Volume 1, Issue 3, December, 2012
Energy and Environmental Engineering Journal

Analysis, Modeling and Development of Manual Charkha Based Power Generation System

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Abstract
This paper presents the analysis & development of Manual Charkha Based Power Generation System as there is a requirement to supply the rural areas of India with reliable electricity. Local institutions like Panchayats might play an important role in the implementation, operation and maintenance of the proposed power generation system. The unregulated voltage generated by the proposed power generation system has been regulated with the help of electronic circuits.

Keywords: DC generator; prime mover; voltage regulator

1 Introduction

Most of the rural areas of India don't have reliable access to electricity [1]. The cost of installation and maintenance of transmission lines in these areas is quite high due to low population densities. Some of these areas won't have access to reliable electrical power even in the next ten years [2]. Therefore alternate means of generating electrical energy will have to be utilized at local level. One such alternative is to produce electrical energy using Manual Charkha Based Power Generation System.

India has abundant manpower. This can be utilized in the generation of electrical energy. A wheel coupled to an electric generator may be rotated to produce electricity. However, the revolutions per minute (rpm) required by the generator prime-mover is quite high for obtaining the suitable at armature terminals. This problem can be solved by using a gear-system or by using wheels of different radii. As the gear system leads to considerable increase in weight of the apparatus. Hence, wheels of different radii are employed.

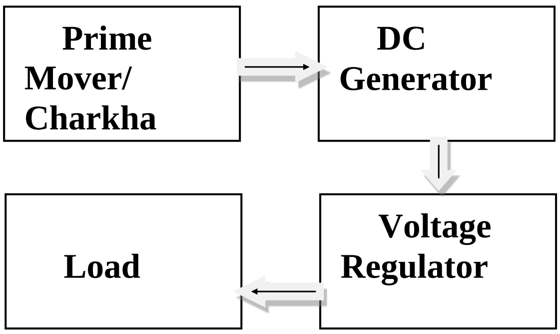

Figure 1 Block diagram of the Proposed Power Generation System

This power generation system can be used to provide energy to light loads such as lighting, mobile charging, i-pod charging, charging of flashlights etc. However these equipments require constant voltages. Hence a constant voltage regulator will have to be used such as 78XX. Mobile-charger will require 7805 to obtain a constant voltage.

2 Energy Scenario in Rural India

Rural population constitutes 70% of India's population hence there is approximately 120 to 140 million families or households of which 30%-40% approximately is without electrification [approximately 20 million households according to a report], from this it could be inferred that an enhanced living standards at 1kW/household at 4 hours usage per day draws 105MWh per year/house hold which is over 250MW approximately for household consumption sector alone.

Rural electrification in India has suffered badly over the last decades mainly because of the poor operational and financial health of SEBs [3]. Moreover, the use of electricity in rural areas for households and other productive purposes such as small industries are rather limited. Rural people are often not in a position to afford the cost of electricity and they meet their basic energy needs through the use of energy sources like firewood, cow dung, agricultural residue and kerosene [4]. However, inefficient exploitation of these resources has led to environmental degradation. An action plan on 100 percent village electrification within the next 6 years has been prepared in which rural electrification would be treated as a basic minimum service under the Prime Minister Gramodya Yojana. Other elements of the action plan include; setting up credit support from Rural Electrification Corporation to SEBs for speedy electrification in the backward areas, improving the quality of power supply in villages by strengthening the distribution network, earmarking a sum of at least Rs. 750 Crores out of the Rural Infrastructure Development Fund for rural electrification works and augmenting the resources of REC by allowing it to float capital gains tax exemption bonds.

The features of rural electricity viz, low and dispersed loads, high T & D costs and seasonality of the load favors decentralized power plants for meeting rural electricity needs in a sustainable manner. Local institutions like Panchayats might play an important role in the implementation, operation and maintenance of the proposed power generation system. This will not only minimize transaction costs but also minimize transmission and distribution costs.

3 Manual Charkha Based Power Generation

A spinning wheel or charkha is a device for spinning thread or yarn from natural or synthetic fibers. The earliest clear illustrations of the spinning wheel come from Baghdad (drawn in 1237), China (1270) and Europe (1280), and there is evidence that spinning wheels had already come into use in both China and the Islamic world during the eleventh century. According to literature, the spinning wheel was introduced into India from Iran in the thirteenth century. The spinning wheel replaced the earlier method of hand spinning with a spindle. The first stage in mechanizing the process was mounting the spindle horizontally so it could be rotated by a cord encircling a large, hand-driven wheel. The great wheel is an example of this type, where the fiber is held in the left hand and the wheel slowly turned with the right. Holding the fiber at a slight angle to the spindle produced the necessary twist. The spun yarn was then wound onto the spindle by moving it so as to form a right angle with the spindle.

Hand powered spinning wheels are powered by the spinner turning a crank for flywheel with their hand, as opposed to pressing pedals or using a mechanical engine. The table-top or floor charkha is one of the oldest known forms of the spinning wheel. The charkha works similarly to the great wheel, with a drive wheel being turned by hand, while the yarn is spun off the tip of the spindle. The floor charkha and the great wheel closely resemble each other. With both, the spinning must stop in order to wind the yarn onto the spindle.

The charkha (etymologically related to Chakra) was both a tool and a symbol of the Indian independence movement. The charkha, a small, portable, hand-cranked wheel, is ideal for spinning cotton and other fine, short-staple fibers, though it can be used to spin other fibers as well. The size varies, from that of a hardbound novel to the size of a briefcase, to a floor charkha. Mahatma Gandhi brought the charkha into larger use with his teachings.

He hoped the charkha would assist the peoples of India achieve self-sufficiency and independence, and so used the charkha as a symbol of the Indian independence movement and included it on earlier versions of the Flag of India.

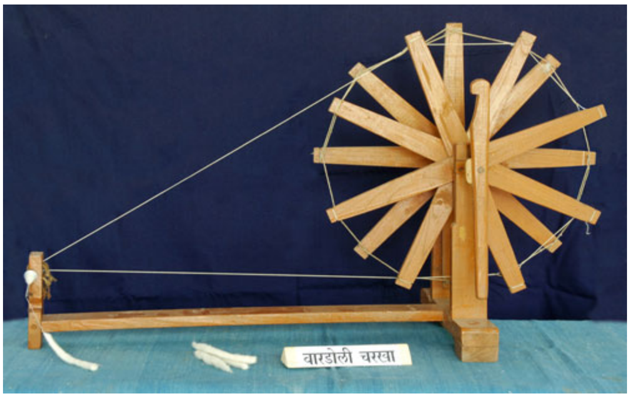

Figure 2 Traditional Charkha

3.1 Observation Table of rpm of Generator and Output Voltage

Table 1 RPM of Generator and output Voltage

RPM of Generator	Output Voltage (V)
645	5.00
750	6.28
775	6.50
910	7.50
950	7.85
1030	8.00
1105	8.55
1193	9.00

Hence for E=7.50 V, rpm= 910

3.2 Calculation of Various Radii

D1 - Diameter of wheel on which manual power is applied

D2 - Diameter of wheel directly below the handled wheel

D3 - Diameter of wheel coupled with the second wheel

D4 - Diameter of wheel attached with PM dc generator

N1 - input mechanical rpm

N2 - rpm of wheel having diameter D2

N3 - rpm of wheel having diameter D3

N4 - required rpm of PM dc generator

Because of same linear velocity

$$\pi D4*N4=\pi D3*N3$$

Hence, N3 = (D4/D3)*N4

Our generator has D4=2.4 cm

For voltage=7.5 V, the reqd. rpm = 910

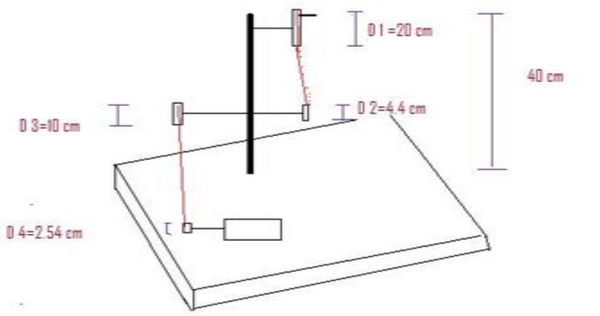

Figure 3 Diagrammatic Representation of Multi-Wheel Charkha

Therefore, N3=2184/D3

Now, N2=N3

Hence, D1=2184 X (D2/D3)/N1

Assuming N1=50 rpm

D1D3/D2=43.6 cm

We choose,

D1=20 cm D2=4.6cm D3=10 cm

4 Experimental Setup

The design of the proposed power generation system has been developed in the laboratory by following the above given parameters and by implementing the circuit given below.

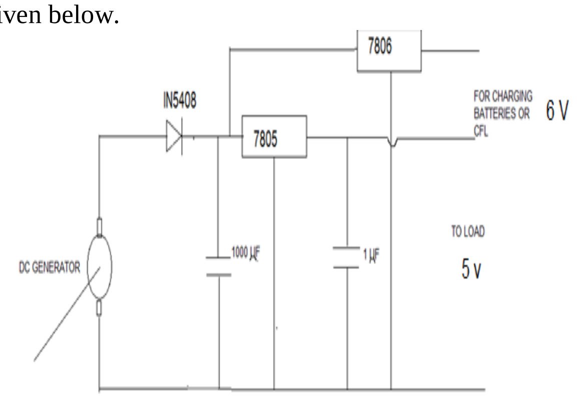

Figure 4 Circuit Diagram of Manual Charkha Power Generation

The various components used in the above circuit are

1. Voltage Regulators- 7805 and 7806
2. Capacitors- 1000 µF and 1 µF
3. Diode- IN5408
4. DC Generator

The proposed model of manual based power generation system is shown below.

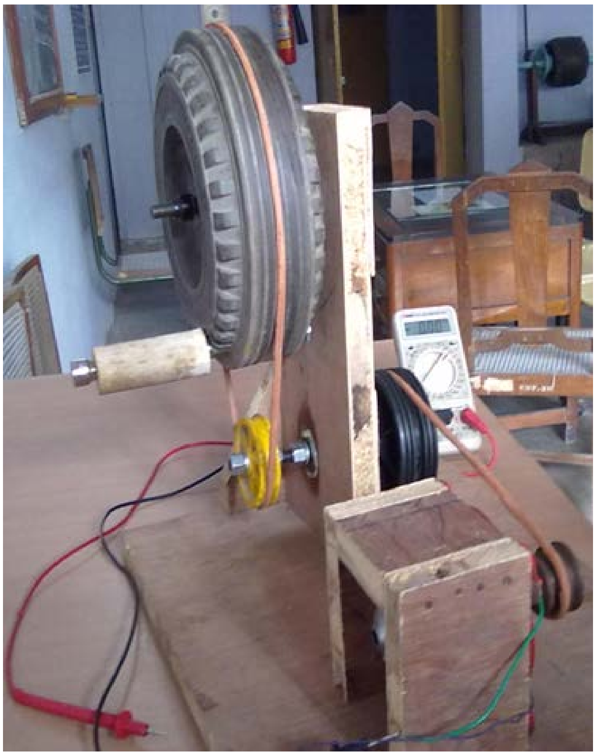

Figure 5 Model for Charkha Based Manual Power Generation System

5 Results

The developed model has been tested in the laboratory and the results are tabulated below. As shown in the Table 2, the regulated voltage is 5 Volts which is the requirement for all mobile charging units.

Table 2 Unregulated and regulated Voltage

RPM of Generator	Unregulated Output Voltage (V)	Regulated Output Voltage (V)
645	5.00	4.97
750	6.28	4.97
775	6.50	4.97
910	7.50	4.98
950	7.85	4.98
1030	8.00	4.98
1105	8.55	4.98
1193	9.00	4.98

6 Conclusion

The analysis and the experimental results of the proposed power generation system show that this system can be used in rural/remote areas for low power applications. The proposed system may be installed easily and economically in remote locations with the help of the local committees like panchayats etc. as the system exhibits high performance and low cost to be implemented. It is reliable, simple, and an excellent option to be employed for low power applications. Many countries have enormous manpower in rural areas, so this research is very significant.

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