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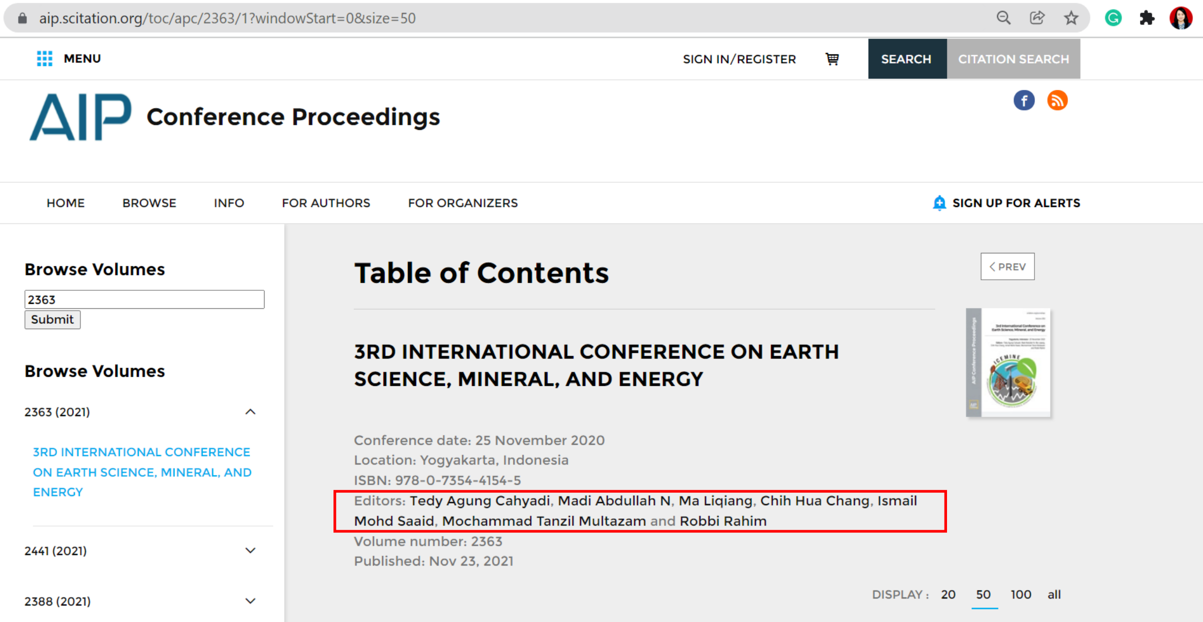

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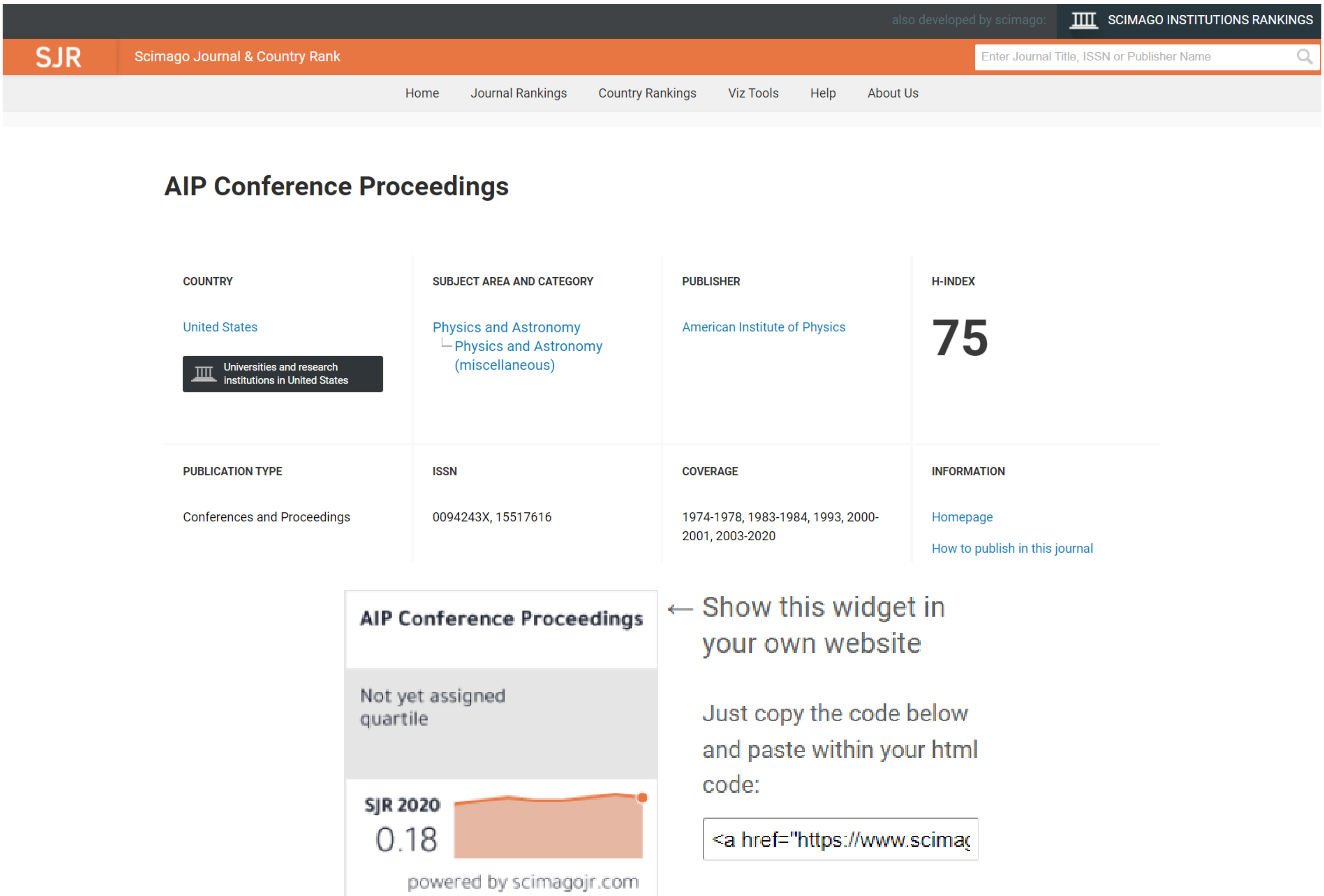

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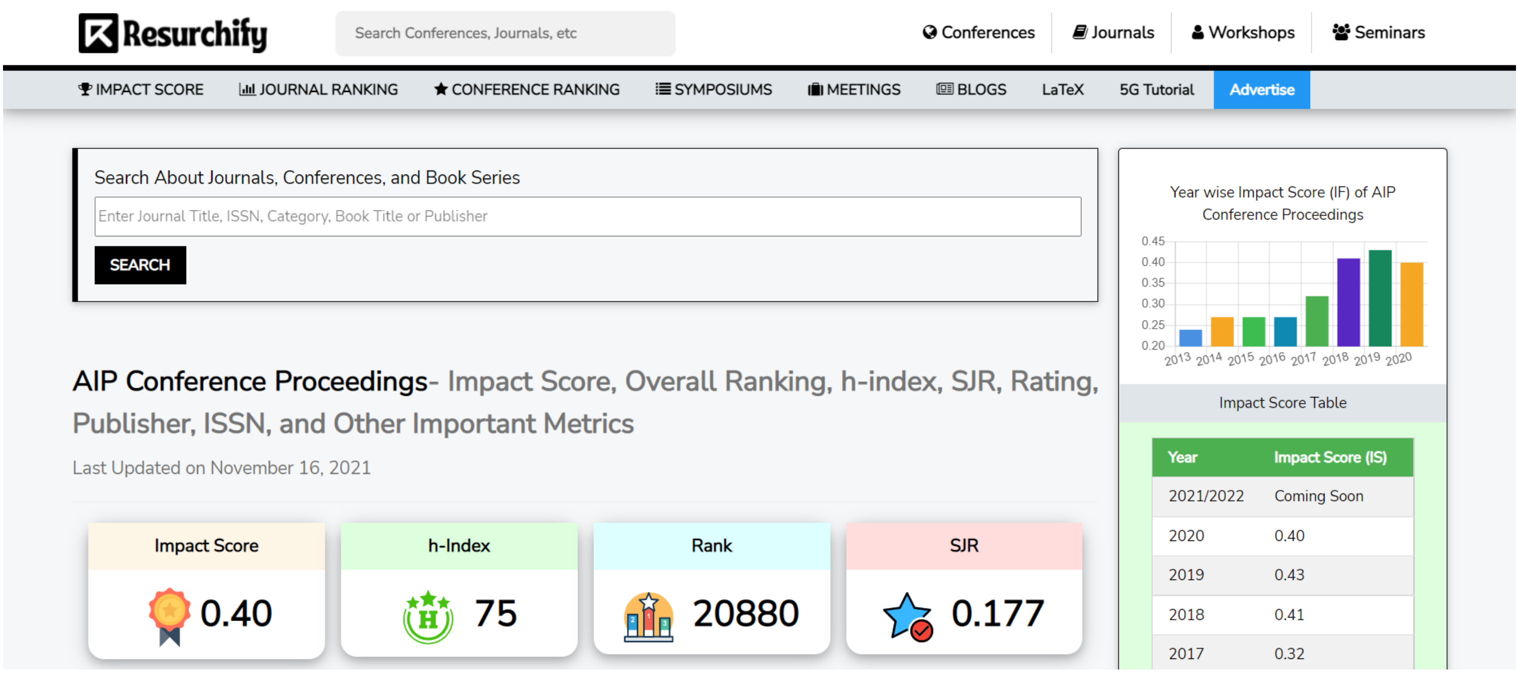

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Suliestyah, Pancanita Novi Hartami, Edy Jamal Tuheteru, et al.

Effect of Coal Grain Size and Time of Polymer Contacts on Coal Surface in Increasing the Calorific Value of Coal

Suliestyah[a)], Pancanita Novi Hartami, Edy Jamal Tuheteru and Indah Permata Sari

Trisakti University, Indonesia

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ABSTRACT Most of Indonesia's coal reserves are of low quality with high moisture content and low calorific value, so upgrading is needed to increase the calorific value of coal. Research has been carried out by adding polymers to the surface of coal taken from PT CTSP. Polymer addition was carried out with variations in polymer concentration (10%, 20% and 30%), variations in coal grain size (-7 + 5cm, and +7 cm), and variations in contact time between the polymer and coal surface (2, 24, 48, and 72 hours). The experiment was carried out by coating the polymer onto the coal surface in batches. In coal sized -7 + 5 cm, the most effective polymer concentration is 10% with an increase in calorific value of 15.8%. While in coal sized +7 cm, the most effective polymer concentration is 30% with an increase in calorific value of 3%. After obtaining the most significant concentration of polymer to increase the calorific value, the study was continued by adding the contact time between the polymer and coal with a variation of time 24, 48 and 72 hours. The most significant increase in calorific value occurred at 72 hours contact time, which is 18.94% of coal -7 +5 cm in grain size and 19% for coal of +7 cm in grain size respectively. This polymer has the potential for coal upgrading.

Keywords: Coal grain size, contact time, calorific value, polymer, coal upgrading.

INTRODUCTION

Indonesia is one of the largest coal-producing countries in the world. Indonesia's coal reserves reached 37.6 billion tonnes in December 2019, mostly low and medium rank coal. The high reserves of low-rank coal make this type of coal promising to be used as a supplier of energy for industrial needs. However, low-rank coal has high water content and causes a low calorific value of the coal. Also, the utilization of low-rank coal has disadvantages such as high fuel and power consumption, low combustion efficiency and high transportation costs [1]. The coal surface which consists of oxygen-containing groups and large hydrophilic functional groups causes high water content in coal due to hydrogen bonds that form on the coal surface [2]. Groups that contain oxygen on coal consist of active oxygen groups such as carboxyl, phenol, carbonyl, methoxyl, and non-active oxygen group such as ether. These active oxygen groups possess higher density that is why it is easier for hydrogen to bind water vapor and create coals with high water content and low heat value [3]. The solution to this situation is by increasing hydrophobidity of coal surface to lower water content and increase heat value. One of the usable methods is the utilization of polymer or surfactant. Emulsion polymer that contains surfactant can lower coal-water content and increase its heat value. Surfactant possesses amphiphilic nature, hydrophobic on its head area and hydrophilic on the other end, making it able to be used in interface modification [4]. When emulsion polymer that contains surfactant is sprayed on coal surface, surfactant will block coal pores and prevent water from going in, which produces coal with lower water content [5].

Several studies of polymer spraying to increase the calorific value of coal by reducing its moisture content have been carried out. Devasahayam et al. (2015) has conducted research on coal dewatering using Poly (Acrylamide-Co-Potassium Acrylic) polymer with a polymer concentration of 0 to 30% and a contact time of 1 to 6 hours [6]. Murdiana et al. (2018) carried out surfactant spraying as a wetting agent on the coal surface and obtained a decrease in water content from 37.95% to 21.42% [7]. Liu et al. utilize CTAB surfactant to lower hydrophilicity of lignite

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METHODS

Coal Sampling

Coal sampling was carried out at PT Citra Tobindo Sukses Perkasa with the channel sampling method assisted by a mechanical device and a hoe. In the initial stage, the required coal sample, is shredded with mechanical means from the work surface.

Coal Sample Preparation

The coal sample preparation process is carried out in the coal laboratory of Puslitbang Tekmira. The coal samples were divided into two, the original condition coal samples that were not reduced and the coal samples that had been reduced in size and sprayed with polymer. For sample preparation not sprayed with polymer, the sample is immediately put into a drying shed oven to be dried at 40ºC. For samples to be sprayed with polymers, the coal samples from the field in the form of chunks of coal are reduced in size to approximately -7 +5 cm and +7 cm. After the sample is reduced in size, the samples are sprayed with polymers with various concentrations that have been determined and left for up to 2 hours. Then the drying shed oven is carried out. Furthermore, all of the samples were reduced in size to 4.75 mm to speed up the drying process and dried in the drying shed oven. After that, it was reduced to a size of 250 μm (60 mesh) for coal quality analysis. The minimum weight for the overall analysis (General Analysis) is 50 grams. (ASTM D2013 / 2013-M).

Analysis of Coal Sample Quality

After sample preparation is carried out, a test is carried out to determine the calorific value of the coal using a bomb calorimeter. Besides that, a conduction of coal proximate analysis that includes total water content, ash content, moisture content, volatile matter, fixed carbon was implemented, along with coal sulfur content determination.

RESULT AND DISCUSSION

Coal Rank Analysis

Proximate analysis, heat value and coal sulfur determination were conducted to acknowledge the rank of used coal. The analysis result is described in Table 1:

TABLE 1: Proximate analysis, heat value, and coal sulfur content

Total moisture (%)	Ash content (%)	Inherent Moisture (%)	Volatile Matter (%)	Fixed Carbon (%)	Calorific Value (cal/gram)	Sulfur content (%)
46.89	2.75	20.74	38.71	37.80	4873	0.17

Coal obtained from PT. CTSP is lignite coal, based on ASTM D388 [9]. This type of coal is a low-rank coal that contains high water content and low heat value.

Effect of Polymer on Coal Quality

TABLE 2 shows the impact of polymer addition against coal quality that contains water content, ash content, fly material content, bind carbon, and coal heat value. The utilization of emulsion polymer lowers water content on coal. This happened because hydrophilic group on polymer produces hydrogen bonding between polymer and coal surface [10]. When the hydrophilic end of emulsion polymer interact by binding hydrogen with coal hydrophilic surface, the hydrophobic end of the surfactant or emulsion polymer will face out [8]. This causes the increase of hydrophobicity of coal and lower coal-water content and increases its heat value.

TABLE 2. The impact of polymer addition of coal quality

No	Coal sizes (cm)	Polymer conc. (%)	Total moisture (%)	Ash content (%)	Inherent moisture (%)	Volatile matter (%)	Fixed carbon (%)	Calorific value (adb) (cal/gram)	Sulfur content (%)
1	*Raw Material*	0	46.89	2.75	20.74	38.71	37.80	4873	0.17
		10	46.23	2.84	20.14	45.86	31.16	5644	0.17
2	-7 +5	20	46.64	2.75	21.84	43.28	32.13	5452	0.16
		30	46.53	2.41	21.54	44.40	31.65	5496	0.16
		10	48.07	2.69	22.29	39.38	35.64	4918	0.17
3	+7	20	47.42	2.33	21.01	39.94	36.72	5022	0.16
		30	45.80	2.53	20.05	40.29	37.13	5025	0.17

Effect of Polymer Concentration on Coal Calorific Value

The effect of polymer concentration on increasing the calorific value of coal was analyzed by spraying a polymer with a concentration of 10%, 20% and 30% on each coal size. **FIGURE 1** shows that polymer spraying causes an increase in the calorific value of coal. At a coal size of -7 +5 cm, the most massive increase in calorific value occurred in the addition of polymer with a concentration of 10% with a coal calorific value of 3800 cal/g. Whereas in the coal sample measuring +7 cm, it can be seen that the increase in polymer concentration resulted in an increase in the calorific value of coal with the highest value of 3407 at a polymer concentration of 30%. This is because the increase in polymer concentration causes the hydrophobicity of the coal to increase along with the increasing number of polymers that interact with the coal surface. The presence of oxygen-containing groups in coal causes electrostatic interactions and hydrogen bonds between the polymer and the coal surface [11]. The addition of polymer causes a cross-linking process which causes the polymer to bind moisture-free in the coal and then the water content is released into free air based on the principle of equilibrium. This causes a decrease in moisture content and an increase in the calorific value of coal.

Based on Figure 1, we can also see that the coal size affects the increase of coal heat value. On coal with 7+5 cm size, optimum heat value was obtained on the utilization of polymer 10%, meanwhile on coal with +7 cm size optimum heat value was obtained on the utilization of polymer 30%. This happens because the difference between coals sizes which eventually leads to different coal surfaces. The larger the coal surface, the higher the interaction between polymer and coal.

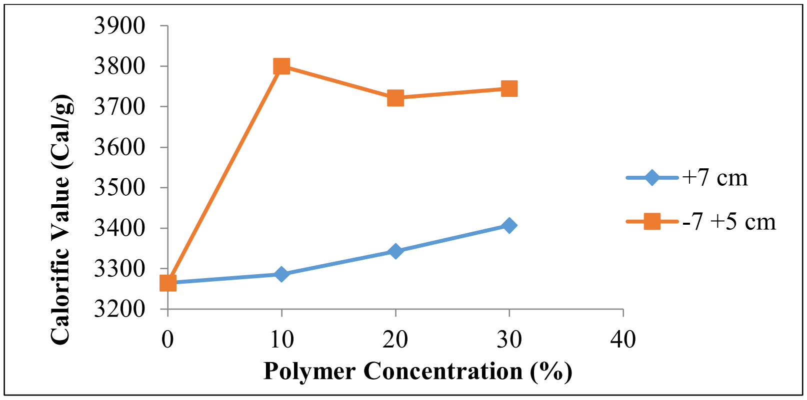

FIGURE 1. Effect of polymer concentration on coal calorific value (ar)

The Effect of Addition of Polymer Contact Time on the Calorific Value of Coal (ar)

In the analysis of the effect of polymer concentration, 2 hours of polymer contact time were used. A follow-up study was conducted to determine the effect of increasing the polymer contact time with the coal surface with a variation of 24 hours, 48 hours and 72 hours. For coal measuring -7 +5 cm which has been sprayed with polymer with a concentration of 10%, the calorific value of coal is 3901 cal/gr, 4567 cal/gr and 5087 cal/gr, respectively. Whereas for coal with a size of +7 cm which has been sprayed with polymer with a concentration of 30%, the calorific value of coal in as-received basis is 3969 cal/gr, 4459 cal/gr, and 4844 cal/gr. The effect of polymer contact time on coal calorific value can be seen in **FIGURE 2.**

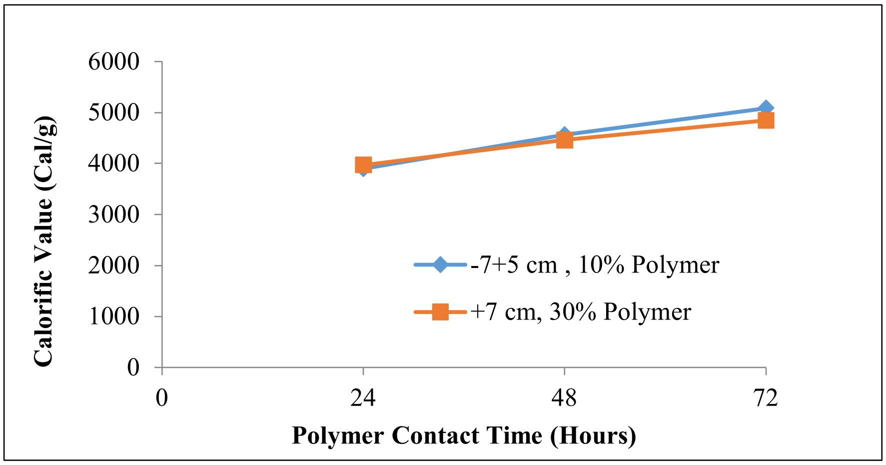

FIGURE 2. Effect of polymer contact time on coal calorific value (ar)

In **FIGURE 2**, it can be seen that the calorific value of coal increases with increasing polymer contact time. With increasing contact time, the electrostatic interactions and hydrogen bonds formed between the polymer and the activated carbon surface also increase. The addition of this interaction results in more reductions in the moisture content of coal and results in an increase in the calorific value of coal.

Determination of the Variables that Most Affect the Calorific Value of coal Using SPSS Software

SPSS software was used to determine the factors that most influence the increase in the calorific value of coal. Hypothesis testing is done by using the t-test. The independent variable in this study is the polymer contact time, coal size and polymer concentration, while the dependent variable is the calorific value of coal. The level of confidence used is 95% so that if the resulting significance is ≤ 0.05, the independent variable influencesthe dependent variable partially. In contrast, if the resulting significance level is> 0.05 then the independent variable has no effect on the dependent variable partially. The test results show that the significance values for the variable coal size, polymer concentration and polymer contact time are 0.676, 0.397 and 0.013, respectively. From these results it is concluded that only the contact time variable significantly affects the calorific value of coal**.**

TABLE 3. Impact of Independent Variable against Heat Value Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	5154.884	215.960		23.870	0.000
	Size	-22.066	51.171	-0.135	-0.431	0.676
	Concentration	8.152	9.162	0.273	0.890	0.397
	Contact Time	8.110	2.628	0.706	3.086	0.013

CONCLUSION

The quality of the coal was improved through decreased moisture content and increased calorific value using polymers. The addition of polymer causes an interaction between polymer and groups on the coal surface which causes water absorption and a decrease in water content and increases the calorific value of coal. The increase in the optimal calorific value of coal occurs at a contact time of 2 hours with a 10% polymer concentration in coal sizes -7 +5 cm. A concentration of 30% in coal sizes +7 cm. In addition to contact time, the calorific value of coal increases with increasing contact time. The most significant increase was at 72 hours of contact time, namely 923 cal/g and 926 cal/g in coal sizes of -7 +5 cm and +7 cm, respectively. Among the three variables, namely contact time, polymer concentration and coal size, the variable that most influences the calorific value of coal is the polymer contact time.

REFERENCES

[1] J. Yu, A. Tahmasebi, Y. Han, F. Yin, and X. Li, "A review on water in low-rank coals: The existence, interaction with coal structure and effects on coal utilization," *Fuel Process. Technol.*, vol. 106, pp. 9–20, 2013, doi: 10.1016/j.fuproc.2012.09.051.

[2] S. Dey, "Enhancement in hydrophobicity of low-rank coal by surfactants - A critical overview," *Fuel Process. Technol.*, vol. 94, no. 1, pp. 151–158, 2012, doi: 10.1016/j.fuproc.2011.10.021.

[3] Y. Zhang, X. Jing, K. Jing, L. Chang, and W. Bao, "Study on the pore structure and oxygen-containing functional groups devoting to the hydrophilic force of dewatered lignite," *Appl. Surf. Sci.*, vol. 324, pp. 90–98, 2015, doi: 10.1016/j.apsusc.2014.10.126.

[4] D. Das, U. Dash, J. Meher, and P. K. Misra, "Improving stability of concentrated coal-water slurry using mixture of a natural and synthetic surfactants," *Fuel Process. Technol.*, vol. 113, pp. 41–51, 2013, doi: 10.1016/j.fuproc.2013.02.021.

[5] X. Liu, S. Liu, Y. Cheng, and G. Xu, "Decrease in hydrophilicity and moisture readsorption of lignite: Effects of surfactant structure," *Fuel*, vol. 273, no. August 2019, 2020, doi: 10.1016/j.fuel.2020.117812.

[6] S. Devasahayam, M. A. Ameen, T. V. Verheyen, and S. Bandyopadhyay, "Brown coal dewatering using poly (Acrylamide-co-potassium acrylic) based super absorbent polymers," *Minerals*, vol. 5, no. 4, pp. 623–636, 2015, doi: 10.3390/min5040512.

[7] I. W. Murdiana, A. Triantoro, and A. Mustofa, "Studi Pengaruh Penggunaan Cairan Surfaktan Wetting Agent Pada Proses Barging Batubara," *J. GEOSAPTA*, vol. 4, no. 01, 2018, doi: 10.20527/jg.v4i01.4436.

[8] X. Liu, S. Liu, M. Fan, and L. Zhang, "Decrease of hydrophilicity of lignite using CTAB: Effects of adsorption differences of surfactant onto mineral composition and functional groups," *Fuel*, vol. 197, pp. 474–481, 2017, doi: 10.1016/j.fuel.2017.02.065.

[9] J. G. Speight, *Handbook of coal analysis*, Second. John Wiley & Sons, Inc., Hoboken, New Jersey, 2015.

[10] A. Coal and T. Water, "Pengaruh Konsentrasi Polimer dan Waktu Kontak Polimer dengan Batubara terhadap Kadar Air Total Batubara,"Indonesian Mining and Energy Journal, vol. 2, no. 1, pp. 6–12, 2019.

[11] S. Liu, X. Liu, Z. Guo, Y. Liu, J. Guo, and S. Zhang, "Wettability modification and restraint of moisture re-adsorption of lignite using cationic gemini surfactant," *Colloids Surfaces A Physicochem. Eng. Asp.*, vol. 508, pp. 286–293, 2016, doi: 10.1016/j.colsurfa.2016.08.073.

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by Suliestyah Suliestyah

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1	*Raw Material*	0	46.89	2.75	20.74	38.71	37.80	4873	0.17
		10	46.23	2.84	20.14	45.86	31.16	5644	0.17
2	-7 +5	20	46.64	2.75	21.84	43.28	32.13	5452	0.16
		30	46.53	2.41	21.54	44.40	31.65	5496	0.16
		10	48.07	2.69	22.29	39.38	35.64	4918	0.17
3	+7	20	47.42	2.33	21.01	39.94	36.72	5022	0.16
		30	45.80	2.53	20.05	40.29	37.13	5025	0.17

Effect of Polymer Concentration on Coal Calorific Value

The effect of polymer concentration on increasing the calorific value of coal was analyzed by spraying a polymer with a concentration of 10%, 20% and 30% on each coal size. **FIGURE 1** shows that polymer spraying causes an increase in the calorific value of coal. At a coal size of -7 +5 cm, the most massive increase in calorific value occurred in the addition of polymer with a concentration of 10% with a coal calorific value of 3800 cal/g. Whereas in the coal sample measuring +7 cm, it can be seen that the increase in polymer concentration resulted in an increase in the calorific value of coal with the highest value of 3407 at a polymer concentration of 30%. This is because the increase in polymer concentration causes the hydrophobicity of the coal to increase along with the increasing number of polymers that interact with the coal surface. The presence of oxygen-containing groups in coal causes electrostatic interactions and hydrogen bonds between the polymer and the coal surface [11]. The addition of polymer causes a cross-linking process which causes the polymer to bind moisture-free in the coal and then the water content is released into free air based on the principle of equilibrium. This causes a decrease in moisture content and an increase in the calorific value of coal.

Based on Figure 1, we can also see that the coal size affects the increase of coal heat value. On coal with 7+5 cm size, optimum heat value was obtained on the utilization of polymer 10%, meanwhile on coal with +7 cm size optimum heat value was obtained on the utilization of polymer 30%. This happens because the difference between coals sizes which eventually leads to different coal surfaces. The larger the coal surface, the higher the interaction between polymer and coal.

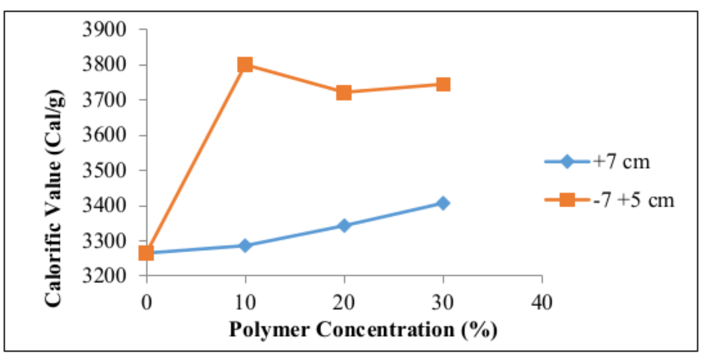

FIGURE 1. Effect of polymer concentration on coal calorific value (ar)

The Effect of Addition of Polymer Contact Time on the Calorific Value of Coal (ar)

In the analysis of the effect of polymer concentration, 2 hours of polymer contact time were used. A follow-up study was conducted to determine the effect of increasing the polymer contact time with the coal surface with a variation of 24 hours, 48 hours and 72 hours. For coal measuring -7 +5 cm which has been sprayed with polymer with a concentration of 10%, the calorific value of coal is 3901 cal/gr, 4567 cal/gr and 5087 cal/gr, respectively. Whereas for coal with a size of +7 cm which has been sprayed with polymer with a concentration of 30%, the calorific value of coal in as-received basis is 3969 cal/gr, 4459 cal/gr, and 4844 cal/gr. The effect of polymer contact time on coal calorific value can be seen in **FIGURE 2.**

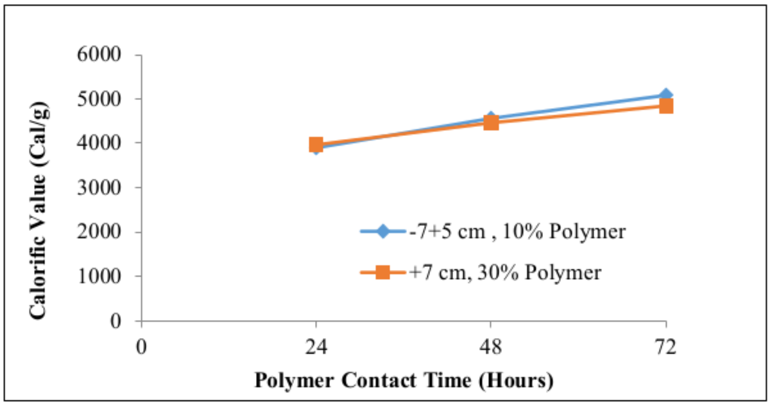

FIGURE 2. Effect of polymer contact time on coal calorific value (ar)

In **FIGURE 2**, it can be seen that the calorific value of coal increases with increasing polymer contact time. With increasing contact time, the electrostatic interactions and hydrogen bonds formed between the polymer and the activated carbon surface also increase. The addition of this interaction results in more reductions in the moisture content of coal and results in an increase in the calorific value of coal.

Determination of the Variables that Most Affect the Calorific Value of coal Using SPSS Software

SPSS software was used to determine the factors that most influence the increase in the calorific value of coal. Hypothesis testing is done by using the t-test. The independent variable in this study is the polymer contact time, coal size and polymer concentration, while the dependent variable is the calorific value of coal. The level of confidence used is 95% so that if the resulting significance is ≤ 0.05, the independent variable influencesthe dependent variable partially. In contrast, if the resulting significance level is> 0.05 then the independent variable has no effect on the dependent variable partially. The test results show that the significance values for the variable coal size, polymer concentration and polymer contact time are 0.676, 0.397 and 0.013, respectively. From these results it is concluded that only the contact time variable significantly affects the calorific value of coal.

TABLE 3. Impact of Independent Variable against Heat Value Coefficients

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	T	Sig.
1	(Constant)	5154.884	215.960		23.870	0.000
	Size	-22.066	51.171	-0.135	-0.431	0.676
	Concentration	8.152	9.162	0.273	0.890	0.397
	Contact Time	8.110	2.628	0.706	3.086	0.013

CONCLUSION

The quality of the coal was improved through decreased moisture content and increased calorific value using polymers. The addition of polymer causes an interaction between polymer and groups on the coal surface which causes water absorption and a decrease in water content and increases the calorific value of coal. The increase in the optimal calorific value of coal occurs at a contact time of 2 hours with a 10% polymer concentration in coal sizes -7 +5 cm. A concentration of 30% in coal sizes +7 cm. In addition to contact time, the calorific value of coal increases with increasing contact time. The most significant increase was at 72 hours of contact time, namely 923 cal/g and 926 cal/g in coal sizes of -7 +5 cm and +7 cm, respectively. Among the three variables, namely contact time, polymer concentration and coal size, the variable that most influences the calorific value of coal is the polymer contact time.

REFERENCES

[1] J. Yu, A. Tahmasebi, Y. Han, F. Yin, and X. Li, "A review on water in low-rank coals: The existence, interaction with coal structure and effects on coal utilization," *Fuel Process. Technol.*, vol. 106, pp. 9–20, 2013, doi: 10.1016/j.fuproc.2012.09.051.

[2] S. Dey, "Enhancement in hydrophobicity of low-rank coal by surfactants - A critical overview," *Fuel Process. Technol.*, vol. 94, no. 1, pp. 151–158, 2012, doi: 10.1016/j.fuproc.2011.10.021.

[3] Y. Zhang, X. Jing, K. Jing, L. Chang, and W. Bao, "Study on the pore structure and oxygen-containing functional groups devoting to the hydrophilic force of dewatered lignite," *Appl. Surf. Sci.*, vol. 324, pp. 90–98, 2015, doi: 10.1016/j.apsusc.2014.10.126.

[4] D. Das, U. Dash, J. Meher, and P. K. Misra, "Improving stability of concentrated coal-water slurry using mixture of a natural and synthetic surfactants," *Fuel Process. Technol.*, vol. 113, pp. 41–51, 2013, doi: 10.1016/j.fuproc.2013.02.021.

[5] X. Liu, S. Liu, Y. Cheng, and G. Xu, "Decrease in hydrophilicity and moisture readsorption of lignite: Effects of surfactant structure," *Fuel*, vol. 273, no. August 2019, 2020, doi: 10.1016/j.fuel.2020.117812.

[6] S. Devasahayam, M. A. Ameen, T. V. Verheyen, and S. Bandyopadhyay, "Brown coal dewatering using poly (Acrylamide-co-potassium acrylic) based super absorbent polymers," *Minerals*, vol. 5, no. 4, pp. 623–636, 2015, doi: 10.3390/min5040512.

[7] I. W. Murdiana, A. Triantoro, and A. Mustofa, "Studi Pengaruh Penggunaan Cairan Surfaktan Wetting Agent Pada Proses Barging Batubara," *J. GEOSAPTA*, vol. 4, no. 01, 2018, doi: 10.20527/jg.v4i01.4436.

[8] X. Liu, S. Liu, M. Fan, and L. Zhang, "Decrease of hydrophilicity of lignite using CTAB: Effects of adsorption differences of surfactant onto mineral composition and functional groups," *Fuel*, vol. 197, pp. 474–481, 2017, doi: 10.1016/j.fuel.2017.02.065.

[9] J. G. Speight, *Handbook of coal analysis*, Second. John Wiley & Sons, Inc., Hoboken, New Jersey, 2015.

[10] A. Coal and T. Water, "Pengaruh Konsentrasi Polimer dan Waktu Kontak Polimer dengan Batubara terhadap Kadar Air Total Batubara,"Indonesian Mining and Energy Journal, vol. 2, no. 1, pp. 6–12, 2019.

[11] S. Liu, X. Liu, Z. Guo, Y. Liu, J. Guo, and S. Zhang, "Wettability modification and restraint of moisture re-adsorption of lignite using cationic gemini surfactant," *Colloids Surfaces A Physicochem. Eng. Asp.*, vol. 508, pp. 286–293, 2016, doi: 10.1016/j.colsurfa.2016.08.073.

Effect of coal grain size and time of polymer contacts on coal surface in increasing the calorific value of coal

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