Design and Manufacturing of Dye Sensitized Solar Cell Assembly Machine

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***Abstract*—There has been steady accretion of power of nonconventional sources of energy one of the viable means discovered is dye sensitized solar cells. The replacement complying cost, flexibility and profound production rate has led to its acknowledgment. In this work, a prototype of DSSC manufacturing system is presented. With the utilization of motor-driven conveyor belts, linear actuators, dispensing system, heating plate, blowers competent DSSC cell is assembled. The accuracy of the automated assembled cell is superior to the manual cell.**

***Keywords*— Nonconventional source of energy, Dye sensitized solar cell.**

I. INTRODUCTION

Due to Industrial revolution and rapid growth of technology, the dependence on fossil fuels as source of energy is quite unreliable as they are depleting at exponential rates and contribute significantly to global warming. As a solution to energy crises, we have turned towards Photovoltaic Solar Cells due to abundance of solar energy. Though they have proven to be sustainable and profitable, they are quite expensive. An inexpensive alternative for fossil fuels turns out to be Dye Sensitized Solar Cell using natural dyes. DSSCs have gained popularity since last two decades due to lighter weight and low cost. They have evolved a lot by experimenting with different natural dyes, electrolyte, etc. to achieve better efficiency and stability. Manual fabrication of DSSCs is an exacting process. Every step has to be carried out with an accuracy which is quite unachievable if done manually. So by studying and analyzing different fabrication process, automation of each step can be done by involving technology which eliminates human interference and carries out each step with a certain accuracy. Automation of fabrication of DSSCs can result into increased efficiency and stability. Also, mass producing these efficient, low cost DSSCs can help to meet the energy demands and provide the world a better and sustainable source of energy.

A. Construction of DSSC.

DSSC consists of a transparent conducting glass electrode with a porous layer TiO2 coated with a dye that serves as light sensitizer, an electrolyte layer, and a counter electrode, typically coated with graphite. DSSC is third generation solar cell based on a semiconductor formed between a photo sensitized anode and an electrolyte. In the assembly of the DSSC, dyes play an important role in the harvesting of the solar energy, therefore the cell performance is mainly dependent on the type of dyes used as sensitizer.

Fig.1. Manually made DSSC solar cell(Chaudhari et al,2021)

B. Fabrication of DSSC

Materials- ITO glass, TiO2 paste, Ethanol, Dye (Eosin Y), Pure iodine, Potassium Iodide, Ethylene glycol, Scotch tape, Hot plate and Binder clips.

1. The conductive side of ITO glass was covered with scotch tape leaving out a squared shaped gap for application of TiO2 paste.
2. Preparation of TiO2 paste involved addition of ionized water to TiO2 powder. The mixture was continuously stirred until desired consistency was obtained.
3. TiO2 paste was uniformly applied on ITO glass with assistance of Roller blade.

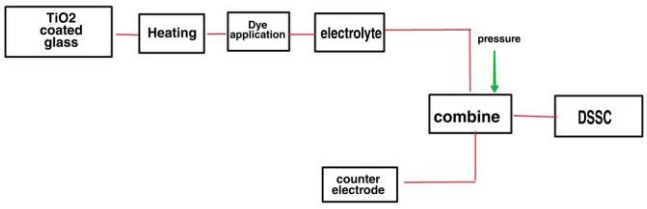
4. Once the TiO2 paste was dried, the scotch tape on the glass was removed and glass was sintered using hot plate at 100 degree Celsius for 15 mins.
5. Drops of Ethanol based dye were added to the TiO2 on the glass. This concluded preparation of light sensitizer electrode.
6. For preparation of Counter electrode, the conductive side of second FTO glass was coated with graphite.
7. For electrolyte, X g of pure iodine and X g of potassium iodide were added to 10 ml of Ethelene glycol. A drop of this solution was inserted between the two electrodes.
8. The two electrodes are joined with help of binder clips and output voltage is checked.

II. METHODOLOGY

After analyzing every step in the fabrication process of DSSC, the assembly machine is designed. It consists of a series of stations working harmoniously to deliver the desired product. The components like Conveyors, Hopper, Automated dispensing machine, Rollerblade, Linear actuators, Heating plate, Ethanol spray, Dye dispensing machine and blower are used in the assembly machine at various stations

The assembly machine has in total 7 stations as shown in fig. The function of station 1 is to locate the conductive glass carefully on the conveyor belt. In order to achieve this, a hopper mechanism is designed which is located at one end of the conveyor. This mechanism is actuated by solenoid which gently pushed each glass on the conveyor belt. After the glass is positioned on the conveyor, it moves to station 2 where TiO2 paste is applied on the glass with help of an automated dispensing machine.

Further, on station 3 the paste is uniformly distributed with assistance of rollerblade to form a thin layer

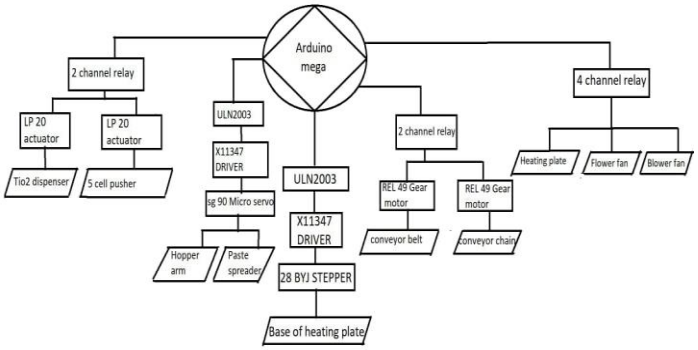


of TiO2 paste on the glass. The glass moves on the conveyor until 5 units are collected on the other end. These five glasses are pushed on a heating plate with the aid of a linear actuator. Heating plate forms station 4 which heats the glass up to 150 degrees Celsius for 10 minutes. With the support of a linear actuator, the glasses are transferred to a chain belt conveyor from the heating station. Once the glasses are located on the conveyor, they are washed and cooled at station 5 by the means of an ethanol spray. Now, the glasses advance to station 6 for the dye dipping process. A continuous flow of dye acts on each glass for 10 minutes so that the dye is uniformly absorbed. The set of five glasses moves to station 7 where they are dried by utilizing a blower. After collecting the glass from the conveyor belt, a drop of electrolyte is added manually and the spacer is placed on the glass. This is now sandwiched with the counter electrode coated with carbon to obtain the desired product.

A. Automation.

As Previously mentioned, Arduino mega 2560 was employed to superintend the control aspect of our system. This system board is programmed using Arduino IDE software which supports c programming and is employed with Atmega microcontroller. This board comes with USB cable port that is used to connect and transfer code from computer to the board and supports multitasking parallel programming.

Arduino relay module (2/4 channel) designed for wide range of microcontrollers is employed for regulating several circuits using one signal. To instill smooth autonomous running flags are used which allow sequential operating process through conditional statements in program.
Different library scripts easing Arduino programming is nested. our system is embedded with 2 DC gear motors thus “Dc_motor.h” library was included. For 28 BYJ stepper motor



“stepper.h” header file is used and for sg 90 micro servo motor inculcated to actuate hopper arm and paste spreader is functioned using “servo.h” header file. This library grant control over number of steps and speed with ease.
The relative manufacturing process was administrated using distinctive program codes. The composition of each code directed overall automated system.

III. RESULT AND ANALYSIS

Prototype DSSC and handmade DSSC were compared on basis of output voltage. Table I. shows the results for the comparison done for analysis. As the assembly machine has low degree of automation, the performance of the prototype DSSC has been compromised. The performance can be enhanced if the automation is very precise in every step of fabrication.

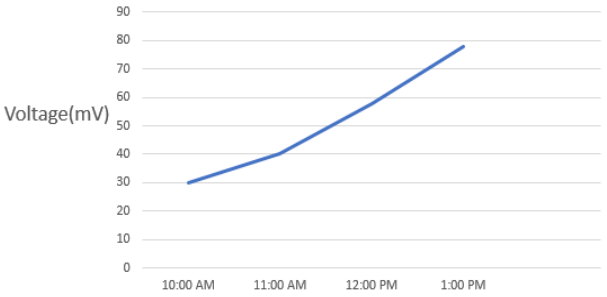


Fig.2. Voltage produced throughout a day

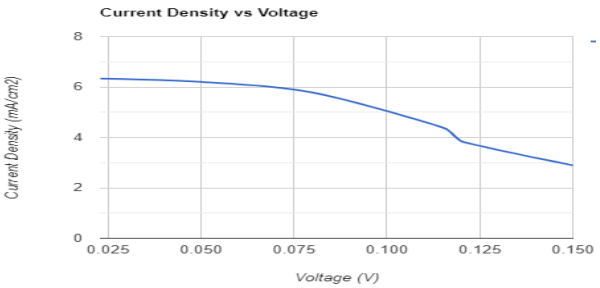


Fig.3. Voltage in DSSC based on current density

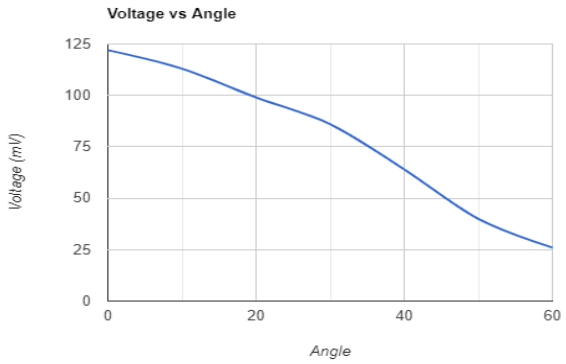


Fig.4. Voltage prodeced by DSSC at different angles

TABLE I. HAND-MADE DSSC VS. PROTOTYPE DSSC.

Type of Solar Cell	*Output Voltage in Sunlight*	*Comment*
Hand-Made DSSC	80 mV	
Prototype DSSC		

Factors such as thickness of TiO2 paste, Duration of heating, Absorption of dye, etc. have direct influence on DSSC's performance. The stations for the same in the assembly machine cannot provide the precision and accuracy it requires for better efficiency due to low degree of automation used.

IV. CONCLUSION.

This works presents a prototype in order to put into visualization the idea of automated assembly machine for fabrication of DSSC. The main aim of the assembly machine presented is to eliminate human interference in fabrication of DSSC. This aim is partially achieved as last stage of packing is done manually due to complexity of the step. By improving the automation at each station, efficient DSSCs can be obtained.

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