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UTILIZATION HEAT ENERGY FROM GEOTHERMAL HOT SPRING WATER FOR AGRICULTURE DRYING PROCESS IN BAKAN VILLAGE, NORTH SULAWESI

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ABSTRACT

Traditionally drying proccess for agriculture products in Bakan Village, Bolaang Mongondow, North Sulawesi often constrained in rainy days. The devices of heat exchanger *Fin and Tube* type was installed in the field. It is used to extract heat from geothermal hot spring water for drying process of agricultural product.

Heat energy contained in the hot water geothermal manifestation in the Bakan Village, subdistrict Modayag, Bolaang Mongondow, North Sulawesi can be utilized directly for drying agriculture products such as cacao, coconut etc.

Heat energy of 176.94 kJ/s which is released by hot spring with 2,1585 kg/s discharge and temperature of 80^{o}C which is passed into heat exchanger can raise the temperature of the drying chamber from 32^{o}C to 50 ^{o}C. The results of measurements and observation in the field shows that the average efficiency of this device is about 76% . Drying by using this device can reduces wet weight of the material of about 30% in average.

1. INTRODUCTION

1.1. Background

There are many geothermal energy sources that found in the district Bolaang Mongondow, North Sulawesi not yet developed optimally, either for power generation or used directly for drying agricultural products.

Base on the Geothermal Area Distribution Map and Its Potential In Indonesia Status of year 2005 released by the Ministry of Energy and Mineral Resources of Republic of Indonesia, The district of Bolaang Mongondow has a total potential geothermal energy is about 185 Mwe which distributed in Kotamubagu region and surrounding.

Beside has a geothermal energy, Bolaang Mongondow district also produces cocoa, coconut and rice etc, where in the rainy days, its quality decreases because not enough dried.

The Bakan Drying Agriculture Project is located in the Bakan village, Kotamubagu District, North Sulawesi, approximately 4 hours by vehicle or 180 km south of the city of Manado. This Project is owned by the Research and Development Centre for Technology of Electrical, New and Renewable and Energy Conservation (RDENREEC), Research and Development Agency for Energy and Mineral Resources, The Ministry of Energy and Mineral Resources of Republic of Indonesia.

1.2. Research Purpose

The main puposes of this research is to utilize heat energy from geothermal hot spring for drying agriculture products process directly. Heat energy from geothermal hot spring is extracted by using heat exchanger. There are 6 trays where each tray consist of 6 heat exchangers.

2. PROFILE OF REASEARCH AREA

2.1. Population

Administratively, the district of Bolaang Mongondow is divided into 12 districts and 192 villages. District with the highest number of villages is Dumoga Utara District consisting of 26 villages, while the lowest one is Bilalang District which only consists of 7 villages.

Population of Bolaang Mongondow Regency in 2010 as many as 213,484 persons (based on the population census 2010)[6].

2.2. Demography and Climatic Condition

The average of precipitation in district of Bolaang Mongondow in year of 2011 is about 13,161 mm with annual rainy days is about 90 – 120 days. The highest precipitation is in November to April, meanwhile dry season is in June to August. The average temperature is 25,2 ^{o}C with maximum ambient temperature is 30,4 ^{o}C and minimum is 22,1 ^{o}C and the humidity is recorded about 73,4%[6].

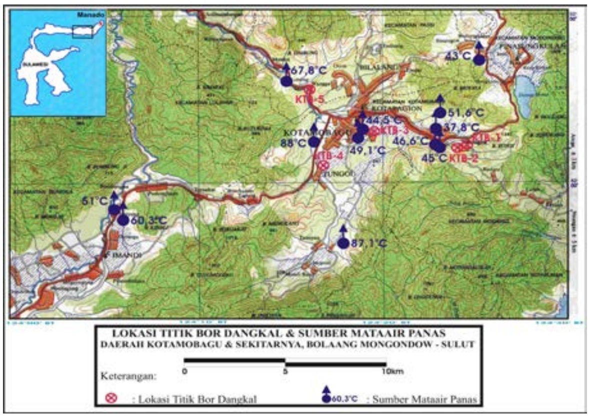
Bakan village covers an area of 8,354 km^2. Farmer is the main job of local people and from 3,121 peoples in productive age, there are 1,174 (±37.6%) people has a job and 1,974(±63.4%) people were unemployed person. So, the project gives an opportunity of job for local people either in construction period or in plant management after the project finished.

2.2. Geothermal Energy Resources and Agriculture Potential

There are at least 13 hot spring surface manifestations that distributed in Bolaang Mongondow district (Figure-1).

Geothermal energy sources that are found in the district Bolaang Mongondow, North Sulawesi are not yet developed optimally, either for power generation or used directly for drying agricultural products.

Base on the Geothermal Area Distribution Map and Its Potential In Indonesia Status of year 2005 released by the Ministry of Energy and Mineral Resources of Republic of Indonesia, The district of Bolaang Mongondow has a total potential geothermal energy is about 185 Mwe which distributed in Kotamubagu region and surrounding.



Figure–1. Distribution of surface manifestations in the Bolaang mongondow district[1].

Beside has potential of geothermal energy sources, Bolaang Mongondow district also produces cocoa, coconut and rice etc, where in the rainy days, its quality decreases because not enough dried. Based on data from Statistic Centre Agency on 2011, production of estate crops by districts and type of crop in Bolaang Mongondow status of year 2011 is tabulated in table-1[6] .

3. METHODOLOGY

After doing survey, we choose Bakan Village as a location of research. This project location has some good charactristic i.e near coconut plant, easy to access, hot spring temperature of 80 °C and pH = 6 - 8 (neutral).

Taking into account the potential that exists in this regions, we designed the dryer by utilizing hot water from geothermal hot spring for drying agriculture products.

4. DESIGN AND APPLICATION OF THE DRYER

The technical of Bakan Drying Agriculture Project was designed by Research and Development Center for Electrical, New Energy, Renewable and Energy Conservation. The overall local content of the plant exceeds 90% therefore it is a good example of successful and sustainable capacity building and technology transfer. Detail specifications and design of the dryer can be seen in the table-2;

This project was funded by government of Indonesia, under the project of Ministry of Energy and Mineral Resources. The Bakan Drying Agriculture Project utilizes heat energy from geothermal hot spring water in Bakan Villages with design debit of 2.1585 kg/second. Geothermal hot water flows to heat exchanger through ± 100 m pipe with diameter 2 inch. Heat is extracted and transferred to the air then increase the temperature from 30 °C become 50°C.

Table-1
Production of Estate Crops
by District and Type of Crop in Bolaang Mongondow
Regency status of year 2011[6]

NO	DISTRICTS	AGRICULTURE PRODUCTION (Tons)			
		Coconut	Nutmeg	Coffee	Cocoa
1	West Dumoga	598.46	2.44	83.57	307.02
2	North Dumoga	506.62	3.24	60.32	202.31
3	East Dumoga	667.22	3.37	50.96	273.65
4	Lolayan	3608.03	6.28	1015.64	384.05
5	West Passi	1134.02	1.24	143.84	42.85
6	East Passi	779.85	2.75	343	73.07
7	Bilalang	786.67	0.85	260.97	40.9
8	Poigar	4125.44	0.75	16.87	63.79
9	Bolaang	3065.22	2.93	51.35	59.62
10	East Bolaang	2817.88	0.61	33.69	35.96
11	Lolak	8376.33	0.86	8.41	41.91
12	Sang Tumbolang	2179.08	0.50	22.09	90.35

Table-2
Design Technical Parameters of The Dryer

NO	PARAMETER	VALUE	UNIT
A	DESIGN PARAMETER		
	1. Ambient temperature	34	°C
	2. Working fluid	Hot geothermal water	
	3. Inlet temperature	80	°C
	4. inlet pressure	0.165	Barg
	5. Fluid mass flow	2.1585	kg/s
	6. Dimensions	4,000 x 810 x 880	mm
B	HEAT TRANSFER CALCULATION		
	1. Heat transfer area (A)	127.5	m^2
	2. Outer tube diameter (OD)	25.4	mm
	3. Tube thickness (t_{tube})	2.108	mm
	4. Tube length (L)	800/800/1350	mm
	5. Tube number (n)	27/27/27	pieces
	6. Log mean temperature difference (ΔT_{LMTD})	33.4/31.5/28.8	°C
	7. Air temperature inlet ($T_{w,out}$)	34	°C
	8. Air temperature inlet ($T_{o,out}$)	55	°C
	9. Air flow rate (m_w)	419/419/706	m^3/min
	10. Air pressure drop (Δp_w)	9.64	Pa
	11. Overdesign	52.42/42.86/33.51	%
	12. Overall thermal conductivity (U)	2x22.723/22.343	$W/m^2.K$
	13. Number of transfer unit (NTU)	0.472	-
C	MATERIAL		
	1. Tube material	Carbon steel/SA179	
	2. Fin material	Aluminium 10600H14/SB 209	

The first dryer which has a total capacity of about 25 - 30 kg of cocoa or coconut was constructed in 2007 to serve as implemented project for drying processes of the agriculture products. Due to the corrosion, deposition of the plug in the pipe, leakages in the joint, and the difficulties for cleaning, therefore, the dryer performances decrease after 5 years operation. Some improvements/ redesign is needed and in the 2013, the new design of dryer was installed and used by local people for drying cocoa and coconut. Figure – 2 shows old and new design of dryer.

A single heat exchanger can be seen in figure – 2 and it's specification are tabulated in table-3 below;

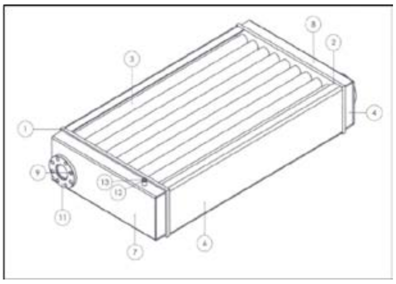


Figure – 2 Scheme of Dryer in Bakan Village

Table – 3
Spesification of The Heat Exchanger

ITEM	QTY	PART NAME	MATERIAL	REMARKS
13	2	Square Head Plug 0.5"	SA 105	Standard
12	2	Shock 0.5" Class 1000	SA 105	Standard
11	2	Flat Faced SlipOn Flanges 3"JIS 10K	SA 105	Standard
10	1	Nozzle Outlet	SA 106 Gr B	Ø3" x 50 mm
9	1	Nozzle Inlet	SA 106 Gr B	Ø3" x 50 mm
8	1	Tank-2	SA 516 Gr 70	780 x 402 x 10 mm
7	1	Tank-1	SA 516 Gr 70	780 x 402 x 10 mm
6	2	Frame	SA 36	1306x400x5 mm
5	2	Partition Plate	SA 516 Gr 70	283 x 69 x 8 mm
4	4	Side Plate	SA 516 Gr 70	264 x 69 x 8 mm
3	27	Fin & Tube	SA 179 SA 209 1040 H14	Tube : 25.4 x 2.1x1350 mm (OD x t x L) Fin : 57.15 x 25.4 x 0.4 (OD x ID x t)
2	1	Tube sheet 2	SA 516 Gr 70	800 x 300 x 20 mm
1	1	Tube sheet 1	SA 36	800 x 300 x 20 mm

The dryer are consist of two serial heat exchangers were arranged parallel and piping system can be seen in figure-3 below;

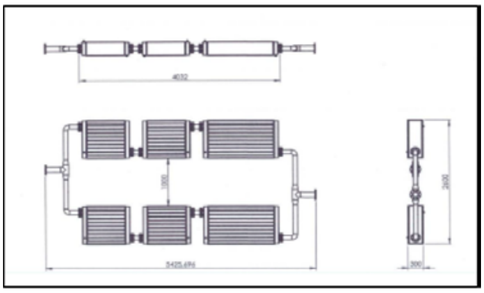


Figure – 3 Piping Assembling of Dryer

(a) (b)

Figure–2. a). Old Design of Dryer b). New design of Dryer

In order, the geothermal hot water can flow gravitationally, the installation of dryers lowered 2 meter down. This dryer is managed by local people, where every farmer can use this dryer for drying their product without any charge.

5. DISCUSSION

The 80 ^{o} C of Geothermal hot spring water flows to dryer with debit of 2 m^3/hours through a 100 m long of 2" pipe. The hot water will transfer heat to heat exchanger and increase the air temperature until 50^{o}C. The performance of heat exchanger units as is shown in table – 4.

Tabel-4
Performances Test Results

No	Time Mnt	Temperature			
		Hot spring	HE	Dryer	Outlet
1	0	80	50	32	75
2	10	80	65	45	73
3	20	80	70	49	72
4	30	80	72,5	50	71

Total heat released from hot water and transfered to the air is calculated by using heat transfer principle. Heat will increase room temperature from 32^{o}C to 50^{o}C vary with air velocity changing. Heat losses calculation result are shown in table–5

The heat maximum could be transfered to the air is about 176,94 kJoule/second at air velocity of 38 m^3/second in 30 minute duration.

Tabel-5
Heat Losses Calculatuon Results at
$T_{sources}$ = 85^{o}C and Water Debit = 2 m^3/hours

T in, ^{o}C	T Dryer, ^{o}C		V air (m^3/s)	Heat Losses (kJ/s)	Remaks
	int	End			
50	27	50	13	87.27	
			14	91.84	
			18	109.22	
			38	176.94	

Figure-4 indicate that the higher air velocity the higher amount of heat will transfer to the air. The amount of heat which is needed for increasing temperature per 10 minute of measurement are shown in table-6. Relationship between temperature increasing with amount of heat loss can be shown in figure-5.

Figure-5 below indicates that drying room temperature is closer inlet temperature of *heat exchanger* and the lower the heat transfered to the air the longer the time to incraese temperature of 1 ^{o}C, equilibrium conditions has already reached.

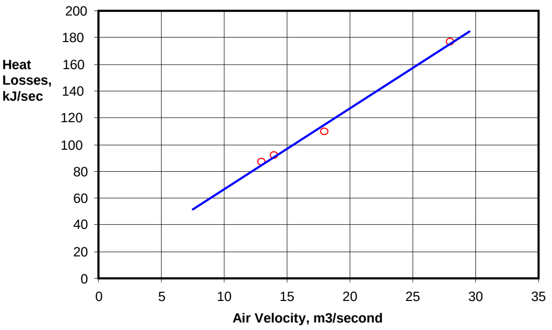


Figure-4. Graph of Relationship between Air Velocity with Heat Loss

Tabel-6
Heat Losses Calculation Results
Per Measurement Time

Time, (Min)	T in, °C	T Dryer, °C		V air (m^3/s)	Heat Loss (kJ/s)	Remaks
		Int	End			
0	50	27	32	13	27.61	
				14	29.08	
				18	34.59	
				38	56.01	
10	65	32	45	13	23.00	
				14	24.23	
				18	28.81	
				38	46.65	
20		45	49	13	18.90	
				14	19.91	
				18	23.68	
				38	38.43	
30		49	50	13	17.67	
				14	18.62	
				18	22.14	
				38	35.85	

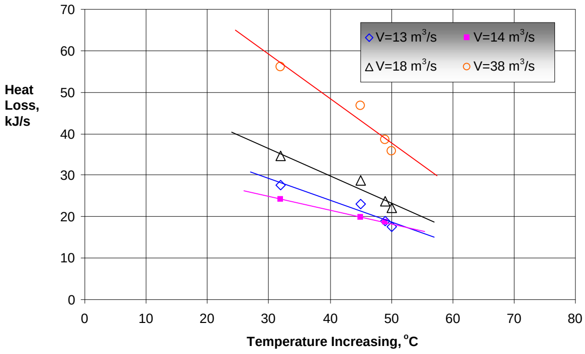


Figure-5. Graph of Relationship Between Temperature Increasing with Amount of Heat Loss

Based on investigation is known that the optimal drying processes occured at flowing heat air condition.

Table-7 shows that decreasing coconut and cocoa weigth after drying.

Table-7
Weight Decreasing After Drying for 1 day

No	Comodities	WEIGTH, kg		D	Remakrs
		Before	*After*		
1	Coconut	25	8	1 day	If drying by the sun need 3 – 4 days
2	Cocoa	25	8.9	1 day	

6. CONCLUSION AND RECOMENDATION

6.1. CONCLUSION

a. Heat that tarnsfered to the air through the heat exchanger is about 176,94 kJoule/second at air vlecity of 38 m^3/second in 30 minute period.

b. By using geothermal hot spring of 2 m^3/hours and temperature of 72,5°C in inlet heat exchanger can increase drying room temperature from 32°C to 50°C.

c. The higher the air velocity, the higher the heat loss during the drying process, therefore the room also increases.

d. Decreasing of coconut and cocoa weight are more than 60% after drying.

6.2. RECOMENDATION

For the purposes of this research can be achieved in accordance with the objectives and beneficial to society, the local government is expected to facilitate the establishment of management so that the tool can be well maintained.

REFERENCES

1. Apandi & Bachri, Peta Geologi Lembar Kotamubagu – Sulawesi , Pusat Penelitian dan Pengembangan Geologi, Bandung, 1997.

2. Amdebrhan, Y.1987: Non electric use of geothermal energy, Soda ash project, Ethiopia. Geothermal Institute, Auckland University. Project for Diploma in Energy Technology, 1987.

3. Anderson, D.N. and Lund, J.W., 1979: Direct Utilization of Geothermal Energy: A Technical Handbook, Geothermal Resources Council Special Report No.7.

4. ASHRAE 1987 Handbook of Fundamentals S I Edition. Chapter 10. Physiological Factors in Drying and Storing Farm Crops. American Society of Heating, Refrigerating and Air-conditioning engineering Inc, USA.

5. ASHRAE 1988 Equimpent Handbook. Chapter 3 and 30. American Society of Heating, Refrigerating and Air-conditioning engineering Inc, USA.

6. Kabupaten Bolaang Mongondow Dalam Angka, Bolaang Mongondow in Figure 2012, ISSN : 0215-7055, Katalog BPS: 1101001.7101, page 3, 9, 97, Board of Planning of Bolaang Mongondow Regency and Statistic of Bolaang Mongondow Regency.

7. Birol Kilkis, 1087: Solar Energy and Fluidized-bed: A New Concept in Agricultural Drying. Drying 87, Hemisphere Publising Corporation, USA.

8. Cain, D., Robert, A., Barrow, H. 1972: A Theoretical Study of Fully Developed Flow and Heat Transfer in Elliptical Ducts. Compact Heat Exchangers, Institute of Mechanical Engineers Symposium, paper C120/72.

9. Chan, K.F., Neusen, DeBellis, C. 1985: Synthetic Brine Fouling of a Geothermal Heat exchanger. Heat Transfer – Denver 1985. AIChe Symposium Series No. 245, Vol 81. American Institute of Chemical Engineering, New York.

10. Edwards, F.J, Henry, T.A., Hayward, G.L., 1972: The Characteristics of the Tube and Continuous Plate Fin Type of Compac Heat Exchanger. Compact Heat Exchangers, Institute of Mechanical Engineers Symposium October 1972, paper C122/72.

11. Ganguli, A., Tung, S.S., Taborek, J. 1985: Parametric Study of Air-cooled Heat Exchanger Finned Tube Geometry. Heat Transfer - Denver 1985.

12. AIChe Symposium Series No. 245, Vol 81. American Institute of Chemical Engineering, New York.

13. Guiamas, J.A. 1991: Tobaco drying steam design and evaluation. Geothermal Institute, Auckland University. Project for Diploma in Geothermal Energy Technology.

14. Holman, J.P. 1989: Heat Transfer. S I Metric Edition. McGraw-Hill Book Company.

15. Houghton, J.M., Ingham, D.B., Heggs, P.J. 1990: Osicillatory Heat Transfer in Extended Surfaces. Heat Transfer 1990 Vol 4 paper 10-EH-19. Hemisphere Publishing Corporation USA.

16. HVAC Handbook 1987. Chapter 38: Drying and Storing Farm Corps. American Society of Heating, Refrigerating and Air-conditioning Engineering Inc, USA.

17. Kanzaka, M., Iwabuchi, M., Aoki, Y., Ueda, S. 1989: Study on Heat Transfer Characteristics of Pin Finned Type Heat Exchangers. Heat Transfer - Philadelphia 1989. AIChe Symposium Series No. 69, Vol 85. American Institute of Chemical Engineering New York.

18. Kays, W.M., London, A.L. 1958: Compact Heat Exchangers. McGraw-Hill Book Company, Inc. New York.

19. Keey, R.B. 1975: Drying: Principles and Practice. Pergamon Press, U.K.

20. Keey, R.B. 1978: Introduction to Industrial Drying Operations. Pergamon Press, U.K.

21. Kern, D.Q. 1983: Process Heat Transfer. International Student Edition. McGraw-Hill International Book Company.

22. Kraus, A.D., Landis, F. 1990: The Analysis of Extended Surfaces With a Variable Heat Transfer Coefficient. Heat Transfer 1990 Vol 4 paper 10-EH-20. Hemisphere Corporation USA.

23. Massey, B.S. 1989: Mechanics of Fluids. Sixth Edition. Van Nostrand Reinhold (International) Co. Ltd. London.

24. Pantilag, Jr, F.L.1992: Development plan of a multi crop drying plant for Palinpinon- I. Geothermal Institute, Auckland University. Project for Diploma In Energy Technology, 1992.

25. Patil, N.D. 1987: Energy Saving in Continuous Flow Grain Dryers. Drying 87, Hemisphere Publishing Corporation, USA.

26. Saunders, E.A.D., 1988: Heat Exchangers: Selection, Design, and Construction. Longman Scientific & Technical England.

27. Sherwin, K. 1972: Development of Finned Tubes for Forced-Draught Air-Cooled Heat Exchangers. Institute of Mechanical Engineers Symposium, paper C121/72.

28. Snider, A.D., Kraus, A.D., Graff, S., Rodriquez, M., Kusmierczyk, A.G. Optimal Fin Profiles-Classical and Modern. Heat Transfer 1990 Vol 4 paper 10-EH-3. Hemisphere Publishing Corporation, USA

29. ------------------, Peta Lembar Kotamubagu – Sulawesi, Bakorsurtanal, 2000.