Modification and Performance Test of Indirect Type Solar Dryer with Various Forms of Solar Collector in Agricultural Product Drying Process

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Abstract

In this study, modification and analysis of the energy performance of indirect type solar dryers with various forms of solar collector for the drying process of agricultural commodities were carried out. The assessment of energy performance is intended to determine the influence of various parameters on energy performance of the designed solar dryer such as the shape of the solar collector used, the type of airflow, and the absorber media used in the drying process. The solar collector used in this study is flat and curved. The energy performance of the solar drying system to be studied includes temperature profile and drying rate. The results of the study showed that the solar dryer designed with a curved solar collector and coated with aluminum foil has the best drying performance with the highest drying rate, which is 0.016 kg/hour. The use of aluminum foil for both collector cases is also able to increase the drying rate by an average of 6.7%. The use of blowers to generate forced flow systems in solar dryers with flat-shaped solar collectors was proven to result in an increase in drying rates of 6.1% and 18.7% compared to drying rates without blowers.

Keywords : solar dryer, solar collector, airflow, absorber, energy performance

Abstrak

Dalam penelitian ini dilakukan modifikasi dan analisis kinerja energi pengering surya tipe tak langsung dengan berbagai bentuk kolektor surya untuk proses pengeringan komoditi pertanian. Pengkajian terhadap kinerja energi dimaksudkan untuk mengetahui pengatuh berbagai parameter terhadap kinerja energi pengering surya yang dirancang seperti bentuk kolektor surya yang digunakan, jenis aliran udara, dan media absorber yang digunakan dalam proses pengeringan. Kolektor surya yang digunakan dalam penelitian ini adalah berbentuk datar dan lengkung. Kinerja energi sistem pengering surya yang akan dikaji di antaranya profil temperatur dan laju pengeringan. Hasil penelitian menunjukkan bahwa pengering surya yag dirancangan dengan kolektor surya berbentuk lengkung dan dilapisi dengan aluminium foil mempunyai kinerja pengeringan yang paling baik dengan laju pengeringan tertinggi, yakni 0,016 kg/jam. Penggunaan aluminium foil untuk kedua kasus kolektor juga mampu meningkatkan laju pengeringan rata-rata sebesar 6,7 %. Penggunaan blower untuk menghasilkan sistem aliran paksa pada pengering surya dengan kolektor surya berbentuk datar terbukti menghasilkan peningkatan laju pengeringan sebesar 6,1 % dan 18,7 % dibandingkan laju pengeringan tanpa blower.

Keyword : pengering surya, kolektor surya, aliran udara, absorber, kinerja energi

1. Introduction

Currently, the development of solar energy drying technology to overcome various weaknesses of direct drying methods with sunlight has been widely developed, one of the solar drying technologies that has been developed is an indirect type or distributed type solar energy drying system. In this system, the agricultural products to be dried are not exposed to direct solar radiation, so that the occurrence of discoloration, cracking on the surface and contamination of the dried products can be minimized [5]. In addition, this drying system can also save drying time by up to 50% - 80% [1]. Research that has been conducted by S. S. M. Goud et al. [2] revealed that non-direct type solar dryers with a forced flow system generated by solar energy operated blowers (Solar PV/PLTS) and this is advantageous for regulatory techniques because these dryers are useful for farmers and industries without additional energy sources.

Efforts to improve the performance of indirect system solar dryers continue to be sought by adding new absorbers of sand, gravel [3], the use of Concentrated Solar Power/CSP technology [16,17] to solar dryers with additional heating from biomass [7]. Another result of the development of solar dryers is the use of absorber plates with varied corrugated surfaces [14]. From this study, it can be seen that large wave solar dryers have better performance than small wave solar dryers. Another study was reported by Robiandi et al. [15] who conducted research on parabolic trough type solar collectors using aluminum tape-polyester reflectors for air heating applications in drying cabinets. Based on the results

of experiments and data analysis that have been carried out, it is known that a parabolic trough type solar collector using an aluminum tape reflector can increase the temperature of the absorber chamber up to 51.5 ºC.

The results of the review of the development of solar dryers that have been carried out by Barbosa et al. [20] showed that solar dryers that integrate TES (tThermal Energy Storage) in various drying processes are able to improve the efficiency of the overall system. The tests studied included the use of sand, gravel, PCM, and CSP systems. The results of the study also show that a lot of progress has been made in developing solar drying systems. However, there is still much to be done including the development of solar dryers integrated with high-efficiency TES systems.

2. Materials and Method

The method used in this study is a direct test of the modified solar dryer designed by A.A. Berinyuy [3] as follows :



Figure 1. Modified solar dryer

The first test was carried out using a flat plate solar collector without and with aluminum foil, then continued with a curved plate solar collector without and with aluminum foil and finally tested with a flat plate solar collector without and with a blower. The absorber used is gravel and the parameters measured include the temperature of the absorber room, the temperature of the drying room and the change in the mass of the dried material. Testing is carried out starting at 5 hours, 3 hours under the solar radiation directly and 2 hours in a shady place. Data collection was carried out every 10 minutes for temperature using a thermocouple, while the mass of dried material was measured using a digital scale at the beginning of the drying process and at the end of the drying process.

3. Results and Discussion

Based on the results of the performance test of the solar dryer based using a flat and curved zinc solar collector with a gravel absorber, the following results were obtained:

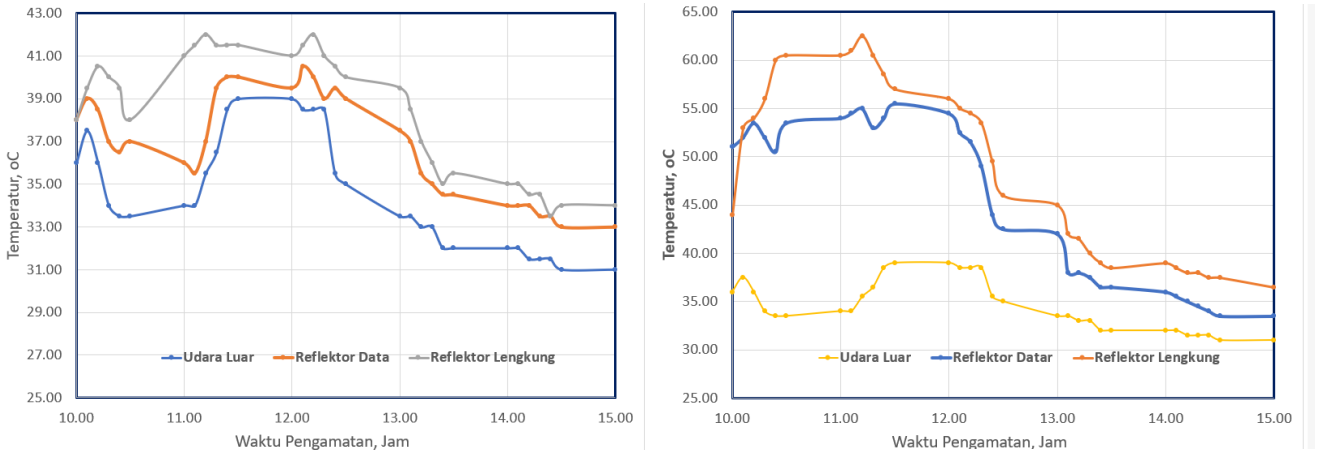


Figure 2. Characteristics of Outdoor Air Temperature, Drying Chamber and Absorber Chamber

From the graph above, it is known that the absorber room temperature of the solar dryer is able to produce a higher temperature compared to the outside air temperature and drying room. This proves that the combination of a solar collector and a gravel absorber media is able to collect (concentrate) the heat energy emitted by the sun so that it is able to produce a higher temperature. From the test results, it can also be seen that the ability of curved collector to collect (concentrate) the heat energy emitted by the sun is greater than that of flat collector. This can be seen from the temperature profile of

the absorber room produced by the curved collector is higher than that of the flat collector and the temperature in the drying room with the curved collector is also higher than the temperature of the drying room with the flat collector.

The use of aluminum foil in solar collectors, both flat and curved, is able to improve the temperature performance of the absorber room and drying room of the designed solar dryer. The highest temperature performance is achieved by the curved collector coated with aluminum foil. This is because the use of aluminimum foil in the curved collector can increase the reflection of solar heat radiation due to the properties of aluminum foil so that it increases the heat collection (concentration) in the absorber and will automatically improve the temperature performance of the drying room.

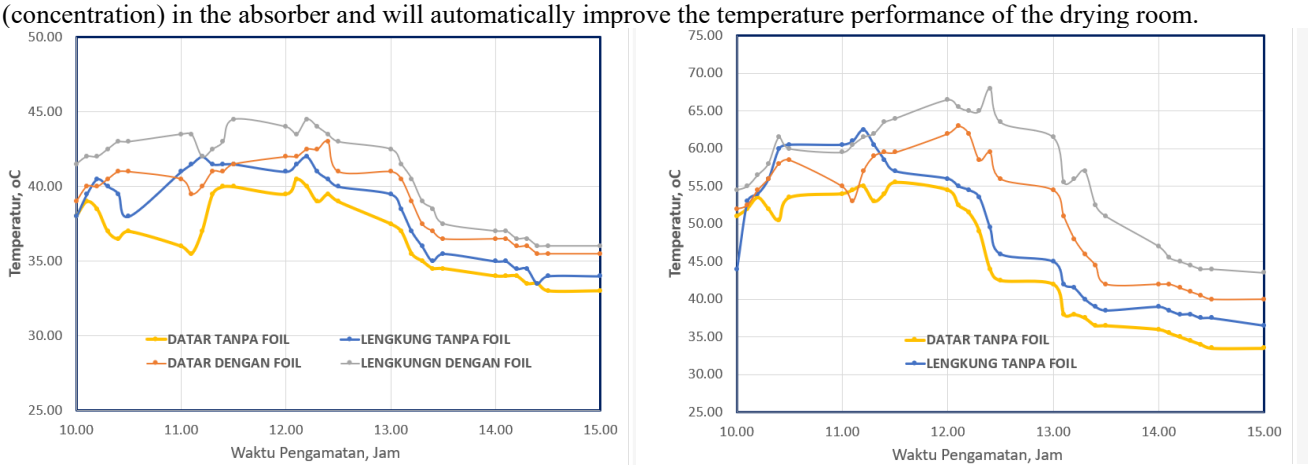


Figure 3. Temperature Performance Comparison of Drying Room and Absorber Room

The use of blowers to produce forced flow in the drying process under solar radiation directly produces a lower temperature profile than the temperature profile produced by a solar dryer without a blower, this is due to the process of radiation and convection heat transfer that occurs in the absorber room causing the solar radiation heat concentrated in the absorber room to be carried by the air flow until the air comes out of the solar dryer so that it will produce the lower temperature profile. However, the forced flow generated by the blower is able to increase the heat and mass transfer process in the drying chamber resulting in a greater drying rate (see table 1).

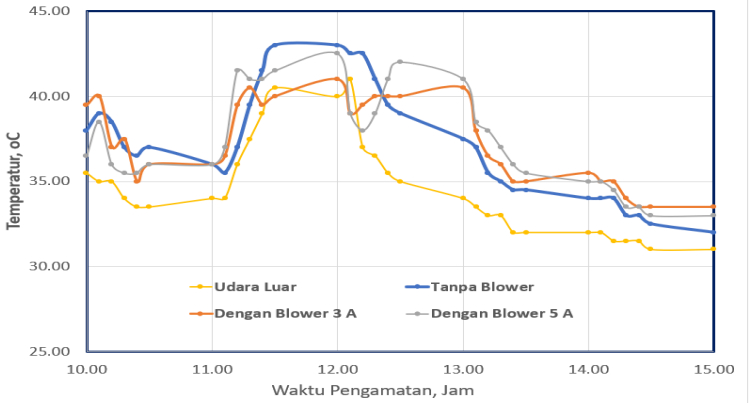


Figure 4. Comparison of Temperature Performance of Drying Room

Based on the drying rate test, the data for various variations of collectors are obtained as follows :

Tabel 1. Data Hasil Perhitungan Laju Pengeringan

No.	Collector	Variations	Decrease in Moisture Content (%)	Drying Rate (kg/h)
1	Flat Collector	Without Aluminum Foil	12,60	0,013
		With Aluminium Foil	13,70	0,014
2	Curved Collector	Without Aluminum Foil	14,50	0,015
		With Aluminum Foil	15,60	0,016
4	Datar + Blower 3 A	Without Aluminum Foil	14,10	0,014
5	Datar + Blower 5 A	Without Aluminum Foil	15,50	0,016
5	Outside the Dryer	Direct Drying	12,30	0,012

From the table above, it can be seen that the solar dryers with curved collector and coated with aluminum foil has the best drying performance with the highest drying rate, which is 0.016 kg/hour. The use of aluminum foil for both

collector cases also increased the drying rate by an average of 6.7%. The use of blowers to generate forced flow systems in solar dryers with flat collector was proven to result in an increase in drying rates of 6.1% and 18.7% compared to drying rates without blowers.

4. Conclusion

From the results of the analysis of test data for all cases studied, it can be concluded that the shape of the collector used in the solar dryers has an effect on the performance of the solar dryers. The curved collector on the solar dryer produces higher energy performance compared to flat collector. The use of aluminum foil in solar dryers is able to improve energy performance for both solar collector cases used in the test. The solar dryer designed with an curved collector and coated with aluminum foil has the best drying performance with the highest drying rate, which is 0.016 kg/hour. The use of aluminum foil for both collector cases also increased the drying rate by an average of 6.7%. The use of blowers to generate forced flow systems in solar dryers with flat reflectors was proven to result in an increase in drying rates of 6.1% and 18.7% compared to drying rates without blowers.

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