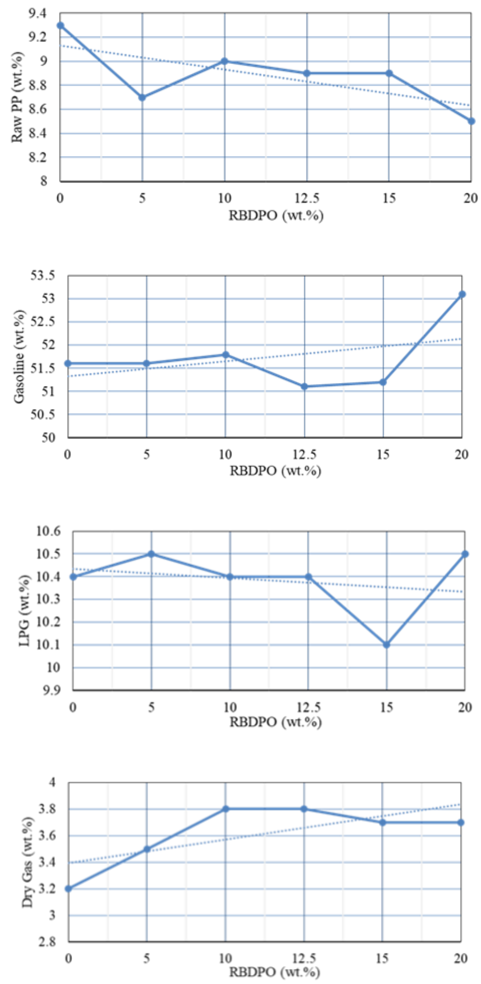

Figure 2 Effect of feed composition on the yield main product FCC unit

3.1. Quantity Dry Gas product

In terms of product yield quantity, there is an increase compared to the base condition before the injection of RBDPO in the trial stage, as shown in Table 3 and Figure 2. The increase in the composition of RBDPO injection leads to positive impacts on the quantity. In terms of quality, it is necessary to calculate and consider the potential increase in impurities in order to determine the RBDPO processing plan properly.

3.2. Quantity analysis of Raw PP product

The results of data analysis based on Table 3 and Figure 2 shows a tendency to decrease the yield of Raw PP products along with the increase in RBDPO injection as well as Purity Raw PP (propylene content). This leads to a continuous decline in line despite being above the minimum threshold needed, namely 66.12% mol in 10% wt injection RBDPO vs 64% mole of Purification Unit (Polypropylene Refinery Purification Unit spec feed) [18].

3.3. Quantity of LPG product

The quantity of LPG products tends to be constant and increases at 20% RBDPO, as shown in Figure 2. LPG yield and olefin compounds increase in accordance with good operating trend by changing catalysts regularly to minimize the occurrence of hydrogen transfer reactions, increase conversion, and reduce the residence/product vapour time in the reactor before entering the main column. This is achieved by adding the ZSM-5 catalyst additive [22][23].

3.4. Quantity Analysis of Cat Naphtha products

Cat Naphtha is the main product from the FCC Unit used as components of Premium blending (HOMC). It has an optimal quantity, with an increase in trend line by 20% RBDPO injection. The increase in Cat Naphtha quantity is due to a rise in the optimization level of operating conditions, and change in the composition due to RBDPO injection in the feedstock.

Further studies need to be carried out to verify the impact cracked by RBDPO on the quality of Cat Naphtha, which is later used as Green Gasoline. It is necessary to ensure that the impact on vehicle engine performance is anticipated early. Therefore this review or evaluation provides comprehensive results.

Cat naphtha also meets the specifications or standard quality with an increase in Yield Quantity by 20% RBDPO, thereby making it able to affect the obtained margins.

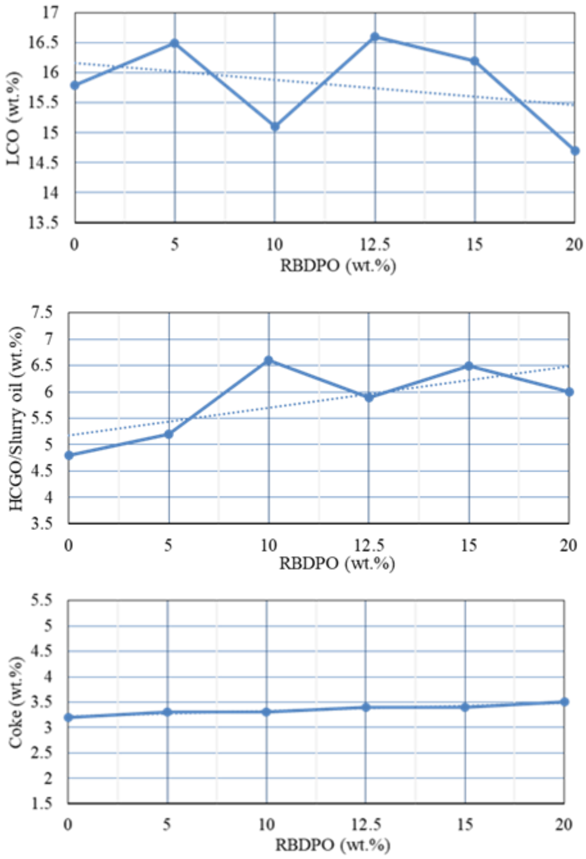

Figure 3 The influence of feed composition on side products

3.5. Quantity Analysis of LCO products

The FCC Unit fractionation tower uses several options to increase the LCO yield due to the need to maintain maximum cracking severity. Therefore, the easiest way to increase the LCO yield is by lowering the gasoline endpoint (cat Naphtha) by decreasing the main column's top temperature in accordance with an increase in the top pump or reflux rate. LCO products are used as a component of Industrial Fuel Oil (IFO) product blending [23]. The yield of LCO products obtained from the research shows a decrease, especially in the 20% RBDPO conditions, as shown in Table 3 and Figure 3, due to an increase in gasoline yield (cat naphtha).

3.6. Slurry product quantity analysis

Slurry or Decant Oil (DO) is the heaviest product from FCC Unit. It is dependent on the DO location of the refinery and availability of carbon black feedstock (CBFS), as a recycled product for the deblending base fuel oil with HCO. From the results of Slurry Oil analysis, it was found that there was a tendency to show an increase as seen in Table 3 and Figure 3.

3.7. Coke quantity analysis

Coke yield is relatively constant, as shown in Table 3 and Figure 3. It produces enough coke to provide heat stability. However, delta coke is the most essential, with its catalyst difference dependent on the ability to regenerate. At certain reactor temperature, the CO2/CO ratio in delta coke controls the regenerator temperature. A smaller delta coke lowers the regenerator temperature with several advantages. However, higher cat/oil ratio values improved product selectivity and provided flexibility in processing heavier feeds. Many factors influence the delta coke, including the quality of the feedstock, the feed design in the injection system, the riser design, operating conditions, and catalyst type [23].

4. CONCLUSION

In conclusion, the FCC Unit refinery in Pertamina in Indonesia is able to process RBDPO through the Co-processing method with 5 to 20% wt processing variation on feed (2800T/D) and minimum operational constraints. Furthermore, the main product yield has shifted along with an increase in RBDPO injection in accordance with a downward trend by raw PP yield, relatively stable Cat Naphtha, and an increase compared to the condition before injection. The optimum yield product and co-processing composition were obtained at 20% RBDPO feed composition.

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