Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 9, September -2017

REVIEW ON SOLAR PHOTOVOLTAIC OPERATED WATER FOUNTAIN

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Abstract -*World has large energy demands and difficult to fulfill those needs through non-renewable energy technology is increasing daily. Thus, sustainable methods are required to ensure food security and energy security.There are various demonstrational projects of renewable energy in modern cities, parks and campuses for fulfil energy demand by clean and pollution free techniques. This paper investigated a solar fountain of typical application of solar energy, as well as its configuration and working principle, which can be installed in city to beautify humanoid living atmosphere, purify water and save power. The effect of the solar photovoltaicwater fountain installed in city/campus is shown with some most beautifulimages. In this paper focused on different type of solar water fountain and their performance analysis by various researchers recently.*

Keyword: *water fountain, renewable energy, photovoltaic,*

1. INTRODUCTION

World has large energy demands and difficult to fulfill those needs through non-renewable energy technology is increasing daily. Due to raise in energy demand and fuel depletion the alternate sources like wind, solar, biomass, and fuel cell were being more and more utilised. Biomass is presently the most important supply of renewable energy, accounting for approximately 10-15% (or 45 ± 10 EJ) of the world's total energy provide[1]. Energy is one of the major contributions for the economic development of any developed or developing country. In the side of the developing countries, the energy sector considered a critical importance in view of the ever-increasing energy demands requiring huge investments to meet them.A solar energy operated water fountain includes a submersible pump submersed within a water-filled storage container, and a solar panel is temporary connected in electrical circuit with the centrifugal pump for their controlling operation, whereby the quantity of water discharged from the pump and the display patterns produced by the pump are directly responsive to variations in light level at the solar panel.[2]

2. SOLAR PHOTOVOLTAIC CELLS -

Photovoltaic cells are devices which 'absorb the sun light and convert it into electricity. The cells are connected by wire in series, sealed between sheets of glass or plastic, and supported inside a metal frame. These frames are called solar modules or panels. They are used to energy a variability of applications ranging from calculators and wrist-watches to complete home appliance and heavy power generation plants. Photovoltaic cells are manufactured by thin silicon wafers; which is a semi-conducting material. When sunlight is captivated by these semiconducting materials, the solar energy hits electrons loose from their atoms, permitting the electrons to flow through the material to produce electric energy. This process of converting sunlight to electrical energy is called the "photovoltaic effect".

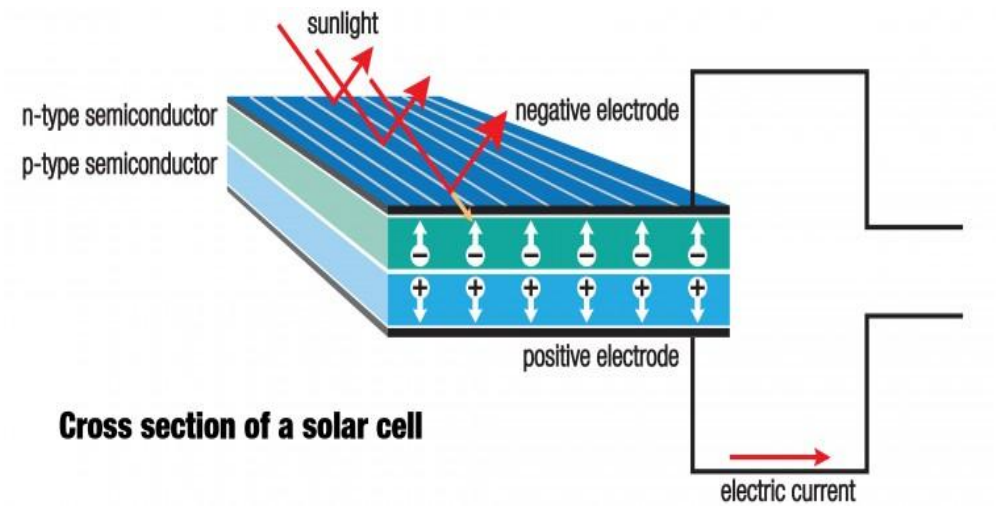

Figure 1. working of solar photovoltaic cell

3. SYSTEM CONFIGURATED COMPONENT AND WORKING PRINCIPLE:

The system configurated component and working principle of solar water fountain was shown in Figure 1, from which we could see that the system was involved of the following component[3]:

3.1 Solar Array-When you combine several solar panels, you create a solar array. All the energy required for solar fountain system operating come from solar PV array. It generallycontains of many solar PV cells which link with each other in parallel and series.

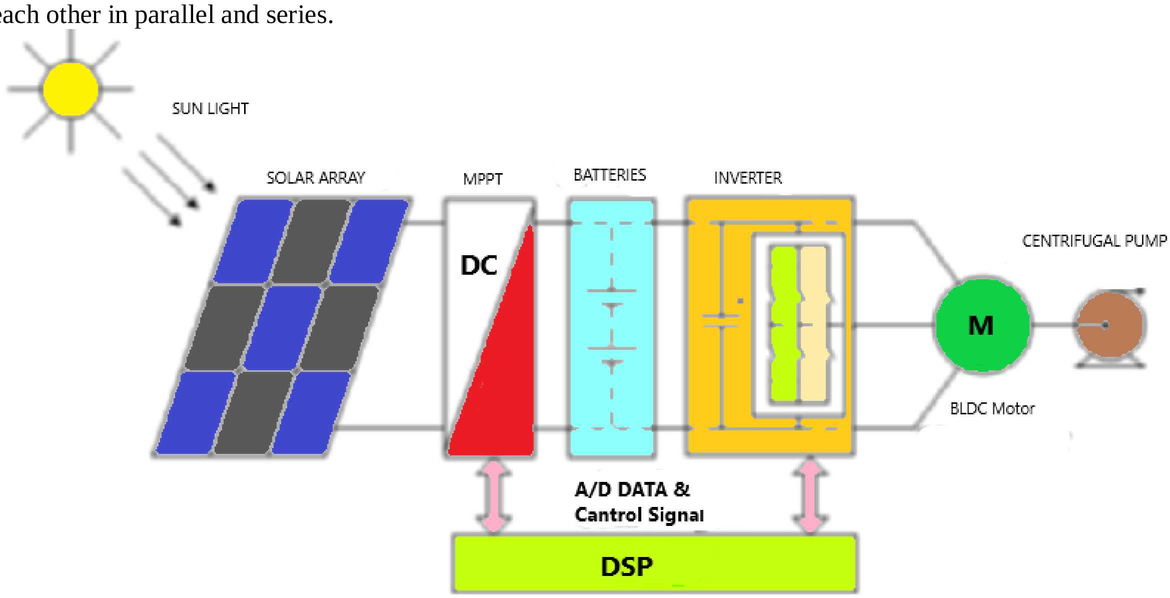

Figure 2. block diagram of solar water fountain system

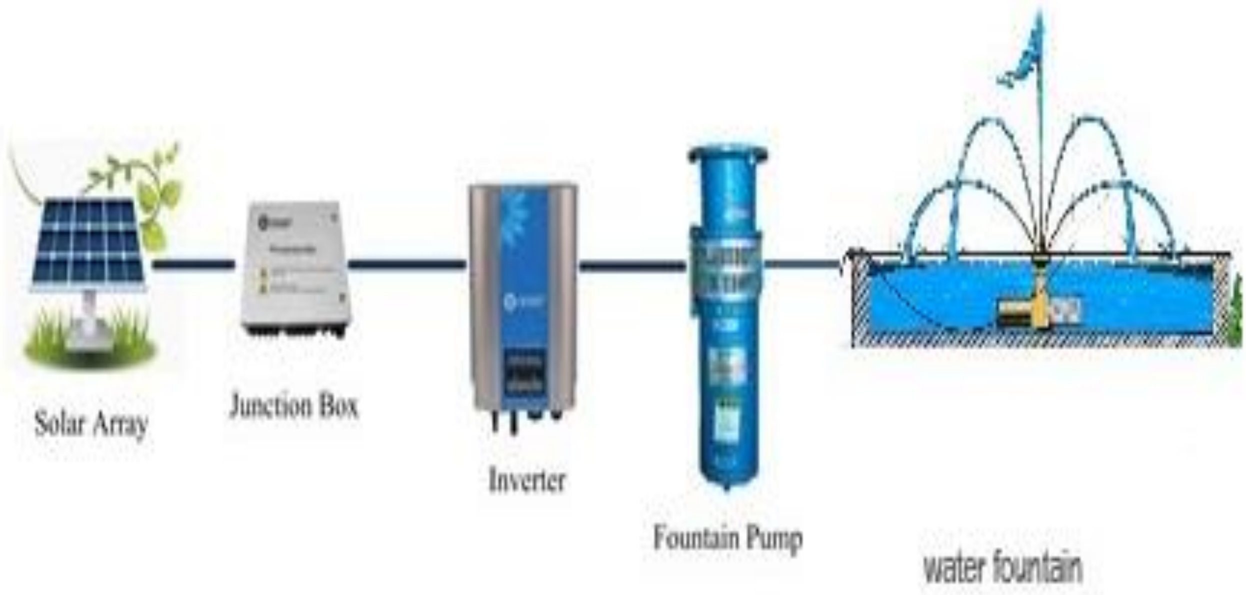

Figure 3. systematic diagram of solar PV water fountain

3.2 Solar Fountain Controller

The solar battery charger with Maximum Power Point Tracking,solar water fountain running Brushless DC Permanent Magnetic motor inverter and controller combines to the solar fountain controller. The main roles of this part are to fulfill charge and discharge of the solar batteries which are used for storing the electric energy converted by solar photovoltaic cells, control the running time of pumps and switching and LED, output PWM driving signal to Brushless DC Permanent Magnetic motor, and supply various of safety measures to system, such as the defenses of over voltage, over current, over discharging, overheating, overcharging, etc.

3.3 Batteries

It's the storage device of the system, which also can be seemed as energy buffer. It will overcome the defect of instability of solar cell's energy output, and provide the loads with stable energy output, which might make sure the decorative effects of the solar fountain, meanwhile, even within the night or within the weather, the fountain will still work as was common. Considering the voltage and power demand of the loads, and the depth of the battery charging and discharging,

3.4 BLDC PM Motor

The energy output of the solar PV panel is proscribed; therefore, the energy should be utilized a lot of effectively. The BLDC PM Motor that was equipped during this system adopts the technology of double plastic packaging for the mechanical device and rotor of motor, that makes the water lubrication possible, therefore will bring perfect cooling effect and fewer friction losses, consequently, the efficiency of the motor is improved.

3.5 Pump

The centrifugal pump was utilized in this system. consistent with the Q-H (Quantity-Head) characteristic, within the condition of identical motion speed of the bearing, the output power of the pump keeps constant, and also the amount has the reciprocally proportional to the head. Since the head of the solar fountain is low, a low head-high amount centrifugal pump was chosen as the solar water pumping system.

3.6 Fountain

This part consists of type of pipes and nozzles, the main function of that is to manage and direct a flow of fluid. 2 types of nozzles were chosen for the solar fountain that might be seen within the Fig. 3.

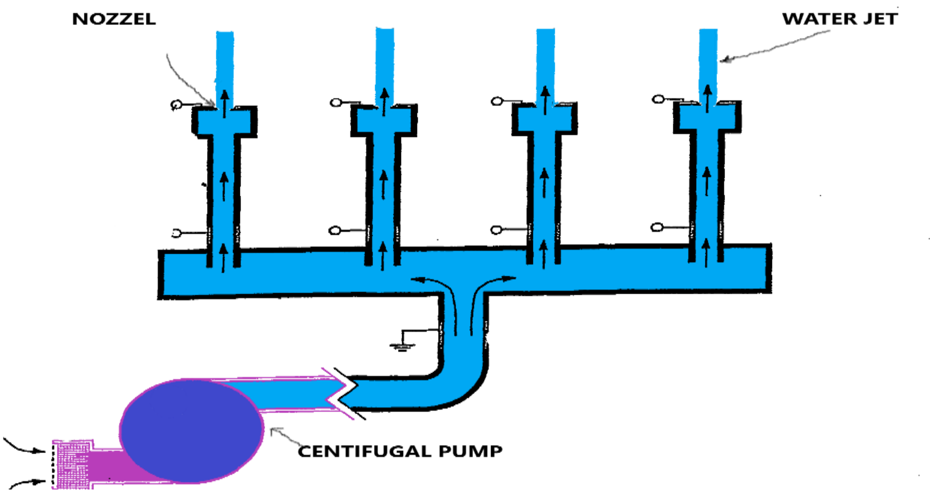

Figure 4schematic diagram of nozzle of solar fountain system with pump

3.7Nozzle

According to their internal workings, nozzles can be classified as[4]:

- **3.7.1.- Solid jet nozzle:** traditionally, this was the primary nozzle and includes of a pipe, through that water runs out under certain pressure. With simply a number of little changes within the nozzle, its performance is considerably improved.
- **3.7.2.- Water-drawing nozzle:** based on the Venturi effect, this nozzle uses the speed of the propelled water to draw water from the basin, which, once mixed with the initial stream, forms a way larger body of water than the initial one
- **3.7.3.- Air-suction nozzle:** this nozzle is predicated on a similar principle because the previous one however due to its special design, attracts air rather than water from the basin. This air mixture produces a really foamy effectwithin the water.

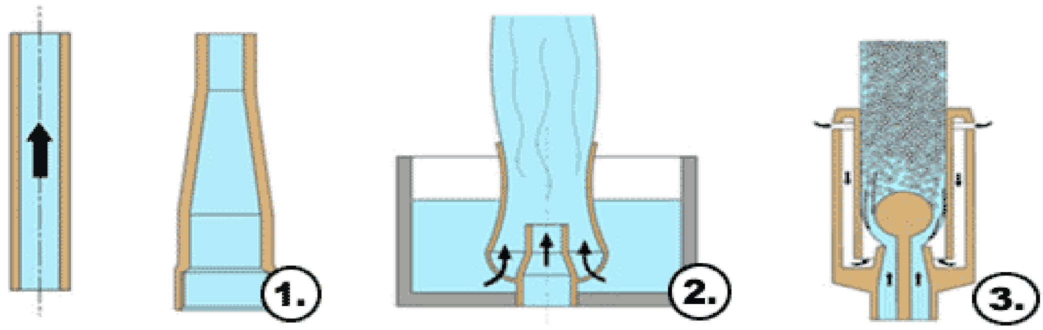

Figure 5. water fountain nozzles (1) Solid jet nozzle, (2)Water drawing nozzle, (3) Air suction nozzle

3.7.4.- Water-drawing and air-suction nozzle: This nozzle achieves the result of the two previous nozzles by drawing air and water from the fountain basin. It produces a really frothy effect within the water jets and larger consistency against wind, thereby creating it a pretty choice for outside water features

3.7.5.- laminar effect nozzle: because of its special design, this nozzle sprays a wall or sheet of water in a very certain form. These nozzles have a tool at the highest finish that is liable for forming the required shape in every case.

3.7.6.- Spraying Jet Nozzle: an internal helical device rotates the water gratingly in order that it's discharged as a spray, forming a cloud of extremely plastic cloud.

3.7.7.- Dynamic nozzle: Equipped with a hydraulic spindle, this nozzle rotates throughout operation to produce periodic effects which will produce an interactive play fountain, differentiating it from the models delineate above.

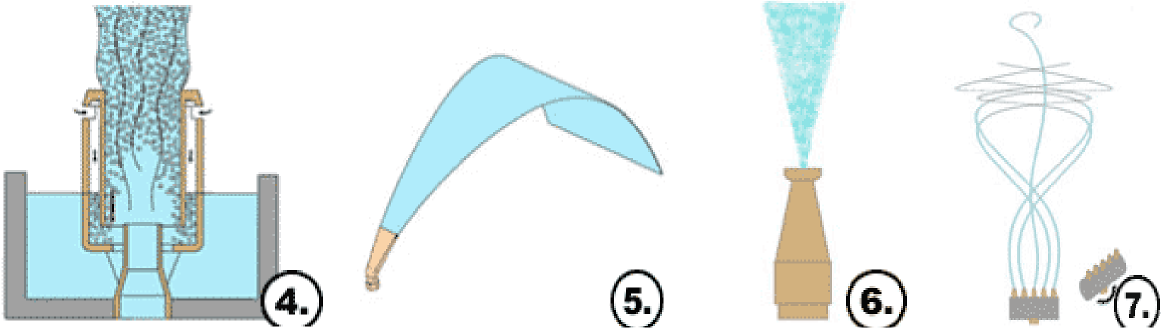

*Figure 6. water fountain nozzle **(**4) Water-drawing and air-suction nozzle (5) Laminar effect nozzle (6) Spraying Jet Nozzle**,** (7) Dynamic nozzle*

4. ADVANTAGES OF SOLAR WATER FOUNTAIN

- ✓ No need for electrical outlets.
- ✓ Solar fountains are extremely user-friendly.
- ✓ Solar fountains are "green" in that they do not use electricity.
- ✓ Solar fountains are virtually maintenance free.
- ✓ There is no noise, emissions, or fuel.

5. VARIOUS PARAMETER FOR SOLAR WATER FOUNTAIN

5.1 Height of fountain or water jet:

Bernoulli's equation can be used to calculate pressure at any point along a pipe. Let sub-index 1 in figure 7 is the pump's outflow point and 2 is the point at the base of a nozzle, the relationship between the elevations head, velocities head and energy head losses can be representing as being caused by the effects of a pipe's length and accessories:

$$Z_1 + P_{1(M.W.C)} + \frac{{V_1}^2}{2g} = Z_2 + P_{2(M.W.C)} + \frac{{V_2}^2}{2g} + hf + sum\ h_{accessories}$$

Height of fountain or pressure losses is given below

$$h_f = f\,\frac{L}{D}\frac{V^2}{2_g} \qquad (1)$$

Where:

- f: Darcy- Weisbach friction factor. Depends on the nature and temperature of the liquid and its Reynolds number.
- L: length of the pipe.
- D: interior diameter of the piping.
- V: flow velocity.

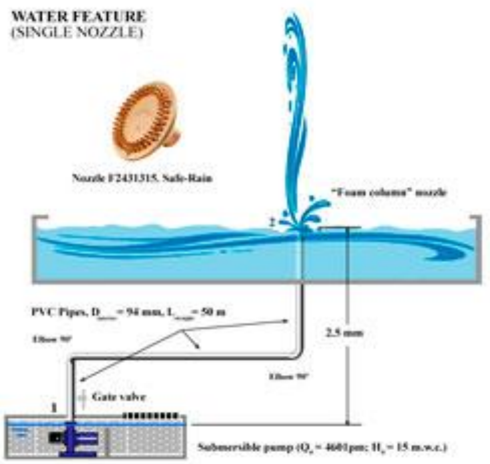

Figure 7. Diagram of a water feature with single nozzle

5.2 Pressure losses: following expression can be used for calculate the pressure losses in each accessory of a pipe:

$$h_1 = K_{accessory}\ \frac{V^2}{2g} \qquad (2)$$

Where:

- $K_{accessory}$: coefficient depending on the type of accessory: 90º elbow, 45º elbow, valve, etc.

- V: flow velocity.

In this case, it may be obtained using tables or the following expression: $L_{equivalent} = K_{accessory}$ *D/ f, the lengths of straight pipe. The sum of all the equivalent lengths and also the total length of the straight sections is employed because the length for calculating energy losses in a pipeline.

5.3 CALCULATION FOR SOLAR FOUNTAIN PUMP:

The efficiency of motor-pump is given by

$$\eta_{mp} = \frac{\rho g Q H}{VI} \tag{3}$$

The overall system efficiency depends on the PV array efficiency and the motor-pump efficiency, and it is given by

$$\eta = \eta_e \eta_{mp} \tag{4}$$

The PV array, the dc PM motor, and the centrifugal pump load parameters. The PV array parameters are put in the – (1), and it becomes

$$V = -0.0864I + \frac{1}{0.1616} In(1 + \frac{N_P I_{PH} - I}{0.00225}) \tag{5}$$

For the steady-state operation, the electromagnetic torque of dc motor becomes.

$$T_E = C + D_\omega + T_e = 0.23 + 0.001\omega + 1.6523^{*}10^{-5}\omega^2 \tag{6}$$

Where,

C is Torque constant for rotational losses.

D is Viscous torque constant for rotational losses.

I_{PH} is Photon current of each cell.

N_P is Solar cells in parallel.

T_e is Electromagnetic and centrifugal pump load torque.

V& I is PV array voltage and current.

η_e is PV array efficiency.

6. LITERATURE REVIEW-

6.1)Lei, X., et al., (2007)present research paper deals with a solar fountain-a typical application of solar energy, including its configuration and working principle, which can be installed in district to beautify human living environment, purify water and save energy. The impact of the solar fountain installed in field was shown with some vivid photos. based on the analysis of its benefits and disadvantages, the prediction of market prospects was mentioned at the end of this paper.[3]

6.2)According to Cuadros et al., (2004), this technique was appropriate for determining the dimensions and so viability of those solar powered irrigation systems since the price of photovoltaic (PV) systems is fairly high. Not only is the viability checked out in terms of the price of PV systems however also the land area needed for implementation[5].

6.3)Bologeorges, J. et al., (2005)present the disclosed technology can be used to implement water movement effects (e.g., water fountains) during a water feature (e.g., bird baths) by, for instance, submersing one or additional solar cells below a surface of the water within the water feature to convert sunlight energy received thereby into electrical energy adequate to directly or indirectly drive a pump (which may also, but need not, be submersible below the water surface) that provides a hydraulic pressure/suction that forms a desired water movement effect[6].

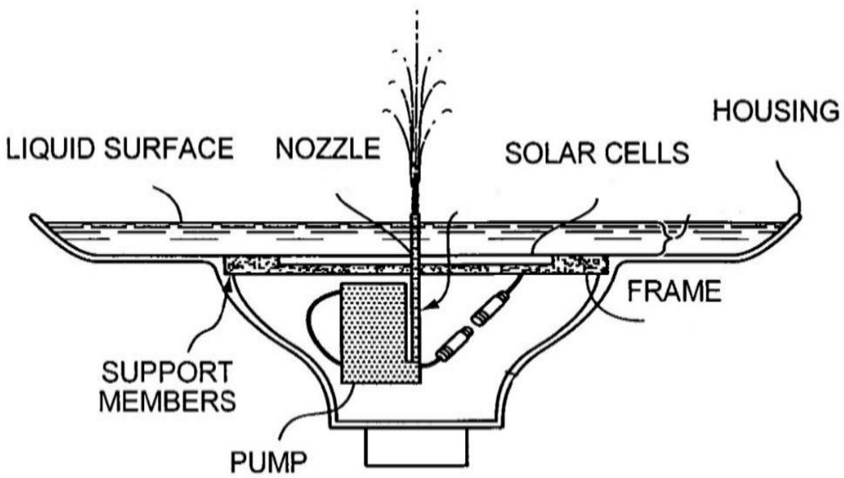

Figure 8. model of solar fountain is given by Bologeorges

6.4) Kelley et al., (2010) suggested that solar photovoltaic irrigation was technically and economically feasible, as long as there was enough land available for the solar PV panel. One of the concerns regarding the use of solar panels for producing power is the number of panels required and the area they would occupy. In the case of agriculture this is especially important since it directly impacts the area that would be left for planting This work showed that only a small percentage would be required on the two-acre plot for the panels. This demonstrates the practicability and application of using solar PV to supply energy for the pumping needs for drip irrigation[7].

6.5)Hamidat et al., (2003) accordance the setup of a PV system is also very flexible. The most efficient use of solar energy is when the panels are directly connected to the load. In fact, the success of water pumping lies part with the elimination of the intermediate section, particularly the battery bank, for energy storage. With a direct connection between the PV array and the pump, water can be pumped during sunlight hours. The most efficient form of direct-connect systems is when the water is being pumped to an elevated storage tank, thus the electrical energy from the panels is converted to potential energy of the elevated water, to be used on demand, often by gravity[8].

6.6)Kolhe et al., (2004) investigate the performance of a PV-powered dc permanent-magnet (PM)motor coupledwithacentrifugalpumphasbeenanalyzed at differentsolarintensitiesandcorrespondingcelltemperature.The results obtained by experiments are compared with the calculated values, and it's ascertained that this system incorporates a good match between the PV array and therefore the electromechanical system characteristics. Through manual tracking (i.e., changing the orientation of PV array, three times a day to face the sun) the output obtained is 20% more compared to the fixed tilted PV array. It has been ascertained that the torque-speed curve at low solar intensities for a PV electromechanical system should be steeper than at higher solar intensities, and therefore the load torsion-speed curve should be as steep as attainable within the in operation region with low beginning torque[9].

6.7)Gupta, S.K.et al.,analyses different simulation has been performed to find out the I-V and P-V characteristics of system. A solar panel having several modules in series and parallel is designed and track the maximum power point in the panel. A DC-DC Buck-Boost converter is used with the purpose of keeping constant voltage at the terminals of the motors regardless of the load current for all realistic solar illuminations. Furthermore, this controlled constant voltage is fed to the DC motors connected with the pump and investigate the change in the characteristics of DC motors and the pump under different environmental conditions of solar system. The results give an efficient model for solar energy based control of DC drives with water pumping system. The modelling and simulation has been done in Simulink software environment with MATLAB[10].

7. CONCLUSION

This review paper summarized the status and different aspects of the solar photovoltaic water fountain system(SPVWFS). The first part defines the system and its parts. SPVWFS is included of three main parts; solar PV module, control system, and centrifugal motor-pump. The solar PV array converts solar energy into electrical energy. The second part summed up the effect of parameters relevant to system parts and ambient conditions on the performance of SPVWFS. Different parameters have different influence on SPVWFS. This review paper also presented different applications of SPVWFS in different regions of the world. These applications differ with reference to the kind and power of PV array, pump, and motor. The demand and nature of use is different for every mentioned application and it was found that PV system is appropriate choice to be used in decoration and change of state of municipal areas.

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