Adi

Submission date: 29-Oct-2023 11:30PM (UTC-0400)
Submission ID: 2198232384
File name: Adi_Putra_Kinerja_boiler.docx (127.76K)
Word count: 3311
Character count: 18346

E-ISSN-2580-7129
Print- ISSN-1978-6107

TECHNO: JURNAL PENELITIAN
Journal homepage: http://ejournal.unkhair.ac.id/index.php/Techno
Issue 09 Number 02 October 2020 DOI: http://dx.doi.org/10.33387/tk.v9i2

Boiler Performance with Variations in Fuel Mix Composition Feeding

Adi Putra Winarto[1], Dessy Agustina Sari[2*]

[1,2] *Chemical Engineering Program, Engineering Faculty, Universitas Singaperbangsa Karawang, Indonesia.*
Email: dessy.agustina8@staff.unsika.ac.id

Received:
Accepted:
Available online:

ABSTRACT

PKS Kertajaya is a subsidiary of PTPN VIII, which focuses on the palm oil industry. a number of main processing and supporting equipment for this factory. One of the key aspects of the production process is the use of the boiler. This equipment produces steam, which is needed by various palm oil production processes and even factory utility areas. Therefore, the research study focused on the quantity of fuel used in producing the steam. The palm oil industry utilizes the solid waste from fresh fruit bunches, namely fibers and shells. The variable variation is in the percentage of the two fuels. From the estimation results using the direct method, it was found that the feeding conditions of 50:50, 60:40, and 70:30% were able to provide an increase in boiler efficiency values along with decreasing operational fuel costs. However, if you compare it with the quantity of fuel that has been applied by the industry, the percentage of 50:50% is the optimum condition, both in terms of boiler efficiency and economic value, which is one level higher than the current condition. This consideration is viewed from the estimation side as well as the amount of carbon content owned. Apart from that, the palm oil industry continues to maintain performance during routine maintenance of boiler equipment. Ingredients other than carbon are able to make short- to long-term contributions to producing steam.

Keywords: bunches of fresh fruit, boiler efficiency, crude palm oil, factory utilities, palm fiber.

ABSTRAK

PKS Kertajaya merupakan anak perusahaan PTPN VIII yang berfokus di bidang industri kelapa sawit. Dari sejumlah peralatan utama proses maupun pendukung pabrik ini. Ssalah satu aspek kunci proses produksinya berada pada penggunaan boiler. Peralatan ini menghasilkan uap air yang dibutuhkan ragam proses produksi minyak kelapa sawit bahkan area utilitas pabrik. Oleh karena itu, kajian penelitian difokuskan ke kuantitas bahan bakar yang digunakan dalam memproduksi *steam* tersebut. Pihak industri kelapa sawit memanfaatkan peran limbah padat dari tandan buah segar, yaitu serabut dan cangkang. Variasi variabel berada pada persentase kedua bahan bakar tersebut. Dari hasil estimasi melalui penggunaan metode langsung didapatkan bahwa kondisi pengumpanan 50:50, 60:40, dan 70:30% mampu memberikan peningkatan nilai efisiensi boiler dengan seiring menurunnya biaya operasional bahan bakar. Akan tetapi, jika membandingkan dengan kuantitas bahan bakar yang telah diterapkan pihak industri maka persentase 50:50% adalah kondisi optimum baik sisi efisiensi boiler dan nilai ekonomi yang lebih tinggi satu tingkat dari kondisi saat ini. Pertimbangan ini ditinjau dari sisi estimasi dan juga jumlah kandungan karbon yang dimiliki. Selain itu, pihak industri kelapa sawit tetap menjaga performa selama terutama pelaksanaan perawatan rutin peralatan boiler. Kandungan selain karbon mampu memberikan kontribusi baik jangka pendek hingga panjang dalam memproduksi uap air.

Kata Kunci: efisiensi boiler, kelapa sawit, minyak kelapa sawit, tandan buah segar, utilitas pabrik.

INTRODUCTION

PT Perkebunan Nusantara VIII (commonly known as PTPN VIII) Kertajaya PKS Unit focuses on the palm oil processing industry into CPO (crude palm oil) and PKO (palm kernel oil). The institution has a production capacity of 60 tons of FFB (fresh fruit bunches) per hour. Kertajaya palm oil processing has 10 stations, starting with the weighing station, sorting, loading ramp, sterilizer, drum thresher, clarification, kernel, boiler, utilities, and ending with the water treatment station. The thresher drum station generally produces empty fruit bunches after processing CPO and PKO. The processing waste is useful as a fertilizer option for PTPN VIII again. Then, the kernel station produces waste in the form of fiber and shell. Both are reprocessed as fuel in the boiler station. The main requirements for biomass waste that can be used at this station are the percentage content of carbon, nitrogen, hydrogen, sulfur, ash, and water (Dinata *et al*., 2019).

Operational PKS Kertajaya has a supporting unit with a utility station to provide water, steam (water vapor), electricity supply, and fuel. In some process equipment, the quantity of steam acts as a heater and drives the turbine generator. Equipment that generally supplies steam comes from a boiler. Obviously, the performance of this equipment requires attention when problems arise or it requires periodic maintenance. Its role in the productivity of palm oil processing will directly or indirectly be able to temporarily stop factory work operations. The existence of the boiler is also able to act as the heart of the operation (Maulana *et al*., 2016), one of which is the PTPN VII Kertajaya PKS Unit.

Boilers contribute to maintaining the smooth operation of palm oil mills. A boiler is a closed container that operates by involving pressure variations. In addition, this process equipment also involves heating from combustion with heat contact into water to produce hot water or water vapor (Nasution & Napid, 2022). The pressurized hot water or steam is then used in various processing processes and also to generate electricity in plant operations.

Boilers based on the type of fluid used are divided into fire pipe boilers and water pipe boilers (Muzaki & Mursadin, 2019). The main difference between the two lies in the capacity and pressure of the steam produced. Fire pipe boilers produce lower capacity and steam pressure than other types (Hanifah et al., 2019). Furthermore, the two main components of the boiler are the combustion chamber which functions to convert chemical energy into heat energy, and the evaporator which converts heat energy from combustion into steam potential energy (Nugroho *et al*., 2021). Boiler efficiency is measured through the ratio between the heat generated by fuel combustion and the amount of steam produced (Sugiharto, 2020). Every industry with a boiler unit implements periodic checks to maintain its performance.

Generally, industries that have boiler equipment in them use fuel oil to support steam production. In contrast, the palm oil industry utilizes waste from the main raw material of palm oil products in operating boilers. The industry uses fibers (SB) and shells (CK) to produce water vapor.

Previously, the application of palm oil industry waste has been studied (Nasikin, 2016). SB and CK were fed with a percentage of 90:10 and 80:20%, respectively. The continuation of the ratio variation is a research opportunity to determine the optimum condition of boiler performance in producing steam. Therefore, this study will analyze the boiler efficiency of both fuels. The variations between SB and CK that will be applied are 50:50, 60:40, and 70:30%. The method used during the review of data in the industrial field is the direct method. The advantage of this method is that there is no need for a number of laboratory analyses to estimate the heat generated from the two fuels. Field data such as the amount of SB and CK used by the industry is required to recalculate the enthalpy quantities through a mathematical equation approach and supporting tables for both saturated and superheated steam reviews.

MATERIALS AND METHOD

The research was conducted at Kertajaya PKS, Banjarsari District, Lebak Regency, Banten Province. This study used three samples by varying the percentage between SB and CK by 50:50, 60:40, and 70:30%. Then, the flow of research performance is presented in Figure 1 below. Tracing boiler performance begins with field data on the composition of fuel, SB, and CK. Table 1 is the content of the two materials in calculating boiler efficiency. The first step is to find the composition value of the chemical elements of fibers and shells.

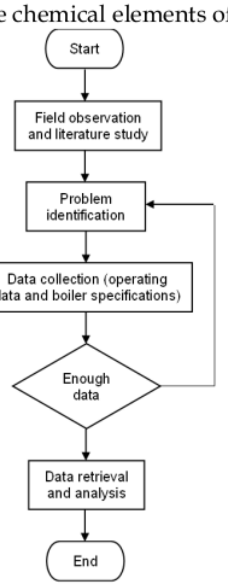

Figure 1. Boiler performance analysis work steps

Table 1. Fuel content of palm oil

Component	SB, %	CK, %
Carbon, C	49.22	52.12
Hydrogen, H_2	6.38	6.01
Oxygen, O_2	23.40	25.45
Ash	12.41	11.00
Sulfur, S	4.48	2.44
Moisture content, M	0,00	0.00

The second step is to calculate the heating value of the fuel utilizing the mathematical equation (1), which is the Dulong equation (Goswami & Kreith, 2017). Equations (4.1–4.2) are other mathematical equations that support the study of HHV (high heating value) and LHV (low heating value) (Culp, 1996; Novita & Damanhuri, 2010). The difference between LHV and HHV lies in the form of water. Both are the amount of heat generated by one kilogram of fuel. LHV focuses on gaseous water (Napitupulu, 2006), and HHV is liquid (Kasrun *et al*., 2016).

The third step is to review the temperature data from the industry by involving saturated and superheated steam standard data (Smith *et al*., 2018). The interpolation steps in the mathematical equation (2) will support the steam estimation (Pravitasari et al., 2017) and proceed to the calculation of boiler efficiency (Roni *et al*., 2021) through the following equation (3).

$$Q = 14544C + 62028\left(H - \frac{O}{8}\right) + 4050S \quad (1)$$

Interpolation, H

$$H_{(Px,Tx)} = A + B \quad (2)$$

$$A = \left[\left(\frac{(T_2 - T_x)}{(T_2 - T_1)}\right) H_{(P1,T1)} + \left(\frac{(T_x - T_1)}{(T_2 - T_1)}\right) H_{(P2,T1)}\right] \frac{P_2 - P_x}{P_2 - P_1}$$

$$B = \left[\left(\frac{(T_2 - T_x)}{(T_2 - T_1)}\right) H_{(P1,T2)} + \left(\frac{(T_x - T_1)}{(T_2 - T_1)}\right) H_{(P2,T2)}\right] \frac{P_x - P_1}{P_2 - P_1}$$

Boiler efficiency

$$\eta = \frac{\text{Steam generation energy}}{\text{System enegy}_{\text{inlet}}} \times 100\% \quad (3)$$

$$\eta = \left(\frac{W_{steam} - W_{fuel}}{W_{steam}}\right) \times 100\%$$

HHV

$$= 33{,}950C + 144{,}200\left(H_2 - \frac{O_2}{8}\right) + 9400S \quad (4.1)$$

HHV - LHV

$$= 2400\,(M + 9H_2) \quad (4.2)$$

Table 2 provides monthly average data for the palm oil industry to support the use of mathematical equations (1) to (4) as well as Table 1.

Table 2. Palm oil mill operating conditions, KOP

Parameter		
Boiler		
Feed water temperature	°C	90
Outlet water temperature	°C	283.838
Superheated steam pressure	kPa	2,375
Fuel consumption for		
Shell	kg/day	75,057
Fiber	kg/day	44,863
Steam flow rate	kg/day	341,333

RESULTS AND DISCUSSION

Review of boiler performance at Kertajaya PKS Banjarsari District, Lebak Regency, Banten Province through direct methods provides the results presented in Table 3 below. The use of direct methods to review boiler performance found that KOP data is the performance of the steam-generating unit. The current boiler efficiency and the estimated percentage ratio of fibers and shells are not significantly different. However, the economic price of both fuels ranges from Rp. 100 to Rp. 1,500 and Rp. 1,500 to Rp. 2,500 per kilogram. In order of magnitude, the operational costs for KOP ranked second highest after the use of shell fuel alone (100%). Similarly, the lowest economic value was obtained when only fibers were used as boiler fuel, with the highest boiler efficiency value. The different achievements are due to the mass fraction contribution of carbon (C), hydrogen (H_2), and oxygen (O_2) components, while sulfur (S) is neglected.

Table 3. Boiler performance through the application of the direct method

SB : CK, %	Mr_{mix}	Q, kJ/kg	Boiler Efficiency
50:50	17.94	4,606.071	65.160
60:40	17.90	4,622.616	65.394
70:30	17.86	4,639.234	65.629
KOP	17.99	4,585.347	64.867
100:0	17.74	4,689.538	66.341
0:100	18.14	4,524.438	64.005
50:50	17.94	4,606.071	65.160

The results of other studies by applying different equations state that the high net calorific value is influenced by two things, namely the heating heat value (HHV and the low heating value (LHV (Demirbas, 2007). The focus of HHV is similar to the application of equation (1), which involves the mass fraction for the components C, H_2, O_2, and S. Meanwhile, LHV is in the form of H_2, and the moisture content of the fuel is in both fibers and shells. Researchers (Sukarta & Ayuni, 2016) revealed that the quantity of moisture content in the fuel is able to influence the LHV value and the heat generated by the boiler in producing steam.

Achievements related to the existence of LHV are also supported by (Gunawan & G, 2020). The lower the moisture content of the fuel, the less energy is wasted in the process of water evaporation. Thus, SB and CK materials have added value to the palm oil industry and are also supported by more affordable prices compared to fuel oil.

The quantity of carbon in the fuel also contributes to increasing the LHV due to the release of CO_2 levels after combustion (Putro *et al*., 2015). Carbon in the fuel When a fuel containing carbon is burned, the carbon reacts with oxygen in the air and produces heat, CO_2 (a product of complete combustion), and even CO (if the combustion process is incomplete). This process increases the LHV value due to the release of additional heat resulting from the chemical reaction between carbon and oxygen. Therefore, the percentage of carbon content in the fuel can increase the potential energy produced and can also have a positive impact on the performance of boiler equipment and (Fitria *et al*., 2022; Sari *et al*., 2016, 2017) the sustainable performance of production equipment and plant utilities.

Another parameter that must be considered in boiler efficiency is the amount of fuel consumed. The amount of fuel consumed is related to the amount of LHV value produced by the type of fuel used (Hartanto *et al.*, 2020). This is in accordance with research (Hasibuan & Napitupulu, 2013) that the greater the LHV value, the less fuel is used and the more efficient the boiler's performance.

Industry managers also focus on reducing or maintaining the quantity of fuel used. This has a significant impact on operational costs, and the combustion gases also contribute to the surrounding environment. The more efficient the use of fuel, the less greenhouse gas emissions and other pollutants are produced (Nurhayati *et al*., 2010). These actions support the company's efforts to comply with applicable environmental regulations by directing tangible contributions in a sustainable manner.

Reducing fuel consumption also has a positive impact on the availability of limited natural resources. More efficient use of fuel enables the palm oil industry to reduce dependence on non-renewable fossil resources. This is in line with the global trend towards clean energy in a sustainable manner. To achieve more efficient fuel consumption, the industry usually conducts regular monitoring of its boiler systems, implements regular maintenance, and implements the latest technology and practices in the operation of boiler equipment units. In addition, awareness-raising and training for operators are also annual activities with the aim of optimizing fuel use in the context of boilers. In this way, the palm oil industry and other companies can achieve and maintain optimum boiler efficiency values, reduce operational costs, and maintain sustainability in terms of environmental health contributions.

CONCLUSION

Boiler performance analysis activities utilizing palm oil industry waste have been carried out. From the percentage between fibers and shells, it is known that the 50:50% ratio is the optimum variable when compared to the current application of SB and CK composition. The predicted efficiency value is also one level above (65.150 vs. 64.867%) and includes a more efficient operational cost of 5.922%. This achievement is supported by the higher carbon content compared to the 60:40 and 70:30% percentages, which is 50.670% by mass fraction of the overall feedstock. This will further assist the palm oil industry with the continued implementation of regular maintenance schedules on boiler equipment units. Because components other than carbon are able to contribute to boiler performance by producing steam and supporting the palm oil production process.

ACKNOWLEDGEMENTS

The authors would like to thank PTPN VIII Kertajaya PKS Unit, Banjarsari District, Lebak Regency, Banten Province, for providing the opportunity to do practical work and case study analysis, both morally and spiritually.

NOTATION

Q	Net heating value, Btu/lb with C, H, O, and S as mass fractions
H	Interpolated enthalpy, kJ/kg
H (Px, Tx)	Enthalpy at Px and Tx with the help of steam table, kJ/kg
Tx	Intermediate steam temperature at T1 and T2, ^{o}C
T1	Initial temperature of steam, ^{o}C
T2	Final steam temperature, ^{o}C
P1	Intermediate steam pressure at P1 and P2, kPa

P2	Initial pressure of steam, kPa
ŋ	Final steam pressure, kPa
W_{steam}	Boiler efficiency, %
H_g	Amount of steam produced by the boiler, kg/h
H_f	Enthalpy of superheated steam, kJ/kg
W_{fuel}	Enthalpy of saturated steam, kJ/h
W_{steam}	Fuel (fibers and shells) used, kg/h

REFERENCES

Culp, A. W. (1996). *Prinsip-prinsip konversi energi*. Erlangga.

Demirbas, A. (2007). Effects of moisture and hydrogen content on the heating value of fuels. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *29*(7), 649–655. https://doi.org/10.1080/009083190957801

Dinata, T. A., Kurniawan, E., & Nawawi, J. H. H. (2019). Studi pemanfaatan biomassa limbah padat pabrik kelapa sawit (PKS) untuk pembangkit energi listrik. *Jurnal Teknologi Rekayasa Teknologi Mesin*, *1*(1), 1–8.

Fitria, I. A., Sari, D. A., Fahriani, V. P., & Djaeni, M. (2022). Shell and tube heat exchanger fouling factor via Heat Transfer Research Inc (HTRI) software. *Reka Buana: Jurnal Ilmiah Teknik Sipil dan Teknik Kimia*, *7*(2), 104–113. https://doi.org/10.33366/rekabuana.v7i2.4030

Goswami, D. Y., & Kreith, F. (2017). *Energy conversion* (2nd ed). Taylor & Francis Group, LLC.

Gunawan, W., & G, B. A. (2020). Studi efisiensi boiler terhadap nilai kalor batubara pada boiler jenis pulverizer coal kapasitas 300 t/h (studi kasus PT XYZ). *Jurnal InTent*, *3*(2), 122–130.

Hanifah, U., Susanti, N. D., & Andrianto, M. (2019). Simulasi kebijakan penambahan areal tanam dan peningkatan produktivitas dalam mendukung tercapainya swasembada jagung. *Agritech*, *39*(3), 200–206. https://doi.org/10.22146/agritech.44539

Hartanto, L. B., Sibarani, M., & Tuapetel, J. V. (2020). Analisa teknis dan biaya penggunaan bahan bakar cangkang kelapa sawit dan batu bara pada boiler DZL4 di PT Lautan Luas Tbk. *Jurnal Teknik Mesin*, *4*(1), 17–23. https://doi.org/10.31543/jtm.v4i1.301

Hasibuan, H. C., & Napitupulu, F. H. (2013). Analisa pemakaian bahan bakar dengan melakukan pengujian nilai kalor terhadap performansi ketel uap tipe pipa air dengan kapasitas uap 60 ton/jam. *Jurnal E-Dinamis*, *4*(4), 239–243.

Kasrun, A. W., Anggono, W., & Sutrisno, T. (2016). Karakteristik pembakaran briket dari limbah daun pohon bintaro. *Jurnal Teknik Mesin*, *16*(2), 64–70.

Maulana, K., Lukman, L., Burhanduddin, F., & Sanjaya, A. S. (2016). Analisa efisiensi water tube boiler berbahan bakar fiber dan cangkang di palm oil mill kapasitas 60 ton TBS/jam dengan menggunakan Chemicalogic Steamtab Companion version 2.0. *Chemica: Jurnal Teknik Kimia*, *3*(2), 46–54. https://doi.org/10.26555/chemica.v3i2.6687

Muzaki, I., & Mursadin, A. (2019). Analisis efisiensi boiler dengan metode input– output di PT Japfa Comfeed Indonesia Tbk. Unit Banjarmasin. *Scientific Journal of Mechanical Engineering Kinematika*, *4*(1), 37–46. https://doi.org/10.20527/sjmekinematika.v4i1.50

Napitupulu, F. H. (2006). Pengaruh nilai kalor (heating value) suatu bahan bakar terhadap perencanaan volume ruang bakar ketel uap berdasarkan metode penentuan nilai kalor bahan bakar yang dipergunakan. *Jurnal Sistem Teknik Industri*, *7*(1), 60–65.

Nasikin, R. F. (2016). Analisa pengaruh nilai kalor bahan bakar fibre dan cangkang terhadap efisiensi boiler pipa air. *Jurnal Teknik Mesin*, *3*(2), 27–30.

Nasution, M., & Napid, S. (2022). Aplikasi boiler sebagai pembangkit uap dalam menentukan efisiensi. *Buletin Utama Teknik*, *17*(3), 314–319.

Novita, D. M., & Damanhuri, E. (2010). Perhitungan nilai kalor berdasarkan komposisi dan karakteristik sampah perkotaan di Indonesia dalam konsep waste to energy. *Jurnal Teknik Lingkungan*, *16*(2), 103–114.

Nugroho, A. F., Iskandar, N., & Irawan, O. W. (2021). Perencanaan ulang tube boiler type AL-LSB-6000 pada pusat pengembangan sumber daya manusia minyak dan gas Cepu. *Jurnal Teknik Mesin*, *5*(2), 59–68.

Nurhayati, A. D., Aryanti, E., & Saharjo, B. H. (2010). Kandungan emisi gas rumah kaca pada kebakaran hutan rawa gambut di Pelalawan Riau. *Jurnal Ilmu Pertanian Indonesia*, *15*(2), 78–82.

Putro, S., Musabbikhah, M., & Suranto, S. (2015). *Variasi temperatur dan waktu karbonisasi untuk meningkatkan nilai kalor dan memperbaiki sifat proximate biomassa sebagai bahan pembuat briket yang berkualitas*. M-282-M–288.

Roni, K. A., Widaputra, Y., & Dewi, D. K. (2021). Analisis pengaruh rasio serabut dan cangkang kelapa sawit sebagai bahan bakar pada boiler. *Jurnal Redoks*, *6*(1), 1–6. https://doi.org/10.31851/redoks.v6i1.5230

Sari, D. A., Iksanudin, I., & Hakiim, A. (2017). A case study on maintenance of overheat—Spot welding machine. *ADRI 4th International Multidiscplinary Conference and Call for Paper 2017*, *1*, 442. https://doi.org/10.31227/osf.io/9h4ct

Sari, D. A., Soepryanto, A., & Burhanuddin, S. (2016). Re-design electric submersible pump pada PT Chevron Pacific Indonesia – Minas Pekanbaru. *Barometer*, *1*(1), 25–33. https://doi.org/10.35261/barometer.v1i1.356

Smith, J., Ness, H. V., Abbott, M., & Swihart, M. (2018). *Introduction to chemical engineering thermodynamics* (8th ed). Mc-Graw Hill Education.

Sugiharto, A. (2020). Perhitungan efisiensi boiler dengan metode secara langsung pada boiler pipa api. *Majalah Ilmiah Swara Patra*, *10*(2), 51–57. https://doi.org/10.37525/sp/2020-2/260

Sukarta, I. N., & Ayuni, P. S. (2016). Analisis proksimat dan nilai kalor pada pellet biosolid yang dikombinasikan dengan biomassa limbah bambu. *JST (Jurnal Sains dan Teknologi)*, *5*(1), 728–735. https://doi.org/10.23887/jst-undiksha.v5i1.8278

Adi

ORIGINALITY REPORT

5%	4%	2%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ejournal.unkhair.ac.id Internet Source	1%
2	Submitted to University of Mauritius Student Paper	1%
3	A. Demirbas. "Effects of Moisture and Hydrogen Content on the Heating Value of Fuels", Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 2007 Publication	<1%
4	Nazaruddin Matondang, Juliza Hidayati, Buchari, Erik Permana Arifin, Jeffrey Panama. "Analysis of Crude Palm Oil Supply Chain using Food Supply Chain Network (FSCN): A Case Study", IOP Conference Series: Materials Science and Engineering, 2020 Publication	<1%
5	123dok.com Internet Source	<1%
6	journals.unihaz.ac.id Internet Source	<1%

7	repository.um-palembang.ac.id Internet Source	<1%
8	www.researchgate.net Internet Source	<1%
9	A Nugroho, N A Pambudi, B Harjanto, A Febryanto, R A Firdaus, N D Setyawan, M Syamsiro, I M Gandidi. " Production of solid fuel by hydrothermal treatment using peels waste as renewable energy sources ", Journal of Physics: Conference Series, 2019 Publication	<1%
10	digitalcommons.lsu.edu Internet Source	<1%
11	jurnal.untan.ac.id Internet Source	<1%
12	nusantaranews.co Internet Source	<1%

Exclude quotes Off
Exclude bibliography On
Exclude matches Off

Adi

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8