

## LAMPIRAN PERHITUNGAN

Lampiran 1. Perhitungan % FFA dan % Bilangan Asam Minyak Jelantah

Data: m Minyak jelantah = 1 gram

$$\begin{aligned} \text{ml NaOH} &= 2 \text{ gram} + 3,5 \text{ gram} \\ &= 5,5 \text{ gram (Persamaan (2))} \end{aligned}$$

***Banyaknya katalis untuk 100 ml minyak jelantah***

$$\text{Gram NaOH} = \frac{x}{100 \text{ ml}} = \frac{5,5 \text{ gram}}{1000 \text{ ml}}$$

$$= 0,55 \text{ gram}$$

$$\text{BM FFA} = 280,77$$

$$\text{BM NaOH} = 40$$

a. Normalitas NaOH

$$\begin{aligned} N \text{ NaOH} &= \frac{\text{gram NaOH}}{Mr \text{ NaOH}} \times \frac{1000}{V \text{ pelarut (ml)}} \\ &= \frac{1 \text{ gram}}{40} \times \frac{1000}{1000 \text{ ml}} \\ &= 0,025 \text{ N} \end{aligned}$$

b. Kadar Asam Lemak Bebas

$$\begin{aligned} \% \text{ FFA} &= \frac{\text{ml NaOH} \times N \times \text{BM FFA}}{\text{Berat sampel} \times 1000} \times 100\% \\ &= \frac{5,23 \text{ ml} \times 0,025 \text{ N} \times 280,77}{0,85350 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 4,301 \% \end{aligned}$$

c. Kadar Bilangan Asam

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{5,23 \times 0,025 N \times 40}{0,8530 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,613\end{aligned}$$

Lampiran 2. Perhitungan % Bilangan Asam Biodiesel

**a. %Bilangan Asam pada T= 45°C dan t= 5 menit**

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8636 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0810 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,8 \times 0,025 N \times 40}{0,8766 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0912 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,8 \times 0,025 N \times 40}{0,8539 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0936 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam Rata-rata} &= (0,0810\% + 0,0912\% + 0,0936\%) / 3 \\ &= 0,0886\%\end{aligned}$$

**b. %Bilangan Asam pada T= 45°C dan t= 10 menit**

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8525 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0703 \%\end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,8 \times 0,025 N \times 40}{0,8585 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0931 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8583 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0815 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam Rata-rata} &= (0,0703\% + 0,0931\% + 0,0815\%) / 3 \\ &= 0,0816\% \end{aligned}$$

**c. %Bilangan Asam pada T= 45°C dan t= 30 menit**

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,5 \times 0,025 N \times 40}{0,8615 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0580 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8583 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0699 \% \end{aligned}$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,6 \times 0,025 N \times 40}{0,8616 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0696 \%$$

$$\% \text{ Bilangan Asam Rata-rata} = (0,0580\% + 0,0699\% + 0,0696\%) / 3$$

$$= 0,0658\%$$

**d. %Bilangan Asam pada T= 55°C dan t= 5 menit**

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,7 \times 0,025 N \times 40}{0,8648 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0809 \%$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,8 \times 0,025 N \times 40}{0,8648 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0925 \%$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,7 \times 0,025 N \times 40}{0,8581 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0815 \%$$

$$\% \text{ Bilangan Asam Rata-rata} = (0,0809\% + 0,0925\% + 0,0815\%) / 3$$

$$= 0,0849\%$$

**e. %Bilangan Asam pada T= 55°C dan t= 10 menit**

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8499 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0823 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8590 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0698 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8568 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0816 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam Rata-rata} &= (0,0823\% + 0,0698\% + 0,0816\%) / 3 \\ &= 0,0779\%\end{aligned}$$

**f. %Bilangan Asam pada T= 55°C dan t= 30 menit**

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8546 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0702 \%\end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8645 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0694 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8529 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0703 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam Rata-rata} &= (0,0702\% + 0,0694\% + 0,0703\%) / 3 \\ &= 0,0699\% \end{aligned}$$

**g. %Bilangan Asam pada T= 65°C dan t= 5 menit**

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8479 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0707 \% \end{aligned}$$

$$\begin{aligned} \% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8550 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0818 \% \end{aligned}$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,7 \times 0,025 N \times 40}{0,8574 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0816 \%$$

$$\% \text{ Bilangan Asam Rata-rata} = (0,0707\% + 0,0818\% + 0,0816\%) / 3$$

$$= 0,0780\%$$

**h. %Bilangan Asam pada T= 65°C dan t= 10 menit**

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,7 \times 0,025 N \times 40}{0,8561 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0817 \%$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,6 \times 0,025 N \times 40}{0,8531 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0703 \%$$

$$\% \text{ Bilangan Asam} = \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\%$$

$$= \frac{0,7 \times 0,025 N \times 40}{0,8554 \times 1 \text{ gram} \times 1000} \times 100\%$$

$$= 0,0818 \%$$

$$\% \text{ Bilangan Asam Rata-rata} = (0,0810\% + 0,0703\% + 0,0818\%) / 3$$

$$= 0,0777\%$$



**i. %Bilangan Asam pada T= 65°C dan t= 30 menit**

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,5 \times 0,025 N \times 40}{0,8499 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0588 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,7 \times 0,025 N \times 40}{0,8548 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0818 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam} &= \frac{\text{ml NaOH} \times N \times \text{BM NaOH}}{M \times 1000} \times 100\% \\ &= \frac{0,6 \times 0,025 N \times 40}{0,8624 \times 1 \text{ gram} \times 1000} \times 100\% \\ &= 0,0695 \%\end{aligned}$$

$$\begin{aligned}\% \text{ Bilangan Asam Rata-rata} &= (0,0588\% + 0,0818\% + 0,0695\%) / 3 \\ &= 0,0700\%\end{aligned}$$

Lampiran 3. Perhitungan Massa jenis biodiesel (gram/ml) dengan menggunakan piknometer ( $V_{\text{biodiesel}} = 25 \text{ ml}$ )

**a. Massa Jenis pada  $T= 45^{\circ}\text{C}$  dan  $t= 5$  menit**

$$\begin{aligned}\rho_{\text{Biodiesel}} &= \frac{m}{V} \\ &= \frac{21,5914 \text{ gram}}{25 \text{ ml}} \\ &= 0,8636 \text{ gram/ml} \\ \rho_{\text{Biodiesel}} &= \frac{m}{V} \\ &= \frac{21,9157 \text{ gram}}{25 \text{ ml}} \\ &= 0,8766 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{\text{Biodiesel}} &= \frac{m}{V} \\ &= \frac{21,3482 \text{ gram}}{25 \text{ ml}} \\ &= 0,8539 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8636 + 0,8766 + 0,8539) / 3 \text{ (gram/ml)} \\ &= 0,8647 \text{ gram/ml}\end{aligned}$$

**b. Massa Jenis pada  $T= 45^{\circ}\text{C}$  dan  $t= 10$  menit**

$$\begin{aligned}\rho_{\text{Biodiesel}} &= \frac{m}{V} \\ &= \frac{21,3137 \text{ gram}}{25 \text{ ml}} \\ &= 0,8525 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4639 \text{ gram}}{25 \text{ ml}} \\ &= 0,8585 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4587 \text{ gram}}{25 \text{ ml}} \\ &= 0,8583 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8525 + 0,8585 + 0,8583) / 3 \text{ (gram/ml)} \\ &= 0,8564 \text{ gram/ml}\end{aligned}$$

**c. Massa Jenis pada T= 45°C dan t= 30 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,5398 \text{ gram}}{25 \text{ ml}} \\ &= 0,8615 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4588 \text{ gram}}{25 \text{ ml}} \\ &= 0,8583 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,5408 \text{ gram}}{25 \text{ ml}} \\ &= 0,8616 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8615 + 0,8583 + 0,8616) / 3 \text{ (gram/ml)} \\ &= 0,8604 \text{ gram/ml}\end{aligned}$$

**d. Massa Jenis pada T= 55°C dan t= 5 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,5179 \text{ gram}}{25 \text{ ml}} \\ &= 0,8607 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,6208 \text{ gram}}{25 \text{ ml}} \\ &= 0,8648 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4540 \text{ gram}}{25 \text{ ml}} \\ &= 0,8581 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8607 + 0,8648 + 0,8581) / 3 \text{ (gram/ml)} \\ &= 0,8612 \text{ gram/ml}\end{aligned}$$

**e. Massa Jenis pada T= 55°C dan t= 10 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,2495 \text{ gram}}{25 \text{ ml}} \\ &= 0,8499 \text{ gram/ml}\end{aligned}$$

$$\rho_{Biodiesel} = \frac{m}{V}$$

$$= \frac{21,4767 \text{ gram}}{25 \text{ ml}}$$

$$= 0,8590 \text{ gram/ml}$$

$$\rho_{Biodiesel} = \frac{m}{V}$$

$$= \frac{21,4223 \text{ gram}}{25 \text{ ml}}$$

$$= 0,8568 \text{ gram/ml}$$

$$\text{Massa Jenis rata-rata} = (0,8499 + 0,8590 + 0,8568) / 3 \text{ (gram/ml)}$$

$$= 0,8553 \text{ gram/ml}$$

**f. Massa Jenis pada T= 55°C dan t= 30 menit**

$$\rho_{Biodiesel} = \frac{m}{V}$$

$$= \frac{21,3674 \text{ gram}}{25 \text{ ml}}$$

$$= 0,8546 \text{ gram/ml}$$

$$\rho_{Biodiesel} = \frac{m}{V}$$

$$= \frac{21,6144 \text{ gram}}{25 \text{ ml}}$$

$$= 0,8645 \text{ gram/ml}$$

$$\rho_{Biodiesel} = \frac{m}{V}$$

$$= \frac{21,3228 \text{ gram}}{25 \text{ ml}}$$

$$= 0,8529 \text{ gram/ml}$$

$$\text{Massa Jenis rata-rata} = (0,8636 + 0,8766 + 0,8539) / 3 \text{ (gram/ml)}$$

$$= 0,8647 \text{ gram/ml}$$

**g. Massa Jenis pada T= 65°C dan t= 5 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,1986 \text{ gram}}{25 \text{ ml}} \\ &= 0,8479 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,3786 \text{ gram}}{25 \text{ ml}} \\ &= 0,8550 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4357 \text{ gram}}{25 \text{ ml}} \\ &= 0,8574 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8479 + 0,8550 + 0,8574) / 3 \text{ (gram/ml)} \\ &= 0,8534 \text{ gram/ml}\end{aligned}$$

**h. Massa Jenis pada T= 65°C dan t= 10 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,4040 \text{ gram}}{25 \text{ ml}} \\ &= 0,8561 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,3284 \text{ gram}}{25 \text{ ml}} \\ &= 0,8531 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,3859 \text{ gram}}{25 \text{ ml}} \\ &= 0,8554 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8561 + 0,8531 + 0,8554) / 3 \text{ (gram/ml)} \\ &= 0,8549 \text{ gram/ml}\end{aligned}$$

**i. Massa Jenis pada T= 65°C dan t= 30 menit**

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,2491 \text{ gram}}{25 \text{ ml}} \\ &= 0,8499 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,3700 \text{ gram}}{25 \text{ ml}} \\ &= 0,8548 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\rho_{Biodiesel} &= \frac{m}{V} \\ &= \frac{21,5610 \text{ gram}}{25 \text{ ml}} \\ &= 0,8624 \text{ gram/ml}\end{aligned}$$

$$\begin{aligned}\text{Massa Jenis rata-rata} &= (0,8499 + 0,8548 + 0,8624) / 3 \text{ (gram/ml)} \\ &= 0,8557 \text{ gram/ml}\end{aligned}$$

Lampiran 4. Perhitungan Viskositas biodiesel (cSt)

**Viskositas air = 1 cp**

$$\mu = k (\rho \text{ bola} - \rho \text{ air}) t_0$$

$$1 \text{ cp} = k (8,02 \text{ gr/ml} - 1 \text{ gr/ml}) 10,66 \text{ s}$$

$$k = \frac{1 \text{ cp}}{7 \text{ gr/ml} \times 10,66 \text{ s}}$$

$$= 0,01336$$

**a. Viskositas pada T= 45°C dan t= 5 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8647 \text{ gr/ml}) \times 16,71 \text{ s}$$

$$\mu = 1,5973 \text{ cp} / 0,8647 \text{ gr/ml}$$

$$\mu = 1,85 \text{ cSt}$$

**b. Viskositas pada T= 45°C dan t= 10 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8564 \text{ gr/ml}) \times 15,88 \text{ s}$$

$$\mu = 1,5198 \text{ cp} / 0,8564 \text{ gr/ml}$$

$$\mu = 1,77 \text{ cSt}$$

**c. Viskositas pada T= 45°C dan t= 30 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8604 \text{ gr/ml}) \times 15,70 \text{ s}$$

$$\mu = 1,5017 \text{ cp} / 0,8604 \text{ gr/ml}$$

$$\mu = 1,75 \text{ cSt}$$



**d. Viskositas pada T= 55°C dan t= 5 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8612 \text{ gr/ml}) \times 15,48 \text{ s}$$

$$\mu = 1,4805 \text{ cp} / 0,8612 \text{ gr/ml}$$

$$\mu = 1,72 \text{ cSt}$$

**e. Viskositas pada T= 55°C dan t= 10 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8553 \text{ gr/ml}) \times 15,44 \text{ s}$$

$$\mu = 1,4779 \text{ cp} / 0,8553 \text{ gr/ml}$$

$$\mu = 1,73 \text{ cSt}$$

**f. Viskositas pada T= 55°C dan t= 30 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8573 \text{ gr/ml}) \times 15,35 \text{ s}$$

$$\mu = 1,4688 \text{ cp} / 0,8573 \text{ gr/ml}$$

$$\mu = 1,73 \text{ cSt}$$

**g. Viskositas pada T= 65°C dan t= 5 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8534 \text{ gr/ml}) \times 15,23 \text{ s}$$

$$\mu = 1,4582 \text{ cp} / 0,8534 \text{ gr/ml}$$

$$\mu = 1,71 \text{ cSt}$$

**h. Viskositas pada T= 65°C dan t= 10 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8549 \text{ gr/ml}) \times 15,12 \text{ s}$$

$$\mu = 1,4473 \text{ cp} / 0,8549 \text{ gr/ml}$$

$$\mu = 1,69 \text{ cSt}$$

**i. Viskositas pada T= 65°C dan t= 30 menit**

$$\mu = k (\rho \text{ bola} - \rho \text{ biodiesel}) t_0$$

$$\mu = 0,01336 \times (8,02 \text{ gr/ml} - 0,8557 \text{ gr/ml}) \times 14,76 \text{ s}$$

$$\mu = 1,4127 \text{ cp} / 0,8557 \text{ gr/ml}$$

$$\mu = 1,65 \text{ cSt}$$

## PERHITUNGAN STATISTIKA

Lampiran 5. Perhitungan Statistika Rendemen Biodiesel (%)

| Perlakuan                     | Ulangan |       |       | Total  | Rata-rata |
|-------------------------------|---------|-------|-------|--------|-----------|
|                               | 1       | 2     | 3     |        |           |
| T <sub>1</sub> t <sub>1</sub> | 85      | 80    | 79    | 244    | 81,33     |
| T <sub>1</sub> t <sub>2</sub> | 80      | 79    | 75    | 234    | 78        |
| T <sub>1</sub> t <sub>3</sub> | 79      | 80    | 86    | 245    | 81,67     |
| T <sub>2</sub> t <sub>1</sub> | 74      | 86    | 90    | 250    | 83,33     |
| T <sub>2</sub> t <sub>2</sub> | 75      | 83    | 85    | 243    | 81        |
| T <sub>2</sub> t <sub>3</sub> | 87      | 87    | 86    | 260    | 86,67     |
| T <sub>3</sub> t <sub>1</sub> | 84      | 87    | 81    | 252    | 84        |
| T <sub>3</sub> t <sub>2</sub> | 85      | 82    | 80    | 247    | 82,33     |
| T <sub>3</sub> t <sub>3</sub> | 77      | 85    | 88    | 250    | 83,33     |
| Total                         | 726     | 749   | 750   | 2225   | 741,66    |
| Rata-rata                     | 80,67   | 83,22 | 83,33 | 247,22 | 82,4      |

| Suhu | Waktu   |          |          |
|------|---------|----------|----------|
|      | 5 menit | 10 menit | 30 menit |
| 45°C | 85      | 80       | 79       |
|      | 80      | 79       | 80       |
|      | 79      | 75       | 86       |
| 55°C | 74      | 75       | 87       |
|      | 86      | 83       | 87       |
|      | 90      | 85       | 86       |
| 65°C | 84      | 85       | 77       |
|      | 87      | 82       | 85       |
|      | 81      | 80       | 88       |

**Tabel Dua Arah antara Faktor A dan Faktor B**

| Suhu                     | Waktu   |          |          | Jumlah (Y <sub>i</sub> ) |
|--------------------------|---------|----------|----------|--------------------------|
|                          | 5 menit | 10 menit | 30 menit |                          |
| 45°C                     | 244     | 234      | 245      | 723                      |
| 55°C                     | 250     | 243      | 260      | 753                      |
| 65°C                     | 252     | 247      | 250      | 749                      |
| Jumlah (Y <sub>j</sub> ) | 746     | 724      | 755      | 2225                     |

## Analisis Sidik Ragam

$$\begin{aligned} \text{a. } FK &= \frac{(2225)^2}{(3 \times 3 \times 3)} \\ &= \frac{4950625}{27} \\ &= 183356,48 \end{aligned}$$

$$\begin{aligned} \text{b. } JK_{\text{total}} &= ((85)^2 + (80)^2 + (79)^2 + (80)^2 + (79)^2 + (75)^2 + (79)^2 + (80)^2 + (86)^2 + (74)^2 + (86)^2 + (90)^2 \\ &\quad + (75)^2 + (83)^2 + (85)^2 + (87)^2 + (87)^2 + (86)^2 + (84)^2 + (87)^2 + (81)^2 + (85)^2 + (82)^2 + (80)^2 \\ &\quad + (77)^2 + (85)^2 + (88)^2) - FK \\ &= ((7225) + (6400) + (6241) + (6400) + (6241) + (5625) + (6241) + (6400) + (7396) \\ &\quad + (5476) + (7396) + (8100) + (5625) + (6889) + (7225) + (7569) + (7569) + (7396) \\ &\quad + (7056) + (7569) + (6561) + (7225) + (6724) + (6400) + (5929) + (7225) \\ &\quad + (7744)) - 183356,48 \\ &= 183847 - 183356,48 \\ &= 490,52 \end{aligned}$$

$$\begin{aligned} \text{c. } JK_{\text{Suhu (A)}} &= \frac{(723)^2 + (753)^2 + (749)^2}{r \times b} - FK \\ &= \frac{(522729) + (567009) + (561001)}{3 \times 3} - 183356,48 \\ &= \frac{1650739}{9} - 183356,48 \\ &= 183415,44 - 183356,48 \\ &= 58,96 \end{aligned}$$

$$\begin{aligned} \text{d. } JK_{\text{Waktu (B)}} &= \frac{(746)^2 + (724)^2 + (755)^2}{r \times a} - FK \\ &= \frac{(556516) + (524176) + (570025)}{9} - 183356,48 \\ &= \frac{1650717}{9} - 183356,48 \\ &= 183413 - 183356,48 \\ &= 56,52 \end{aligned}$$

**e. JK<sub>AB</sub>**

$$\begin{aligned} &= \frac{(244)^2+(234)^2+(245)^2+(250)^2+(243)^2+(260)^2+(252)^2+(247)^2+(250)^2}{r} - FK - JKA - JKB \\ &= \frac{(59536)+(54756)+(60025)+(62500)+(59049)+(67600)+(63504)+(61009)+(62500)}{3} - 183356,48 - \\ & \quad 58,96 - 56,52 \\ &= \frac{550479}{3} - 183356,48 - 58,96 - 56,52 \\ &= 183493 - 183356,48 - 58,96 - 56,52 \\ &= 21,04 \end{aligned}$$

**f. JK Galat Percobaan** = JK<sub>total</sub> - JK<sub>Suhu (A)</sub> - JK<sub>Waktu (B)</sub> - JK<sub>(AB)</sub>

$$\begin{aligned} &= 490,52 - 58,96 - 56,52 - 21,04 \\ &= 354 \end{aligned}$$

| Sumber Keragaman | dB | JK     | KT                            | F <sub>hitung</sub> | F <sub>tabel</sub> |      |
|------------------|----|--------|-------------------------------|---------------------|--------------------|------|
|                  |    |        |                               |                     | 0,05               | 0,01 |
| Suhu             | 2  | 58,96  | 29,48                         | 1,49                | 3,55               | 6,01 |
| Waktu            | 2  | 56,52  | 28,26                         | 1,43                | 3,55               | 6,01 |
| Suhu × Waktu     | 4  | 21,04  | 5,26                          | 0,26                | 2,93               | 4,58 |
| Galat Percobaan  | 18 | 354    | 19,66                         |                     |                    |      |
| Total            | 26 | 490,52 | Koefisien Keseragaman = 5,38% |                     |                    |      |

**f. Koefisien Keseragaman (KK)**

$$\begin{aligned} KK &= \frac{\sqrt{KT \text{ Galat Percobaan}}}{y} \times 100\% \quad ; y = \frac{2225}{(9 \times 3)} = \frac{2225}{27} = 82,4 \\ &= \frac{\sqrt{19,66}}{82,4} \times 100\% \\ &= 0,0538 \times 100\% \\ &= 5,38\% \end{aligned}$$

### **g. Kesimpulan**

- Suhu (A)

Karena  $F_{hitung\ A} (1,49) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

- Waktu (B)

Karena  $F_{hitung\ A} (1,43) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

- Interaksi Suhu  $\times$  Waktu (A $\times$ B)

Karena  $F_{hitung\ A\times B} (1,43) < F_{tabel} (2,93)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

Lampiran 6. Perhitungan Statistika Massa Jenis Biodiesel (g/ml)

| Perlakuan                     | Ulangan |        |        | Total  | Rata-rata |
|-------------------------------|---------|--------|--------|--------|-----------|
|                               | 1       | 2      | 3      |        |           |
| T <sub>1</sub> t <sub>1</sub> | 0,8366  | 0,8766 | 0,8539 | 2,5671 | 0,8557    |
| T <sub>1</sub> t <sub>2</sub> | 0,8525  | 0,8585 | 0,8583 | 2,5693 | 0,8563    |
| T <sub>1</sub> t <sub>3</sub> | 0,8615  | 0,8583 | 0,8616 | 2,5814 | 0,8604    |
| T <sub>2</sub> t <sub>1</sub> | 0,8606  | 0,8648 | 0,8581 | 2,5835 | 0,8611    |
| T <sub>2</sub> t <sub>2</sub> | 0,8499  | 0,859  | 0,8568 | 2,5657 | 0,8552    |
| T <sub>2</sub> t <sub>3</sub> | 0,8546  | 0,8645 | 0,8529 | 2,572  | 0,8573    |
| T <sub>3</sub> t <sub>1</sub> | 0,8479  | 0,855  | 0,8574 | 2,5603 | 0,8534    |
| T <sub>3</sub> t <sub>2</sub> | 0,8561  | 0,8531 | 0,8554 | 2,5646 | 0,8548    |
| T <sub>3</sub> t <sub>3</sub> | 0,8499  | 0,8548 | 0,8624 | 2,5671 | 0,8557    |
| Total                         | 7,6696  | 7,7446 | 7,7168 | 23,131 | 7,709     |
| Rata-rata                     | 0,8521  | 0,8605 | 0,8574 | 2,5701 | 0,8566    |

| Suhu | Waktu   |          |          |
|------|---------|----------|----------|
|      | 5 menit | 10 menit | 30 menit |
| 45°C | 0,8366  | 0,8525   | 0,8615   |
|      | 0,8766  | 0,8585   | 0,8583   |
|      | 0,8539  | 0,8583   | 0,8616   |
| 55°C | 0,8606  | 0,8499   | 0,8546   |
|      | 0,8648  | 0,859    | 0,8645   |
|      | 0,8581  | 0,8568   | 0,8529   |
| 65°C | 0,8479  | 0,8561   | 0,8499   |
|      | 0,855   | 0,8531   | 0,8548   |
|      | 0,8574  | 0,8554   | 0,8624   |

**Tabel Dua Arah antara Faktor A dan Faktor B**

| Suhu                     | Waktu   |          |          | Jumlah (Y <sub>i</sub> ) |
|--------------------------|---------|----------|----------|--------------------------|
|                          | 5 menit | 10 menit | 30 menit |                          |
| 45°C                     | 2,5671  | 2,5693   | 2,5814   | 7,7178                   |
| 55°C                     | 2,5835  | 2,5657   | 2,572    | 7,7212                   |
| 65°C                     | 2,5603  | 2,5646   | 2,5671   | 7,692                    |
| Jumlah (Y <sub>j</sub> ) | 7,7109  | 7,6996   | 7,7205   | 23,131                   |

## Analisis Sidik Ragam

$$\begin{aligned} \text{a. } \mathbf{FK} &= \frac{(23,131)^2}{(9 \times 3)} \\ &= \frac{535,043}{27} \\ &= 19,81 \end{aligned}$$

$$\begin{aligned} \text{b. } \mathbf{JK}_{\text{total}} &= (0,8636)^2 + (0,8766)^2 + (0,8539)^2 + (0,8525)^2 + (0,8585)^2 + (0,8583)^2 + (0,8615)^2 \\ &\quad + (0,8583)^2 + (0,8616)^2 + (0,8607)^2 + (0,8648)^2 + (0,8581)^2 + (0,8499)^2 + (0,859)^2 \\ &\quad + (0,8568)^2 + (0,8546)^2 + (0,8645)^2 + (0,8529)^2 + (0,8479)^2 + (0,855)^2 + (0,8574)^2 \\ &\quad + (0,8561)^2 + (0,8531)^2 + (0,8554)^2 + (0,8499)^2 + (0,8548)^2 + (0,8624)^2 - \mathbf{FK} \\ &= (0,7458) + (0,7684) + (0,7291) + (0,7268) + (0,7370) + (0,7367) + (0,7422) + \\ &\quad (0,7367) + (0,7424) + (0,7408) + (0,7479) + (0,7363) + (0,7223) + (0,7379) + \\ &\quad (0,7341) + (0,7303) + (0,7474) + (0,7274) + (0,7189) + (0,7310) + (0,7351) + \\ &\quad (0,7329) + (0,7278) + (0,7317) + (0,7223) + (0,7307) + (0,7437) - \mathbf{19,81} \\ &= 19,8638 - 19,81 \\ &= 0,0538 \end{aligned}$$

$$\begin{aligned} \text{g. } \mathbf{JK}_{\text{Suhu (A)}} &= \frac{(7,7178)^2 + (7,7212)^2 + (7,692)^2}{r \times b} - \mathbf{FK} \\ &= \frac{(59,56) + (59,61) + (59,16)}{3 \times 3} - \mathbf{19,81} \\ &= \frac{178,33}{9} - \mathbf{19,81} \\ &= 19,8164 - 19,81 \\ &= 0,00647 \end{aligned}$$

$$\begin{aligned} \text{c. } \mathbf{JK}_{\text{Waktu (B)}} &= \frac{(7,7109)^2 + (7,6996)^2 + (7,7205)^2}{r \times a} - \mathbf{FK} \\ &= \frac{(59,457) + (59,283) + (59,606)}{9} - \mathbf{19,81} \\ &= \frac{178,346}{9} - \mathbf{19,81} \end{aligned}$$



$$= 19,8162 - 19,81$$

$$= 0,0062$$

**d. JK<sub>AB</sub>**

$$= \frac{(2,5671)^2 + (2,5693)^2 + (2,5814)^2 + (2,5835)^2 + (2,5657)^2 + (2,572)^2 + (2,5603)^2 + (2,5646)^2 + (2,5671)^2}{r} - FK - JKA - JKB$$

$$= \frac{(6.7294) + (6.6013) + (6.6636) + (6.6750) + (6.5828) + (6.5551) + (6.5772) + (6.5772) + (6.5900)}{3} - 19,81 - 0,00647 - 0,0062$$

$$= \frac{59,5516}{3} - 19,81 - 0,00647 - 0,0062$$

$$= 19,85 - 19,81 - 0,00647 - 0,0062$$

$$= 0,0273$$

**e. JK Galat Percobaan** = JK<sub>total</sub> - JK<sub>Suhu (A)</sub> - JK<sub>Waktu (B)</sub> - JK<sub>(AB)</sub>

$$= 0,0538 - 0,00647 - 0,0062 - 0,0273$$

$$= 0,01383$$

| Sumber Keragaman | dB | JK      | KT                            | F <sub>hitung</sub> | F <sub>tabel</sub> |      |
|------------------|----|---------|-------------------------------|---------------------|--------------------|------|
|                  |    |         |                               |                     | 0,05               | 0,01 |
| Suhu             | 2  | 0,00647 | 0,00323                       | 4,25                | 3,55               | 6,01 |
| Waktu            | 2  | 0,0062  | 0,0031                        | 4,07                | 3,55               | 6,01 |
| Suhu × Waktu     | 4  | 0,0273  | 0,0068                        | 8,94                | 2,93               | 4,58 |
| Galat Percobaan  | 18 | 0,01383 | 0,00076                       |                     |                    |      |
| Total            | 26 | 0,0538  | Koefisien Keseragaman = 3,24% |                     |                    |      |

**f. Koefisien Keseragaman (KK)**

$$KK = \frac{\sqrt{KT \text{ Galat Percobaan}}}{y} \times 100\% \quad ; \quad y = \frac{23,131}{(9 \times 3)} = \frac{23,131}{27} = 0,85$$

$$= \frac{\sqrt{0,00076}}{0,85} \times 100\%$$

$$= 0,032 \times 100\%$$

$$= 3,24\%$$

### **g. Kesimpulan**

- Suhu (A)

Karena  $F_{hitung} A (4,25) > F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan berbeda signifikan (berbeda nyata pada taraf  $\alpha 0,05$ ).

Karena  $F_{hitung} A (4,25) < F_{tabel} (6,01)$  maka pada taraf kepercayaan 99% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha 0,01$ ).

- Waktu (B)

Karena  $F_{hitung} A (4,07) > F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan berbeda signifikan (berbeda nyata pada taraf  $\alpha 0,05$ ).

Karena  $F_{hitung} A (4,07) < F_{tabel} (6,01)$  maka pada taraf kepercayaan 99% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha 0,01$ ).

- Interaksi Suhu  $\times$  Waktu (A $\times$ B)

Karena  $F_{hitung} A (8,94) > F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan berbeda signifikan (berbeda nyata pada taraf  $\alpha 0,05$ ).

Karena  $F_{hitung} A (8,94) > F_{tabel} (6,01)$  maka pada taraf kepercayaan 99% perlakuan dinyatakan sangat berbeda signifikan (sangat berbeda nyata pada taraf  $\alpha 0,01$ ).

Lampiran 7. Perhitungan Statistika Viskositas (cSt)

| Perlakuan                     | Ulangan |       |       | Total | Rata-rata |
|-------------------------------|---------|-------|-------|-------|-----------|
|                               | 1       | 2     | 3     |       |           |
| T <sub>1</sub> t <sub>1</sub> | 1,69    | 1,60  | 1,50  | 4,79  | 1,60      |
| T <sub>1</sub> t <sub>2</sub> | 1,53    | 1,54  | 1,50  | 4,56  | 1,52      |
| T <sub>1</sub> t <sub>3</sub> | 1,49    | 1,49  | 1,53  | 4,51  | 1,50      |
| T <sub>2</sub> t <sub>1</sub> | 1,48    | 1,53  | 1,44  | 4,44  | 1,48      |
| T <sub>2</sub> t <sub>2</sub> | 1,47    | 1,49  | 1,73  | 4,69  | 1,56      |
| T <sub>2</sub> t <sub>3</sub> | 1,52    | 1,48  | 1,44  | 4,38  | 1,48      |
| T <sub>3</sub> t <sub>1</sub> | 1,46    | 1,44  | 1,48  | 4,34  | 1,46      |
| T <sub>3</sub> t <sub>2</sub> | 1,40    | 1,46  | 1,49  | 4,34  | 1,45      |
| T <sub>3</sub> t <sub>3</sub> | 1,48    | 1,42  | 1,34  | 4,24  | 1,41      |
| Total                         | 13,52   | 13,44 | 13,44 | 40,29 | 13,46     |
| Rata-rata                     | 1,50    | 1,49  | 1,49  | 4,48  | 1,50      |

| Suhu | Waktu   |          |          |
|------|---------|----------|----------|
|      | 5 menit | 10 menit | 30 menit |
| 45°C | 1,69    | 1,53     | 1,49     |
|      | 1,60    | 1,54     | 1,49     |
|      | 1,50    | 1,50     | 1,53     |
| 55°C | 1,48    | 1,47     | 1,52     |
|      | 1,53    | 1,49     | 1,48     |
|      | 1,44    | 1,73     | 1,44     |
| 65°C | 1,46    | 1,40     | 1,48     |
|      | 1,44    | 1,46     | 1,42     |
|      | 1,48    | 1,49     | 1,34     |

**Tabel Dua Arah antara Faktor A dan Faktor B**

| Suhu                     | Waktu   |          |          | Jumlah (Y <sub>i</sub> ) |
|--------------------------|---------|----------|----------|--------------------------|
|                          | 5 menit | 10 menit | 30 menit |                          |
| 45°C                     | 4,79    | 4,56     | 4,51     | 13,86                    |
| 55°C                     | 4,44    | 4,69     | 4,38     | 13,51                    |
| 65°C                     | 4,34    | 4,34     | 4,24     | 12,92                    |
| Jumlah (Y <sub>j</sub> ) | 13,57   | 13,59    | 13,13    | 40,29                    |

## Analisis Sidik Ragam

$$\begin{aligned} \text{a. } FK &= \frac{(40.29)^2}{(9 \times 3)} \\ &= \frac{1623,28}{27} \\ &= 60,12 \end{aligned}$$

$$\begin{aligned} \text{b. } JK_{\text{total}} &= ((1.69)^2 + (1.60)^2 + (1.50)^2 + (1.53)^2 + (1.54)^2 + (1.50)^2 + (1.49)^2 + (1.49)^2 + (1.53)^2 + (1.48)^2 \\ &\quad + (1.53)^2 + (1.44)^2 + (1.47)^2 + (1.49)^2 + (1.73)^2 + (1.52)^2 + (1.48)^2 + (1.44)^2 + (1.46)^2 + (1.44)^2 \\ &\quad + (1.48)^2 + (1.40)^2 + (1.46)^2 + (1.49)^2 + (1.48)^2 + (1.42)^2 + (1.34)^2) - FK \\ &= (2.843) + (2.570) + (2.259) + (2.338) + (2.356) + (2.235) + (2.223) + (2.205) + \\ &\quad (2.344) + (2.179) + (2.341) + (2.065) + (2.170) + (2.217) + (2.993) + (2.320) + \\ &\quad (2.199) + (2.059) + (2.129) + (2.079) + (2.179) + (1.971) + (2.117) + (2.205) + \\ &\quad (2.176) + (2.016) + (1.806) - 60,12 \\ &= 60,593 - 60,12 \\ &= 0,473 \end{aligned}$$

$$\begin{aligned} \text{a. } JK_{\text{Suhu (A)}} &= \frac{(13,86)^2 + (13,51)^2 + (12,92)^2}{r \times b} - FK \\ &= \frac{(192,09) + (182,52) + (166,92)}{3 \times 3} - 60,12 \\ &= \frac{541,53}{9} - 60,12 \\ &= 60,17 - 60,12 \\ &= 0,05 \end{aligned}$$

$$\begin{aligned} \text{b. } JK_{\text{Waktu (B)}} &= \frac{(13,57)^2 + (13,59)^2 + (13,13)^2}{r \times a} - FK \\ &= \frac{(184,14) + (184,68) + (172,39)}{9} - 60,12 \\ &= \frac{541,21}{9} - 60,12 \\ &= 60,13 - 60,12 \\ &= 0,01 \end{aligned}$$

$$\begin{aligned}
 \text{c. } JK_{AB} &= \frac{(4.79)^2 + (4.56)^2 + (4.51)^2 + (4.44)^2 + (4.69)^2 + (4.38)^2 + (4.34)^2 + (4.34)^2 + (4.24)^2}{r} - FK - JKA - JKB \\
 &= \frac{(22.963) + (20.784) + (20.313) + (19.740) + (22.015) + (19.158) + (18.870) + (18.870) + (17.969)}{3} - 60,12 - 0,05 - 0,01 \\
 &= \frac{180,684}{3} - 60,12 - 0,05 - 0,01 \\
 &= 60,228 - 60,12 - 0,05 - 0,01 \\
 &= 0,048
 \end{aligned}$$

$$\begin{aligned}
 \text{d. } JK \text{ Galat Percobaan} &= JK_{\text{total}} - JK_{\text{Suhu (A)}} - JK_{\text{Waktu (B)}} - JK_{(AB)} \\
 &= 0,473 - 0,05 - 0,01 - 0,048 \\
 &= 0,365
 \end{aligned}$$

| Sumber Keragaman | dB | JK    | KT                        | F <sub>hitung</sub> | F <sub>tabel</sub> |      |
|------------------|----|-------|---------------------------|---------------------|--------------------|------|
|                  |    |       |                           |                     | 0,05               | 0,01 |
| Suhu             | 2  | 0,05  | 0,025                     | 1,25                | 3,55               | 6,01 |
| Waktu            | 2  | 0,01  | 0,005                     | 0,25                | 3,55               | 6,01 |
| Suhu × Waktu     | 4  | 0,048 | 0,012                     | 0,6                 | 2,93               | 4,58 |
| Galat Percobaan  | 18 | 0,365 | 0,02                      |                     |                    |      |
| Total            | 26 | 0,473 | Koefisien Keragaman = 25% |                     |                    |      |

**e. Koefisien Keragaman (KK)**

$$\begin{aligned}
 KK &= \sqrt{\frac{KT \text{ Galat Percobaan}}{y}} \times 100\% \quad ; y = \frac{40,29}{(9 \times 3)} = \frac{40,29}{27} = 1,49 \\
 &= \sqrt{\frac{0,004}{1,49}} \times 100\% \\
 &= 0,0518 \times 100\% \\
 &= 5,18\%
 \end{aligned}$$

#### **f. Kesimpulan**

- Suhu (A)

Karena  $F_{hitung\ A} (1,25) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

- Waktu (B)

Karena  $F_{hitung\ A} (0,25) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

- Interaksi Suhu  $\times$  Waktu (A $\times$ B)

Karena  $F_{hitung\ A\times B} (0,6) < F_{tabel} (2,93)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

Lampiran 8. Perhitungan Statistika Bilangan Asam Biodiesel (%)

| Perlakuan                     | Ulangan |       |       | Total | Rata-rata |
|-------------------------------|---------|-------|-------|-------|-----------|
|                               | 1       | 2     | 3     |       |           |
| T <sub>1</sub> t <sub>1</sub> | 0,08    | 0,09  | 0,09  | 0,26  | 0,086     |
| T <sub>1</sub> t <sub>2</sub> | 0,07    | 0,09  | 0,08  | 0,24  | 0,08      |
| T <sub>1</sub> t <sub>3</sub> | 0,06    | 0,07  | 0,07  | 0,20  | 0,066     |
| T <sub>2</sub> t <sub>1</sub> | 0,08    | 0,09  | 0,08  | 0,25  | 0,083     |
| T <sub>2</sub> t <sub>2</sub> | 0,08    | 0,07  | 0,08  | 0,23  | 0,076     |
| T <sub>2</sub> t <sub>3</sub> | 0,07    | 0,07  | 0,07  | 0,21  | 0,07      |
| T <sub>3</sub> t <sub>1</sub> | 0,07    | 0,08  | 0,08  | 0,23  | 0,076     |
| T <sub>3</sub> t <sub>2</sub> | 0,08    | 0,07  | 0,08  | 0,23  | 0,076     |
| T <sub>3</sub> t <sub>3</sub> | 0,06    | 0,08  | 0,07  | 0,21  | 0,07      |
| Total                         | 0,65    | 0,71  | 0,7   | 2,06  | 0,686     |
| Rata-rata                     | 0,072   | 0,078 | 0,077 | 0,228 | 0,076     |

| Suhu | Waktu   |          |          |
|------|---------|----------|----------|
|      | 5 menit | 10 menit | 30 menit |
| 45°C | 0,08    | 0,07     | 0,06     |
|      | 0,09    | 0,09     | 0,07     |
|      | 0,09    | 0,08     | 0,07     |
| 55°C | 0,08    | 0,08     | 0,07     |
|      | 0,09    | 0,07     | 0,07     |
|      | 0,08    | 0,08     | 0,07     |
| 65°C | 0,07    | 0,08     | 0,06     |
|      | 0,08    | 0,07     | 0,08     |
|      | 0,08    | 0,08     | 0,07     |

**Tabel Dua Arah antara Faktor A dan Faktor B**

| Suhu                     | Waktu   |          |          | Jumlah (Y <sub>i</sub> ) |
|--------------------------|---------|----------|----------|--------------------------|
|                          | 5 menit | 10 menit | 30 menit |                          |
| 45°C                     | 0,26    | 0,24     | 0,20     | 0,7                      |
| 55°C                     | 0,25    | 0,23     | 0,21     | 0,69                     |
| 65°C                     | 0,23    | 0,23     | 0,21     | 0,67                     |
| Jumlah (Y <sub>j</sub> ) | 0,74    | 0,7      | 0,62     | 2,06                     |

## Analisis Sidik Ragam

$$\begin{aligned} \text{a. } FK &= \frac{(2,06)^2}{(9 \times 3)} \\ &= \frac{4,2436}{27} \\ &= 0,1571 \end{aligned}$$

$$\begin{aligned} \text{b. } JK_{\text{total}} &= ((0,08)^2 + (0,09)^2 + (0,09)^2 + (0,07)^2 + (0,09)^2 + (0,08)^2 + (0,06)^2 + (0,07)^2 \\ &\quad + (0,07)^2 + (0,08)^2 + (0,09)^2 + (0,08)^2 + (0,08)^2 + (0,07)^2 + (0,08)^2 + (0,07)^2 \\ &\quad + (0,07)^2 + (0,07)^2 + (0,07)^2 + (0,08)^2 + (0,08)^2 + (0,08)^2 + (0,07)^2 + (0,08)^2 \\ &\quad + (0,06)^2 + (0,08)^2 + (0,07)^2) - FK \\ &= (0,0066) + (0,0083) + (0,0088) + (0,0049) + (0,0087) + (0,0066) + \\ &\quad (0,0034) + (0,0049) + (0,0048) + (0,0065) + (0,0086) + (0,0066) + (0,0068) \\ &\quad + (0,0049) + (0,0067) + (0,0049) + (0,0048) + (0,0049) + (0,0050) + \\ &\quad (0,0067) + (0,0067) + (0,0067) + (0,0049) + (0,0067) + (0,0035) + (0,0067) \\ &\quad + (0,0048) ) - 0,1648 \\ &= 0,1634 - 0,1571 \\ &= 0,0063 \end{aligned}$$

$$\begin{aligned} \text{c. } JK_{\text{Suhu (A)}} &= \frac{(0,7)^2 + (0,69)^2 + (0,67)^2}{r \times b} - FK \\ &= \frac{(0,49) + (0,4761) + (0,4489)}{3 \times 3} - 0,1571 \\ &= \frac{1,415}{9} - 0,1571 \\ &= 0,15722 - 0,1571 \\ &= 0,00012 \end{aligned}$$

$$\begin{aligned} \text{d. } JK_{\text{Waktu (B)}} &= \frac{(0,74)^2 + (0,7)^2 + (0,62)^2}{r \times a} - FK \\ &= \frac{(0,5476) + (0,49) + (0,3844)}{9} - 0,1571 \end{aligned}$$



$$= \frac{1,422}{9} - 0,1571$$

$$= 0,158 - 0,1571$$

$$= 0,0009$$

**e. JK<sub>AB</sub>**

$$= \frac{(0,26)^2 + (0,24)^2 + (0,20)^2 + (0,25)^2 + (0,23)^2 + (0,21)^2 + (0,23)^2 + (0,23)^2 + (0,21)^2}{r} - FK - JKA - JKB$$

$$= \frac{(0,0676) + (0,0576) + (0,04) + (0,0625) + (0,0529) + (0,0441) + (0,0529) + (0,0529) + (0,0441)}{3} - 0,1571 - 0,00012 - 0,0009$$

$$= \frac{0,4746}{3} - 0,1571 - 0,00012 - 0,0009$$

$$= 0,1582 - 0,1571 - 0,00012 - 0,0009$$

$$= 0,00008$$

**f. JK Galat Percobaan** = JK<sub>total</sub> - JK<sub>Suhu (A)</sub> - JK<sub>Waktu (B)</sub> - JK<sub>(AB)</sub>

$$= 0,0063 - 0,00012 - 0,0009 - 0,00008$$

$$= 0,00716$$

| Sumber Keragaman | dB | JK      | KT                          | F <sub>hitung</sub> | F <sub>tabel</sub> |      |
|------------------|----|---------|-----------------------------|---------------------|--------------------|------|
|                  |    |         |                             |                     | 0,05               | 0,01 |
| Suhu             | 2  | 0,00012 | 0,00006                     | 0,153               | 3,55               | 6,01 |
| Waktu            | 2  | 0,0009  | 0,00045                     | 1,153               | 3,55               | 6,01 |
| Suhu × Waktu     | 4  | 0,00008 | 0,00002                     | 0,05                | 2,93               | 4,58 |
| Galat Percobaan  | 18 | 0,00716 | 0,00039                     |                     |                    |      |
| Total            | 26 | 0,0063  | Koefisien Keseragaman = 25% |                     |                    |      |

**g. Koefisien Keseragaman (KK)**

$$KK = \frac{\sqrt{KT \text{ Galat Percobaan}}}{y} \times 100\% \quad ; \quad y = \frac{2,06}{(9 \times 3)} = \frac{2,06}{27} = 0,076$$

$$= \frac{\sqrt{0,00039}}{0,076} \times 100\%$$

$$= 0,25 \times 100\%$$

$$= 25\%$$

#### **h. Kesimpulan**

- Suhu (A)

Karena  $F_{hitung\ A} (0,153) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

- Waktu (B)

Karena  $F_{hitung\ A} (1,153) < F_{tabel} (3,55)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

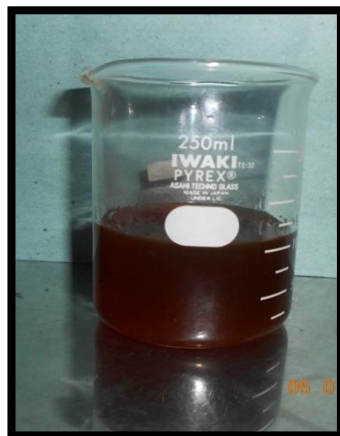
- Interaksi Suhu  $\times$  Waktu (A $\times$ B)

Karena  $F_{hitung\ A\times B} (0,05) < F_{tabel} (2,93)$  maka pada taraf kepercayaan 95% perlakuan dinyatakan tidak berbeda signifikan (tidak berbeda nyata pada taraf  $\alpha$  0,05).

## FOTO-FOTO PENELITIAN



Gambar 1. Rangkaian Alat Pembuatan Biodiesel



(a) Minyak jelantah



(b) Biodiesel + Gliserol



(c) Pencucian pertama



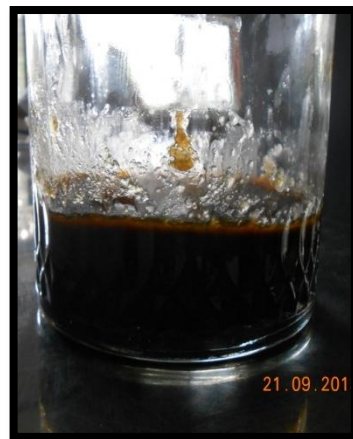
(d) Pencucian kedua



(e) Pencucian ketiga



(f) Biodiesel

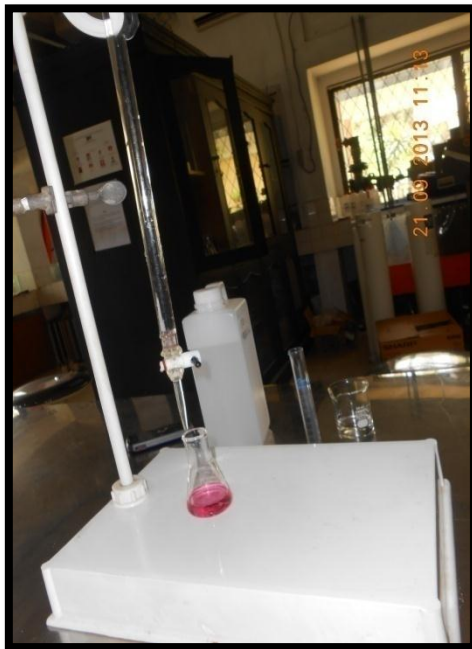


(g) Gliserol

Gambar 2. Tahapan Pembuatan Biodiesel



Gambar 3. Proses Pemisahan Biodiesel yang dicuci dengan menggunakan Corong Pemisah



Gambar 4. Proses Titrasi untuk Menentukan Kadar Bilangan Asam



Gambar 5. Uji Viskositas Biodiesel



Gambar 6. Uji Kapilaritas Biodiesel dan Minyak Tanah



Gambar 7. Biodiesel yang dihasilkan