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PowerLift: Generating Energy through Gym

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ABSTRACT

As the need for sustainable energy solutions increases, this study investigates a new method for combining fitness with renewable energy production. The suggested system transforms human physical effort in exercise into electrical energy by utilizing a lat pulldown machine linked to a pneumatic energy collection device. A piston-cylinder apparatus compresses air while the user raises and lowers weights, storing it in a pressure tank. The compressed air is subsequently expelled through a turbine that powers an alternator to produce alternating current (AC) electricity. The produced AC is converted to DC, stored in a battery bank, and subsequently transformed back to AC with an inverter for distribution to the grid. The generated energy is saved in batteries or capacitors and can be used to power the gym's lighting, HVAC systems, or even fed back into the local power grid. A power tracking system is incorporated to oversee electricity generation, connecting energy output to specific users via RFID or biometric verification. Users are motivated by a reward program, where energy contributions result in reduced gym fees. This system encourages physical exercise while also improving energy sustainability by decreasing the gym's dependence on traditional power sources.

Keywords- *Energy Conversion, Gym Machine, Electricity Generation Through Gym Machine*

INTRODUCTION

This system integrates fitness with the generation of sustainable energy by capturing the mechanical energy produced during lifting weights. It employs a piston mechanism to compress air, which is subsequently stored in a tank. The stored compressed air is then released to activate a turbine, which drives an alternator to produce electricity. This electricity is stored in a battery and can be converted into usable power for the electrical grid.

The initiative seeks to promote physical activity by providing incentives, such as reduced gym membership fees for individuals who participate in energy generation.

By engaging in workouts, participants can lower their annual membership expenses, thereby encouraging both fitness and renewable energy practices. This method offers a distinctive means of supporting sustainable energy while promoting a healthier lifestyle. It resonates with the increasing focus on renewable energy sources and energy efficiency. The system delivers a dual advantage: improving physical health while benefiting the environment

PROTOTYPES

Design 1—Using Gearbox

In this gym's wrist curl machine, traditional weight stacks are replaced with a gearbox system consisting of multiple gears connected to an alternator to generate electricity. As the user increases the gear ratio, the final gear spins faster, enabling the alternator to produce more energy. The system is designed to capture the user's effort while curling the wrist upward, causing the gears to turn and power the generator. When the user releases the handle, counterweights return it to its original position, rotating the gears in the opposite direction and generating additional electricity. This innovative design replaces conventional weights with a gear-driven mechanism and efficiently captures energy from both the curling and releasing motions.

Design 2—Using Rack and Pinion

In this design, a wrist curl gym machine replaces traditional weights with an energy-producing mechanism using a rack and pinion system. The setup features a horizontally mounted linear rack that drives a pinion gear connected to an alternator. As users perform the wrist curl motion, the handle's upward movement activates the rack, causing the pinion to rotate and generate electricity. When the handle is released, counterweights return it to the starting position, moving the rack in the opposite direction and producing additional energy. This dual-phase energy harvesting approach ensures maximum efficiency and reduced mechanical complexity, delivering a smooth and effective workout. The system enhances user engagement through energy conversion while promoting sustainability in fitness equipment by capturing kinetic energy during exercise.

Design 3—Using Compressed Air

In this cutting-edge wrist curl gym machine, mechanical movement is converted into air compression through a piston-cylinder setup linked to a resistance system. When the user curls the handle upward, the resistance mechanism activates, causing a piston to compress air within a horizontally aligned cylinder. As the user releases the handle, the resistance system resets, drawing fresh air into the piston chamber, preparing it for the next repetition. This consistent process compresses air with every cycle of the wrist curl movement.

The compressed air is channeled through a pipeline into a storage tank, where a pressure sensor monitors air levels. A safety valve ensures that excess pressure is safely released if it exceeds the designated threshold. Once the tank reaches the target pressure, a one-way valve opens, allowing the high-pressure air to flow toward a turbine. The fast-moving air spins the turbine blades, converting air pressure into rotational mechanical energy. This energy is then transferred to an alternator, which generates AC electricity.

The produced AC power passes through a rectifier to convert it into DC power, which is stored in a battery bank. When needed, the DC power can be converted back to AC using an inverter, supplying electricity to the gym or feeding it into the power grid. A power monitoring system tracks the energy generated by each user, awarding energy points that can be redeemed for discounts or rewards, encouraging participation.

Regular maintenance ensures the proper functioning of the piston system, air tank, turbine, alternator, and electrical components, while the incentive program is regularly updated to keep users engaged with their energy contributions.

METHODOLOGY

Step-by-Step Procedure for Energy Generation from Wrist Curl Machine

I. Mechanical Motion to Air Compression

A piston-cylinder setup is linked to the weight stack of the wrist curl machine. As the individual curls the weights upward, the weight stack rises, causing the piston to compress the air inside the cylinder. When the individual lowers the weights, the weight stack descends, allowing fresh air to enter the piston for the next cycle. This process of air compression happens consistently with each exercise cycle.

II. Storing Compressed Air in the Tank

The compressed air from the piston travels through a pipeline to a storage tank designed for compressed air. A pressure sensor within the tank continuously monitors the air pressure levels. A safety valve is included to release any excess pressure if it surpasses the safe threshold.

III. Converting Compressed Air into Mechanical Energy

Once the storage tank reaches the preset pressure level, a one-way valve opens, allowing the compressed air to flow out. The air is then directed towards a turbine connected to the system. The high-velocity air flows over the turbine blades, causing them to spin, which converts the air pressure into rotational mechanical energy.

IV. Mechanical Energy to Electrical Energy

The turbine shaft is connected to an alternator, which transforms the mechanical energy into alternating current (AC) electricity. A power meter measures the AC electricity produced during this process.

V. Power Conditioning and Storage

The AC power generated by the alternator is passed through a rectifier, which converts it into direct current (DC) electricity. This DC power is then stored in a battery bank. When required, the stored DC energy is converted back into AC power by an inverter. The AC power is either used for gym operations or fed into the power grid.

VI. Incentivizing the Exerciser

A power tracking system logs the electricity generated by each user. Users are awarded energy points based on the amount of energy they produce. These points can be redeemed for coupons or discounts on their annual gym membership fees. The gym can display real-time data on the energy produced by users, encouraging healthy competition and active participation.

VII. Maintenance and Monitoring

Routine checks on the piston system should be conducted to ensure there are no leaks or wear and tear. The compressed air tank must be inspected to ensure it meets pressure safety standards. The turbine, alternator, and electrical systems should also be regularly checked for proper functioning. The incentive system should be refreshed and users kept informed about their energy contributions.

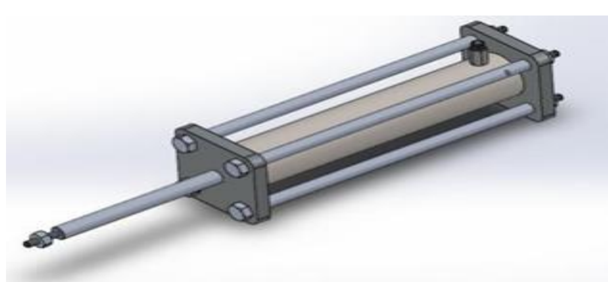
This setup not only promotes fitness but also contributes to sustainable energy generation.

COMPONENTS REQUIRED

1. Wrist Curl Machine

Function: Provides resistance for forearm exercises while powering the piston mechanism.
Working: The user curls the wrist handle upward against the resistance system, triggering the movement of the piston. As the resistance mechanism engages, the piston compresses air within the cylinder. When the user releases the handle, the resistance system resets, allowing the piston to return to its original position. This back-and-forth motion compresses air in the piston-cylinder setup with each repetition.

2. Pneumatic Cylinder Piston



Function: Converts the mechanical motion of the lat pull down machine into compressed air.
Working: The piston is attached to the weight stack of the lat pull down machine. When the user pulls the bar, the piston descends, compressing air within a sealed chamber. When the user releases the bar, the piston rises, enabling fresh air into the cylinder. This procedure is repeated, resulting in continuous compressed air production.

3. Compressed Air Tank.

Function: Its purpose is to store compressed air for use in powering the turbine at a later time.
Working: Compressed air from the piston is delivered to the air storage tank via pipes. The tank stores air until it reaches a predetermined pressure limit. A pressure sensor measures the air pressure within the tank. When the tank is full, the system releases a valve to let air into the turbine. If the pressure exceeds the safety limit, a safety valve opens to expel the extra air.

4. One-Way Valve

Function: Prevents backflow and guarantees that compressed air only flows in one direction.
Operation: The valve opens to release air towards the turbine when the tank's air pressure reaches a high level. The valve automatically shuts off when the air passes it, preserving tank pressure. By doing this, compressed air cannot return to the piston system.

5. Air Turbine (Forward Curve Impeller Blade Turbine)

Function: Converts compressed air energy to rotational mechanical energy.
Working: Upon opening of the valve, compressed air is let through nozzles and high-speed airflow is produced. This airflow creates forces on the turbine

blades which causes them to rotate; the rotating energy of the turbine then drives the alternator.

6. Dynamo

Function:It converts the mechanical rotation from the turbine into electrical energy, typically in the form of DC power.

Working:The turbine's rotating shaft is connected to the rotor of the dynamo. As the shaft spins, it causes a coil (or armature) inside the dynamo to rotate within a magnetic field.

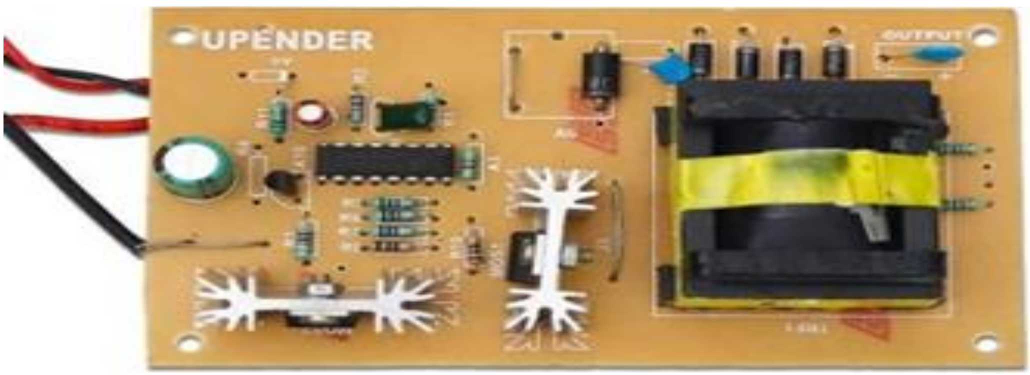
This movement induces an electric current in the coil through electromagnetic induction, generating direct current (DC) electricity. The output depends on the turbine's rotational speed and the volume of compressed air driving it.

7. Battery

Function: Stores DC electricity.

Working: The rectifier feeds DC electricity into the battery. The battery keeps energy in chemical form. When needed, the system pulls the stored DC power from the battery and sends it to an inverter to change back to AC. The battery makes sure power keeps flowing even when nobody's working out.

8. Inverter



Function: Changes DC power stored in the battery to AC power for the electrical grid.

Working: DC power from the battery goes into the inverter. The inverter uses switching circuits Fig – Wrist Curl Machine

DESIGN AND CAD MODELING

AutoCad

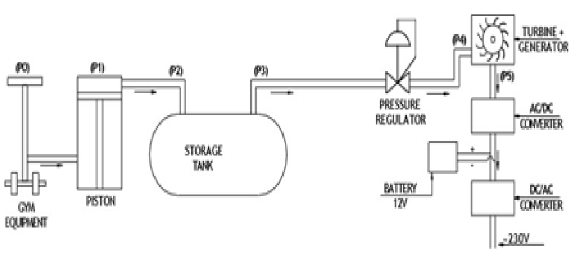


Fig - Map of project setup

Solidworks

Fig – Wrist Curl Machine

Fig – Compressed Air Storage

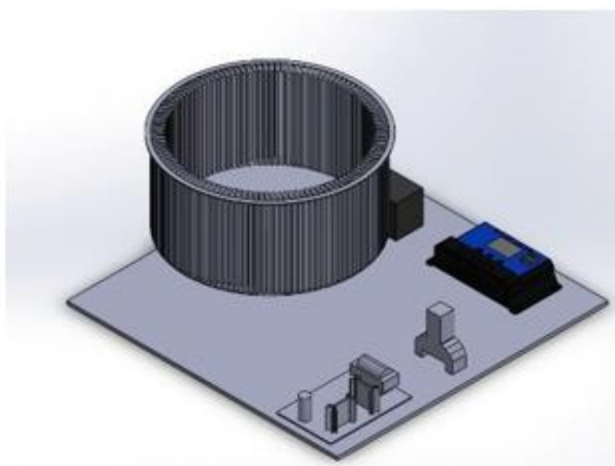
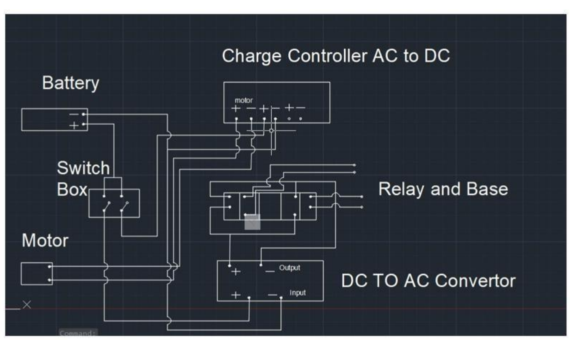


Fig – Rotational Energy Converted into Electrical Energy

Circuit Diagram



CALCULATIONS

Mechanical Work Calculation

Pressure And Volime Of Air Displaced Per Stroke Calculation For Piston

Piston dimensions: = 20 x 160 where, lenght of piston = 160mm

= 0.16m

bore diameter of piston= 20mm

= 0.02m

mass of dumbell for the gym equipment= 4 kg now,

For Pressure per stroke,

we require force and area, hence from the equation

$$P = \frac{F}{A}$$

Where Force= m x g

m= mass of dumbell= 4kg g= gravitational force= 9.81

F = 4 x 9.81 = 39.24 N

Area= r^2

radiusofpiston = r = 0.01m

= $3.14x(0.01)^2$

= 3.14x10−4m^2

Pressure becomes,

$$P = \frac{F}{A}$$

$$P = \frac{39.24}{3.14 \times 10^{-4}}$$

P = 124904.77N/mm^2

= 124904.77Pa

= 18.22psi

= 1.24Bar

= 0.124MPa

Volume of air displaced per stoke V = A X L

=r2XL

= $3.14x(0.01)^2$x0.16

V olumePerStroke = 5.026x10^{-5}m3

volume Per Stoke in litres comes out to be, V = 50.26 X 10^{-5} X 1000

= 0.05026Litres

Total number of strokes to fill up the compressor tank

Now, total number of strokes required to fill 30 liter storage tank,

For this,

total volume= 30 liters

pressure getting transferred to storage tank= 1.24 bars volume per stroke = 0.0502 litre

As per assuming,Temperature rises upto 40c as pressure increases in the storage tank

So we need

Real Gas Law,   PV = ZnRT Z = Compressibility factor

for z > 1, gas is hard to compress, hence requires more strokes.

So for 8 bar pressure and assumed temperature 40 °C Z = 1.066

here we are assuming temprature in the storage tank reaches upto 40C

Storage tank temprature = 40C = 313K

Assumption,

Practically if the temprature rises in the storage tahnk, then pressure also rises without re- quiring more air bieng

compressed.
But this is temporary.
By Gay Lussac's Law, P/T = K(Costant) P1/T1 = P2/T2
P1/295 = 8/313 P1 = 7.5 Bar
So, we will reach the requirement of 8 Bar within 7.5 bar only, if the temprature increases in tank.
Now, total volume required to fill air of 8 Bar pressure,
Vtotal = V X IN (P1/P0) Vtotal = 30 x IN (8/1.24) V = 55.92 Litres
Now we need to take value of Z = 1.066 as it is real gas
For real gas, Vtotal x Z
55.92 x 1.066
= 59.27

Total Number of strokes required are

$$= \frac{57.23}{0.0502}$$

= 1180.67 strokes

Therefore, for filling up a 30L tank, 1180 strokes are required.

Efficiency of the setup from piston
Efficiency

$$= \frac{idealstroke}{actualstroke}$$

$$= \frac{1140}{1415}$$

= 0.8339
= 83.39

Electrical Work Outout Calculations
Battery Charging Current and Battery Charging Time formula
Charging Time of battery = Battery Ah / Charging Current

$$T = \frac{Ah}{A}$$

Example,
Assume for 8 Ah battery,
First of all, we will calculate charging current for 8 Ah battery. As we know that charging current should be 10 so charging current
for120Ah Battery = 8 x (10/100) = 0.8 Amperes.

but due to losses, we can take 0.6 – 0.8 Amperes for charging purpose. suppose we took 7Amp for charging purpose, then charging time for 8 Ah battery
= 8 / 0.7 = 11.42 = 12 Hrs. but this was an ideal case.

practically, this is noted that 40 % of losses(in case of battery charging)
then,
8 x (40 / 100) = 3.2(8 Ah x 40% of losses)
therefore, 8 + 3.2 = 11.2 Ah (8 Ah + Losses) Now Charging Time of battery = Ah/Charging Current 11.2 / 0.7 = 16 Hrs (in real case)

Therefore, an 8Ah battery would take 16 Hrs for completely charging (with 0.7A charging current).

Battery Chemistry Lead Acid (VRLA) Battery Cell Size 12V Voltage - Rated 12V Capacity 7Ah Size / Dimension 5"* 3"* 5" H Termination Style Spade,

.187" (4.7mm) Discharge Rate 2Hr Standard Charge Current 1.0 Ah Standard Charge Time 4.5H Weight 4.2 kg

PROJECT MODEL

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