Model Formulation By Statistical Package For Social Sciences (SPSS) For A Solar Updraft Tower With Variable Geometric Parameter

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Abstract - Solar updraft towers is acts like a green house heat exchanger which produce electricity based on a relatively simple, is a robust green energy plant, that proven method of harnessing the energy of the sun to an air collector. It is known as a solar thermal power plant which consists of an air collector (green house), for generating solar induced convective flow a central updraft tower and a turbine driven by the hot air passing through blades due to natural draft. The hot air entrapped beneath the green house, to produce energy in the form of electricity. 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 SPSS model.The Consequently, Recommendations for future and on-going solar tower projects are offered.

Keywords - Solar energy, updraft towers, chimney, collector, wind Turbine,solar Radiations, wind,SPSS.

I. INTRODUCTION

Solar updraft tower will play an important role in the field of renewable energies. The solar updraft tower meets the crucial conditions and makes it possible to take the crucial step towards a global solar energy economy.on the basis of experience and knowledge gathered so far, Economic appraisals shows that cost of generating energy by large scale solar updraft towers (≥ 100 MW) are at costs close to those of conventional power plants.. This reason is enough to further develop this form of solar energy utilization to encompass large, economically viable units. The Solar Chimney uses hot air instead of water,which is particularly useful in arid areas.It operates like a hydroelectric power plant.. The solar chimney power plant system consists of four major components—collector, chimney, energy storage layer and one or more turbo generators at the base. Air underneath the low circular transparent glass open at the circumference is heated by radiation from the sun. The chimney, a vertical tower tube with large air inlets at its base, stands in the centre of the collector.
The joint between the collector and the chimney is such that it is airtight. The wind turbine is installed at the bottom of the chimney for the large-scale solar chimney system; there may be several wind turbines inside.

II. Working Principal

The model works on the principle that in the collector, solar radiation is used to heat an absorber (ordinarily soil or water bags) on the ground, and then a large body of air is heated by convection currents as the density of hot air inside the system is less than that of the cold air in the environment at the same height, the hot air is forced by the buoyancy to move up the chimney as a hot wind which acts as a driving force by this suction effect it flows through either one large turbine or numerous smaller turbines. The energy of the air flow is converted into mechanical energy at the base of the tower, and ultimately into electrical energy by electric generators. Fig 1: Shows Schematic diagram of a Solar Chimney Power Plant

III. EXPERIMENTAL MODEL

For generating electricity from solar power the solar updraft tower is a renewable-energy power plant Sunshine passes through a very wide greenhouse-like roofed transparent collector structure surrounding the central base of a very tall chimney tower. Due to convection a hot air updraft in the tower is caused by the chimney effect. Due to buoyancy updraft of airflow created in the chimney which drives wind turbines placed or around the chimney base to produce electricity. Primarily two factors on which Power output depends: collector area and chimney height. A larger area of collector collects and warms a greater volume of air beneath ,to flow up the chimney;Turbines with a vertical axis can be installed in a ring around the base of the tower.

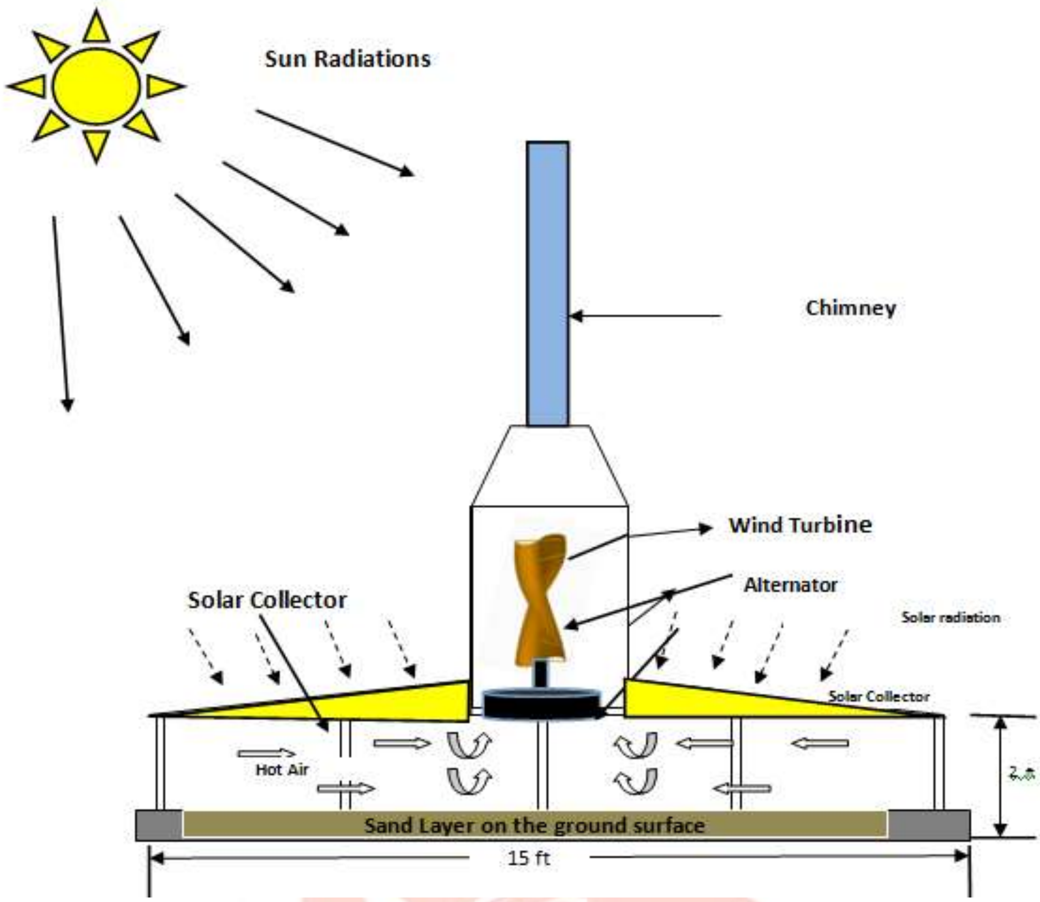


Fig. 1.Working model of the solar updraft tower

IV. Experimentation

The experimentation is performed to evaluate the power output produce from the solar chimney power plant. Four Different types of Collector materials used viz Glass, UV sheet, Polycarbonate sheet and Crystalline. Chimney height varied by using 12 feet and 16 feet Pipe. The test is performed using different instrumentation for measuring different variables. Regularly the plant was run on a daily basis. As soon as the air velocity in the tower reaches 1.5m/s, the plant started up automatically and electricity generated at the load connected to the circuit from turbine. During this period, the plant ran smoothly and electricity generated gradually with the increase of air velocity with a solar global horizontal irradiation of over 150 W/m² .Total operation time of the plant was 6 hours daily, The average power outputs for warm air condition between 45˚C to 55˚C in the tower found practically ranged between 3 watts to 6 watts for 12 feet height tower and between 6 watts to 9 watts for 15 feet height tower.

V. Identification of variables

Following table shows the independent variables and dependent variables identified for this research work. To validate the results obtained from various mathematical model we used SPSS software tool.

Table 1: Variables (independent variables and dependent variables) **pie terms**

Sr. No	**Independent Dimensionless ratios**	**Nature of basic Physical Quantities**
01	$\pi_1=\left(\frac{H_{gc}*T_{cc}*\theta_c}{D_c^2}\right)$	Collector material
02	$\pi_2=\left(\frac{H_{ch}*D_{ch}*N_b}{D_c^2}\right)$	Solar Chimney
03	$\pi_3=\left(H_u\right)$	Relative Humidity
04	$\pi_4=\left(\frac{(T_a*T_c)(V_i*V_o)D_c^2}{g^2}\right)$	Ambient Condition
05	$\square_5=\left(\frac{(\sqrt{g}*T_h*A_{oi})}{D_c^{5/2}}\right)$	Heating duration
06	$\pi_6=\left(\frac{D_c*Q}{K}\right)$	Heat flux
	Dependent Dimensionless ratios or π terms	

01	$\pi_{01}=\left(\sqrt{\frac{D_c}{g}} * N_T\right)$	Turbine Speed
02	$\pi_{02}=\left(\frac{P_d}{K * D_c}\right)$	Power Developed

VI. Model formulation by Statistical Package for Social Sciences (SPSS)

One of the most popular statistical packages which can perform highly complex data manipulation and analysis with simple instructions is **Statistical Package for Social Sciences (SPSS** . SPSS is capable of handling large amounts of data and can perform all of the above analyses covered in the text and much more. In this study descriptive statistics (arithmetic mean, standard deviation, maximum and minimum value of variables,etc.),data testing (Normality test,Data adequacy,Reliability and Validity)and final analysis(Internal consistency,factor analysis, multiple regression analysis ,analysis of variance and hypothesis testing)are carried out by SPSS software version 20.0.

VII.Developing the SPSS model individual Pi terms

Here six independent pi terms (i.e. $\pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6$) and two dependent pi terms (π_{01},π_{02}) have been identified in the design of experimentation and are available for the model formulation.

Independent π terms = ($\pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6, \pi_7, \pi_8$)

Dependent π terms = ($\pi_{01},\pi_{02},\pi_{03}$)

Every dependent π term is assumed to be function of the available independent π terms

By using the SPSS software version 20.0, the linear regression carried out, linear regression is used to specify the nature of the relation between two variables.

SPSS Log linear model:Pi01

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.968[a]	.938	.934	3.384834669	1.174

a. Predictors: (Constant), Pi6, Pi2, Pi3, Pi4, Pi1

b. Dependent Variable: Pi01_N

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	12784.832	5	2556.966	223.177	.000[b]
	Residual	847.826	74	11.457		
	Total	13632.657	79			

a. Dependent Variable: Pi01_N

b. Predictors: (Constant), Pi6, Pi2, Pi3, Pi4, Pi1

Coefficients[a]

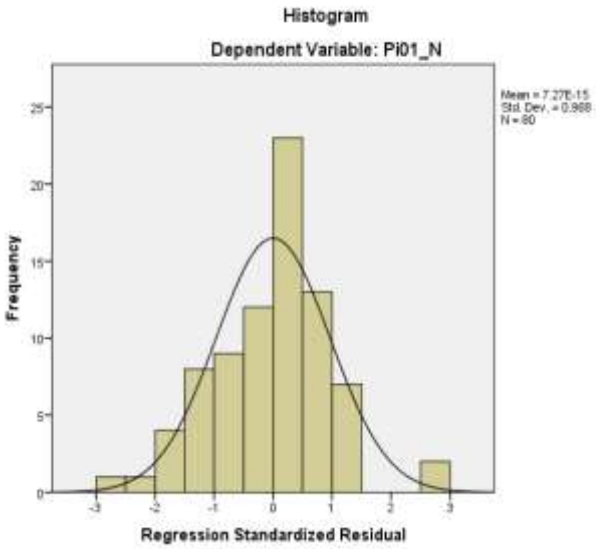
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	209.776	12.200		17.194	.000
	Pi1	-3749201.306	398587.845	-1.540	-9.406	.000
	Pi2	107.335	43.392	.073	2.474	.016
	Pi3	28.731	38.611	.031	.744	.459
	Pi4	2.088	.180	.670	11.619	.000
	Pi6	-.006	.001	-1.858	-11.419	.000

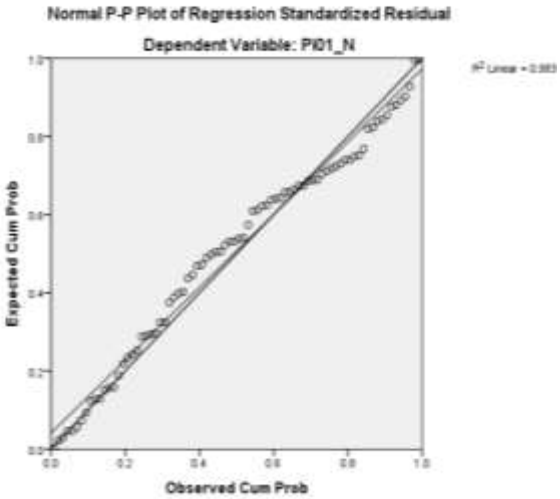
a. Dependent Variable: Pi01_N

Model Equation:

Pi01=209.776-3749201.306*Pi1+107.335*Pi2+28.731*Pi3+2.088*Pi4+0*Pi5-0.006*Pi5

$$\pi_{01} = 209.776 - 3749201.306 * \left(\frac{H_{gc} * T_{cc} * \theta_c}{D_c^{2}}\right) + 107.335 * \left(\frac{H_{ch} * D_{ch} * N_b}{D_c^{2}}\right) + 28.731 * (H_u) + 2.088 * \left(\frac{(T_a * T_c)(V_i * V_o) D_c^2}{g^2}\right) + 0 * \left(\frac{(\sqrt{g} * T_h * A_{oi})}{D_c^{5/2}}\right) - 0.006 * \left(\frac{(\sqrt{g} * T_h * A_{oi})}{D_c^{5/2}}\right)$$





Similarly other SPSS output was calculated form SPSS software for Power developed **Pi02**

SPSS Log linear model:Pi02

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.934[a]	.873	.865	.544582203	1.727

a. Predictors: (Constant), Pi6, Pi2, Pi3, Pi4, Pi1

b. Dependent Variable: Pi02_Pd

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	151.061	5	30.212	101.872	.000[b]
	Residual	21.946	74	.297		
	Total	173.007	79			

a. Dependent Variable: Pi02_Pd

b. Predictors: (Constant), Pi6, Pi2, Pi3, Pi4, Pi1

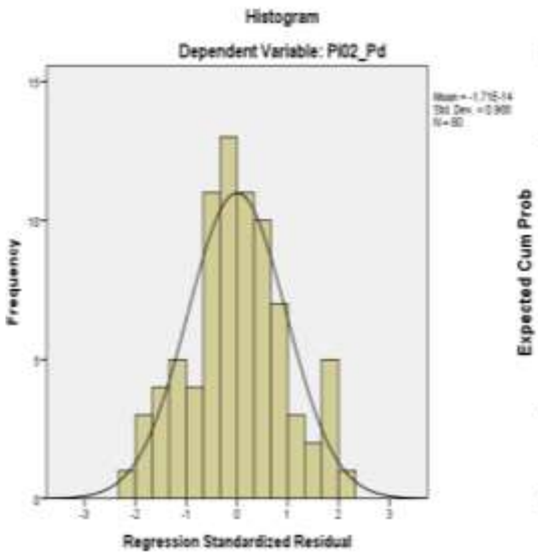
Coefficients[a]

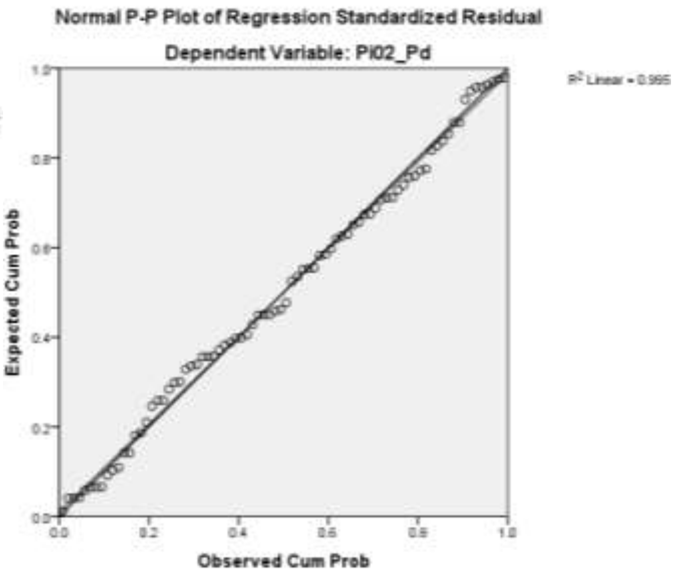
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.098	1.963		7.182	.000
	Pi1	-676232.757	64128.345	-2.466	-10.545	.000
	Pi2	7.442	6.981	.045	1.066	.290
	Pi3	8.678	6.212	.083	1.397	.167
	Pi4	.158	.029	.449	5.456	.000
	Pi6	.000	.000	-1.366	-5.878	.000

a. Dependent Variable: Pi02_Pd

Pi02=14.098-676232.757*Pi1+7.442*Pi2+8.678*Pi3+0.158*Pi4+0*Pi5-0.0005*Pi5

$$\pi_{02}=14.098-676232.757*\left(\frac{H_{gc}*T_{cc}*\theta_c}{D_c^{\,2}}\right)+7.442*\left(\frac{H_{ch}*D_{ch}*N_b}{D_c^{\,2}}\right)+8.678*(H_u)+0.158*\left(\frac{(T_a*T_c)(V_i*V_o)D_c^2}{g^2}\right)+0*\left(\frac{\left(\sqrt{g}*T_h*A_{oi}\right)}{D_c^{5/2}}\right)-0.0005*\left(\frac{\left(\sqrt{g}*T_h*A_{oi}\right)}{D_c^{5/2}}\right)$$





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VIII. Conclusion

The above developed SPSS model for Turbine speed and Power developed shows that the model is perfectly fit for the generated data set. Here the effectiveness of pi terms is shown in above graphs. The first pi term i.e. Collector area is more effective and influencing the output of process and sixth pi term i.e. heat flux is less effective to the output of process. Thus this developed SPSS model is SPSS is capable of handling large amounts of data and can perform all of the above analyses covered in this study are carried out through SPSS software version 20.0 statistics (arithmetic mean, standard deviation, maximum and minimum value of variables etc.), data testing (Normality test, Data adequacy, Reliability and Validity) and final analysis (Internal consistency, factor analysis, analysis of variance ,multiple regression analysis and hypothesis testing)

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