Solar Powered Regenerative Sewing Machine Using PMDC Motor

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***Abstract* - This paper captures the opportunities of a livelihood decentralized energy nexus where no grid availability is an issue. The intervention of manual sewing machine into solar photovoltaic array fed sewing machine incorporates energy efficiency. Solar energy into existing system which made a clear impact in reducing the electricity consumption, improving productivity, financial inclusion and enhancing their income.**

The solar powered regenerative sewing machine is basically a sewing machine designed to run for local entrepreneur's tailoring business in small cities and villages where little or eight operating hours are required on solar energy. The other components are charge controller, pedal control. Solar panel with battery was used to provide eight hours of backup per day.

***Index Terms* - Sewing Machine, PMDC Motor, Solar Panel, Charge Controllers, Intervention, Regeneration.**

I.INTRODUCTION

Tailoring is one of the most important livelihoods in India. Traditional tailors who generally serve local customers in small cities and villages use manual sewing machine. To compete on the existing market and achieve higher productivity some of them have modified their machines by retrofitting the motor. However, in places with little or no grid availability, it is difficult to meet the increasing demands. Hence this paper come up with a viable solar solution for them.

Solar is an ideal solution for micro generation. But the main challenge was to make it affordable for small scale business. Hence this paperwork made it possible by understanding the actual energy need and introducing energy efficiency measures. Hence this paperwork takes the benefit of sunlight energy as input which is free and plentiful, and it is exceedingly advantageous and inexpensive to numerous household and industrial applications.

This work presents the intervention of manual sewing machine by using PMDC (permanent magnet dc) motor with regeneration of electric power when needed. The other major components include solar photovoltaic cell, battery, charge controller, pedal control. This substantially reduced the cost of solar powering the equipment as well.

Sewing machines were invented during the first Industrial Revolution to decrease the amount of manual sewing work performed in clothing companies. Since the invention of the first sewing machine, generally considered to have been the work of Englishman Thomas Saint in 1790, the sewing machine has greatly improved the efficiency and productivity of the clothing industry.

Home sewing machines are designed for one person to sew individual items while using a single stitch type at a time. In a modern sewing machine, the process of stitching has been automated so that the fabric easily glides in and out of the machine without the inconvenience of needles, thimbles and other tools used in hand sewing. Early sewing machines were powered by either constantly turning a handle or with a foot-operated treadle mechanism. Electrically powered machines were later introduced. Industrial sewing machines, by contrast to domestic machines, are larger, faster, and more varied in their size, cost, appearance, and task.

II. MEASURES OF INTERVENTION OF SEWING MACHINE

A. Energy Efficiency Measures

Mostly in existing electric sewing machine a universal motor of 1/10 HP or 1/12 HP is used along with a simple pedal control. These motors are highly inefficient. It was noticed that while a 1/12 HP universal motor consumed more than 100W to run a tailoring machine at nearly 1000 SPM (stitches per minute) speed, the same results could be achieved by a 60W PMDC motor consuming maximum 75W. By introducing a more efficient PMDC motor the energy consumption has been brought.

B. Energy Conservation Measures

This type of machine has a clutch attached to the motor. When the pedal is pressed, the clutch gets engaged and the machine begins stitching. After the pedal is released, the clutch gets detached but the motor still rotates at no load, consuming at around 100W. This clutch motor was by a variable frequency drive (VFD) controlled 1/3 induction motor. The VFD eliminates the idol running of the motor and saves more than 50% of the energy consumed. As a result the cost of the system gets reduced more than it suppresses the high starting current of the motor and avoids the need for oversized inverter just to withstand the high starting current. At the same time the inversion efficiency gets increased due to improved percentage loading.

III. BLOCK DIAGRAM AND COMPONENT DETAILS

A. Block Diagram

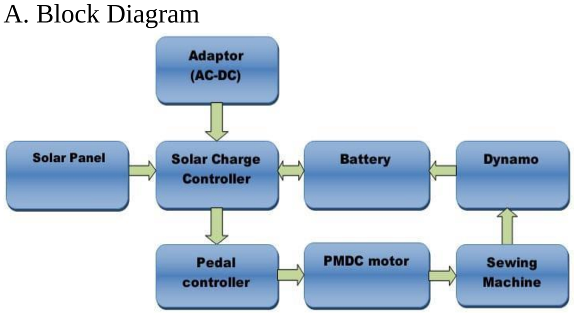
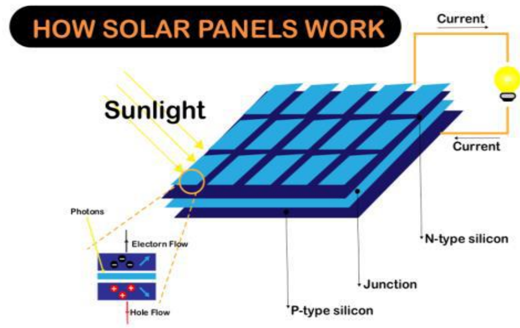


Figure A. Solar Powered Regenerative Sewing Machine Using PMDC

The photovoltaic solar cell is the input energy and the output terminals of it are fed to the charge controller. Battery is used as a storage device to store the charges of solar cell and the two output terminals of battery are connected to the charge controller to get good efficient solar operation. The pedal controller monitors the speed of the motor. Hence we can say solar cell, battery and pedal control are simultaneously connected to the charge controller unit. The PMDC motor of sewing machine is connected to pedal control.

B. Solar Photovoltaic Cell:



A Solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photovoltaic cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light.

The common single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. Solar cells are described as being photovoltaic, irrespective of whether the source is sunlight or an artificial light.

Sunlight is composed of photons, or bundle or radiant energy, when photons strike a PV cell Photovoltaic solar plates absorb sunlight as a source of energy to generate electricity.

Solar panels are constructed as a collection of lots of small solar cells that are spread over a large area to provide enough power. The larger the concentration of light hits the cell the more electricity or heat is produced.

Solar panels work by converting light photons into electricity through the solar photo-voltaic (PV) effect. This allows for direct conversion of sunlight into solar power.

C. Solar Charge Controller

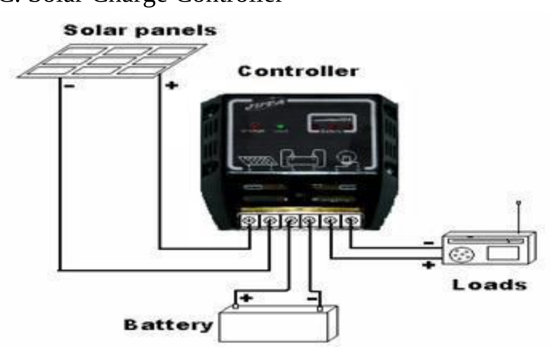


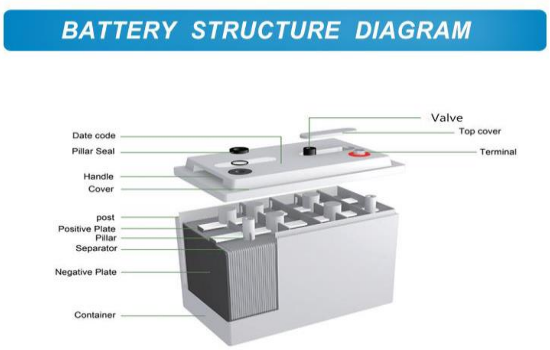
Figure c. solar charge controller

A solar charge controller is fundamentally a voltage or current controller to charge the battery and keep electric cells from overcharging. It directs the voltage and current hailing from the solar panels setting off to the electric cell.

Generally, 12V boards/panels put out in the ballpark of 16 to 20V, so if there is no regulation the electric cells will damaged from overcharging. Generally, electric storage devices require around 14 to 14.5V to get completely charged. The solar charge controllers are available in all features, costs and sizes. The range of charge controllers are from 4.5A and up to 10A to 20A.

The most essential charge controller basically controls the device voltage and opens the circuit, halting the charging, when the battery voltage ascents to a certain level. More charge controllers utilized a mechanical relay to open or shut the circuit, halting or beginning power heading off to the electric storage devices.

D. Battery:



A battery is a device consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars.

When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal.

When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell.

A battery's capacity is the amount of electric charge it can deliver at the rated voltage. The more electrode material contained in the cell the greater its capacity. A small cell has less capacity than a larger cell with the same chemistry, although they develop the same open-circuit voltage.

The rated capacity of a battery is usually expressed as the product of 20 hours multiplied by the current that a new battery can consistently supply for 20 hours at 68 °F (20 °C), while remaining above a specified terminal voltage per cell. For example, a battery rated at 100 Ah can deliver 8A over a 21 hour period at room temperature. Figure 3.2.3 shows battery construction.

The fraction of the stored charge that a battery can deliver depends on multiple factors, including battery chemistry, the rate at which the charge is delivered (current), the required terminal voltage, the storage period, ambient temperature and other factors.

E. Sewing Machine:

A sewing machine is a machine used to stitch fabrics, clothes, etc. Sewing machines were invented during the first industrial revolution to decrease the amount of manual sewing work performed in clothing companies.

Since the invention of the first working sewing machine, generally considered to have been the work of Elias Howard and Englishman Thomas saint in 1790.

The sewing machine has greatly improved the efficiency and productivity of the clothing industry.

Home sewing machines are designed for one person to sew individual items while using a single stitch type.

The different part of the sewing machine and its functions help the operator to know the functioning of a sewing machine. There are different types of sewing machine used in the manufacturing of garments.

A sewing machine controls the fabrics with feeding devices and forms a perfect stitch to join the fabrics. It has various parts and attachments, each of which have their own importance and use. There are mainly two categories of sewing machine that is, domestic sewing machine and industrial sewing machine. Figure.3.2.4 Sewing Machine.

F. Permanent Magnet dc Motor:

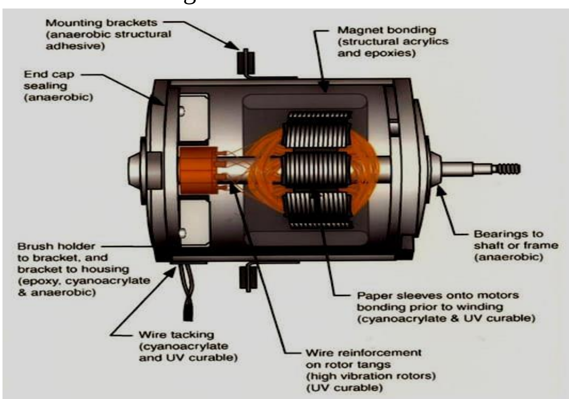


Figure f. PMDC Motor

A dc motor whose poles are made of permanent magnet is known as permanent magnet dc (PMDC) motor.

The magnets are radially magnetized and are mounted on the inner periphery of the cylindrical steel stator.

The stator of the motor serves as a return path for the magnetic flux. The rotor has a dc armature, with commutator segment and brushes.

In this paper we are using a PMDC motor for the purpose of regeneration of electrical energy. PMDC motor or direct current motor converts electrical energy into mechanical energy.

A PMDC motor is a fairly simple electric motor that uses electricity and magnetic field to produce torque which turns the rotor and give mechanical work.

The permanent magnet DC motor generally operates on 6v, 12v or 24v DC supply obtained from the batteries the axial current carrying rotor conductors and the magnetic flux produces by the permanent magnets results in the generation of the torque.

It was noticed that while a 1/12 HP universal motor consumed more than 100W to run a tailoring machine at nearly 1000-1200 SPM (stitches per minute) speed, the same results could be achieved by a 36W PMDC motor.Figure.3.2.5 shows block diagram of PMDC motor.

G. Adapter Ac to Dc:

Figure G. AC to DC adapter

An AC adapter, AC/DC adapter, or AC/DC converter is a type of external power supply, often

Other common names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, power brick, wall charger, and power adapter. Adapters for battery-powered equipment may be described as chargers or rechargers (see also battery charger).

AC adapters are used with electrical devices that require power but do not contain internal components to derive the required voltage and power from mains power. The internal circuitry of an external power supply is very similar to the design that would be used for a built-in or internal supply.Figure.3.2.6 shows the diagram of AC to DC adapter.

External power supplies are used both with equipment with no other source of power and with battery - powered equipment, where the supply, when plugged in, can sometimes charge the battery in addition to powering the equipment.

Use of an external power supply allows portability of equipment powered either by mains or battery without the added bulk of internal power components and makes it unnecessary to produce equipment for use only with a specified power source; the same device can be powered from 120 VAC or 230 VAC mains, vehicle or aircraft battery by using a different adapter. Another advantage of these designs can be increased safety; since the hazardous 120- or 240-volt mains power is transformed to a lower, safer voltage at the wall outlet and the appliance that is handled by the user is powered by this lower voltage.

H. Dynamo:

A dynamo is an electrical generator that creates direct current using a commutator. Dynamos were the first electrical generators capable of delivering power for industry, and the foundation upon which many other later electric-power conversion devices were based, including the electric motor, the alternating-current alternator, and the rotary converter. The Figure.3.2.7 shows the block diagram of dynamo ratings of 12V, 36W.

Dynamo is a device used to generate electricity. It works on the principle of magnetism which is called as induction. Dynamos are similar to alternators in the manner of operation with the only difference that a dynamo is equipped with a permanent magnet.

The dynamo produces alternating current at its output terminals due to the presence of the permanent magnet. There are two types of dynamos namely bottle dynamo and hub dynamo. Hub dynamo is also referred to as the bicycle dynamo since it is constructed by incorporating it into the hub of the bicycle.

On the other hand a bottle dynamo acts as a small generator which is fitted into the rear wheel of the bicycle. This is basically used for powering bicycle lights at night.

The rotation of the permanent magnet in the dynamo produces a varying magnetic field which generates electricity.

I. Pedal (controlling sewing speed):

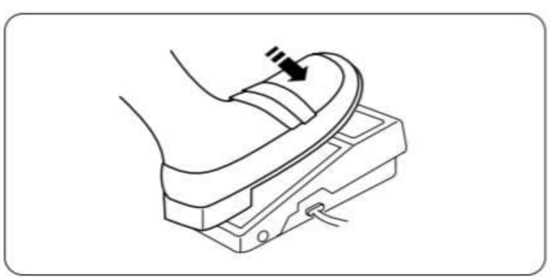


Figure I. *Pedal controlling sewing speed*

- Controlling Sewing Speed Depress the foot control to start the machine.
- The further down you press on the foot control, the faster the machine runs.
- The maximum sewing speed can be varied by the speed control pedal.
- This is working like accelerator in several types of vehicles.
- This is completely electrically operating accelerator type of speed controller.

IV. CIRCUIT DAIGRAM AND ITS EXPLANATION

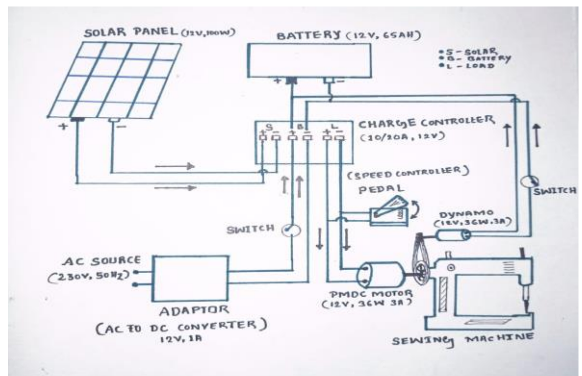


Figure 4.1 Circuit Diagram of Solar Powered Regenerative Sewing Machine using PMDC Motor

A. Proposed Work:

In this paperwork, the inefficient universal motor is replaced with PMDC motor (36W) and solar powered system. Solar panels of 100W with 65Ah battery were used to provide 21 hours of backup/day. If universal motor had not replaced with a PMDC motor then solar panels of 100W would have to be used and the system would have been doubled the cost. Hence it was important step to scout and implement a more efficient motor i.e. PMDC motor. A dynamo of 12V, 36W is mechanically coupled with PMDC motor which regenerate the power and directly connected to battery.

B. Role of Regeneration using PMDC Motor with Sewing Machine:

During the uncertain power cutouts regeneration solar sewing machine could regenerate electrical power for running light loads.

When there is no power available and the weather conditions are not suitable to generate electric power from photovoltaic solar cells then we can shift to manual mode of sewing machine so that the sewing machine will rotate the PMDC motor and the motor

will act as generator, then this power is used to run loads.
The main objective behind this regenerative part is to provide energy to communities without electricity supply or people deprived of electricity for the basic needs like electrical power for small electronic devices like charging a cell phone or glowing LED lamps during night or when needed or running other small appliances.
Normally sewing machines without any electric supply is used in the countryside. Hence the idea conceived is to generate DC with the rotation of the rotating ridged knob the belt of the machine.
The usage of this innovative experimental work will be for rural or tribal areas or islands remotely located area.
The major application will be for battery charging and lightning.
Any person with normal health condition will be able to run a sewing machine. The machine does not require any major modifications.
Hence solar powered sewing machine can easily use to regenerate electrical power.

C. Operation and working:
As we know, when the photovoltaic cells exposed to the sunlight, a solar board essentially is a p-n Semiconductor junction which gives dc power.
The charge controller for solar deals with the power moving towards the battery from the PV cells. It assures that there should not be any deep discharge of battery, and also not overcharged during the sunny days, it also uses a diode across the PV panel so that there should not be any reverse flow of current.
This controller helps in extending the efficiency of the power delivered to the load via This power then fed to PMDC motor which is then operated and produce enough torque and speed to drive the wheel of sewing machine. Hence the machine starts operating. The pedal controller plays an important role of controlling the speed of Sewing machine by controlling the speed of PMDC motor.
Dynamo is mechanically coupled with PMDC motor which regenerate the electricity and connected to the battery for recharge. Hence this increases the overall efficiency of the drive.

V. CALCULATION

Solar Panel Ratings: 100W, 12V
So, current rating =P/V =100W/12V =8.3A
Battery Ratings =12V, 65Ah

Time Taken To Charge From Solar Panel: T solar hours
Formula: IA × T hours = (IT) Ah
8.3A × T solar hours =65Ah
T solar hours=65Ah/8.3A =7.8 hours.
So, time taken to charge battery fully from solar panel is 7.8 hours.

Time taken to charge from dynamo =T dynamo h
Dynamo ratings: 36W, 12V, 3A
3A × T dynamo h = 65Ah
T dynamo h = 65Ah /3A =21.7 hours.

Time Taken To Charge Battery Fully From Adaptor: T adpt hours
Adapter ratings: 12V, 1A
1A × T adpt hours = 65Ah /1A = 65hours.

Time Taken to Discharge Battery Fully by DC Motor = T discharge hours
Motor ratings: 36W, 12V, 3A
3A × T discharge hours = 65Ah
T discharge hours = 65Ah / 3A= 21.7hours.

VI. FINANCIALS

The total cost of solar powering the whole system will be RS.18, 000. But this work could increase the revenues from RS.350–400 a day to RS.700–800 a day. Due to solar powering the setup, the electricity bill could come down by RS. 16 – 18 a month based on initial calculation. There has been a significant increase in income after solar powering the machine. Previously the poor power supply conditions restricted local tailor’s working hours to approximately 4 hours per day and this included an hour of manual pedaling. But after the intervention, they could work for 8 hours per day. Initially such local tailors were catering 2-3 customers per day and could get profits of about Rs.2000-2500 per month but after the intervention, they can cater to 6-7 customers per day and have the profit of about Rs.4500 to Rs.5000 per month and could also save Rs.16-18 on electricity bill per month.

VII. PHOTO OF GROUP

VIII.CONCLUSION

The solar powered regenerative sewing machine using PMDC motor has many applications in tailoring, in small scale industries as well as in large scale industries. This paper establishes the actual operation of the hardware with relative costing and shows the advantages of intervention over manual sewing machine. Hence this paper shows that PMDC motor saves more electrical energy and hence more efficient that traditional universal motor which would help to local tailors to earn more profits.

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