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Power Generating Knee straps with Hints at End

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ABSTRACT: Human power is an attractive energy source. Muscle converts food into positive mechanical work with peak efficiencies of approximately 25%, comparable to that of internal combustion engines. while a typical mobile phone consumes a modest 0.9 W electrical requiring a 18 g Li-ion battery for 3 hours of talk time, a typical laptop computer requires a 720 g Li-ion battery to satisfy its 28 W electrical power needs, lasting less than 4 hours. The power generation which is designed to fit onto the outside of the knee, is circular and consists of two spur gears. The spur gear rotates as the knee joint goes through a walking motion. The knee itself is an ideal starting point for energy generation as it has a large change in angle during walking and does so at significant speeds. A spur gear attached to the joint could therefore generate large amounts of power.

Key words: Pyro electric, DC motor, Battery, Heel strike etc.

I. INTRODUCTION

From mobile phones to laptop computers, society has become increasingly dependent on portable electronic devices. Because batteries almost exclusively power these devices, and the energy per unit mass in batteries is limited, there is a trade-off between device power consumption, battery weight and duration of operation. This trade-off is particularly severe in the design of powered prosthetic joints that need to be lightweight while performing their sophisticated task over a full day of typical use. The manufacturers of the C-leg, Rheo Knee and Proprio Foot indicate that their devices operate for more than 36 hours from a single charge of a battery that weighs about 230 g battery equating to an average power consumption of less than 1W electrical. Substantial improvement to the operating time or performance of a portable device, while avoiding the unattractive solution of simply heavier batteries, requires an alternative to current battery technology.

A. Pyro electric

The pyro electric effect converts a temperature change into electric current or voltage. It is analogous to the piezoelectric effect, which is another type of ferroelectric behaviour. Pyro electricity requires time-varying inputs and suffers from small power outputs in energy harvesting applications due to its low operating frequencies. However, one key advantage of pyro electrics over thermoelectric is that many pyro electric materials are stable up to 1200 ^{0}C or higher, enabling energy harvesting from high temperature sources and thus increasing thermodynamic efficiency.

B. Heel strike

Several devices have been built to generate energy from heel-strike motion. Some devices use the energy from the relative motion between the foot and the ground during the stance phase (the phase in which the foot is on the ground). Others use the energy from the bending of the shoe sole. In both cases, the device aims to use the energy that would otherwise have been lost to the surroundings. An example of such a device is a hydraulic reservoir with an integrated electrical magnetic generator that uses the difference in pressure distribution on the shoe sole to generate a flow during the gait cycle.

II. LITERATURE SURVEY

A. Literature Survey

A team of scientists from the U.K.'s Cranfield University invented pizzicato knee-joint energy harvester. The result is a wearable piezoelectric device that converts knee movement into electricity but it is not produce higher energy densities. The research community, within both academia and industry, has been addressing these problems. They are invented new gadget called biomechanical energy harvester. It is consist of the some gear attached through micro-generator. The gear and micro-generators is that use to produce electricity.

Part of the mass and the mechanical complexity was due to the implementation of gears which increase the rotational speed of the electromagnetic generator to increase its efficiency.

B. Vibrational Energy Harvesting Using Mems Piezoelectric generators (2009)

In recent years, energy harvesting using piezoelectric materials has become a very popular research topic. Various device sizes and structures have been tested, but it is difficult to compare power measurements as device fabrication and experimental methods vary from paper to paper. In an effort to standardize comparisons in spite of these changing parameters, the dependence of generator power output on device dimensions has been investigated. Though MEMS scale devices have been produced, comparatively little work has been done using aluminum nitride (AlN). This project utilizes AlN due to its ease in processing and potential for on-chip integration. By operating at a MEMS scale, the benefit is that arrays of piezo generatorscan be placed on the same die. With the process advantages of AlN, a long term goal of an integrated power-harvesting chip becomes feasible. However, theoretical results of scaling predict that raw power output and even power per unit volume will decrease with scaling.

C. RF-based Wireless Charging and Energy Harvesting Enables New Applications and Improves Product Design (2012)

RF energy is currently broadcasted from billions of radio transmitters around the world, including mobile telephones, handheld radios, mobile base stations, and television/ radio broadcast stations. The ability to harvest RF energy, from ambient or dedicated sources, enables wireless charging of low-power devices and has resulting benefits to product design, usability, and reliability. Battery-based systems can be trickled charged to eliminate battery replacement or extend the operating life of systems using disposable batteries. Battery-free devices can be designed to operate upon demand or when sufficient charge is accumulated. In both cases, these devices can be free of connectors, cables, and battery access panels, and have freedom of placement and mobility during charging and usage.

D. Kinetic energy-harvesting shoes a step towards charging mobile devices (2011)

Although you may not be using a Get Smart-style shoe phone anytime soon, it is possible that your mobile phone may end up receiving its power from your shoes. University of Wisconsin-Madison engineering researchers Tom Krupenkin and J. Ashley Taylor have developed an in-shoe system that harvests the energy generated by walking. Currently, this energy is lost as heat. With their technology, however, they claim that up to 20 watts of electricity could be generated, and stored in an incorporated rechargeable battery.

III. HARDWARE DESCRIPTION

In this chapter the block diagram of the project and design aspect of independent modules are considered. Block diagram is shown in fig.1:

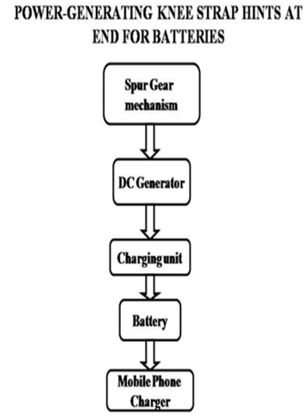

Fig. 1. Block Diagram.

A. Spur gear Mechanism

Gears are machine elements used to transmit rotary motion between two shafts, normally with a constant ratio. The pinion is the smallest gear and the larger gear is called the gear wheel.. A rack is a rectangular prism with gear teeth machined along one side- it is in effect a gear wheel with an infinite pitch circle diameter. In practice the action of gears in transmitting motion is a cam action each pair of mating teeth acting as cams. Gear design has evolved to such a level that throughout the motion of each contacting pair of teeth the velocity ratio of the gears is maintained fixed and the velocity ratio is still fixed as each subsequent pair of teeth come into contact.

Fig. 2. Gear.

B. D.C Generators

Generator principle: An electrical generator is a machine which converts mechanical energy (or power) into electrical energy (or power).

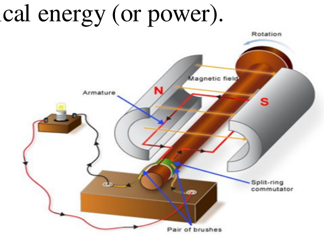

Fig. 3. Dc Generator.

Induced e.m.f is produced in it according to Faraday's law of electromagnetic induction. This e.m.f causes a current to flow if the conductor circuit is closed.

C. Working of Geared DC Motor

Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.

External Structure. At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones.

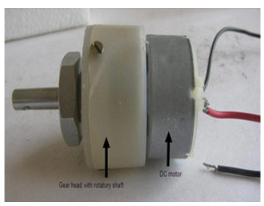

Fig. 4. Gear Dc Motor.

The lateral view of the motor shows the outer protrudes of the gear head. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly.

Engine-generator. An engine-generator is the combination of an electrical generator and an engine (prime mover) mounted together to form a single piece of self-contained equipment. The engines used are usually piston engines, but gas turbines can also be used. And there are even hybrid diesel-gas units, called dual-fuel units. Many different versions of engine-generators are available - ranging from very small portable petrol powered sets to large turbine installations. The primary advantage of engine-generators is the ability to independently supply electricity, allowing the units to serve as backup power solutions.

Human powered electrical generators. A generator can also be driven by human muscle power (for instance, in field radio station equipment).

Human powered direct current generators are commercially available, and have been the project of some DIY enthusiasts. Typically operated by means of pedal power, a converted bicycle trainer, or a foot pump, such generators can be practically used to charge batteries, and in some cases are designed with an integral inverter. The average adult could generate about 125-200 watts on a pedal powered generator, but at a power of 200 W, a typical healthy human will reach complete exhaustion and fail to produce any more power after approximately 1.3 hours portable radio receivers with a crank are made to reduce battery purchase requirements, see clockwork radio.

E. Charging Circuit

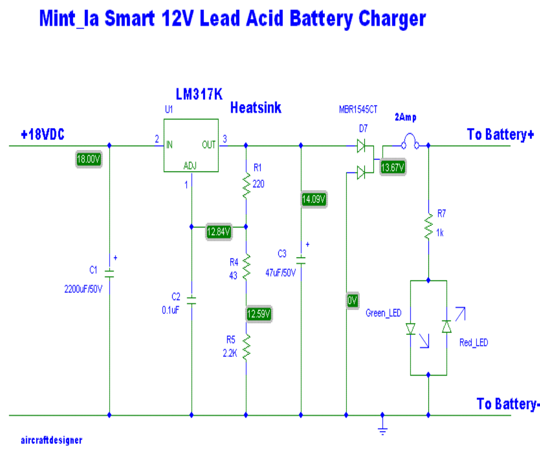

Fig. 5. Charging Circuit.

From the above circuit diagram, we can see that the 18v AC is being converted to 18V pulsating DC which is in turn converted to smooth DC with the help of the Capacitor. This 18V Smooth DC is converted to 12V DC by the Voltage Regulator 7812. At the output of the regulator, we get some spikes which are not desirable. These spikes are removed with the help of another capacitor used. We can get 12V Steady DC at the output terminal which can be indicated if the LED glows.

F. Rechargeable battery

A rechargeable battery, storage battery, or accumulator is a type of electrical battery. It comprises one or more electrochemical cells, and is a type of energy accumulator. It is known as a secondary cell because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of chemicals are commonly used, including: lead–acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

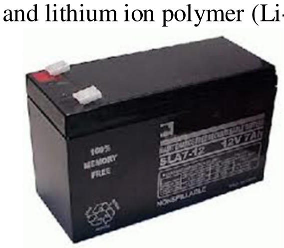

Fig. 6. Battery.

Charge Mode. Constant voltage charge (constant voltage and constant resistance charge) is recommended.

Charging current is limited, so be sure to charge via a charge-limiting resistor.

The specified charge voltage must also be observed.

If you are considering adopting constant current and constant voltage charge mode, contact SII.

Charge Voltage Range. Observe the specified charging voltage range.

* Charging at a voltage higher than the upper limit may degrade the electrical characteristics or lead to leakage or bursting.

* Charging at a voltage lower than the lower limit significantly reduces discharge capacity.

Charging rechargeable batteries. Type into the calculator your rechargeable battery's capacity number, normally can be red on the battery body e.g. 1700 mAh (milli-ampere-hours). Then select the battery type/size in the left column (NiMH – NiCd – AAA – AA – C – D – 9V (9 volt)) and in the right side select a current output (electric power output) of your charger in mA.

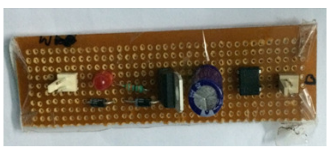

Fig. 7. Charging Circuit kit.

IV. METHODOLOGY

A. Walking mechanics and energetics

On average, there is no net mechanical work performed on the body during walking at a constant speed on level ground as there is no net change in kinetic or potential energy. This is accomplished by a number of sources–including muscle, tendon, clothing and air resistance–contributing to perform equal amounts of positive and negative mechanical work. Selectively engaging a generator at the right times and in the right locations could assist with performing negative mechanical work on the body, replacing that normally provided by other sources such as muscle. This is similar to how regenerative braking generates power while decelerating a hybrid car. We have termed this form of energy harvesting generative braking as the electricity is not reused to directly power walking but is available for other uses.

Typical knee joint mechanics and muscle activity during walking (subject mass = 58 kg; speed = 1.3 m/s; step frequency = 1.8 Hz. Data from). A) Knee joint angle where 180 degrees is full knee extension. B) Knee joint angular velocity using the convention that positive angular velocity is motion in the extension direction. C) Knee joint torque with the convention that extensor muscle torques are positive. D) Knee joint power. E) Rectified and filtered electromyograms (EMG) from one knee flexor muscle (solid line) and one knee extensor muscle (dashed line).

In principle, generative braking can produce electricity while reducing the metabolic cost of walking. When performing positive mechanical work, active muscle fibres shorten while developing force, converting chemical energy (i.e. metabolic energy) into mechanical energy. The peak efficiency of positive muscle work is approximately 25%. That is, a muscle producing 1 W mechanical requires 4W metabolic and dissipates 3W as heat. When performing negative work, muscle fibres develop force but are compelled to lengthen by an external force. This braking system is not passive–muscles require metabolic energy to perform negative work. The peak efficiency of negative work production is approximately -120%. That is, a muscle producing -1 W mechanical requires 0.83 W metabolic and dissipates 1.83 W heat. We refer to generating electricity by increasing positive muscle work–as is the case with hand cranks and bicycle generators–as conventional generation. Generating electricity in this manner will cause a relatively large increase in effort, while electricity generation that results in a decrease in negative muscle work will result in a relatively small decrease in effort.

While muscles are the only source of positive work in walking, there are other sources of negative work in addition to muscle. These include air resistance, damping within the shoe sole and movement of soft tissue. These are considered passive sources of negative work in that, unlike muscle, they don't require metabolic energy to dissipate mechanical energy. While the contribution of air resistance and shoe sole damping are thought to be small during walking, the quantitative contribution of soft tissue movement to negative work is not yet clear. While muscles do not perform all of the required negative mechanical work during walking, it is believed that they perform a substantial fraction. Nevertheless, it is possible for negative work by an energy harvesting device to replace negative work by a passive source, such as soft tissue, resulting in no change in metabolic cost to the user.

Fig. 8. Knee Strap Structure.

V. DESCRIPTION

A. Device Design

The biomechanics of walking presented four main challenges for designing a device to harvest energy from the motion of the knee joint. The first challenge was to determine an effective mechanism for converting biomechanical power into electrical power. This generator had to be worn on the body so it needed to be small and lightweight. The second challenge was to design a mechanism for converting the intermittent, bi-directional and time-varying knee joint power into a form suitable for efficient electrical power generation. The third challenge was to optimize the system parameters in order to maximize the electrical power generation without adversely affecting the walking motion. At any given point in the walking cycle, there is only a certain amount of knee mechanical power available–attempting to harvest too much power will cause the user to limp or stop walking while harvesting too little results in less electrical power generated. The final design challenge was to determine a mechanism for selectively engaging power generation during swing extension to achieve generative braking.

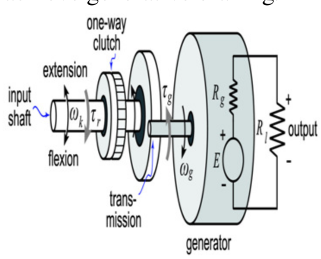

Fig. 9. Basic Mechanism structure.

The simulated device reaction torque, efficiency and generated electrical power depend on the transmission gear ratio and the external electrical load. A) A contour plot of simulated device reaction torque at different combinations of gear ratio and external load.

B. Device Description

We operated the device in four different modes. In the generative braking mode, the control system selectively engaged and disengaged power generation to target the swing extension negative work region. In the continuous generation mode, the control system was deactivated, the power generation circuit was always completed, and electrical power was generated whenever the generator was in motion. In the flexion dissipation mode, the control system engaged power generation during the swing and stance knee flexion phases to completely dissipate the kinetic energy in the transmission and generator that had accumulated during knee extension. This testing mode was used to determine the amount of torque and mechanical power produced due to friction and inertia during the knee extension phases, independent of generator back-EMF. In the disengaged mode, the roller clutch was manually disengaged so that the transmission was never in motion. This testing mode served as a control condition for human subject experiments to account for any physiological changes that resulted from carrying the added mass independent of physiological changes resulting from energy harvesting.

VI. RESULTS

The project "Power-Generating Knee Strap Hints At End For Batteries" was designed such that to generate electrical power as non-conventional method by simply walking with knee strap set up using spur gear mechanism. Non-conventional energy using walking or running using converting mechanical energy into the electrical energy.

Using these device, the cost of harvesting by conventional generation would be approximately 6.2–each additional Watt of electricity would require 6.2 Watts of metabolic power. This was estimated from the peak device efficiency (64.7%) and the peak efficiency of performing positive muscle work (25%). The COH in generative braking (0.7 ± 4.4)–calculated from dividing the additional metabolic power required for generative braking relative to that required for the disengaged mode (5 ± 21 W) by the measured electrical power (4.8 ± 0.8 W)–was substantially lower than for conventional generation indicating that it did not depend entirely upon additional positive muscle work to produce electricity. That we measured a slight increase in metabolic cost indicated that generative braking did not simply replace negative muscle work. If it had done so, we would have expected a 7.3 W decrease in metabolic cost calculated by dividing the measured electrical power by the product of the device efficiency (54.6%) and the efficiency of performing negative muscle work (-120%). The likely source for the additional metabolic cost is the positive muscle work required to overcome the added resistance during stance extension (Figure 6). The continuous generation COH (2.3 ± 3.0) fell between that for generative braking and that for conventional generation indicating that its electrical power production (7.0 ± 0.7 W) was partially by conventional generation with a high COH and partially by generative braking with a very low COH.

VII. CONCLUSION

We have developed a biomechanical energy harvester for generating electricity from walking. The device operated about the knee to take advantage of the large amount of negative work that muscles perform about this joint. It used a one-way clutch to transmit only knee extensor motions, a spur gear transmission to amplify the angular speed, a brushless DC rotary magnetic generator to convert the mechanical power into electrical power, and a control system to determine when to engage and disengage the power generation based on measurements of knee angle.

A customized orthopaedic knee brace supported the hardware and distributed the device reaction torque over a large leg surface area. For convenient experimentation, the control system resided on a desktop computer and resistors dissipated the generated electrical power. The device was efficient and the control system was effective at selectively engaging power generation. Consequently, subjects were able to generate substantial amounts of electrical power with little additional effort over that required to support the device mass. While we have focused on harvesting energy from swing extension, power generation is possible from other periods of the gait cycle. At the beginning of the stance phase, for example, the knee flexes while the knee extensor muscles generate an extensor torque performing substantial negative work to aid in the redirection of the centre of mass velocity (Figure 1). The amount of available energy at moderate walking speeds is only slightly less than that at the end of swing and it increases strongly with speed. Consequently, our initial device design attempted to also harvest energy from stance flexion. It used two oppositely-oriented roller clutches on the input shaft, causing the generator to spin in the same direction regardless of the direction of knee motion, and an extra stage of gearing to increase the gear ratio during flexion. While the higher gear ratio was required to better match the low angular velocity and high torque characteristics of stance flexion mechanical power (Fig. 1), the transmission and generator friction and inertia presented awkwardly large resistive forces during the high angular velocity swing flexion phase. This was not an issue for knee extension where power generation was engaged during swing extension, when knee angular velocity is high, and disengaged during stance extension, when knee angular velocity is low. While this drawback forced us to disregard power generation during stance flexion, power generation could be doubled with a more suitable design. For now, generative braking during stance flexion is best considered a hypothesis that must be tested empirically as it is not yet known how much of the negative work during this period is stored and subsequently returned during stance extension.

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