Design and Development of Mechanism for Harvesting Energy from Gym Equipment

Harshith R.Reddy[1] Karthik Kapur[2] Raghav Nandakumar[3] Ravi Kiran V V[4]
[1,2,3]BE Student [4]Assistant Professor
[1,2,3,4]Dayananda Sagar College of Engineering, Banglore-78 India

Abstract— The energy crisis in today's world and the growing impact of electricity production on the environment is a topic of grave importance. There is an urgent need to find alternate ways of producing electricity and finding ways to harvest energy from renewable sources of energy. Many innovative concepts are being worked on currently to achieve this. One such idea is to recover the energy expended by humans while working out in a gym. There are many commercial products that generate electricity from machines like elliptical trainers and gym cycles, etc., but none for the cable and pulley machine. This project aims to create a mechanism to harvest energy from any cable and pulley machine in a gym. The mechanism will be an easy retrofit onto current equipment eliminating the need to purchase a new machine altogether.

Key words: Harvest Energy, Gym Equipment, Working Out, Cable and Pulley Machine

I. INTRODUCTION

Already the world's third-largest emitter of carbon dioxide and other greenhouse gases, India is attempting to do something no nation has ever done: build a modern industrialized economy, and bring light and power to its entire population, without dramatically increasing carbon emissions. Simply to keep up with rising demand for electricity, it must add around 15 gigawatts each year over the next 30 years. The country gets most of its electricity from aging, dirty coal-fired plants. (It has little domestic production of oil or natural gas.) And its energy infrastructure is in dismal shape. The obsolescence of its power grid was demonstrated by a massive 2012 outage that left more than 600 million people in the dark and drew attention to a utility sector in disarray, with an estimated $70 billion of accumulated debt.

If current trends continue and India follows the traditional path in which emissions increase as living standards rise, it will be disastrous not only for Indians but for the entire planet. China is now the world's largest emitter of carbon. India's per capita emissions as of 2012, the last year for which figures are available, were 1.68 tons per year, and its 2014 GDP was $1,631 per person. Its population is expected to grow by another 400 million people over the next three decades, bringing it to 1.7 billion by 2050. If India follows a path similar to China's, that will add another eight billion tons of carbon to the atmosphere each year—more than total U.S. emissions in 2013. By 2050, India will have roughly 20 percent of the world's population. If those people rely heavily on fossil fuels such as coal to expand the economy and raise their living standards to the level people in the rich world have enjoyed for the last 50 years, the result will be a climate catastrophe regardless of anything the United States or even China does to decrease its emissions. Reversing these trends will require radical transformations in two main areas: how India produces electricity, and how it distributes it.

We all know that fitness exercise equipment help us stay fit and healthy. But what about the energy that is consumed while is using those equipments? On one hand, the energy we release during exercise goes untapped while on the other, we use external energy to run the fitness equipment. Until late 2014, although the technology to retrofit exercise equipment to send electricity back to the grid existed, it was not cost effective to do so. You would have to purchase regular equipment and then retrofit it. Although the power output for fitness equipment can't be compared apples to apples with solar or wind due to the limitations of human power (and motivation), it is important to remember this is exercise equipment, and there are already millions of exercise machines in use all over the world. Nothing needs to be done to get ready for this power source, except wait until the current equipment needs to be replaced. We don't need to purchase land and build large structures to harness this energy. The gyms have already been built. Its better than Solar/Wind where you need to get permits and pay professionals to install.

II. OBJECTIVES

A. *Primary Objectives*

- Develop a mechanism to generate electricity from cables and pulleys machine
- Harvest electricity produced to help power the gym

B. *Secondary Objectives*

- Reduce costs by saving electricity consumed to power the gym from the grid
- Generate a current proportional to the effort exerted, as far as possible

III. PROBLEM IDENTIFICATION

The field of energy conservation is becoming an increasingly notable subject of research among the scientific community today. Over the past decade, scientists and engineers around the world have been designing unprecedented energy-harvesting systems, drawing power from a variety of sources. One of the most creative and unlimited sources available is the kinetic energy produced from human exercise. Although recent designs of energy-harvesting exercise equipment have been introduced into the market, these systems are costly and do not produce a noticeable output of power. These systems need to be improved and designed for maximum power output, cost-efficiency, and marketability.

IV. METHODOLOGY

As the main concern is to make the mechanism common among the range of cable and pulley machines. The problem

that is encountered is that the current design is applicable to only gym cycles and cross trainers and as a result, design improvement is required. This requires adequate information about the various gym equipment such as dimensions, type and amount of usage. This information would enable us to modify the designs to retrofit it to cable and pulley machine. Once that is studied, Specifications of mechanism can be developed. Based on these values, alternate mechanisms can be designed. The alternate designs are then analyzed and evaluated to obtain the expected output.

The concepts that were used for the project were:

- Concept 1: Derailleur sprocket and chain
- Concept 2: Multiple gear trains
- Concept 3: Simple Dynamo coupling
- Concept 4: Simple Gear Train Mechanism
- Concept 5: Complex Gear and Gear Train Mechanism

The concept 1 was selected because of the cost effectivity and performance of functions.

V. DESIGN AND DRAFTING

After identifying the most efficient concept, new designs were developed. The different type of designs that were created are:

A. Design 1 (Derailleur Sprocket Mechanism)

The dynamo is coupled to a gear and sprocket mechanism with a derailleur to multiply rotations as well as to convert effort applied by the user into usable power by increasing load with decrease in sprocket diameter. It is shown in figure 1.

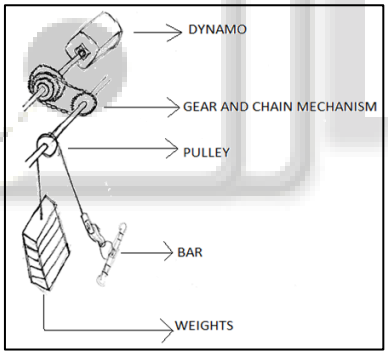

Fig. 1: Design 1

VI. DESIGN SKETCHES

The prototype of the concept selected has been sketched with fixed dimensions based in the available material obtained from the market. The front view and the top view of the sketches are shown in figure

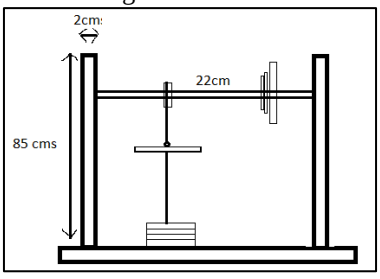

Fig. 2: Front View

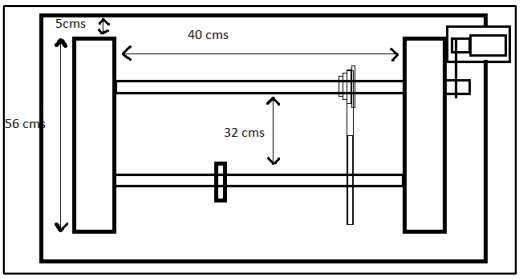

Fig. 3: Top View

VII. TESTING

In our testing procedure we conducted three main tests, in order to determine the output current per cycle in relation to load applied, the output voltage in relation to the load applied by connecting a multimeter in series with the output of the Dynamometer and also a test to determine the current generated in a real world case by measuring the time required to complete a complete cycle on the machine. The results of the tests are given below.

A. Output RPM

The time taken for the user to pull the bar down (downward travel) and to traverse back (Upward Travel) to the initial position has been determined by timing users in existing gyms. These times are listed below.

- Time taken for downward travel = 4s
- Time taken for reverse travel = 1s
- Total time taken = 5s
- Total cycles per minute = 12

GEAR	DRIVEN GEAR	DRIVE PULLEY	DRIVEN PULLEY	SPEED-UP GEARBOX	ROTATIONS PER MINUTE
1	4.106	4.106	7.134	107.01	1284
2	4.775	4.775	8.300	124.50	1494
3	5.475	5.475	9.520	142.80	1713
4	6.375	6.375	11.09	166.35	1996
5	7.175	7.175	12.48	187.20	2246
6	8.201	8.201	14.26	213.90	2567

Table 1: Output RPM

B. Voltage

In the equipment developed, each gear adds resistance which is in turn adding load to the user. The load obtained in each gear versus the voltage obtained in that gear with certain load has been noted down and the results have been tabulated for 3 gears in the table 2 and figure 2.

GEAR	LOAD	VOLTAGE
2	25	8
	26	10.6
3	31	18.4
	32	19.5
	34	20.2
4	36	21.3
	38	22.1

Table 2: Voltage vs Load

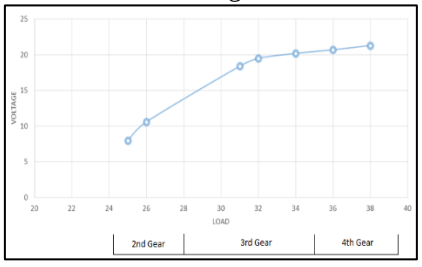

Fig. 4: voltage vs load

C. Current

The Load obtained in each gear versus the current obtained in that gear with certain load has been noted down and the results have been tabulated for 3 gears in the table 3 and figure 3.

GEAR	LOAD	CURRENT
2	35	1.48
	40	1.64
3	42	1.82
	43	1.95
	48	2.20
4	49	2.37
	51	2.49

Table 3: Current vs Load

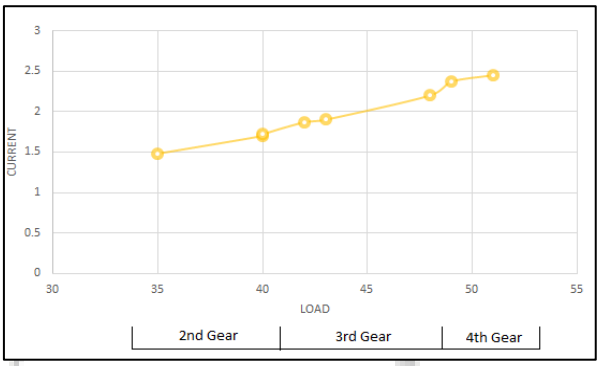

Fig. 5: Current vs. Load

VIII. Results and Discussion

From analysis, it was observed that for Design 1, the average current generated per minute was about 1.13 kW per hour. Among all the designs, the relative cost versus output ratio was the highest for this design.

The design has a good factor of safety and the output is sufficient to charge a battery and power basic appliances like lights.

The cost incurred in making the demonstration model is about Rs. 13,000/- and the expected monthly savings on electricity bills is about Rs. 3,500/- per month.

IX. Conclusion and Scope for Future Work

The design can be further improved by implementing a mechanism to convert bi-directional half rotations to unidirectional complete rotations, of the dynamo. This will ensure uniform current generation from the generator so long as the machine is being used. The machine can also benefit from the use of a dynamo rated at a higher value.

This machine, coupled with the devices already available on the market for generating power from the other equipment like elliptical trainers, gym cycles, rowing machines, etc, in a gym will produce a significant amount of energy from just a single day of usage.

The advantage to having such a huge population is that a small effort by each individual can lead to a significant change. If all our country's gyms can be set up with regenerative equipment, a significant amount of non-renewable resources can be saved, not to mention the environmental impact.

References

[1] https://www.technologyreview.com/s/542091/indias-energy-crisis/
[2] http://www.thegreenmicrogym.com
[3] Elizabeth Huber, Richie Sanchez, Shin Sato - The Power Workout: Converting Exercise into Electrical Energy
[4] Justin Harkaki, Praveen Lawrence, Audrey Nakamura " Energy Harvesting From Exercise Machines" Cal Poly Recreation Center Implementation June 8, 2010
[5] Adam Blechman, George Braker, Brad Chodnicki - A Study of the Benefits of Retrofitting Cardiovascular Exercise Equipment of a Gym with Human Energy Harvesting Technology.
[6] Nicholas Keith Lovgren - Energy Harvesting from Exercise Machines: Forward Converters with a Central Inverter.
[7] Faruk Yildi, Mohammed F. Fahmy "Self- Powered Fitness Equipment'' the Technology Interface, Vol. 10, ISSN# 1523-9926, 2009.
[8] Rerev.com
[9] http://www.gyre9.com/portfolio-item/the-green-revolution/
[10] http://www.electricaleasy.com/2012/12/basic-construction-and-working-of-dc.html
[11] https://en.wikipedia.org/wiki/Derailleur_gears

