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HARVESTING HUMAN EXERCISE POWER USING GYMNASIUM BICYCLE

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Abstract: This paper emphasizes on the idea of finding out the probability of the human muscle power as a non-conventional source of power which are now being wasted while people in the gymnasiums are exercising to lose extra energy of their body. A field research has been done on gymnasiums and peoples who are going to gym. Among various exercising equipment's authors main concern about the stationary bikes, this converts human muscle power into rotational mechanical power. Design and implementation of complete system to producing power in order to burn calories and a charge controller to store the generated power in 12V 55Ah battery is presented in this paper. Thus developed system is safer and power efficient to be used economically at the gymnasiums.

Keywords: *power, Bicycle Exercise, Gymnasium, Battery charging*

1. INTRODUCTION

Energy is everywhere in the environment surrounding us and is available in many forms. Capturing this energy and converting it to electrical energy has been the subject of many research investigations. To meet the worlds increasing energy needs, many companies around the world are investing in the research and development of environmentally sustainable technologies. This research has progressed in the fields of solar, wind and nuclear energy. However, there exists a large untapped source of dissipated energy that has potential to help solve this energy problem. Every day, gym goers produce lots of energy just by doing their daily workout on exercise equipment. This energy, if used as an alternate to fossil fuels could supply clean sustainable energy. However, this energy is produced in mechanical form rather than electrical form, but slight modifications to the exercise equipment would allow the energy being produced to be converted to electrical energy which can be harvested, and stored for a later time. The concept of harvesting energy from an exercise machine was introduced by a Hong Kong gym called „California Fitneśs [1]. Since then, there have been three establishments in the United States that have been working to commercialize this technology [2].

This paper focuses on large scale power generation from the gymnasium stationary bicycle and also finds out its commercial probability as a secondary power source in local gyms. A field research is done on different gymnasiums at Chittagong city on the basis of number of members, working hours, number of bikes available in the gymnasiums, secondary power sources used during load shedding, monthly electric bill, average members per day, daily load shading time and members uses the bike etc. detailed design and construction of the system has been done to convert the people muscle power into electrical power. Performance analysis of the system has been done in terms of individual component efficiency. Cost analysis for implementation of the complete system and feasibility to setup this system in gymnasium is also presented in this paper.

2. IMPLEMENTATION

The bicycle is one of the most efficient uses of the human body's existing musculature and the ergonomic position allows for nearly everyone to utilize. A stationary bicycle is designed to convert human energy into mechanical energy for loosing extra energy. The complete system is consists of four parts as shown in Fig. 1. Firstly, the mechanical energy is translated into electrical energy through the use of coupling belt turning an alternator. A three phase 500W, 220V, 50Hz permanent magnet

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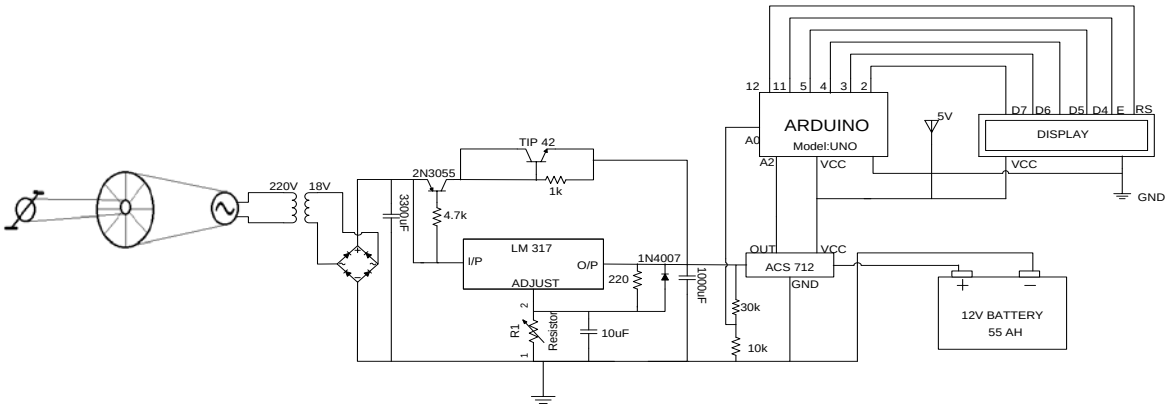

Fig. 1: Circuit Diagram of complete system.

alternator is used due to low loss and less complexity. The coupling belt is rubber made to prevent slip loss. The stationary bike have gear system that can adjust the range of RPMs and makes initial pedaling easier. The user is able to start softly and increase the resistance as momentum is gained.

Secondly, as a 220V alternator is used for power generation a transformer was needed to step down the generated voltage to fade into the charge controller circuit. It has several tapings at both high voltage and low voltage side. In this system 220/18V taping is used. A bridge rectifier circuit is used to converter AC input power into DC output power.

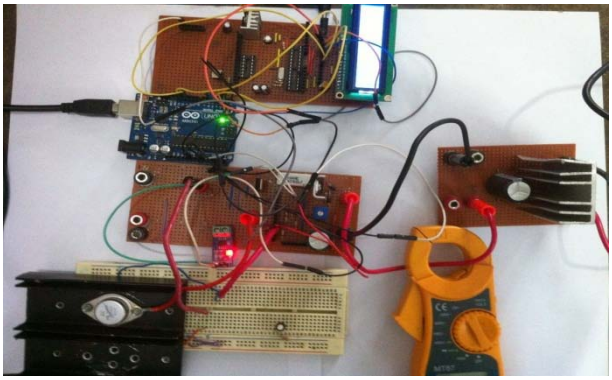

Fig. 2 Implemented Charge Controller

Thirdly, a charge controller circuit is used to convert the dc power into a precise form to be stored efficiently. The designed and implemented charge controller circuit is shown in Fig. 2. The charge controller circuit provides adjustable output voltage. Finally a 12 Volt Lead acid battery is used to store the generated electrical power.

An ACS712 current sensor and a voltage divider are used to measure current and voltage respectively. The large current is drawn by the 2N3055 power transistor. The values are calculated by an ARDUINO(UNO),then it shows the voltage, current, pedaling time and the calorie burned by the user into a LCD display. Thus extra instrument is not required to measure the calorie burned by the user.

3. RESULTS AND DISCUSSION

Validating the system efficiency of a power-electronics circuit is essential in evaluating the overall system performance, design optimization, and sizing of cooling systems. At first efficiency of all the individual components are measured to determine the overall system efficiency.

3.1 Transformer Efficiency

Since a 240VA, 220/18V step down transformer was used; the output voltage and current on the secondary side are 18V and 7.07A respectively. The output power of the transformer is 127VA. The output power is (127/240) = 0.52 times of the rated output. Thus transformer is running at half of its rated full load with unity power factor as the battery is considered as an almost resistive load (except the smoothing capacitor) [4]. Copper loss, W_{cu} = 12.5Watt and core loss, W_i = 6.5Watt are measured from short circuit test and open circuit test respectively. As the transformer is running at half of its rated output, the efficiency is 92.78% . The overall loss of the transformer is 7.22%.

3.2 Alternator Efficiency

To measure the efficiency of the alternator 750 watt dc motor was used as the prime mover. The input power of the prime mover is measured from the voltage and current using a voltmeter and dc ammeter. Subtracted the coupling belt loss from the dc motor input power the input power of the alternator is found. To measure the coupling loss speed and torque of both dc motor and alternator is measured. DC motor and generator coupling efficiency is 97.42 %. DC motor and generator coupling loss is 2.58%.

3.3 Coupling Belt Efficiency

A good coupling may have an efficiency of above 98% [5]. From this setup the coupling belt efficiency is 98.36% and coupling belt loss is 1.64%.

3.4 Cycle Gear Efficiency

At a gear ratio of 3.33 the gear has an efficiency of = 93% [6]. Gear loss is 7%.

3.5 Circuit Efficiency

The efficiency of the rectifier circuit and charge controller circuit is measured at different input and output condition and average efficiency is found equal to 7.74%.

Table 1 Gymnasiums Survey Table

Name	Number of members	Working hour (hour)	Number of bikes	Secondary power source	Monthly electric bill (primary+ secondary) tk	Average members per day	Daily load shading time(hour)	Members uses the bike	Average cycling time (minutes)
1.Fitness Zone	400	15	1	Generator	5000+2000	120	4	50	20
2.Muscle Blast	300	14:30	0	battery	5000	65	2		
3.Lift &Life fitness center	33	13:30	2	battery	40000	22	0	22	20-25
4.The Life style	416	16	2	battery	5000	40		15	20
5.Power Fitness	100	16	0	generator	3000+300	80	3-4		
6.Saikot gym	170	12	1	generator	3000	45	3-4	15-20	20-25
7.Chitttagong multi-sport	160-170	16	0	battery	4000	60	1		
8.Universal Fitness Zone	300	15:30	3	battery	2500	100-110	4-4.5	30-40	30
9.Exercise Zone	800	15	0	battery	3000+400	200-250			
10.Alvira's	300	15	8	generator	88000	170	3	120	20-30

3.6 Overall System Efficiency

The complete efficiency of the system is found by subtracting all losses and it is equal to 48.02 %.

3.7 Outcomes of Gym Survey

Outcomes of the gym survey in the Chittagong city is presented in Table 1. From the survey chart it is found that The average pedaling time per person is about 20 minutes. The average number of member's per day at the gum is about 100.The average number of members per day pedal the bike is about 50.So, daily pedaling time per gym is 1000 minutes.

From experimental setup, the output voltage stays constant at, V = 14.4V.The output average current, I = 4.4A.The average output power, P = V× I = 14.4×4.4 = 63.36 Watts. From this output power daily a gym can harvest 1.056 kWh energy having a market price of Tk. 9.58 [7]. So from the proposed setup the monthly saving is Tk. 303.3. According to Body Building Association of Bangladesh there are more than 100 gymnasiums in the Chittagong city. From whole Chittagong city the monthly savings is Tk. 30349.4

4. CONCLUSIONS

The bike, the stand is already available in the gyms. Again most gyms use IPS as their secondary power source, so they already have the battery. These three items are already available at the gyms. These items cost 71% of the total system cost. Considering from this point of view a gym having these items will have to spend Tk. 12030 for the complete set up and this money will return in something more than in 3 years. This research aimed to design and implement a human exercise power system using gymnasium bicycles. The research goal was to charge a 12V, 55AH battery. This goal was accomplished within the constraints of a low production cost and high safety. The conversion efficiency was less than 50% due to huge loss in alternator. By changing this alternator the efficiency can be increased. In short, the research was a success in proving the concept that electrical energy can be harnessed from human power, specifically in the gymnasiums. This prototype was successfully able to meet most of the requirements established at the beginning of the research and therefore proves the concept of generating electrical power from a stationary exercise bike. This method may also be implemented by trade mill in gymnasiums. Thus a large amount of electrical power can be generated from a city like Dhaka or Chittagong. Thus electrical power generated due to calorie burn of people using gymnasium bicycles not only saves money but also provides safe, green and reliable power to the consumers and also reduces pressure on the national grids.

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