Comparison of Turbine Speed and Power Developed of Solar Updraft Tower recorded during the Experimentation and Computational Simulation

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***Abstract*:** The overall India's need for power is growing at a prodigious rate; annual electricity generation and consumption has increased by about 64% in the past decade and its projected rate of increase is one of the highest in the world [5]. The solar chimney power plant system consists of four major components i.e. collector, chimney, energy storage layer and turbine at the base of chimney. The cost of this plant is very less as compare to conventional power plants and system using PV Cells. Maintenance cost of solar updraft plant is negligible, as plant once installed no other movement of collector and chimney. Moreover cost of materials required for collector and chimney is lesser. Paper details the working model of solar updraft tower and comparison of turbine speed and turbine power developed observation recorded during the experimentation, calculated value of mathematical model and value computed from ANN.

Key Words: Turbine speed, turbine power, solar updraft, mathematical model, experimentation

1. Introduction:

In economic development universally the importance of energy is recognized and relationship between the availability of energy and economic activity is strongly verified by historical data. in energy generation share of fossil fuels along with their CO2 emission, is shown in Table 1

The increase of the world population, energy consumption and industrial activity are responsible for this. . For sustainable development requires long term potential actions in achieving solutions to the environmental problems that humanity faces today.

Table 1: Fossil fuels share in carbon emission and energy generation [6]

Fuel	Energy Generation % Share		Carbon emission % Share	
	India	World	India	World
Coal	55	20.3	69.78	41.2
Oil	30.5	41.3	26.31	42.65
Natural Gas	7.0	21.1	3.9	16.12

In this respect, renewable energy resources such as solar updraft tower appear to be one of the most efficient and effective solutions. This paper detailed the formulation of mathematical model for power developed and turbine speed of solar updraft tower. The experimental data based models evolved for the design data for various responses of solar updraft tower process. These models evolved are to represent various responses of solar updraft tower process. These models evolved are to represent responses variables such as turbine speed, power generated by solar updraft tower.

The utility of such a solar updraft tower unit is to meets the crucial conditions and possible to take the essential step towards a global solar energy economy with no ecological harm and no consumption of resources, not even for the construction at low cost automation.

2. Literature Review: The solar power produced by the solar updraft tower is one of the most important parameter. The production of power depends on the performance of the solar chimney, solar collector and turbine. The literature related to solar updraft tower is as under.

The first contemporary citing of a solar chimney concept appears in a book by Gunther (1931).A proposal is made by B. Dubos is referred in this book on the potential of constructing a solar powered up-draught power plant. Haaf et al. (1983) discuss the basic principles behind the operation, construction and power generation of a solar chimney power plant. Haaf also makes mention of a similar notion used centuries before by Leonardo da Vinci, (according to his sketches of a barbecue-spit driven by an up-draught through a chimney) with a previous study by Simon (1976) as well.

Y .J .Dai et al. (2003) presented a parametrical study of chimney height, diameter of solar collector, ambient temperature, solar irradiance and efficiency of wind turbine, etc. control the performance of power generation. Relevant equations for a solar chimney power plant are also developed by Kroger and Buys (2001). A numerical model for a solar chimney power plant is developed and results shown by simulations.

3. Working

The solar chimney power plant produces electricity from solar energy. Sunshine heats the roofed collector sheets surrounding the central base of a tall chimney tower.In the towerthe chimney effect caused by a hot air updraft due to the resulting convection. This airflow drives wind turbines placed in the chimney updraft or around the chimney base to produce electricity [9]. For centuriesthe solar updraft tower have been familiar for having three essential elements - solar air collector, chimney/tower, and wind turbines.Figure 1shown the working model of the solar updraft tower.

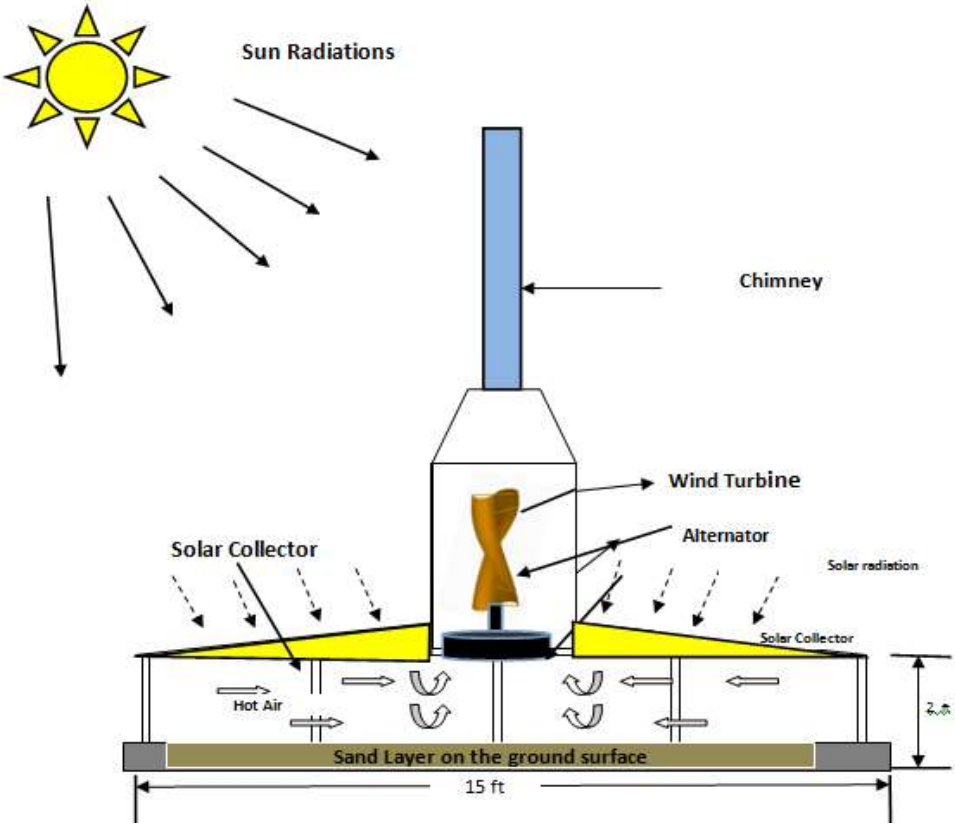

Fig. 1.Working model of the solar updraft tower

4. Computational Simulation

The experimental data based modeling has been achieved based on experimental data for the two dependent π terms for turbine speed and power developed. In such complex phenomenon involving non-linear kinematics where in the validation of experimental data based models is not in close proximity, it becomes necessary to formulate Artificial Neural Network (ANN) Simulation of the observed data. Artificial Neural Network Simulation consists of three layers. First layer is known as input layer. Number of neurons in input layer is equal to the number of independent variables. Second layer is known as hidden layer. Number of neurons in hidden layer is equal to the number of independent variables. The third layer is output layer. It contains one neuron as one of dependent variables. The topology decided for the network is Multilayer feed forward

5. Procedure for formation of ANN Simulation

MATLAB software is selected for developing ANN simulation. To form ANN following are the various steps in developing the algorithm.

1. From the experimentation the observed data is separated into two parts viz. the data of independent pi terms or input data and the data of dependent pi terms or the output data . The program imported the input data and output data respectively
2. Prestd function and appropriately sized reads the input and output data. Function prestd is preprocesses the data so that the mean is 0 and standard deviation is 1.
3. In preprocessing step by using mean and standard deviation the input and output data is normalized
4. The input and output data is then categorized in three categories viz. testing, validation and training. From the 80 observations for power developed and turbine speed of the solar updraft tower initial 75% of the observations for both is selected for training, last 75% data for validation and middle overlapping 50% data for testing.
5. The data is then stored in structures for training, testing and validation.
6. feed forward back propagation type neural network is chosen by Looking at the pattern of the data.The training data is then used for training this network. The actual and target data are computed for the computation errors and then the network is simulated.
7. The regression analysis and the representation is done through the standard functions. The values of regression coefficient and the equation of regression lines are represented on the one different graph plotted for the one dependent pi terms.

6. ANN Program

MATLAB software is selected for developing ANN. The program executed for turbine speed is as follows

```
clear all;
close all;
inputs3=[
]
 a1=inputs3
 a2=a1
input_data=a2;
output3=[
]
 y1=output3
 y2=y1
size(a2);
size(y2);
p=a2';
```

```
sizep=size(p);
t=y2';
sizet=size(t);
[S Q]=size(t)
[pn,meanp,stdp,tn,meant,stdt] = prestd(p,t);
net = newff(minmax(pn),[80 1],{'logsig' 'purelin'},'trainlm');
net.performFcn='mse';
net.trainParam.goal=.99;
net.trainParam.show=200;
net.trainParam.epochs=50;
net.trainParam.mc=0.05;
net = train(net,pn,tn);
an = sim(net,pn);
[a] = poststd(an,meant,stdt);
error=t-a;
x1=1:80;
plot(x1,t,'rs-',x1,a,'b-')
legend('Experimental','Neural');
title('Output (Red) and Neural Network Prediction (Blue) Plot');
xlabel('Experiment No.');
ylabel('Output');
grid on;
figure
error_percentage=100*error./t
plot(x1,error_percentage)
legend('percentage error');
axis([0 80 -100 100]);
title('Percentage Error Plot in Neural Network Prediction');
xlabel('Experiment No.');
ylabel('Error in %');
grid on;
for ii=1:80
xx1=input_data(ii,1);
yy2=input_data(ii,2);
zz3=input_data(ii,3);
xx4=input_data(ii,4);
yy5=input_data(ii,5);
zz6=input_data(ii,6);
pause
yyy(1,ii)=0.5705*power(xx1,-0.9101)*power(yy2,0.0424)*power(zz3,0.0474) *power(xx4,0.3036)*power(yy5,-
0.6156)*power(zz6,-0.4977) ;
yy_practical(ii)=(y2(ii,1));
yy_eqn(ii)=(yyy(1,ii))
yy_neur(ii)=(a(1,ii))
yy_practical_abs(ii)=(y2(ii,1));
yy_eqn_abs(ii)=(yyy(1,ii));
yy_neur_abs(ii)=(a(1,ii));
pause
end
figure;
plot(x1,yy_practical_abs,'r-',x1,yy_eqn_abs,'b-',x1,yy_neur_abs,'k-');
legend('Practical','Equation','Neural');
title('Comparision between practical data, equation based data and neural based data');
xlabel('Experimental');
grid on;
figure;
plot(x1,yy_practical_abs,'r-',x1,yy_eqn_abs,'b-');
legend('Practical’,’ Equation');
title('Comparision between practical data, equation based data and neural based data');
xlabel('Experimental');
grid on;
figure;
plot(x1,yy_practical_abs,'r-',x1,yy_neur_abs,'k-');
```

```
legend('Practical','Neural');
title('Comparision between practical data, equation based data and neural based data');
xlabel('Experimental');
grid on;
error1=yy_practical_abs-yy_eqn_abs
figure
error_percentage1=100*error1./yy_practical_abs;
plot(x1,error_percentage,'k-',x1,error_percentage1,'b-');
legend('Neural','Equation');
axis([0 80 -100 100]);
title('Percentage Error Plot in Equation (blue),  Neural Network (black) Prediction');
xlabel('Experiment No.');
ylabel('Error in %');
grid on;
meanexp=mean(output3)
meanann=mean(a)
meanmath=mean(yy_eqn_abs)
mean_absolute_error_performance_function = mae(error)
mean_squared_error_performance_function = mse(error)
```

Results obtained after execution of ANN program using Mat lab Software is computed in the table 1 and graph 2 and 3.

Table 1: Comparison between observed and computed values of dependent pi term

Dependent Pi term	π_{D1} Dependent Variable Turbine Speed	π_{D2} Dependent Variable Power Developed
Mean Experimental	148.4931	4.0794
Mean ANN	148.9188	3.9496
Mean Model	148.4326	4.0572
Mean absolute error performance function	2.3678	0.2526
Mean squared error performance function	9.7874	0.1172

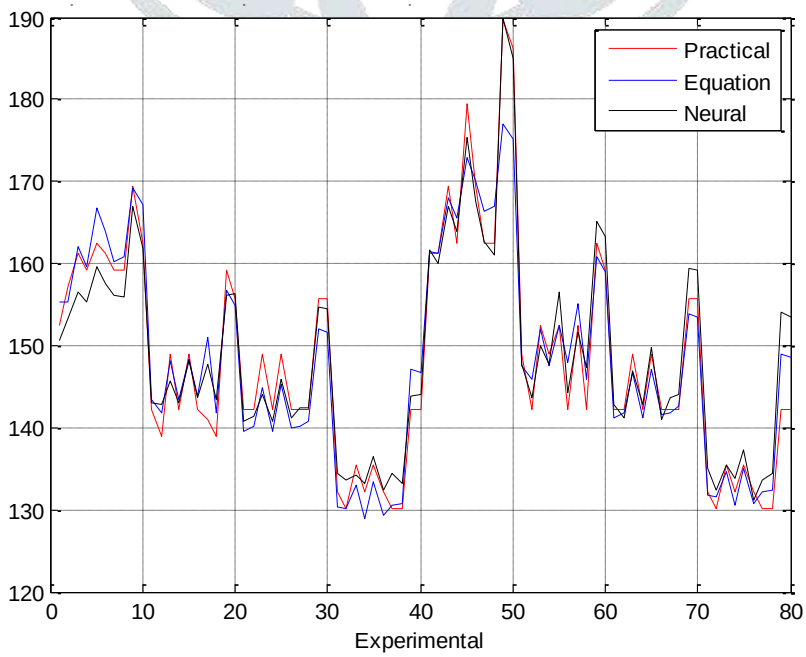

Figure 2: Graph of comparison with experimental data base, neural network prediction and equation base prediction for the network for Turbine Speed

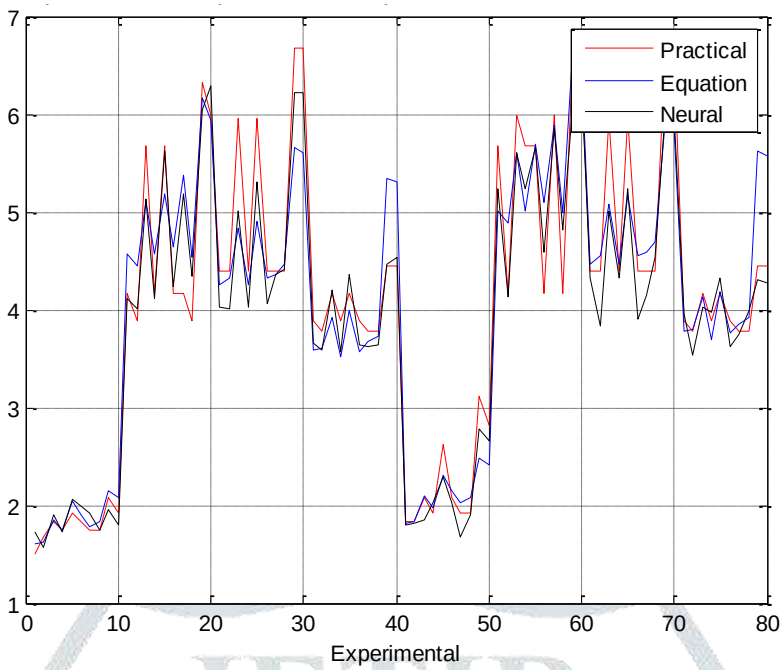

Figure 3: Graph of comparison with experimental data base and neural prediction for the network for turbine power

Conclusion: ANN simulations have been developed for turbine speed and power developed on the solar updraft tower. These simulation results proved to be successful in terms of agreement with actual values of experimentation. It can be concluded that ANN simulation perform accurately to determine the optimal values.

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