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Genetic Algorithm Based Optimization of Crop Driers: A Review

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ABSTRACT

Moisture content is a key index of crop processing, marketing, and storage security. Crop driers are extensively utilized in low drying temperatures to achieve the prescribed moisture content. Since the drying process is energy intensive; it is necessary to determine the best possible control parameters combination to exploit the dryer's full capabilities. Researchers have utilized various optimization techniques to realize the optimum drier efficiency. This paper is a review of researches that have utilized the Genetic Algorithm (GA) to optimize the various drying control parameters. Results from these researches have proved Genetic Algorithm optimization to be reliable, accurate and time saving.

Keywords: Crop Driers, Genetic Algorithm and Optimization Techniques.

1. INTRODUCTION

Crop drying is a valuable contemporary post-harvest conservation method. Improper drying of crops has adverse effects on grain processing, marketing and storage security. Conventionally, crops are dried by means of direct exposure to solar radiation in the open air. This conventional crop drying method is associated with the following drawbacks: susceptibility to precipitation, birds, animals, bugs, dust and other contaminants. Furthermore, it is difficult to regulate the drying control parameters such as temperature and airflow using the conventional drying method. The need to eliminate the highlighted drawbacks has necessitated the advent of crop driers.

Crop driers aid in the achievement of the desired and prescribed moisture content value. However, for the attainment of the dryer optimal efficiency, it is necessary to determine the best possible control parameters combination. One way of achieving the drier optimal efficiency is by means of the Genetic Algorithm (GA) technique. A Genetic Algorithm (GA) is an artificial intelligence-based control parameter optimization method that has gained recognition in recent years. It is a computer science approach for finding approximate solutions to optimization and search problems. The advent of Genetic Algorithms was inspired by evolutionary biology such as inheritance, mutation, selection, and crossover.

2. Literature Review

Rahman et. al. [1] utilized the Genetic Algorithm (GA) technique to carry out energy efficiency optimization during solar drying of long grain. In their study, they used drying temperature, drying time, and air flow rate as the control variables. The influence of several control variable combinations on enzymatic activity and moisture content have been investigated in the study. As the drying control variables were varied, moisture content and enzymatic activity were measured simultaneously. Rahman et. al. [1] used the Genetic Algorithm technique to optimize the drying control variables. The GA model results have been recorded and validated experimentally. It has been observed that the agreement between the GA results and the experimental validation is strong, hence the validation has been successful. Based on the results, they concluded that the grain drying process can be reliably and accurately optimized using a Genetic Algorithm.

To optimize the chilly drying process in a solar tunnel, Dhumne et. al. [2] utilized the Genetic Algorithm technique. They employed the following control parameters during the investigation: air flow rate, drier temperature, cover thickness and absorptivity. An aluminium sheet with an absorptivity value of 0.15 has been used as cover material. The GA technique yielded the following optimized control parameter values: an air flow rate of 0.40m/s, an average temperature of 46.8oC, a chilies layer thickness of 20cm. The model-based results have been validated experimentally, and a comparison is made between these two sets of values using the absolute percentage error method. Table 1 is a presentation of the comparison between optimized and experimental results.

The low absolute percentage error values shown in Table 1. are an indication of good agreement between GA and experimental results. This is also an exhibition of the high optimization accuracy of the GA algorithm. Based on the results, Dhumne et. al. [2] concluded that the use of the Genetic Algorithm in optimizing the red chilies drying tunnel boosts the drier efficiency and minimizes the overall drying time. Therefore, GA technique can be reliably used as an optimization method for drying of chilies in tunnels.

Table 1. Comparison of Optimized & Experimental Results [2]

Parameters	From G.A	Experimental Values	% Error
Air Flow Rate (m/s)	0.38	0.40	5.26%
Dryer Temp. (^{o}C)	47.9	46.8	2.29%
Drying layer (cm)	19	20	5.26%
Cover Thickness (μm)	130	130	0%
Absorptivity	0.15	0.15	0%

The use of the Genetic Algorithm as an optimization tool has been extended to germinated corn malt drying by Santana et. al. [3]. In their study, they used two control variables, namely, drying temperature and time. The response variables in the study are moisture content and enzymatic activity. The drying of the germinated corn seeds has been carried out in an air convective dryer between 54oC and 76oC, while moisture content and enzymatic activity were simultaneously recorded at regular intervals. Optimization of the drying process control variables has been achieved using the Genetic Algorithm technique. The same set of process control variables has also been optimized using the Response Surface Methodology (RSM). A comparison of the results by the utilized models revealed a strong agreement. Santana et. al. [3] concluded that the GA technique demonstrated high efficiency in drying process optimization and can therefore be used as an alternative solution to comparable problems.

Banakar and Akandi [4] have developed a Genetic Algorithm for optimizing control variables during drying of Rosa Petals. In the study, drying temperature, drying time, and air flow rate have been considered as the control variables, while moisture content and drying rate have been the response variables. During the study, moisture content determination has been achieved using a feed-forward neural network. The use of GA technique-based optimized results indicates a considerable reduction in drying time. Banakar and Akandi [4] concluded that the utilization of the GA technique can be noble and suitable to minimize both drying time and energy, while simultaneously improving quality.

Due to the non-linear relationship among the multi-variables at play in driers, Kituu et.al. [5] have investigated the efficiency of the GA technique in the artificial breeding of an optimized solar tunnel dryer. The solar tunnel drier utilized in the study has two compartments, namely, the air-heating chamber and the chimney-drying chamber. Solar energy is harnessed in the air-heating chamber and converted to heat energy. The heat energy is transferred to drying air. It is this drying air that is used in the drying process in the chimney-drying chamber. Simulation of the harnessed energy is carried out in Visual Basic Script, while drier optimization was achieved using Genetic Algorithm technique. Kituu et. al. [5] developed the GA optimized drier and carried out energy harnessing in comparison to the existing solar tunnel drier. To check whether the difference between the chamber temperatures for the two driers is significant; a two-way analysis of variance has been carried out and the results indicate that the difference is significant. According to regression analysis and Student's t-test results, the efficiency of the optimized dryer is better than that of the existing dryer. They concluded that the GA technique is an efficient optimization technique

which can be reliably utilized in solar energy harnessing and artificial solar tunnel drier breeding.

In another paper, Kituu et. al. [6] investigated how a genetic algorithm performs in optimizing a solar tunnel fish drier. The experiment involved drying fish under three different conditions, namely, the optimized drier, non-optimized drier and in the open sun. The quality of fish dried under these three conditions has been assessed. It has been discovered that fish dried under optimized conditions are of better quality in comparison to those dried under contrasting conditions. Kituu et. al. [6] carried out a two-way analysis of variance which revealed that the difference in moisture content between the fish dried using a Genetic Algorithm optimized drier and those drier in non-optimized conditions is significant. The presence of rancidity in fish dried under different conditions has been checked using thiobarbituric acid. Fish dried in the Genetic Algorithm optimized drier did not develop rancidity, which has been observed in those dried in non-optimized conditions. Furthermore, it has been proved that it took the least time to dry fish in an optimized drier as compared to the other dryers. Kituu et. al. [6] concluded that the Genetic Algorithm optimized solar tunnel drier is more superior to both the non-optimized drier and open sun drying.

Taheri-Garavand et. al. [7] applied a hybrid Genetic Algorithm-Artificial Neural Network approach for optimizing and predicting moisture content during the drying of savory leaves in a drier. The Genetic Algorithm technique has been utilized to find the optimum feed forward neural network structure for modelling and estimating moisture content during the drying process. During experimentation stage, three levels of each of the following parameters have been chosen: air temperature, relative humidity, and air velocity. The resultant optimized neural network has two hidden layers, 9 neurons in the first layer and 17 neurons in the second layer. Computation of the model Mean Square Error (MSE) and correlation coefficient has been done, and the results indicate that moisture content can be accurately predicted from the genetic algorithm optimized ANN model. Additionally, it was observed that the optimized model has strong capabilities for on-line prediction of moisture content of savory leaves.

Hugget et. al. [8] devised a method to solve the complexity of a numerical code in finding the objective function. The method involved the use of artificial neural networks and genetic algorithms in the global optimization of an industrial convective grain drier. Initially, a method has been devised to represent a drying model using artificial neural networks. Comparison is made between the neural network-based results and classic numerical method results. It is observed that the neural network-based method reduces simulation times and has good accuracy and generalization properties. The Genetic Algorithm-based optimization is considered, and the results indicate that this method is efficient. Hugget et. al. [8] concluded that "a stochastic method such as Genetic Algorithm technique appeared to be well suited to this kind of problem".

Liu et. al. [9] studied the use of a genetic algorithm in optimizing a neural network topology for moisture content prediction during the grain drying process. They suggested a combination of BP neurons and RBF neurons within the hidden layer. The study used the following drying control parameters: air temperature, grain temperature and initial moisture content. Selection of the optimum neural network structure has been achieved using a genetic algorithm. The optimized neural network structure has been observed to have 6 BP neurons and 10 RFB neurons. It has been discovered through grain drying simulation, that the Genetic Algorithm-based optimized model performed well and has high prediction accuracy.

Dai et. al. [10] investigated functional control schemes for a grain drier and optimized its performance. The following control parameters were used: overshoot, accuracy, and anti-disturbance capabilities. Initially, a genetically optimized fuzzy immune proportional integral derivative controller (GOFIP) has been designed. This controller is a blend of intelligent fuzzy immune feedback control and conventional control. Fuzzy rules have been used to imitate the biological immune feedback mechanism to automatically tune the proportional integral derivative (PID) parameters. Optimization of the controller's input parameters is achieved using the Genetic Algorithm technique. Dai et.al. [10] carried out simulation-based comparisons among the following models: Genetic Algorithm optimized model, general PID controller, fuzzy PID controller and fuzzy immune PID controller. Obtained results reveal that the Genetic Algorithm-based optimized model yields the best results in terms of bringing the final grain moisture content to the prescribed value. Dai et. al. [10] concluded that the use of the GOFIP is reliable, precise and effective in complex systems control.

3. CONCLUSION

This paper is a presentation of researches that have utilized the Genetic Algorithm technique to

optimize control variables in crop drying. It has been revealed that a considerable amount of studies has been carried out on the subject. The prominently used control parameters in the studies are drying temperature, air flow rate and drying time. Moisture content is the most prominent response variable used in these studies. In most of the studies, the GA technique results have been validated experimentally. There is a good agreement between GA results and experimental results. It has also been discovered that the Genetic Algorithm technique is a powerful and dependable tool for designing driers with high energy efficiency. Based on the results from the numerous studies, it can be safely concluded that the genetic algorithm is a time saving and reliable optimization technique. Hence, it can be utilized on almost all crop varieties.

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