Section A-Research paper

ECO-FRIENDLY ELECTRICITY GENERATION VIA GYM EQUIPMENTS

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Abstract:

The majority of recently developed technologies are fully dependent on electricity to function properly, hence the need for energy is rising daily. The development of humans has been greatly influenced by energy. The scientific community is turning its attention to renewable energy sources because conventional energy sources like coal, natural gas, and fossil fuels are finally running out. This study proposes a theoretical model of the Energy Generating Gyms System (EGGS), which will contribute its share to the renewable energy industry. People in today's society are concerned about their health and use gym equipment to practise activities that will help them reach their desired level of fitness. In a gym, numerous machines are physically operated by users exerting effort on the devices. The concept behind smart EGGS is that human energy used on gym equipment should be transformed into electrical energy. Smart EGGS will produce clean, sustainable, and renewable electrical energy. According to research for smart EGGS, people are also a source of renewable energy, and the chemical energy they possess can be turned into electrical energy [1]. EGGS will be tremendously helpful for nations who are suffering from severe energy difficulties. The combined output of all the gym equipment will provide the necessary quantity of electrical energy for the equipment. It is possible to resell extra electrical energy to a utility [2].

Key Words:

EGGS, Renewable energy, smart grid, EGGM, Gymnasium, Lat Pull down machine, DC motor, Prime Mover, unidirectional Pulley, Generator, Inverter.

1. Introduction:

The environment we live in is undergoing substantial change, and technology is becoming one of the main forces behind societal and economic advancement. Information technology (IT) has advanced quickly over the world, changing not just how people think but also how they behave. Since electricity is

used to power almost all modern technology, its share of the primary energy supply is growing more quickly than electricity.

In the present world, everyone is highly concerned about their health, thus they all join gyms to raise their level of fitness and burn calories. It is conceivable to build equipment for gyms that can transform the energy people consume during exercise into electrical energy_[3]. Producing energy-generating gym equipment for cardio charge and lightning is The Great Outdoor Gym (TGO) enterprise in the United Kingdom (UK). The Cardio Charger is a piece of mobile phone charging equipment. Sir George Monoux College, Trafalgar Square, and the Green Heart in Hull City all have green energy-generating exercise equipment installed by TGO. The Cross Trainer, Recumbent Bike, Spinning Bike, and Hand Bike have all been upgraded by TGO to green energy gym equipment, which generates an average of 50 to 100 watts per piece of equipment depending on the user's fitness level and offers a cardiovascular exercise. In 2015, there was 9,384 metric ton oil equivalents (MTOE) consumed globally as final fuel, and by 2040, that number will rise to 10706 MTOE. From 23.4 trillion kilowatt hours (kWh) in 2015 to 34.0 trillion kWh in 2040, the global net power generation grows by 45 %. Fossil fuels continue to be the primary source of energy in the world, accounting for 32.9% of all energy use, according to the World Energy Council. The possibility for renewable energy sources will be increased by the EGGS concept, which will generate electricity from the machinery in a gym's moving parts.

The best source for creating environmentally friendly, renewable energy is sunlight. To meet the energy needs of contemporary society, there are numerous techniques to collect and use solar energy. In nature, photosynthesis is the process.

by which solar energy enters and permeates the food web and food chain. Plant leaves, green algae, and other creatures like cyanobacteria naturally employ a process called photosynthesis to transform light energy into chemical energy that may then be released and used as an energy source by those organisms to power their activities. Carbohydrates like sugars, which are created from CO2 and water, are used to store the chemical energy that has been transformed. In addition to producing fuel, photosynthesis also produces oxygen as a byproduct. The advantages of simulating photosynthesis can be beneficial to all life on Earth in two ways. In this natural cycle, there are producers and energy converters.

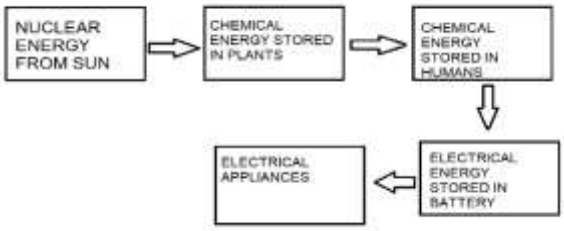

Fig -1: Human body converts solar nuclear energy into electrical energy.

Food (glucose) is produced using water and sunlight, consumed by people, and the chemical energy of this food is transformed into mechanical energy for use in practical work. With the use of EGGS, this mechanical energy can subsequently be transformed into electrical energy. The sequential steps of turning solar nuclear energy into electrical energy are shown in Fig. 1. The definition of energy is the capacity for work, and the human body is incredibly rich in energy, which powers daily tasks [4].

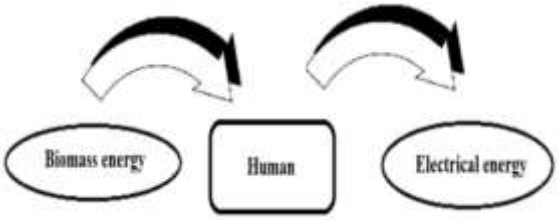

Fig -2: Human as a transducer

2. Proposed work

The graph of energy demand is rising daily, and scientists are looking into new technologies and energy sources to meet this demand. In this essay, we will talk about a technique for using human energy. As illustrated in Fig. 3, the proposed method considers humans to be a machine or devices for converting biomass energy into electrical energy. A transducer is a device that changes one type of energy into another type of energy. Man consumes calories from food and uses them for work, but if his diet is out of balance, too many extra calories will be stored as fat in his adipose tissues, giving him a chubby appearance. People attend gyms where they engage in various forms of exercise like running, weightlifting, and muscle building in order to maintain a healthy appearance and level of fitness. For example, cable preacher curls, close grip bar curls, barbell curls, and dumbbell lifting are some biceps exercises that can be performed on specific machines. Barbell bench presses, flat bench dumbbell presses, low inclined barbell presses, seated machine presses, and others are chest exercises. Cables and pulleys are used in the construction of several of the cardiovascular devices seen in gym equipment. The main focus of this research is on these machines since they can help capture energy. As energy consumption rises daily, it is essential to develop new methods and strategies for producing energy in constrained spaces, such as a house or a gym.

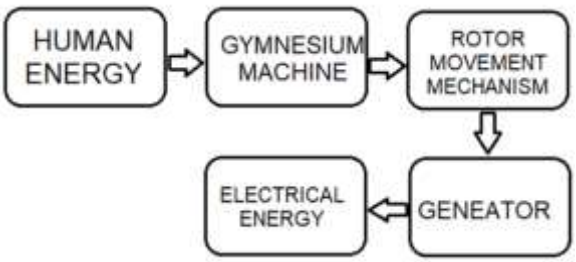

Fig-3: conversion of human energy into electrical energy

People exert effort on machines and use energy to work while exercising in a gym. The authors of this suggested work offer a theoretical method that will allow for the energy harvesting of specific gym equipment. The fundamental concept behind the research is to capture electrical energy from the moving components of gym equipment [5].

2.1 Installation of low RPM generator

A generator produces voltage by revolving at a slow speed while having a large winding.

By including rotor movement mechanisms in the generators, gym equipment can be connected to generators.

2.1.1 Generator components

Rotor/Armature: The generator's rotating armature has wires wound on it. Every time the gym's machine is used, the armature of the Low RPM generator rotates.

Stator: The stator is the stationary component of a generator and is formed of a permanent magnet or an electromagnet wound around a stator coil.

2.1.2 Bidirectional to Unidirectional Gear (BUG) PRIME MOVER:

it is simply a gear system that takes input rotation of both directions, but the output will be in a single and same direction either the input is anticlockwise or clockwise rotation. It contains three pulleys which are connected in the following way.

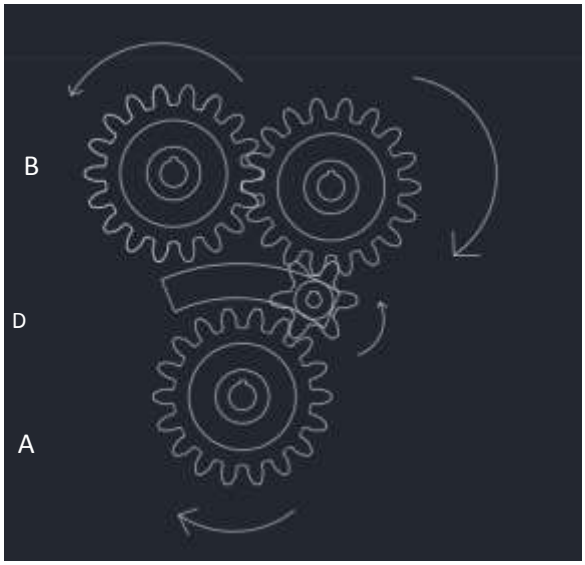

Fig-4: bidirectional to unidirectional gear system

2.1.3 Connection of BUG and generator

The pulley of the gym equipment is connected to pulley A of the gear system (BUG) and the generator is connected on another side of the gear to either pulley B or pulley C. Pulley B and pulley C rotates opposite to each other, but their rotation is unaffected by the direction of rotation of pulley A.

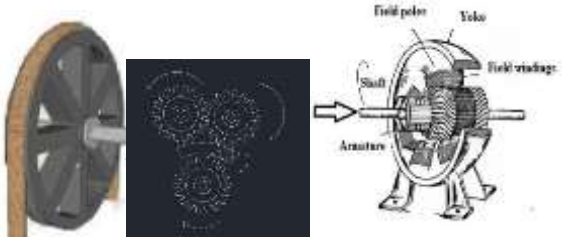

Fig-5: Connection of pulley and generator

2.1.4 Machine rotation of the armature

The grip of the recoil cord will be hooked to the gym equipment, and the rotor movement mechanism will be attached to the generator's shaft. Every time a gym machine is used, the recoil rope on the generator shaft winds and unwinds. When a cord is released, the spring's restoring force causes it to the wind once more. Only clockwise or anticlockwise rotation is made by the generator's armature.

2.1.5 Generator

An electric generator is a device that converts mechanical energy to electrical energy in electricity generation. A three-phase 750W, 220V, 50Hz permanent magnet alternator is used to generate electricity from kinetic energy. Around 2500-3000 RPMs the output current begins reach to its maximum potential [6].

Fig-6: Generator

2.1.6 Recoil spring

Recoil spring is a mechanism that stores energy while rotating and gives out energy by rotating in opposite direction.

Fig-7: Recoil spring

2.1.7 BATTERY

The battery is the most important to provid power for the alternator rotor and the storage purpose of generated power. An electric battery is an advice consisting of one or more electrochemical cells which will convert stored chemical energy into electrical energy. A positive terminal, or cathode, and a negative terminal, or anode, are found in each cell. Electrolytes allow ions to move between the electrodes and terminals, which allows current to effuse of the battery to perform work Battery we used is 12V, 10 Ah rating [6].

2.1.8 Inverter circuit & step-up transformer

The inverter converts DC voltage to AC voltage and a step-up transformer is a type of transformer that stepped up the AC voltage. In this system, the inverter circuit converts 12V DC to 15V AC. Step-up Transformer makes the voltage to 250 V AC from 15 V AC [6].

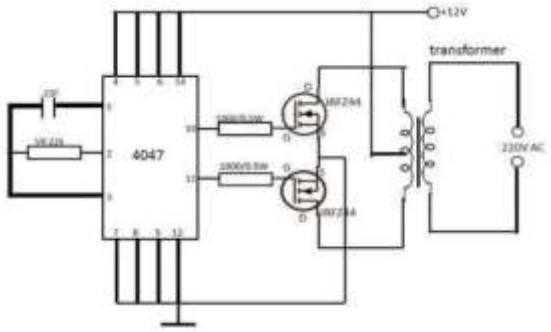

Fig-8: Inverter circuit & step-up transformer

2.2 Energy generating gymnasium machines (EGGM)

1) Lat pull down machine

Latissimus Dorsi, the name of the muscle, is abbreviated as "Lat" in English. Latissimus dorsi muscle development is the goal of the late pull-down machine.

The only components of a pull-down machine are pulleys and metallic cables. The user applies force to the cable's opposite end, which is coupled to an adjustable weight, to lift the weight. Depending on the type of activity, the cable may be dragged up or down. A multipurpose machine used to strengthen the biceps, triceps, shoulders, and legs, the working principle of the lat pull-down machine is shown in Fig. 9. The generator should connect to each stable pulley with the help of BUG and all the generators should be connected in a parallel way to the rectifier. This maintains the voltage constant and adds the current [7].

Fig-9: Lat pull down machine.

2) Butter fly

It goes by the name "butterfly arms" and is typically a standalone apparatus in a gym. The butterfly machine provides good exercise for the shoulders and chest. The purpose of the operation is to build up the chest muscles.

Operation: While seated, place your hands or forearms on the longboards. After pulling your arms together, open up your chest to release the tension.

Slowly revert to the starting position. By adding a low RPM generator, as shown in Fig. 10, it is feasible to transform the butterfly machine into an energy-generating device.

Fig-10: Butterfly gym equipment

3) Leg press machine

The leg press is a well-liked and straightforward exercise that can assist develop important leg muscles.

Fig-11: Leg press machine

The user sits on the machine with his head and back resting pleasantly against the padded support. Legs should form an angle of 90 degrees at the knees when feet are placed on the footplate, with heels kept flat. Knees should not be bent inward or outward and should be in line with the feet. When pressing, be sure to

maintain this alignment and refrain from raising your bottom off the seat. For a comfortable position, the seat is mobile. These offer assistance during the motion and aid in maintaining the proper alignment of your head and spine. A typical error that will ruin one's form is placing the hands on the knees. By adding a pulley, a recoil rope, and a generator in the machine's basement, as shown in Fig. 11, a leg press machine can also be turned into an energy-generating device. Every time a machine is turned on, the recoil rope over the pulley rotates the generator's armature.

4) Leg curls extension machines

A Leg curl machine is used to work out the muscles in the back or posterior of the leg, primarily the hamstrings. The leg extension machine makes the legs straighten against load resistance and thus works the muscles on the front or anterior of the leg called the quadriceps.

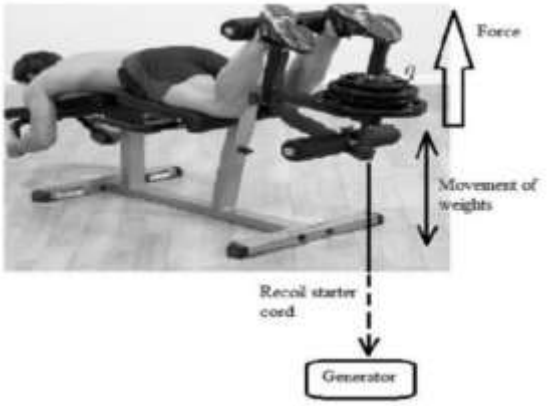

Fig-12: Leg curl machine

Quads: When we utilize the leg extension machine, the quadriceps muscles are engaged. The rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius are the muscles that make up this group. The rectus femoris is the muscle that is most active during a leg extension exercise. The vastus medialis then contracts at the motion's conclusion when your knee is almost straight. Targeting the quadriceps muscle in the legs, the leg extension is a weight-resistance exercise.

Hamstrings: The muscles in the back of the thigh contract when using a leg curl machine to bend the knee. The biceps femoris, semimembranosus, and semitendinosus are the three muscles that make up the hamstrings. The biceps femoris is the largest of the three.

Calves: The gastrocnemius and the soleus are the two muscles that make up the calf; however, the gastrocnemius, which is the most superficial, is the one that is used most frequently during leg curls. When utilizing either of the leg curl machines, it spans the back of the knee and supports the hamstrings. Utilizing a device known as the Leg Extension Machine, the exercise is performed.

5) Stationary bicycle

A stationary bicycle, commonly referred to as an exercise bike or a spinning bike, is a basic device composed of a saddle, pedals, wheels, chain, and possibly handlebars mounted on the frame of a bicycle. The stationary bicycle's rider rotates the pedals, which causes the wheel to spin. Less body fat should be seen in riders after regular riding machine training. The front tire of a stationary bicycle is connected to a generator in such a way that the coils of wire within the generator rotate between the poles of the magnets [7]. By coupling the generator's shaft to the spinning wheel, which causes the generator's armature to

rotate, a stationary bicycle can produce energy. This process is shown in Fig. 13. Due to the load on the generator in this design, more force will be required to spin the bicycle's wheel. In comparison to a leg extension machine, the generator's load will feel like a weight that the rider must lift. Battery packs are then used to store the electrical energy (power packs). A stationary bike is another energy-producing workout equipment (EGGM) [4] [6].

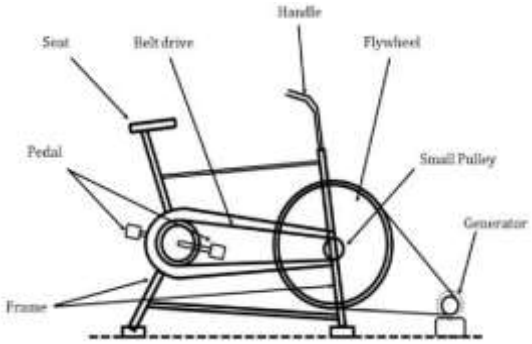

Fig-13: Stationary bicycle

3. SCOPE OF EGGS

In developing nations where young people are becoming more health concerned, the idea of an energy-generating gym system has a lot of potentials. The EGGM system will be able to cover a fair part of a single gym building's electrical needs.

Customers can use microgrids to return excess electricity from distributed energy sources (DES) to the utility under the emerging smart grid system for power distribution in the twenty-first century (MG). The reliability of the system is increased by MG, which is a compact collection of interconnected power generating and control technologies that can function either as part of or apart from a central grid. These systems can be more adaptable than conventional grids by enabling the incorporation of distributed generation (DG), such as wind and solar. As a foundational element for a potential low-voltage distribution system, the MG concept was first put forth in 2002. It was built on the concept of combining many micro sources (Renewables) and loads into a single distinct entity that, from the perspective of the overhead power system, might be understood as a single dispatchable prosumer [8]. The two main distinctions between an MG and a regular power plant are that MGs have a much smaller capacity compared to big conventional power plants and that electricity produced at distribution voltage can be directly fed into the utility distribution network. An MG's technological attributes make it ideal for distributing electricity to rural sections of a nation when access to the national grid system is either complicated by topology, harsh weather conditions, or artificial interruptions [9]. The fundamental benefit of an MG from a grid perspective is that it is regarded as a controllable entity inside the power system [9] [10]. From the perspective of the users, MG is advantageous for locally satisfying their electrical and heating needs and can deliver uninterruptible power, enhance local dependability, lower feeder losses, and provide local voltage support [9]. To run the AC appliances, direct current (D.C.) must first be converted into alternating current (A.C.) using an inverter as mentioned in 2.1 installation of the rpm generator [4].

4. MODELLING & ANALYSIS

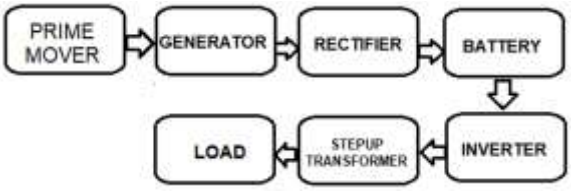

Fig-14: Block diagram of the proposed system.

i. For Stationary bicycle:

The alternator reaches its Maximum Potential at 25003000 RPM let's assume 30 rpm avg. speed of the pedal, so,

Alternator pulley speed (N) = 30 rpm × 5 × 3 × 3 × (3 / 2) × (4 / 3) = 2700 RPM

But coupling belt loss is 4.22% and gear loss is 7%. Subtracting coupling belt losses and gear losses we get 2400 RPM. That's enough to get average potential from the alternator. Normally, a gymnasium consumed 1000 units per month approximately. So,

Load demand (1000/30) /24 = 1.34 kWh.

The average number of members per day at the gym is about 200. The avg. number of members per day pedal the bike is about 60.

Pedalling time per mankind is about 20 minutes. So, the daily pedalling time per gym is 1200 minutes.

The output avg. current, I = 4.5A The output average voltage, V = 15V The average output power,

P = V× I = 15×4.5 = 67.5Watts.

A gym may capture 1.35 kWh of energy each day from this output power. This is enough energy to keep the lights on during load shedding or other maintenance.

EFFICIENCY: The force on the alternator shaft is 6.2 N. Alternator shaft diameter is 0.0254 m So, Torque (T) = F r sinθ = 0.1574 N-m Now, Power = Torque × Speed (rpm)/9.5488 = 39.56 watt

The mechanical input power is 39.56 watts. The obtained output power is 67.5 watt.

Overall efficiency = (output power / input power) × 100% = 58.62%

When all losses are subtracted from the total efficiency of the system, it equals 58.62 percent [6].

ii. For other equipments:

Similarly, we can generate electricity from other gym equipments via above mentioned setups.

5. APPLICATIONS

This project helps to lower the demand for energy. The electricity produced by this initiative will run the lightbulbs, tubes, laptop and mobile phone chargers, among many other things. This technology will assist in the requirement because certain areas are struggling with a lack of electricity. This project also benefits mountainous regions where access to electricity is challenging.

6. AKNOWLEDGEMENT

Prof. Dr. Jyoti Dhanke, Assistant professor, Department of engineering science, Bharati Vidyapeeth College of Engineering, Lavale, Pune, our internal guide and helper has worked very hard to help us mould our ideas and knowledge to match the project requirements. She has helped us complete every project milestone, stood by us when a project fails, and bolstered our confidence when a project succeeds.

7. CONCLUSION

By modelling each gym machine as an EGGM, this paper addressed the evolution of gym equipment. Although speculative, this discovery is a crucial first step toward a new method of producing energy with the help of people. Local DG of electricity through RES integration is the answer to the depletion of energy resources. Humans are regarded as a RES in the proposed research because EGGM would be powered by human labour. And the pulley will make this process easier as it takes input in both directions and gives single unidirectional output.

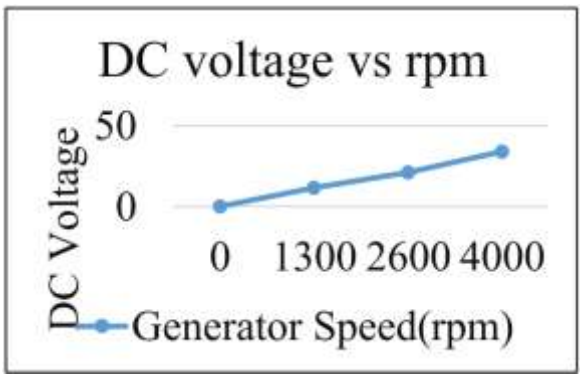

Fig-15: Graph of voltage vs rpm

AUTHORS CONTRIBUTIONS

Dr. Jyoti Dhanke: Supervision.

Hrishikesh Bhavar: Writing articles, Writing- original draft.

Sifan Momin: Concepts

Harshal Patil: Data gathering

Akshay redekar: Validation

Dr. R. N. Patil, Avinash Dadge, Dr. Narayan Phadatare, Prof. P. Pawar : Visualizations.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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