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Biostable Additive For Reducing Filter Blocking Tendency (FBT) And Stability Improvement Of B30 Biodiesel At Offshore Storage Case Study: West Seno Bangka Oil And Gas Field At Makassar Street Offshore East Kalimantan

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ABSTRACT

The implementation of Biodiesel B30 in the West Seno Bangka oil and gas offshore field, located in Makassar Street, East Kalimantan, to support its operations is an important topic that has raised several issues. These include engine failures to start, unplanned stoppages of crew boats, and filter blockages. Therefore, to address these problems, Filter Blocking Tendency (FBT) and Particle Size Distribution (PSD) of B30 were analyzed and observed during offshore storage for operational purposes. The FBT analysis was based on ASTM D2068-20, while the PSD analysis relied on ASTM D7619-17. Over time, both FBT and PSD numbers have increased, which indicated operational issues due to the occurrence of precipitation in B30. To mitigate these issues, a commercial additive called Biostable was introduced into biodiesel to reduce FBT and maintain stability of B30. The laboratory tests showed that additive effectively improved FBT and PSD during a 60-day storage observation period. Following the application of Biostable, there was a significant reduction in FBT by approximately 78%, which decreased from 8.49 to 1.83. This improvement was also evident in the PSD, which maintained good filterability. As a result of these changes, stability and biodiesel quality were enhanced, which led to less frequent fuel filter replacements. The use of Biostable increased the reliability of equipment in the West Seno Bangka feld.

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I INTRODUCTION

The Indonesian government is seriously committed to responding to climate change, CO_2 emissions, and global warming by actively promoting the use of alternate resources to replace existing fossil fuel with renewable energy sources. It was projected that the energy demand in 2050 would reach 1012 MTOE, representing a 102% increase compared to the energy demand in 2030 [1]. This increase was primarily attributed to the following factors: declining and rising crude oil production and consumption, including unpredictable prices, which had prompted the government to accelerate renewable energy programs.

Biodiesel serves as an alternative fuel composed of methyl ester compounds derived from long-chain fatty acids [2]. It was initially produced as pure fuel, before being blended with diesel. The notation for biodiesel blends follows the format BXX, where XX represents its percentage in the mixture (e.g., B30 contains 30% biodiesel and 70% petroleum diesel). Indonesia is the largest producer of biodiesel in the world, due to its ample availability of raw materials. The production of biodiesel in the country has witnessed remarkable growth over the past decade, with output surging by an impressive 300%, rising from 3 million kiloliters in 2016 to 8.5 million kiloliters in 2020. To increase national energy security and fulfill its commitment to reduce greenhouse gas emissions, the Indonesian government has implemented a comprehensive journey plan for biodiesel adoption. This journey started in 2008 with a 2.5% blend of biodiesel into petroleum diesel, followed by a 20% blend in 2016. The most recent milestone was achieved in January 2020 when the mandatory implementation of a 30% biodiesel blend was regulated by Permen ESDM no 12 2015.

Following the adoption of B30 biodiesel blending, the Ministry of Energy and Mineral Resources reported impressive results. In 2020, there was a significant reduction in CO_2 emissions, totaling 22,640 tons. This reduction in emissions was accompanied by an enormous decrease in diesel fuel imports, resulting in substantial cost savings for the energy sector. The implementation of B30 played a role in stabilizing Crude Palm Oil (CPO) prices, which had positive economic impacts. Moreover, some business sectors, including the oil and gas industry, have supported biodiesel implementation efforts.

The West Seno Bangka field, an oil and gas deepwater operation located in Makassar Street offshore East Kalimantan, started using biodiesel for its activities in March 2019. However, its adoption led to certain technical issues, such as engine failures in crew boats and power packs for slick line units, difficulties starting diesel generators due to low fuel pressure, and a substantial increase in the replacement of main fuel filter due to blockages. Managing these problems in a remote area poses considerable difficulties, mainly stemming from logistic issues, and non-productive downtime, which could potentially result in production losses and increased operational costs.

These issues are associated to the properties of biodiesel, including its instability in particle distribution and increased number of Filter Blocking Tendency (FBT) compared to petroleum diesel. Biodiesel is produced through a process called transesterification, which comprises the reaction of lipids with alcohol. The process resulted in the formation of compounds like small amounts of sterol glycosides (SG), monoglycerides (MG), and diglycerides, which are major contributors to precipitates and particle distribution instability, thereby leading to filter clogging [3].

Based on the research conducted by Afton Chemical Industry in 2018, it was reported that a significant portion, specifically 62%, of filter blockages were caused by saturated monoglycerides [4]. Interestingly, even the presence of trace amounts of SG at room temperature can result in the formation of a cloudy haze in biodiesel [5,6].

Biodiesel, as an ester, has the inherent ability to dissolve organic materials, and due to its hygroscopic characteristics, any small amount of water inside the tank can accelerate the corrosion process [7-8]. Biodiesel tends to increase particle size due to the formation of corrosive byproducts or debris, closely associated with filter blockage tendency and the overall performance of fuel filtration systems. Previous research has reported instances of filter plugging during biodiesel operations, primarily attributed to the presence of compounds such as sterol glucosides (SG), saturated monoglycerides (SMG), and carboxylate salts [9,10,11]. Plata et al (2015), also reported that biodiesel precipitates were formed due to free steryl glucosides (FSG) and monoglycerides (MG).

The supporting equipment that used biodiesel is shown in Table 1.

Table 1. *Equipment usage biodiesel for operation in West Seno FPU*

Equipment	No unit	Operational
Operational Boat	2	Daily
Pedestal Crane	4	Daily
Fire Water Pump	4	Weekly test
Turbine Generator dual fuel	1	Back up
Emergency diesel Generator	2	Back up
Power Pack for well services	1	Daily

All this equipment had experienced unplanned stoppages during operations, failed to start, and exhibited poor performance following the usage of biodiesel. Additionally, another issue observed was the plugging of the main fuel filter MAD 5320.

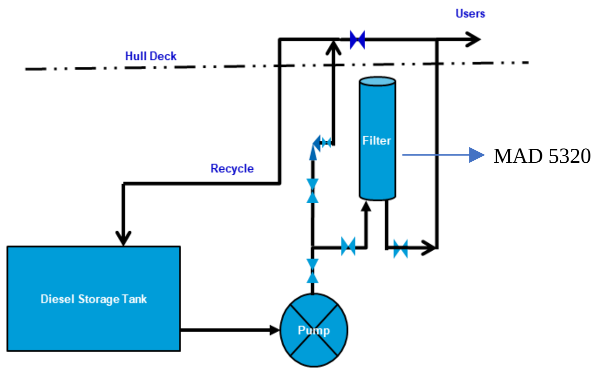

Figure 1. *Simplify diagram of diesel fuel system in FPU hull.*

To effectively address the 600% increase in fuel filter replacements and streamline its stock management, modifications were introduced to the operation of the diesel fuel system. A simplified diagram illustrating these changes is shown in Figure 1. The change included transitioning from a continuous circulation system (where diesel flowing from the tank, is pumped by the fuel line system, and returned to it through the recycle line, with users having access to various nozzles at any time) to an on-demand operational method.

The observation of Particle Size Distribution (PSD) is important to understand the growth of precipitates into granulate and its impact on FBT. Furthermore, FBT and PSD tend to increase over a specific period. In the case of the West Seno Operation, where approximately 500 kiloliters of biodiesel were consumed within three to four months, a significant observation was that most issues occurred relatively a month after fuel bunkering. This indicated a potential correlation between the duration of storage, biodiesel stability, and its FBT.

PSD and FBT analyses based on ASTM D7619 and ASTM D2068 were conducted to investigate issues that emerged after the implementation of B20 or B30 biodiesel. However, FBT which assesses the relationship between fuel volume passing through a standardized 1.6-micron filter and the pressure drop observed during ambient temperature testing, played a critical role in this study [11]. The minimum FBT value is 1, indicating good filterability, while higher values depict poor filterability. Some local standards in the UK, Australia, and New Zealand with a maximum of 2.52, 2.0, and 2.50, respectively for B10 set higher limits of FBT [13-15] [13-15]. The PSD analysis performed by ISO 4406:99, categorizes particle in three size ranges, namely > 4 microns, > 6 microns, and > 14 microns. Both analyses aim to evaluate the behavior of biodiesel stored in the hull tank of the Floating Production Unit offshore over time.

The use of additive named BioStable 8006, was proposed to enhance biodiesel properties such as maintaining stability of storage characteristics, reducing the FBT value, and improving fuel performance. BioStable 8006 is categorized as a cold flow improver because it contains a polymeric stabilizer and dispersant dissolved in a highly aromatic solvent. It also exhibits surfactant characteristics and can maintain and reduce surface tension, thereby preventing particle agglomeration.

The aim of this study is to analyze the behavior of PSD and FBT during storage because these factors have been identified as sources of operational issues. Another objective is to address these issues by introducing an effective additive mixture into biodiesel. This is intended to reduce the FBT value, improving storage stability and fuel performance. The primary goal of this study is to improve the fuel system and minimize equipment downtime, resulting in a significant reduction in the need for filter replacements.

II MATERIALS AND METHOD

2.1. Data Collection & Materials

The data comprised both primary and secondary sources. Primary data was directly collected from the West Seno Bangka field, including information on the frequency of filter replacements before and after biodiesel usage. Biodiesel samples used for FBT and PSD analyses are shown in Figure 3. Additionally, data related to equipment failures attributed to biodiesel and the initial FBT values prior to the introduction of additive were collected. Secondary data was obtained from two distinct sources. The Material Safety Data Sheet (MSDS) for additive was provided by the vendor. Biodiesel specifications were obtained from the final lab test reports issued by Pertamina refinery unit V Balikpapan, which served as biodiesel supplier for the West Seno Bangka field.

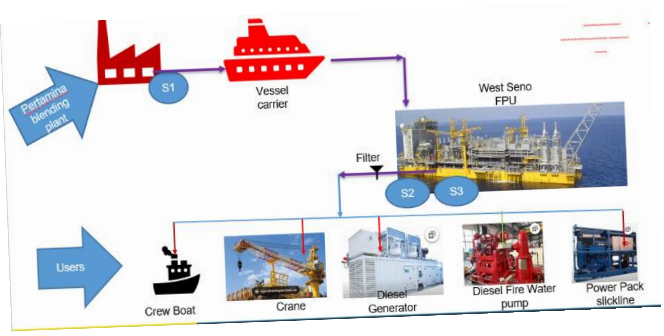

Figure 2. Sample #1, sample#2, and sample#3 of biodiesel from the blending plant and FPU diesel tank.

A visual representation of biodiesel B30 flow, originating from the Pertamina Blending plant and extending to the equipment used in the West Seno Bangka field is shown in Figure 2. During the process, three samples were collected as follows. Sample#1 was taken during biodiesel transfer from the blending plant to the vessel carrier, the aim was to verify the quality supplied by the manufacturer. Sample#2 was taken directly from the FPU diesel tank without any additive. Sample#3 was collected from the FPU diesel tank after the prescribed additive had been introduced. All three samples were analyzed at an independent laboratory. In addition, biodiesel sample was stored in a jerrycan for 60 days to observe changes in PSD and FBT values, and general cleanliness during this time frame.

The study process is primarily outlined in the flowchart shown in Figure 3.

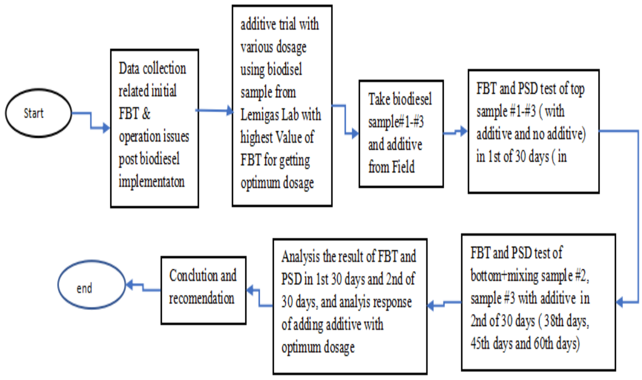

Figure 3. Flowchart illustrating the addition of an additive to reduce FBT and PSD and stabilize biodiesel.

2.2. Methodology.

2.2.1 FBT Analysis.

The FBT analysis followed the ASTM D 2068 standard and involved utilizing a 300 mL sample of biodiesel B30 from the West Seno FPU. This sample was pumped through a designated 1.6-micron filter at a constant flow rate of 20 mL per minute. Throughout the process, the pressure difference across the filter and the volume of biodiesel that passed through it were continuously monitored. This continued until one of two conditions occurred: either the entire 300 mL volume had passed through the filter, or a differential pressure of 105 kPa was reached. However, assuming the 300 mL volume had been fully pumped through before reaching the 105 kPa pressure, the endpoint was used to calculate the FBT number. The reverse was the case when the 105 kPa pressure was attained before the entire 300 mL was pumped through; the volume of biodiesel pumped up to that point served as the basis for calculating the FBT number. Equations 1 and 2 were used to calculate the FBT.

$$FBT = \sqrt{1 + \left(\frac{P}{105}\right)^2} \quad (1)$$

$$FBT = \sqrt{1 + \left(\frac{300}{V}\right)^2} \quad (2)$$

FBT : Filter Blocking Tendency

V : Volume (mL)

P : pressure (kPa)

2.2.2 PSD or Cleanliness Analysis.

PSD or cleanliness was evaluated based on the ASTM D 7619 standard. This test method used a specific automatic particle counter (APC) to count and measure the size of various particles, including dispersed water droplets, dirt, etc. The test applied to a wide range of fuels, including those categorized as light and middle distillates, as well as biofuels like biodiesel and its blends. It covered a comprehensive size range spanning from 4 µm(c) to 100 µm(c), with a specific emphasis on three size bands, namely ≥4 µm(c), ≥6 µm(c), and ≥14 µm(c).

III RESULT AND DISCUSSION

3.1. Profiling Initial FBT B30.

The initial FBT value was analyzed to assess the condition of biodiesel B30 before adding proper additive. Samples were collected at different time intervals for this purpose. The results of the FBT analysis for B30 are shown in Table 2.

Table 2. *Initial FBT value of B30 West Seno Bangka with no additive.*

Sample B30 Non-Additive position	FBT Value	Time
Bottom tank	4.40	Jan 2022
Bottom tank	6.08	July 2022
Bottom tank	15.0	August 2022

According to the results in Table 2, the average FBT value for biodiesel usage is 8.49.

3.2. Additive with Various Dosage

Prior to applying the optimal dose of additive into Biodiesel B30, several experiments were conducted using diverse dosages, namely 400 ppm, 500 ppm, and 600 ppm, mixed with biodiesel obtained from independent lab samples known for their high FBT values. The results of the FBT analysis of these three different dosages of biostable additive are shown in Figure 4.

When an initially blank biodiesel sample with an FBT value of 10.5 was treated with 400 ppm of additive, the FBT decreased to 5.1, representing a 49.3% reduction. Using 500 ppm resulted in a more substantial reduction of 56.2%, while the most significant effect was observed with 600 ppm, which reduced the FBT value by 65.4%. Despite these results, the 500-ppm dosage was implemented in the Bangka West Seno field.

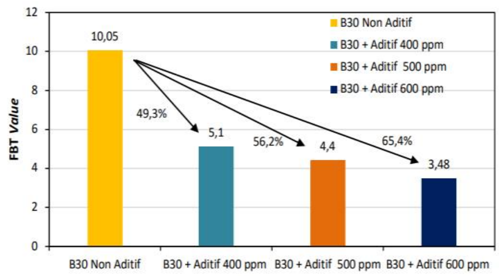

Figure 4. *FBT value with additive biostable with 400ppm, 500 ppm and 600 ppm*

It was selected based on both cost-effectiveness and the significant reduction achieved in the FBT number.

3.3. FBT and PSD of B30 on First of 30 Days Observation in Laboratory.

Three samples were collected from different sources, sample #1 was obtained from the blending plant to verify the quality of biodiesel B30 supplied by the manufacturer. Sample #2 represents biodiesel B30 from the West Seno Bangka FPU field without any additive, while Sample#3 is B30 West Seno Bangka with additive. These samples were securely stored in a laboratory. The objective of this study is to understand the phenomenon of agglomeration in the bottom tank over time. To reflect actual operational conditions, the first 30 days witnessed smooth operations with minimal biodiesel-related interruptions. Therefore, the observation and analysis focused solely on the top sample, specifically on days 0, 10, 20, and 30. PSD or cleanliness of these three samples is shown in Figure 5.

The results showed a consistent decrease in the number of particle greater than 4, 6, and 14 microns over the 30-day observation period. It suggested an improvement in stability of biodiesel across all samples during this time. Even the sample from the blending plant, which initially had 63,226; 18,559, and 2,290 p/mL for >4, >6, and >14 microns, were reduced to 35,698, 17,266, and 4,122 p/mL, respectively. In terms of cleanliness or PSD, both B30 West Seno samples, with and without additive, showed a 40% reduction in the number of particles across various size. Additionally, the B30 sample with additive showed a lesser particle count compared to the one without additive.

FBT data for the top sample showed a consistent decrease from day 0 to 30, as shown in Figure 6. The initial FBT value for the blending plant sample was

2.51, which was reduced to 1.41 over the 30-day observation period. Likewise, FBT values for both samples #2 and #3 also showed a downward trend during this timeframe.

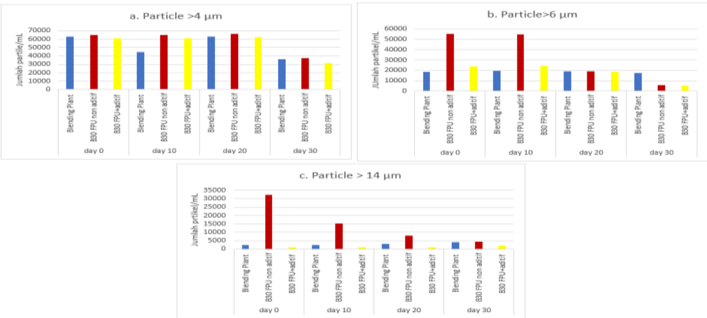

Figure 5. *Number of particles from days 0, 10th, 20th and 30th*

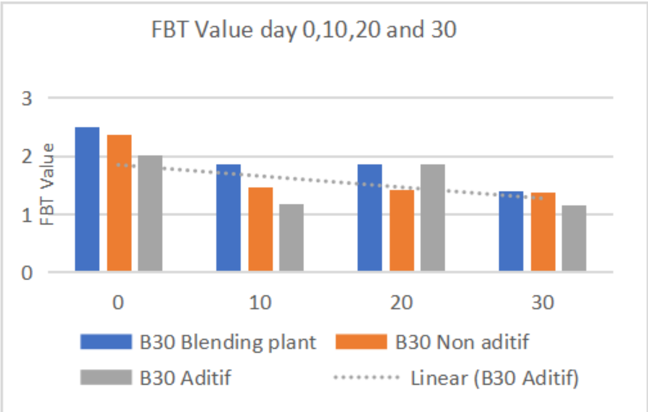

Figure 6*. FBT value from 0, 10,20, and 30 days.*

This phenomenon provided clear evidence that the cleanliness of the upper section of the tank consistently improved during the initial 30 days of observation. The improvement is closely correlated with the decreasing FBT values, indicating a reduction in filter-blocking tendency. Simultaneously, precipitation tends to occur at the bottom of the tank, resulting in a decline in both particle distribution and FBT values in the upper section. Based on the results obtained during the initial 30-day observation period, the study was extended to further investigate the occurrence of agglomeration or precipitation of biodiesel B30. This extended observation spanned an additional 30 days, with a primary focus on the bottom sample. PSD and FBT tests were conducted to compare and determine which operation was more effective.

3.4. FBT and PSD of B30 on Second of 30 Days Observation in Laboratory.

During this phase, the primary focus is on observing the precipitation or agglomeration phenomena occurring at the bottom of the tank. This is of particular significance because certain biodiesel-related issues tend to become more pronounced with extended storage times during the actual operations. The samples under examination include non-additive or blank samples and B30 with additive biostable. The observations were conducted on the 38th, 45th, and 60th day of storage. The results of PSD are shown in Tables 3 and 4. However, in the second phase of the 30-day study, as shown in Tables 3 and 4, there was an observable increase in the number of particles per milliliter, particularly in the bottom-side and mixed samples.

The results of PSD analysis from the first 30 days of observation in the top sample were closely linked to the methods from that of the bottom in the subsequent 30 days. Initially, there was a decrease in the number of particles, which later increased in the following 30 days. This pattern suggested that agglomeration had indeed taken place, leading to the settling of larger particle at the bottom of the sample. The mixed sample contained a smaller number of particles compared to those at the bottom without circulation. It indicated that the bottom sample without circulation experienced a greater degree of biodiesel agglomeration, which comprised glycerol. The operations performed in circulation or mixing mode proved advantageous in maintaining stability of biodiesel by preventing an increase in the number of particles across various size categories as defined by the ISO code (> 4, >6, and >16 microns).

FBT results during the second 30 days of observation in the bottom tank under circulating mode also showed an increase. This establishes a correlation between the increasing number of particles per milliliter and higher FBT values, confirming the occurrence of precipitation over time, from the beginning up to the 60th day. A visual comparison of FBT between the bottom and mixing samples over the 60 days without additive is shown in Figure 7. For the bottom and mixing samples, FBT increased from 2.36 to 2.69, and from 2.02 to 2.36, respectively.

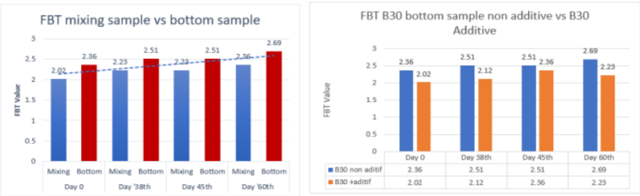

***Figure 7**. FBT value mixing sample vs bottom and B30 non-additive vs additive on 0, 38th, 45th, and 60th day.*

Biostable additive was introduced into the B30 sample and observed for 60 days. The comparison between B30 samples with and without additive is shown in Figure 7. The results obtained clearly showed improved FBT values for all samples after additive was introduced, both in the mixing and bottom samples. The FBT value for the mixing sample is lower than that of the bottom, indicating the effectiveness of additive in its reduction and enhancing stability of particle distribution. The methods from the 60-day laboratory study are in line with the operational issues experienced in West Seno field after the implementation of biodiesel. These issues included high fuel filter consumption due to increased FBT values and the number of particles as per the ISO code. Based on the promising laboratory results, which showed improved FBT and biodiesel B30 stability, biostable additive was added to the daily tank and further analysis of PSD and FBT was conducted.

3.5 FBT and PSD after Biostable Additive Implementation.

After conducting 60-day laboratory study, it was evident that the problem of high fuel filter consumption was unrelated to biodiesel produced at the blending plant. The results of the FBT and PSD analysis at the blending plant consistently met the UK standard [13], boasting an FBT value of 2.51, which was less than the required threshold. The issue was caused by biodiesel B30 stored in the West Seno Bangka tank. Without any additive, the average FBT value for biodiesel B30 was obtained as 8.49. However, after biostable was introduced, significant improvements were observed, as shown in Figure 8. The samples were collected on the 21st, 90th, and 101st day post bunkering. The 500-ppm additive was strategically added at the lowest level in the daily tank, just prior to bunkering.

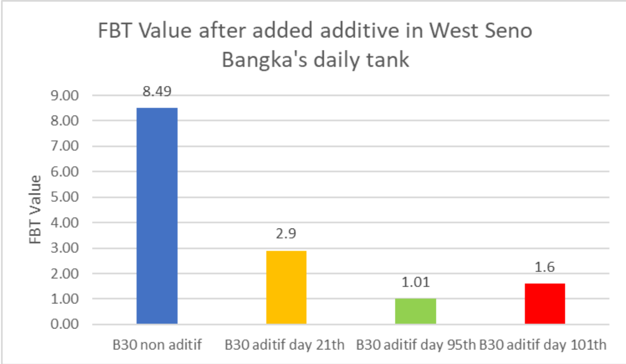

***Figure 8**. FBT value post added additive in West Seno Bangka daily tank*

After bunkering 300 kL of biodiesel mixed with 500 ppm Biostable additive, it was pumped and circulated for 24 hours to ensure homogeneity.

Biostable additive has proven its effectiveness in substantially reducing FBT levels. After introducing additive, the average post-mixing FBT reduced to 1.83, representing an impressive 78.45% decrease in its values. This significant improvement in FBT is similar to the results in Table 5, which provided insights into particle numbers within each category, following the ISO code standards.

In the last two sampling analyses, following the treatment of biodiesel with a 500 ppm Biostable additive, excellent results were observed. Particle numbers consistently remained less than 20,000 p/mL, indicating a significant 69% reduction in particle greater than 4 microns. Moreover, the count was less than 6,000 p/mL, showcasing an impressive 89% reduction in particle greater than 6 microns. Particle greater than 14 microns were maintained at levels less than 700 p/mL, marking an exceptional 98% reduction compared to the cleanliness of the initial biodiesel sample observed at the beginning of the analysis.

The methods indicated that additive effectively improved the characteristics of biodiesel B30, particularly its stability. This positive change was evident in the lower ISO cleanliness code and reduced FBT values. After introducing additive, there was a significant decrease in the frequency of fuel filter replacements (MAD 5320). However, this frequency remained higher compared to diesel petroleum. It is advisable to conduct further assessments to identify potential causes beyond FBT and stability issues related to the implementation of Biodiesel B30 in the West Seno Bangka field.

Table 5. FBT and particle distribution in daily tank West Seno Bangka after added biostable additive.

Implementation additive at West Seno FPU tank					
Parameter	Method	Unit	B30 FPU West Seno Bangka	B30 FPU West Seno Bangka	B30 FPU West Seno Bangka
			28 Dec 2022	6 January 2023	11 January 2023
FBT	ASTM D 2068-20		2.90	1.01	1.60
Volume		mL	110	300	240
Pressure		kPa	105	105	105
Temperature		^{0}C	24.9	25	24.9
Cleanliness	ASTM D 7619-17	ISO code	23/21/18	21/19/15	21/20/17
Particle> 4 µm		p/mL	40742	11469	17252
Particle> 6 µm		p/mL	15653	2882	5803
Particle> 14 µm		p/mL	1414	213	648

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IV CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the results and discussion, several important points were drawn from this study:

1. Biodiesel B30 obtained from the blending plant was found to show good stability, with ISO cleanliness parameters ranging from 23/21/18 to 22/21/19. In addition, it maintained an FBT of 2.51 during the 30-day observation period. These results indicated that Biodiesel B30, when used as feedstock in the West Seno Bangka field, was not the cause of any issues related to post-implementation.
2. In the first 30 days of laboratory observation, PSD or cleanliness of B30 from the West Seno Bangka field, as assessed from top-side samples, was consistently reduced every 10 days. This decline in PSD was accompanied by a corresponding reduction in the FBT values. These methods indicated an enhancement in top-side stability over time.
3. During the second 30-day observation period, which focused on bottom-side samples, there was a clear trend of increased occurrences of FBT and higher particle counts per milliliter in PSD analysis. The cumulative methods from the first and second 30-day observations led to the conclusion that agglomeration and precipitation had occurred, resulting in the instability of biodiesel at the bottom of the tank.
4. The mixing samples were examined to assess the effectiveness of different operational methods in terms of stability and their potential to cause filter blockages compared to non-circulating operations. It was observed that these samples, or circulating operations, showed superior stability and consistently

exhibited lower FBT values when compared to non-circulating operations.

5. The treatment, which involved the addition of biostable additive to West Seno Bangka biodiesel B30 and was observed for 60 days in the laboratory, was found to have effectively improved stability of biodiesel. It also led to a significant reduction in the FBT value.
6. The addition of additive to the daily tank of the West Seno Bangka FPU significantly improved stability and reduced the FBT by 78.45%.
7. Additive, composed of polymeric stabilizers and dispersants in a high-aromatic solvent and categorized as a cold flow improver, was found to possess surfactant characteristics. These were proven to have effectively maintained stability, reduced surface tension, prevented agglomeration, and improved filterability during the operation at West Seno field in the past.

4.2. Recommendation

The following are the recommendations provided in this study:

1. In pursuit of better mixing between biodiesel and additive in the storage tank, the operational mode was switched from intermittent to continuous operation (circulation mode). This strategic change was prompted by consistent observations that the mixing mode offered improved stability and lower FBT.
2. It is advisable to initiate a tank cleaning procedure to remove any remaining sludge and debris that had accumulated at the bottom of the tank. This cleaning was relevant not only before transitioning to biodiesel operation but also due to the issue of biofuel agglomeration since its implementation in 2019. Another concern arises from the fact that the diesel tank at FPU West Seno Bangka has not been cleaned since the inception of its operation, spanning more than 20 years. It is in line with guidance provided by the Ministry of Energy and Mineral Resources concerning the handling and storage of Biodiesel B30 [16], which recommended tank cleaning before using it for biodiesel storage.
3. Conduct further analysis to determine the optimal additive concentration for blending biodiesel beyond B30.

References

[1] Dewan Energi Nasional (DEN), SKK MIgas, IPA conference 2022

[2] LN. Komariah et al, (2018) Biodiesel effects on fuel filter; assessment of clogging characteristic, J. Phys.: Conf. Ser. 1095 012017.

[3]. Rosnani Umar at all, (2020), Transesterification of Refined Bleached Deodorized Palm Oil (RBD PO) Using Homogeneous Base Catalyst and Methanol and Investigation of Factors Filter Blocking Issue in Palm Based Biodiesel Investigation of Factors Filter Blocking Issue in Palm Based Biodiesel, IOP conference 864-012146.

[4] Afton Chemical corporation research, bulletin, 2018.

[5] R O Dunn, 2011 Improving the cold flow properties of biodiesel by fractionation (Soybean - Applications and Technology) 212-240

[6] B Khoshnevisan, S Rafiee, M Tabatabaei, H Ghanavati, S S Mohtasebi, V Rahimi, M Shafiei, I Angelidaki and K Karimi 2018 Int J Life Cycle Assess 23 1788–1805.

[7] K.R. Bukkarapu, Int. J. Ambient Energy 40 (2019) 295

[8] A.T. Hoang, J. Mar. Eng. Technol. (2018) 1

[10] Aguirre A, Peiru S, Eberhardt F, Vetcher L, Cabrera R, Menzella HG. Enzymatic hydrolysis of steryl glucosides, major contaminants of vegetable oil-derived biodiesel. Appl Microbiol Biotechnol 2014; 98:4033e40. https://doi.org/10.1007/s00253-013-5345-4.

[11] Cardeno F, Lapuerta M, Rios L, Agudelo JR. Reconsideration of regulated ~ contamination limits to improve filterability of biodiesel and blends with diesel fuels. Renew Energy 20

[12] A. Anastasov, Biodiesel, Basic Characteristic, technology and perspective, 23:sup1, 755-759, DOI: 10.1080/13102818.2009.10818533

[13] British Standards Institution [BSI], BS EN 590-2013þA1-Automotive fuels -Diesel - Requirements and test methods, 2017, p. 22.

[14] New Zealand Government, Engine Fuel Specifications Regulations 2011, 2011.

[15] Australian Government, “Fuel Standard (Automotive Diesel) Determination 2001, Fed. Regist. Legis., 2001

[16]. ESDM, Pedoman Penanganan dan Penyimpanan Biodiesel dan Campuran biodiesel (B30). 2020.

[17] K.R. Bukkarapu, Int. J. Ambient Energy 40 (2019) 295

[18] Arief Budiman dkk, (2014) Biodiesel, Bahan Baku, Proses dan Teknologi, UGM press.