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Water Contents and Monoglycerides as Development Role of Biodiesel Standard in Indonesia for B30 Implementation

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***Abstract*—Since 2016, Indonesia has implemented a policy of mixing biodiesel into diesel oil by 20 percents, also known as B20, based on regulation of the Minister of Energy and Mineral Resources number 12/2015. B20 is applied to all sectors that use diesel oil. In 2020, Indonesia continues to implement B30. Indonesia is the first nation in the world to implement B30, so Indonesia need biodiesel standard, especially biodiesel based from palm oil. This study is to present development standard of biodiesel in Indonesia. This study based on literature studies, discussion and biodiesel test sampling. The discussion is established by forum group discussion that consisting of government, industries and laboratories, and also by surveys to producers to take the biodiesel sample. This study result that the development of biodiesel standard in Indonesia is done by both road test and laboratory test. Monoglyceride and water content are the main concern of the validation of the biodiesel standard to implement B30 in Indonesia.**

Keywords—B30, biodiesel standard, laboratory test, monoglyceride, road test, water content

I. INTRODUCTION

Diesel oil is one of the biggest fuel needs in Indonesia. In 2018, Indonesia absorbed diesel oil by 30.96 million kilo liters. Diesel oil can only be supplied domestically about 79% of the demand, and the rest is imported. From 2015-2018 there was increased in diesel oil consumption by an average of 5% per annum [1]. Since 2016, Indonesia has implemented a policy of mixing biodiesel into diesel oil by 20%, also known as B20, based on regulation of the Minister of Energy and Mineral Resources (MEMR) number 12/2015. B20 is applied to all sectors that use diesel oil. In 2020, Indonesia continues to implement B30 [2]. Indonesia is the first nation in the world to implement B30, especially biodiesel based from palm oil. But in 2018, only 3 countries have implemented B20, they are United States, Canada and Indonesia. Both United States and Canada have different biodiesel standards with Indonesia. They produce biodiesel from non-palm oil as raw materials, but Indonesia produce it from palm oil. So, biodiesel for B30 in Indonesia also be the new one of biodiesel standard in the nationwide that using palm oil.

The quality of biodiesel is influenced by the quality of raw materials, production processes and parameters achieved in the end products [3]. This study is to present development standard of biodiesel in Indonesia. This study based on literature studies, discussion and biodiesel test sampling. The discussion is established by forum group discussion that consisting of government, industries and laboratories, and also by surveys to producers to take the biodiesel sample. The data is collected as per 1st November 2019.

II. BIODIESEL STANDARD

In implementing B30, Indonesia uses biodiesel derived from palm oil. In research published by the Bogor Forest Products Development and Research Center, biodiesel can actually be produced from nyamplung seeds, malapari, bintaro, kesambi, kepuh and siri pecan [4]. However, as the availability of feedstocks and the big demand to supply B30, Indonesia choosed palm oil as raw material of biodiesel. It is known that throughout 2019, Indonesia could produce 47.18 million tons of palm oil [5]. Indonesia absorbed 6.39 million kiloliters of palm oil into biodiesel [6].

Since 2006, Indonesia has developed palm oil based biodiesel standards, and in 2008 biodiesel was blended of 2.5%. Through the National Standardization Body, the biodiesel standard was established of SNI 7182:2006 [7] and has made two revisions for biodiesel standard, each in 2012 and 2015 [8], [9] and by that time biodiesel was implemented mandatory of 15% (B15) blended with diesel oil for: small medium enterprises, fishing businesses, farming businesses, industries, transportations and public services, while for powerplants blended of 25% (B25). Year later, the proportion of blended biodiesel was increased to 20% or B20, but especially for powerplant increased to 30% or B30. Furthermore, those biodiesel standards were revised through the Regulation of MEMR of KepDirjen EBTKE 332K/10/DJE/2018 [10] and the last revision is established by Regulation of MEMR of Kepdirjen EBTKE 189K/10/DJE/2019 [11], the detailed revision can be seen in table II. Biodiesel producers in Indonesia need to have 23 tests to meet the requirements of biodiesel standard for B30 implementation. Some parameters have changed along the

way in biodiesel standards, there are flash points, sulfur content, acid value, oxidation stability, monoglyceride content, water content, group I metals (Na and K), group II metals (Ca and Mg), and total contamination.

Hence, the other country, most biodiesel standards refer to two established international standards, such as ASTM D 6751-19 and EN 14214:2012+A2:2019. However, Indonesia modified the requirements because Indonesia uses different raw materials that regulated by Kepdirjen EBTKE 189k/10/DJE/2019. Still, the test methods for biodiesel, Indonesia refers to international standards. When compared with Malaysia Standard MS 2008:2014 that using palm oil, Indonesia has different quality requirements. As shown in table I, Indonesian standards require test of: carbon residues, distilled temperatures and colors. Whereas Malaysian standard requires testing of: linolenic acid methyl ester, polyunsaturated (≥ 4 double bonds) methyl esters, methanol content, diglyceride content and triglyceride content.

TABLE I. COMPARISON OF BIODIESEL SPECIFICATION BETWEEN INDONESIA AND THE OTHERS

No	Test	Unit	Kepdirjen EBTKE 189K/10/DJE/2019	EN 14214:2012+A2:2019 [12]	ASTM D 6751-19 [13]	MS 2008:2014 [14]
1	Density at 40 °C	kg/m^3	850 – 890	860 – 900	-	860 – 900
2	Kinematic viscosity at 40 °C	mm^2/s (cSt)	2.3 – 6.0	3.5 – 5.0	1.9 – 6.0	3.5 – 5.0
3	Cetane number	Min	51	51	47	51
4	Flash point	°C, min	130	101	130	120
5	Cloud Point	°C, max	-	Follow location and season	Report	-
6	Copper strip corrosion (3 hours at 50 °C)		class 1	class 1	class 3	class 1
7	Carbon residue	%-mass, max				
	- in sample; or		0.05	-	0.05	-
	- in 10% distilated rest		0.3	-	-	-
8	Water and sediment	%-volume, maks	-	-	500	-
9	Distilated temperature at 90%	°C, max	360	-	360	-
10	Sulfated ash content	%-mass, max	0.02	0.02	0.02	0.02
11	Sulfur content	mg/kg, max	10	10	15	10
12	Phosphorus content	mg/kg, max	4	4	10	4
13	Acid value	mg-KOH/g, max	0.4	0.5	0.5	0.5
14	Free Glycerol	%-mass, max	0.02	0.02	0.02	0.02
15	Total Glycerol	%-mass, max	0.24	0.25	0.24	0.25
16	Methyl esters	%-mass, min	96.5	96.5	-	96.5
17	Iodine value	%-mass	115	120	-	110
		(g-I_2/100 g), max				
18	Oxidation stability	minutes, min				
	Induction period with rancimat method		600	480	180	600
	or					
	Induction period with petro-oxy		45	-	-	-
20	Monoglyceride content	%-mass, max	0,55	0.7	0.4	0.7
21	Color	max	3	-	-	-
22	Water Content	%-mass, max	350	500	-	500
23	CFPP (Cold Filter Plugging Point)	°C, max	15	Follow location and season	-	15

No	Test	Unit	Kepdirjen EBTKE 189K/10/DJE/2019	EN 14214:2012+A2:2019 [12]	ASTM D 6751-19 [13]	MS 2008:2014 [14]
24	Group I metals (Na+K)	mg/kg, max	5	5	5	5
25	Group II metals (Ca+Mg)	mg/kg, max	5	5	5	5
26	Total Contamination	mg/liter, max	20	24	-	24
27	Linolenic acid methyl ester	%-mass, max	-	12	-	12
28	Polyunsaturated (≥4 double bonds) methyl esters	%-mass, max	-	1	-	1
29	Methanol content	%-mass, max	-	0.2	0.2	0.2
30	Diglyceride content	%-mass, max	-	0.2	-	0.2
31	Triglyceride content	%-mass, max	-	0.2	-	0.2
32	Cold soak filterability	s, max	-	-	200	-

In 2008, biodiesel was blended of 2.5% as shown in table II. Then in 2015, Indonesia added much more proportions of blended biodiesel. In 2015, biodiesel was implemented mandatory of 15% (B15) blended with diesel oil for: small medium enterprises, fishing businesses, farming businesses, industries, transportations and public services, while for powerplants blended of 25% (B25). Then in 2016, the proportion of blended biodiesel was increased to 20% or B20, but especially for powerplant increased to 30% or B30. Finally, in January 2020, all sectors implemented B30.

TABLE II. THE REGULATED TIMELINE OF BIODIESEL IMPLEMENTATION IN INDONESIA FROM 2008 TO 2020

Sector	Obligation of Biodiesel Blending Proportion in Indonesia						
	Regulation of MEMR number 32/2008 refer to SNI 04-7182-2006 and SNI 7182:2012 [15]		*Regulation of MEMR number 20/2014 refer to SNI 7182:2012 and SNI 7182:2015 [16]*		*Regulation of MEMR number 12/2015 refer to: SNI 7182:2015, Kepdirjen EBTKE 332K/10/DJE/2018 and Kepdirjen EBTKE 189K/10/DJE/2019*		
	Oct to Dec 2008	*Jan 2009 to June 2014*	*July to Dec 2014*	*Jan to April 2015*	*April to Dec 2015*	*Jan 2016 to Dec 2019*	*Jan 2020 to Dec 2024*
Transportation PSO	1%	1%	10%	10%	15%	20%	30%
Transportation Non PSO	-	1%	10%	10%	15%	20%	30%
Industry and commercial	2.50%	2.50%	10%	10%	15%	20%	30%
Power Plant	0.10%	0.25%	20%	25%	25%	30%	30%

III. METHODS

The method used in this research is analytical methods according to the Kepdirjen EBTKE 189K/10/DJE/2019. For monoglyceride content using SNI 7182: 2015 method [9] and water content using ASTM D-6304 method [17]. Sampling of biodiesel were obtained in 2019 and was carried out from 5 biodiesel producing companies, with 2 samples taken from each company. Data obtained from the test results are presented using descriptive analysis.

IV. RESULT AND DISCUSSION

Before implementing B30 in 2020, first Indonesia test the biodiesel to the actual operation. This is in order to validate the draft standards of biodiesel. In the way to implement B30, Indonesia has conducted a "road test" system by testing biodiesel on 11 new vehicles and in any actual conditions. The test vehicle takes asphalt road conditions (on road) with flat and hilly terrain, and also hot and cold temperatures (mountains). The purpose of the road test with these variations is to find out the performance of the B30 compared to the previous performance on the B20. Road test results show that the B30 has: power, fuel consumption and exhaust emissions that are relatively the same as the B20. The design in the B30 road test focuses on variations in conditions to validate the concerning monoglyceride content parameters in the biodiesel specifications for B30 [18].

Monoglyceride content in biodiesel depends on some factors; reaction condition (temperature, molar ratio, type and quantity of the catalyst), and also other impurities that disturb the triglyceride conversion to fatty acid methyl ester [19].

Monoglyceride contained in biodiesel has an impact on the fuel injection. Under conditions of low ambient temperature, monoglycerides will precipitate that may block the way in the fuel filter [20], [21]. Under heavier loads condition, the clogged fuel filter may cause the engine to misfire (stumble when accelerating). This occurs as precipitate clog the filter and deplete the fuel supply going to the engine. This happens because monoglycerides especially saturated monoglycerides have high melting points and are difficult to dissolve in biodiesel [22], [23]. From the results of tests conducted by Imam Paryanto, using the ASTM D 7501 method for B30, it is proposed to contain monoglycerides between 0.40 - 0.62%. This is shown from the small precipitation, then it can minimize the occurrence of blockages in the fuel filter. In the proposed biodiesel specification for B30, the monoglyceride content is determined not to exceed 0.55% [20].

However, in the process of development and evaluation from the results of the road test, the water content is also highlighted by biodiesel users. The Association of Indonesian Automotive Industries (Gaikindo) has conducted a research to study the impact of the amount of water content on the fuel filter. From the results, a big amount of water will accelerate the replacement of fuel filters in new vehicles. So, the amount of water content is one of the main factors in decreasing the quality of biodiesel [24]. Water in biodiesel can increase growth which can produce sludge and will eventually block the fuel filter. Water also causes the hydrolysis reaction of biodiesel into free fatty acids which eventually block the fuel filter. The phenomenon of blocking fuel filters is often experienced by vehicles that use biodiesel, so that it can drastically reduce engine power [25]. At the storage with high temperatures and the presence of air contact there will be an increase in water content which will increase the decrease in oxidation stability. This is because biodiesel has hygroscopic properties [26]. Under the same relative humidity conditions, biodiesel has the ability to absorb water content 6.5 times greater than diesel oil [27]. With biodiesel that contains high water content will increase the corrosivity [28], [29]. The corrosivity will cause wear on components of fuel injection system such as plunger, nozzle needle, valve, and valve holder [30]. In addition, high water content will increase the potential for biological growth which will result in fuel filter blocking [31]. Finally, in the development process of standard, validation of water content parameters was also carried out prior to the specification and implementation of biodiesel B30. In the proposed biodiesel specification for B30 implementation in Indonesia, the proposed water content should not exceed 350 %-mass.

There are 10 groups of biodiesel companies that supply for B30 in Indonesia. 5 out of 10 groups were randomly selected to be a test sample to validate the ability of producers to produce biodiesel that were able to meet the proposed biodiesel specifications for B30. Testing is established by accredited laboratory. From the test results, especially the monoglyceride testing parameters and water content show that biodiesel producers are able to meet biodiesel specifications for B30 as shown in the table III. The content of monoglycerides are between 0.32% - 0.53%, and the water content are between 200-350 %-mass.

TABLE III. THE TEST RESULT FOR BIODIESEL SAMPLE

No	Test	Unit	Min.	Max.	Sample Code				
					I	***J***	***A***	***G***	***H***
1	Density at 40 °C	kg/m^3	850	890	858.5	857.97	860.6	858.11	858.33
2	Kinematic viscosity at 40 °C	mm^2/s (cSt)	2,3	6	4.56	4.56	4.6	4.54	4.47
3	Cetane number		51	-	53	53.1	53.1	53.3	53.2
4	Flash point	°C	130	-	168	162	174	174	165
5	Cloud Point	°C	-	18	14.6	13.6	13.3	13.3	14.2
6	Copper strip corrosion (3 hours at 50 °C)		-	No. 1	1a	1a	1a	1a	1a
7	Carbon residue	%-mass	-		null	null	null	null	null
	- in sample; or			0,05					
	- in 10% distilated rest			0,3					
8	Distilated temperature at 90%	°C	-	360	346.6	341.5	324.9	335.2	335.6
9	Sulfated ash content	%-mass	-	0,02	0	0	0	0	0
10	Sulfur content	mg/kg	-	10	4.45	3.41	4.02	3.25	3.33
11	Phosphorus content	mg/kg	-	4	0.31	0.34	0.38	0.35	0.38
12	Acid value	mg-KOH/g	-	0,4	0.358	0.46	0.28	0.055	0.205

No	Test	Unit	Min.	Max.	Sample Code				
					I	***J***	***A***	***G***	***H***
13	Free Glycerol	%-mass	-	0,02	0.001	0.008	0.002	0.001	0.001
14	Total Glycerol	%-mass	-	0,24	0.099	0.091	0.119	0.136	0.13
15	Methyl esters	%-mass	96,5	-	99.15	98.94	98.91	98.6	98.92
16	Iodine value	%-mass	-	115	52.22	46.72	49.35	49.63	50.23
17	Oxidation stability	(g-I_2/100 g)	600	-	1498	1504	1579	978	1080
18	**Monoglyceride content**	**%-mass**	**-**	**0,55**	**0.38**	**0.32**	**0.41**	**0.43**	**0.53**
19	Color	max	-	3	0.9	1	1	0.9	0.9
20	**Water Content**	**%-mass, max**	**-**	**350**	**200**	**312**	**350**	**243**	**328**
21	CFPP (Cold Filter Plugging Point)	°C	-	15	15	14	14	14	14
22	Na	mg/kg	-	5	0	0	0	0	0
	K				1.4	1.4	1.4	1.4	1.4
	Ca		-	5	0.3	0.3	0.3	0.3	0.3
	Mg				4.2	4.2	4.2	4.2	4.2
23	Total Contamination	mg/liter	-	20	20.5	21.1	14.5	12.13	13.5

When compared to the ASTM D6751-19, the requirement of monoglyceride content in Indonesian Biodiesel Standard is lower, but still higher than EN 14214:2012+A2:2019. For water content, the Indonesian Biodiesel Standard is higher than both ASTM and EN, even the ASTM D6751-19 standard does not requiring water content. ASTM standard D6751-19 could be the one only international standard that requiring water and sediment.

V. Conclusion

The development of biodiesel standard to implement B30 in Indonesia is approached by concerning both monoglyceride and water content. Both road test and laboratory test validate the draft standard of biodiesel. Indonesia requires higher standard for monoglyceride and water content to implement B30. From the laboratory test, Indonesian Biodiesel Companies can meet the requirement of biodiesel for B30. The road test also shown there are no differences performance significantly between B30 and B20. Next, the biodiesel test should be established for more samples with multiple laboratories involved.

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