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A Review on Computational Fluid Dynamics of Greenhouse Dryer

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ABSTRACT

Solar greenhouse dryer is an instrument used for drying of crops which are needed to be preserved for consumption throughout the year. In recent years, a lot of research has been done to enhance the drying rate of crops. Many researchers have worked experimentally and recently Computational Fluid Dynamics (CFD) as a tool has been used many researchers. Change in the design and operating parameters have been made to study their effect on the performance of greenhouse dryer. In the present paper, a review regarding advances in the solar greenhouse dryers has been presented.

KEYWORDS: Solar greenhouse dryer, crops, drying rate, indirect type greenhouse dryer.

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INTRODUCTION

A greenhouse is a structure which can provide ideal condition for the plant growth, drying of products etc. throughout the year. The inside atmosphere of the greenhouse can be controlled by external factors. The design of greenhouse is such that temperature inside the atmosphere is more than the ambient temperature and relative humidity is less than ambient conditions, which is very ideal situation for crop drying. If products are needed to be dried, they are placed inside the tray of the dryer for the removal of the moisture.[1] Crops are searched &they ever to be consumed throughout the year, to their presentation is must. On the best way for crop presentation is removed of moisture from it. But the moisture removed should be in a controlled environment. So, greenhouse dryer is best suited for it. In the present paper work done related to greenhouse dryer has been reported. Crops are seasonal and their consumption throughout the year, to be needed to be prevented.

REVIEW

Abhay[2] et al. (2018) hours worked for enhancement of heat transfer rate to indirect type solar dryer using artificial roughness on the surface of the absorber plate. Heat transfer characteristics in a solar air collector have been provided with roughness of square shaped rib over the absorber of indirect type solar dryer. Numerical simulations have been performed for flow through the solar air collector for vapors Reynolds number. The design factors which have been considered are Re, relative roughness pitch (P/e), relative roughness height (e/D) and thermo-hydraulic performance parameter (THPP). RNG k–ε has been used for solving governing equation and the results have been compared with those of smooth duct. Numerical results have been compared with exiting literature and found to bean close comparison.

Malekjani & Jafari[3] et al. (2018) have studies the mechanisms underlying the drying processes in dehydration of food and agricultural products. The authors have developed advanced modeling of simulation techniques for new dryers. It has been pointed out that food quality is most important parameters during drying. It has been concluded that computational fluid dynamics CFD can be used to predict fluid flow, heat and mass transfer in dryers. The validation problem of computational fluid dynamics CFD results is also exists because of complexity of gaining experimental data in some dryer designs and conditions. Coupling of computational fluid dynamics CFD with modern techniques such as reaction engineering approach discreate element method can be very advantageous.

Dorouzi[4] et al. (2018) has developed a liquid desiccant-assisted s olar dryer for drying of tomato slices. A photovoltaic thermal solar collector has been used to supply the electrical energy. Colour analysis of dried tomato flakes was carried out & it was included that the increase in the temperature of the drying air increased the lightness, and yellowness values, but the increase in the RH decreased the values of lightness and redness. The temperature of 60c & relative humidity of 23c was recommended for tomato slices in the concluded dryer.

Harjunowibowo[5] et al. (2018) has discussed the recent innovations in greenhouses for energy-saving purposes. It has been suggested that fitting greenhouse with LEDS can save energy by 75% as compared to cost of other artificial lights. It is concluded control system that installing automatic system in greenhouse dryer. Would generate a consistent and cost-effective microclimate, thereby guaranteeing the quality and quantity of the yield.

Mohammadi[6] et al. (2018) have discussed about the importance of greenhouse dryer. The authors discussed about the controlled method such as adaptive, feedback and intelligent control for their presentation. The authors have modeled &experimentally valuated the inside environment of semi solar greenhouse. It has been concluded that the dynamic model with initial values used to predict the inside air and soil temperature. According to the results, the relationship between the results of dynamic model with experimental data according to RMSE, MAPE and EF showed that, the dynamic method can estimate the inside air and soil temperature with 5.3 _C, 10.2%, 0.78% and 3.45 _C, 7.7%, 0.86%, respectively also similar technique can be used to product fuel consumption in greenhouse.

Chauhan[7] et al (2018) has focused on the increasing environmentally concerns and focused on use of solar energy as an alternate source. The authors have suggested use of solar dryer integrated with thermal energy storage system. Use of reflective mirror, improvement in the geometry of flat plate collector to increase heat transfer area and use of selective coatings on absorber plate to increase collection of solar radiation can improve the thermal performance of the dryer. The authors have concluded that use of dryer.

Jyoti[8] et al. (2018) they discussed about the use of parabolic trough in solar collector. It is concluded that the efficiency of this type of collector depend on the thermal energy of sun. Literature review on the parabolic trough solar collector has been presented. It is concluded that the authors have used various optimization technique, and validated the same by use of tools likes ANSYS, fluent etc.

Purusothaman & Valarmathi[9] et al (2018) have performed Computational fluid dynamics (CFD) analysis of greenhouse dryer when expressed to ambient temperature on a hot sunny day for free convection and forced convection processes. The variation has been made in thickness of shut

material & mass flow rate. It is concluded that the solar radiation increased shapely from 10am to noon. Higher temperature is observed in forced convection then natural convection by 41%.

Taki[10] et al (2018) estimated three different variable – inside air, soil and plant temperature using Artificial Neural Network (ANN) &Support Vector Machine (SVM). The authors have studies affect the inside temperature. Among 13 different algorithms thus the author has found out the best model for estimate of real data in greenhouse which can also predict energy lost & exchange actuality.

Sanghi[11] et al (2018) have developed Computational Fluid Dynamics (CFD) model to simulate the corn drying process in a solar cabinet dryer. The performance of the dryer has been simulated at fair and over-cast weather conditions. Temperature, humidity, and air velocity profiles in the dryer have been visualized. The result has been validated with experimental data. The simulated result over predict the variables such as temperature & humidity**.**

Arunsandeep[12] et al **(**2018**)** simulated heat & mass transfer for solar drying of spherical objects such as green peas. Finite difference method with implicit scheme has been used for dissertation. The set of finite difference equations was solved by Tridiagonal Matrix Algorithm and a computer code in MATLAB was developed to solve them. The result has been compared for drying rate with the experimental data from the literature & both are found to be in good agreement.

Khaldi[13] et al **(**2018**)** have numerically studied indirect type solar dryer integrated with thermal storage for drying figs. Unsteady turbulent airflow and heat transfer using two-dimensional model has been carried out.the authors have studied the effect of air inlet size & thickness of backed bed on behavior of dryer.it is conducted that the path of flow helps to find local parameters.

Natarajan[14] et al (2017) experimentally analyzed solar tunnel dryer under the meteorological conditions for drying samples of Vitis viniferaand Momordica charantia for storage of thermal energy, Sand bed, rock bed and aluminum filings have been used. Comparison between open sun drying & the dryer with and without the application of thermal storage materials also has been made. It was concluded that sand was found have higher thermal efficiency among the considered material.

Kant[15] et al (2016) have discussed about the energy storage materials solar dryer. The authors have reported that various studies have been done in last few decades for the same. It has been concluded that for better thermal performance of solar dryers, a PCM with a high latent heat of fusion and with a large surface area for heat transfer is mandatory and is currently being explored widely. Comsol Multi- Physics, CFX, FORTRAN, Open FOAM and Fluent – Ansys, to improve the dryer design also use of commercial package such as have been suggest.

Taki[16] at el (2016) have modeled & experimentally evaluated for solar greenhouse with thermal screen. The author has proposed a semi solar greenhouse dryer and estimated temperature at

six different point. It has been concluded that inside thermal screen can decrease the crop temperature fluctuation at night.

Prakash & Kumar[17] at el (2013) have used ANSYS to predict the behavior of modified greenhouse dryer under active mode in no-load conditions. Weather condition have been taken has input such as Adaptive Neuro Fuzzy Inference system (ANFIS). temperature, ambient temperature ambient relative humidity, global radiation and time of experimentation. As output greenhouse air temperature & relative humidity have been obtained. Results from ANSYS model has been found to be in a good agreement.

Prakash & Kumar[18] et al (2014) have predicted the hourly mass of jaggery during drying process inside greenhouse dryer the natural convection mode. Jaggery has been dried till constant various of mass.Artificial neural network (ANN) has been to study mass of jagging on hourly basic. The result obtained from ANM model have been validated with experiment data. And both were found to be good agreement.

Prakash & Kumar[19] at el (2014) have analysis drying of tomato flakes in modified greenhouse dryer using a mathematical model and experimentally. Experimentally were concluded for tomato flakes initial moisture content of 96% to final moisture 9.09%. The nutrient content of the dried tomato in the dryer as well as open sun drying was examined.Tomato dried in the dryer was found to have more nutrition's then open with sun drying uncertainty was found.

Kumar[20] et al (2013) have experimentally analyzed greenhouse dryer in no load conditions. The ambient temperature, relative humidity, wind velocity, radiation intensity has been measured. It is concluded from experiment that drying conditions in passive mode of greenhouse drying are not favorable because of high relative humidity inside the dryer so an exhaust fan has been proposed.

Ingle[21] et al (2013) has been numerically simulated solar collector grape drying. The authors have used computational fluid dynamics to understand better heat transfer capability. Unstructured grid has been generated using ICEM CFD. And for analysis fluent package has been used.

Gupta[22] at el (2017) have done CFD Computational Fluid Dynamics analysis of direct type greenhouse dryer. Previous experimental data has been used as boundary condition for simulation. Temperature distribution and air flow pattern have been discussed. It has been concluded that numerically obtained result clarify local parameter.

Sahu[23] at el (2016) have experimentally analysis of greenhouse dryer for their drying rate. The modified greenhouse dryer with inclined roof has been formed out to be better than convectional one.

Sahu[24] at el (2016) has remined the various type of drying technologies being used for crops. The focus has been kept on greenhouse dryer. It has been formed out by the authors that photovoltaic integrated greenhouse dryer has higher production rate as per literature.

Dhurve[25] at el (2017) have experimentally compared the drying rate of tomato flakes for traditional greenhouse dryer with modified one. It is concluded that for better drying, high temperature & low related humidity are needed which were found to be found for modified greenhouse.

Kumar[26] at el (2017) have used Computational Fluid Dynamics approach to indenting temperature distribution with maintain in greenhouse drying. CREO 5.0 has been used for geometric modelling. The analysis has been done in fluent for neutral & forced circulation. Numerically obtained results have been compared works & formed to be in comparison.

CONCLUSION

A lot of research has been reported in the field of greenhouse dryers. Solar PV operated fan as an auxiliary attachment to provide forced circulation of air inside the greenhouse dryer has been suggested to achieve higher drying rates. For obtaining better drying rate of dryer, analysis of greenhouse dryer in design stage has proposed using Computational Fluid Dynamics. Local parameters which are very hard to find out experimentally can be easily obtained using CFD.

REFERENCES

1. G. Tiwari, Greenhouse technology for controlled environment. Nervosa Publishing house, New Delhi 2003; 530-541.
2. Abhay, L., Chandramohan, V. P., & Raju, V. R. K., Numerical analysis on solar air collector provided with artificial square shaped roughness for indirect type solar dryer. Journal of Cleaner Production, 2018; 190: 353-367.
3. Malekjani, N., & Jafari, S. M. Simulation of food drying processes by Computational Fluid Dynamics (CFD); recent advances and approaches. Trends in Food Science & Technology 2018; 5: 206-223.
4. Dorouzi, M., Mortezapour, H., Akhavan, H. R., & Moghaddam, A. G. Tomato slices drying in a liquid desiccant-assisted solar dryer coupled with a photovoltaic-thermal regeneration system. Solar Energy, 2018; 162: 364-371.

5. Harjunowibowo, D. E. W. A. N. T. O., Ding, Y., Omer, S., & Riffat ,S. RECENT ACTIVE TECHNOLOGIES OF GREENHOUSE SYSTEMS–A COMPREHENSIVE REVIEW. Bulgarian Journal of Agricultural Science, 2018; 24(1): 158-170.
6. Mohammadi, B., Ranjbar, S. F., & Ajabshirchi, Y. Application of dynamic model to predict some inside environment variables in a semi-solar greenhouse. Information Processing in Agriculture, 2018; 5(2): 279-288.
7. Chauhan, P. S., & Kumar, A. Thermal modeling and drying kinetics of gooseberry drying inside north wall insulated greenhouse dryer. Applied Thermal Engineering, 2018; 130: 587-597.
8. Jyoti, A., Baredar, P., Kumar, H., & Kumar, A. P. A. Design and Optimization of Solar Absorber Tube Using CFD Analysis , INTERNATIONAL JOURNAL ONLINE OF SCIENCE, 2018 ; 4(3): 6-6.
9. Purusothaman, M., & Valarmathi, T. N. Computational fluid dynamics analysis of greenhouse solar dryer. International Journal of Ambient Energy, 2018; 36(2): 1-7.
10. Taki, M., Mehdizadeh, S. A., Rohani, A., Rahnama, M., & Rahmati-Joneidabad, M. Applied machine learning in greenhouse simulation; new application and analysis, Information processing in agriculture, 2018; 5(2): 253-268.
11. Sanghi, A., Ambrose, R. K., & Maier, D., CFD simulation of corn drying in a natural convection solar dryer, Drying Technology, 2018; 36(7): 859-870.
12. Arunsandeep, G., Lingayat, A., Chandramohan, V. P., Raju, V. R. K., & Reddy, K. S. A numerical model for drying of spherical object in an indirect type solar dryer and estimating the drying time at different moisture level and air temperature. International Journal of Green Energy, 2018 ; 15(3): 189-200.
13. Khaldi, S., Korti, A. N., & Abboudi, S. Applying CFD for Studying the Dynamic and Thermal Behavior of Solar Chimney Drying System with Reversed Absorber. International Journal of Food Engineering, 2017: 13(11).
14. Natarajan, K., Thokchom, S. S., Verma, T. N., & Nashine, P. Convective solar drying of Vitis vinifera & Momordica charantia using thermal storage materials, Renewable Energy, 2017; 113: 1193-1200.
15. Kant, K., Shukla, A., Sharma, A., Kumar, A., & Jain, A. Thermal energy storage based solar drying systems: a review. Innovative Food Science & Emerging Technologies, 2016; 34: 86-99.

16. Taki, M., Ajabshirchi, Y., Ranjbar, S. F., Rohani, A., & Matloobi, M. Modeling and experimental validation of heat transfer and energy consumption in an innovative greenhouse structure. Information Processing in Agriculture, 2016; 3(3): 157-174.
17. Prakash, O., & Kumar, A. ANFIS prediction model of a modified active greenhouse dryer in no-load conditions in the month of January. International Journal of Advanced Computer Research, 2013; 3(1): 220-223.
18. Prakash, O., & Kumar, A. Application of artificial neural network for the prediction of jaggery mass during drying inside the natural convection greenhouse dryer. International Journal of Ambient Energy, 2014; 35(4): 186-192.
19. Prakash, O., & Kumar, A. Antimoniacal analysis and mathematical modelling for tomato flakes drying in a modified greenhouse dryer under active mode. International journal of food engineering, 2014; 10(4): 669-681.
20. Anil, K., Om, P., Ajay, K., & Abhishek, T. Experimental analysis of greenhouse dryer in no-load conditions. Journal of Environmental Research and Development, 2013; 7(4): 1399.
21. Ingle, P. W., Pawar, A. A., Deshmukh, B. D., & Bhosale, K. C. CFD analysis of solar flat plate collector. International Journal of Emerging Technology and Advanced Engineering, 2013; 3(4),:337-342.
22. Gupta at el (2017) Gupta, V., Sharma, A., & Gupta, K. S. Numerical Analysis of Direct Type Greenhouse Dryer. In ASME 2017 GasTurbine India Conference (pp.V002T06A008-V002T06A008). American Society of Mechanical Engineers.(2017, December).
23. Sahu at el. SAHU, T. K., GUPTA, V., & SINGH, A. K. (2016). Experimental Analysis of Open, Simple and Modified Greenhouse Dryers for Drying Potato Flakes Under Natural Convection. Ultra- Engineer, 2016; 4(1): 01-06.
24. Sahu at el (2016) Sahu, T. K., Jaiswal, V., & Singh, A. K. A review on solar drying techniques and solar greenhouse dryer. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 2016 ; 13(3): 31-37.
25. Dhurve at el (2017) Dhurve, B., Gupta, V., & Singh, A. K. (2017). Experiment Analysis of Open, Simple and Modified Greenhouse Dryers for Drying Tomato Flakes. International Journal of Research and Scientific Innovation IV (Issue VIS), 2017; 128-131.
26. Kumar at el (2017) Chauhan, P. S., Kumar, A., & Gupta, B. (2017). A review on thermal models for greenhouse dryers. Renewable and Sustainable Energy Reviews, 2017; 7:, 548-558.