Optimization of Solar Tunnel Dryer Using Genetic Algorithm

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Abstract

Drying is one of the oldest methods for the preserving agricultural products. Drying procedures require a significant amount of energy and sun is the major source of this energy. Most low cost technologies such as open sun-drying is time consuming also laying the agricultural product on open ground are subjected to contamination by dust, sand and stones etc. All these factors have led to low quality dried product and are unhygienic for human consumption. One of the best ways of avoiding all these problems is the effective utilization of solar energy using solar tunnel dryer. Performance of solar tunnel dryer is depends upon on different performing parameters. For The optimization of all these performance parameter of the solar tunnel dryer, Genetic Algorithm technique is used. Genetic Algorithms are essentially unique in relation to the optimization algorithm. A Genetic Algorithm is a probabilistic system that has established the standards of genetics for producing the optimized result.

Keywords: Solar Tunnel dryer, sun-drying, optimization, Genetic Algorithm

1. INTRODUCTION

About 80% of the agricultural production in India is rural based where most farmers depends on open sun drying. For some industrial drying purpose, fossil fuels and biomass fuels are also be used as sources of energy. Electricity is normally required in agricultural processing industries as a supplement to fossil fuel. Recently, the prices of fossil fuel and electricity have more than doubled, thereby becoming unaffordable to most small–scale farmers. At the farmer's level, the most viable preservation option is solar drying, in which product is enclosed in a solar dryer, shielding it from contamination, and destruction. Depending on the conditions in the dryer, the product can either be over-dried or under-dried; resulting in heavy losses at household and national level, and therefore, a conducive environment must be provided within the dryer to avoid destruction of product during drying. Based on the above observations, studies were conducted with the objective of optimizing the design and performance parameters of a solar tunnel dryer, using genetic algorithms. India is not only the largest producer but also the largest consumer of chilly in the world. Chilies are the most common spice cultivated in India. Chilly is a universal spice of India. It is cultivated in all the States and Union Territories of the country. India contributes about 36% to the total world production. In India, Chilies are grown in almost all the state throughout the country. Andhra Pradesh is the largest producer of Chilly in India and contributes about 26% to the total area under Chilly, followed by Maharashtra (15%), Karnataka (11%), Orissa (11%), Madhya Pradesh (7%) and other states contributing nearly 22% to the total area under Chilies.

A genetic algorithm (GA) is a technique used in computer science to find true or approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithms that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover.

2. Genetic Algorithm created for Optimization

A Genetic Algorithm is constructed from a number of distinct components which are required for the optimization of solar tunnel dryer. The main components are the chromosome encoding, the fitness function, selection, recombination and the evolution scheme. Genetic Algorithm programming is created in C#.net to get the optimal parameters for higher dryer efficiency and minimum time requirement. For our optimization process, we have created a database of input performance parameters as air flow rate, drying temperature, cover thickness, absorptivity of absorber material and drying layer thickness. Each parameter is identified by an integer. The approach taken was to create and store a list of parameters. The chromosome would store a series of numbers. The chromosome would represent a potential route. However, the chromosome is a special case as it needs to contain each parameter only once. Therefore, it is not possible just to create random chromosomes; therefore it is necessary to create the population manually. The Genetic Algorithm Function (GAF) is used to support a form of crossover called Double Point Ordered which creates a child from a single parent. Two parents are selected and two random points along the chromosome are selected. The genes between the points are passed to the child. The remaining genes are transferred from the same parent, but in the order that they appear in the second parent. The result is that the child contains all of the values from a single parent but includes ordering, and therefore traits, from both parents. Therefore, the Swap Mutate operator has been used. This operator simply takes two genes at random and swaps their position within the chromosome. The constructor of the Population automatically creates the initial set of Genomes by repeatedly calling the Next Generation method, i.e. execution of the algorithm to produce the next generation. Eventually the population converges to the highest fitness scores. It is worth noting that this was the result from the first run, no optimization of the GA was carried out. Sometimes there is a need to adjust some of the population constants such as initial population size, mutation frequency, and crossover fitness to help in balancing convergence and diversity in the solution population. For the fitness evaluation, the Fitness function has been created. This function simply calls Fitness in order to get maximum efficiency of dryer and for the minimum time requirement to dry the product from the chromosome. The terminate delegate function simply stops the GA when 200 generations have taken place. The Genetic Algorithm gives the results shown in Table 1 and comparison is shown in figure 1. Most of the work has been done after 154 generations although leaving the Genetic Algorithm running showed a very slight improvement. The result shows that the maximum value of efficiency is 23.62% and minimum time required is 19 hours which is obtained at Airflow rate = 0.38 m/s, Average dryer temperature= 47.9 oc, Dryer cover thickness= 130 microns, The absobtivity of absorber material = 0.15 and Drying layer thickness = 19 cm

Table-1: Results obtained from GA

Airflow	DryTemperature	Coverthickness	Absorbative	dryinglenghttickness	Instructions
0.7	40.76	200	0.15	26	Efficiency 18.07% Drying hours 26
1	47.10	210	0.15	40	Efficiency 15.94% Drying hours 28
0.7	46.33	130	0.65	28	Efficiency 17.51% Drying hours 29
0.38	**47.9**	**130**	**0.15**	**19**	**Efficiency 23.62% Drying hours 19**
1	42.80	200	0.65	24	Efficiency 19.32% Drying hours 24
0.4	45.77	210	0.65	30	Efficiency 20.34% Drying hours 23
1	43.44	230	0.60	28	Efficiency 14.41% Drying hours 30
0.4	44.67	180	0.60	44	Efficiency 11.33% Drying hours 31
0.7	47.20	230	0.60	20	Efficiency 16.10% Drying hours 28

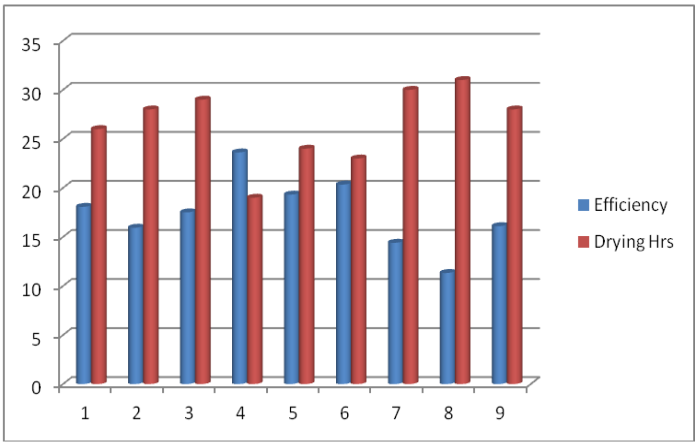

Fig -1: Comparison Of optimized result

3. EXPERIMENTATION

Experimentation is performed in Umred area, Dist. Nagpur (Latitude 20.85 0 N, longitude79.30 E) in month of March 2015, which is the favorable condition for drying chili. The solar tunnel dryer consists of different parts such as drying chamber, absorber plate, collector area and chimney. The drying chamber is covered with UV-stabilized polythene sheet, which is available at the local market. The solar tunnel dryer having semi-cylindrical shape for increasing absorption of solar radiation. The dryer are made to open and close easily for the functions of spreading the drying product at the beginning of the day and cleaning the absorber surface and trays. Base of the tunnel dryer is covered with thermal insulation of thermocol of one inch, in order to reduce the heat loss.

Fig- 2: Experimental Setup

4. Result Obtained After Experimentation

The experimentation carried out with controlled conditions of input performance parameter. The airflow rate is controlled at 0.40 m/s using a damper. The average temperature recorded is 46.8 oc. The cover thickness is 130 microns. The material used as an absorber is Aluminum sheet with a value of Absorptivity as 0.15. The layer thickness of chillies is maintained at 20cm. keeping all these values, when the experimented carried out. The total time required for drying chillies i.e removal of 3.5 kg moisture is 19 hours and based on the observations the efficiency of the dryer is calculated and the other parameters evaluated are given in Table 2.

Table 2: Experimental Result

Date	Initial Loading Kg	Balance Kg	Moisture Removed	M R %	% Efficiency	Hours Per Day	Total Drying Time Hrs
13.03.15	4.7	3.128	1.572	33.44	23.62	5	19
14.03.15	3.128	1.705	1.423	45.49	15.1	7	
15.03.15	1.705	1.283	0.417	24.46	5.14	7	

5. Comparison of Optimized Result with Experimental Result

The table 3 gives the comparison between optimized parameters obtained from Genetic Algorithm and experimental performance evaluation of solar tunnel dryer. From this table we can observe that there is a slight variation in both outputs obtained from Genetic algorithm optimization and the experimental results.

Table-3: Comparison of Optimized & Experimental Results

Parameters	From G.A.	Experimental Values	% Error
Air Flow Rate	0.38	0.40	5.26%
Dryer Temp.(0 c)	47.9	46.8	2.29%
Drying layer	19	20	5.26%
Cover Thickness	130	130	0%
Absobptivity	0.15	0.15	0%

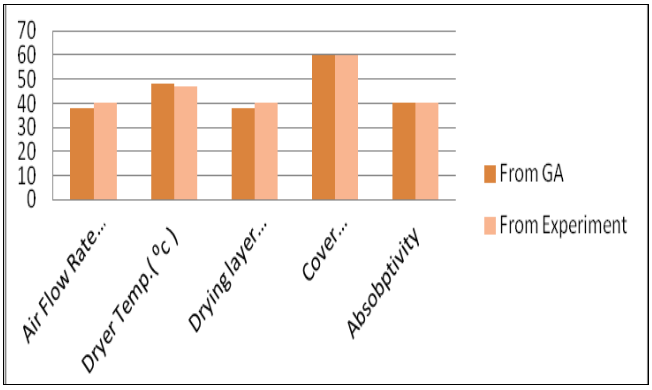

Fig-3: Comparison of Optimized & Experimental Results

6. CONCLUSION

In this particular work, a GA approach was employed to optimize the solar tunnel dryer for drying red chillies. For this purpose, the GA control variables were established. The recommended control condition anticipates both of the controlled variables. The simulation outcomes indicated that by this recommended study, overall performance of drying can be elevated gives the good prediction of maximum efficiency and minimum drying time required. It is found that the best operation zone for drying grain is obtained at the given input performance parameters. Results obtained from the Genetic Algorithm simulation showed good agreement with the experimental result. For the drying process optimization by using Genetic Algorithm showed good performance which indicates that GA technique can be used in drying process successfully.

The developed Genetic Algorithm programming can also be used to predict the potential of the drier for different input parameters and acts as a predictive optimal control algorithm. Using the trained model of Genetic algorithm, the efficiencies and drying time of the solar tunnel dryer is predicted by assuming and substituting an independent random suitable set of input performance parameters. This Genetic Algorithm prediction can be applied to any system where the complexity of data is more and data get in non-linear form like agricultural data.

7. FUTURE SCOPE

Future scope for this application is very large as solar energy is the main source of renewable energy present in the surrounding. Solar tunnel dryer is the elaboration of solar energy for drying of agricultural products, medicinal plants and so many other purposes that are play an important role in environmental science. We can study solar tunnel dryer by using various absorber materials instead of Aluminium sheet and define their behavior with climate conditions. In this project we used Genetic Algorithm for suggesting prediction for the performance of solar tunnel dryer. In future we can use other software for suggesting prediction for the performance of solar tunnel dryer by doing mathematical modeling and simulation also.

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