INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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SPECIAL ISSUE FOR
NATIONAL LEVEL CONFERENCE
"RENEWABLE ENERGY
RESOURCES & IT'S APPLICATION"

HUMAN ENERGY: A SUSTAINABLE OPTION FOR BATTERIES

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Accepted Date: 12/03/2016; Published Date: 02/04/2016

Abstract: The decreasing power requirements of consumer electronics combined with an increasing environmental mindedness of consumers and the increasing use of portable electronic products has set the opportunities for human power as a viable alternative to batteries. No use of batteries means an environmental benefit as well as a consumer benefit. It will lead to new product concepts offering real portable products that can be used anytime and anywhere.

Keywords: Human Energy, Batteries

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Access Online On:

www.ijpret.com

How to Cite This Article:

Sandeep A. Awachar, IJPRET, 2016; Volume 4 (8): 220-227

PAPER-QR CODE

INTRODUCTION

The research into human powered energy systems is one of the PhD projects within the DfS (design for sustainability) research program at the sub-faculty of Industrial Design Engineering at DUT, it started in 1997 and is due to be finalized in the year 2000. The main research question is: For what products and how can human power be a viable alternative to batteries in portable consumer products? The research will explore into ergonomic, mechatronic and environmental issues of human powered energy systems in consumer products.

II. Relevant developments

In the last years we can see an increasing amount of handheld electronic devices (GPS, cellular phones, palmtop computers), increasing mobility, and need for communication and information. Also the percentage of products fully based on electronics is rising. For obvious reasons, the majority of these portable products is powered (rechargeable) batteries; batteries are small, light and have a relative high energy density. The number of batteries, sold throughout the world is steadily growing. In 1996, in the Netherlands only, 110 million primary batteries have been sold (a 3400 miles chain, twice the distance between Boston and Denver!)One other relevant development is the decreasing power consumption of portable consumer electronics. An example is given in Fig. 1., it shows the decreasing power consumption during play mode of different types Sony Walkman during 16years [1]. It is taken as an example because its functionality has not really changed in all these years. The limit in power consumption will be determined by the amount of energy used by the mechanical parts of the Walkman.

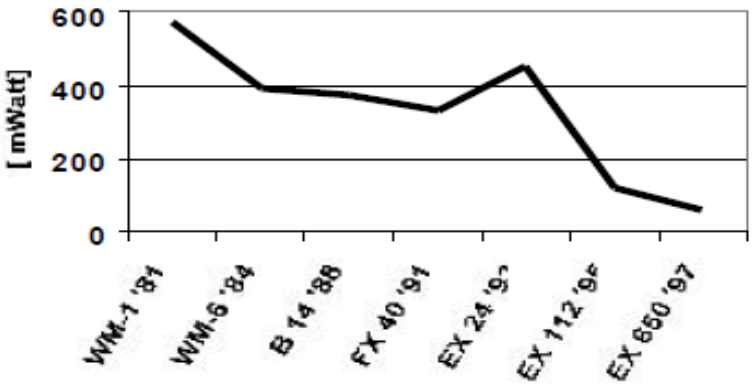

Fig. 1 Power consumption alkman during play

III. Why replace batteries by human power?

Besides their plus points (small, high energy density, freely available, standardized), batteries also have is advantages. The first one is given by the fact that primary batteries contain a restricted amount of energy resulting in a limited life time. So, they have to be replaced regularly (a fact of life is that this always happens when you need the product most). Also without using the product, batteries slowly discharge. Replacing batteries means discomfort for the consumer (costs, inconvenience).The second disadvantage is from an environmental point of view. Empty batteries have to be discarded in an environmental sound way; they have to be returned to the shop or collected as chemical waist. In 1996 in the Netherlands (having a battery take back system), only 54% of the batteries was returned in one way or another [2]! In many countries the collection system for empty batteries is not as organized and therefore many batteries will end up at the land fill or be scattered in the environment.

IV. Human power

Table 1. Energy production by the human body

energy source	forms of energy			
	mechan	electric	thermal	chemical
muscles (active)	x			
movement (pass.)	x			
skin potential		x		
perspiration				x
body heat			x	

As shown in table 1, the human body acts as an energy producer in different ways. Table 1. Energy production by the human body

In the human power project we concentrate on the active use of the muscles. The amount of energy obtained from the human body depends on which body segments are used, the physical and mental condition the user and the design of the interface between the user and the generator. Forshort term tasks (up to 2 minutes) a number of specific measurements [TUD] is presented below.

Table 2. Measurement of required human power for various tasks

description of task	required human power
Pushing button with thumb (as with ballpoint)	0,3 Watt
Squeeze hand generator (Alladin power, Fig. 3)	6 Watt
Turn handle on BayGen Freeplay radio	21 Watt
Ride bike at 25 km/h	100 Watt

Data from literature in most cases focuses on the maximum force applied by users. We estimated the human power potential by using the maximum force exerted by an average male user in-between 20 and30 years of age. The generated power for very short periods is given in Table 3. [3].

Table 3. Estimations for maximum power

description of movement	maximum human power
Push (16 N x 40 mm)	0,64 Watt
Squeeze (400 N x 30 mm)	12 Watt
Rotate crank or handle (30 N x radius 100 mm x 1,5 x 2π)	28 Watt

In a recently started ergonomical research project we will chart the potential of the human body as an energy generator, related to perceived comfort.

V. Power consumption of portable consumer electronics

At DUT a number of recent measurements of the power consumption of portable consumer electronics has been collected, it is presented in the next table. The power consumption

represents the average power consumption during use. A first comparison between the figures from table 2 and 4already shows the possibilities for human power.

Table 4. Measurements of power consumption

product	power consumption
small portable FM radio [4]	30 mWatt
walkman (play mode) [1]	60 mWatt
TV remote	100 mWatt
cell. phone (talk /stand-by) [5]	2 W / 35mWatt
electric torch (flashlight)	4 Watt
video 8 (no LCD screen) [6]	6 Watt
laptop computer Tecra 8000	10 Watt
TV (53/67/wide screen) [6]	50 / 74 / 111 Watt

VI. Human powered products

Combining the data from the previous two paragraphs will result in a number of opportunities for human powered products, as presented in Fig. 2.We assumed a 40% efficiency for the human powered energy system. Fig. 2 Opportunities for human powered products

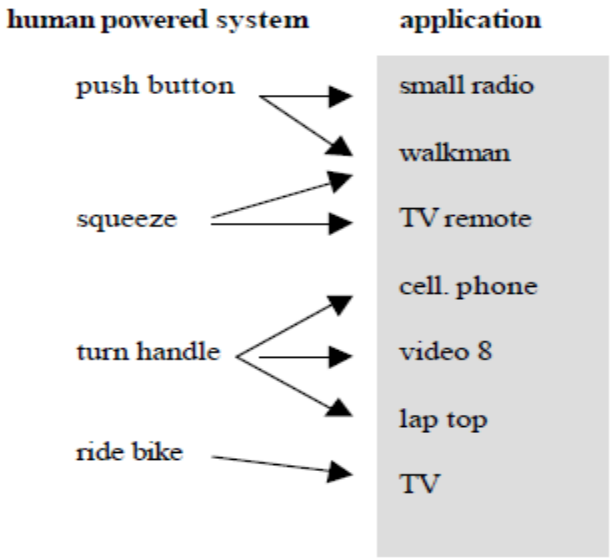

Fig. 2 Opportunities for human powered products

The combinations presented in Fig. 2 will give a direction for projects in the near future. In these projects, the concept of human power will replace power systems of existing products, but also lead to totally new product concepts, combining an improved environmental profile and convenience for the consumer.

A good example is the design of a car remote control using alternative power. This project is now conducted at Volvo Car Company near Goteborg in Sweden. The mean reasons for Volvo to investigate the possibilities of human power are environmental concern and the current discomfort of batteries experienced by the user. The new remote control will feature an improved quality and environmental profile during its life cycle. The analysis of existing human powered products learned there still is room for improvement. From the analysis of the Bay Gen radio, we found an overall efficiency of 26% for the human powered energy system and a high environmental impact of the human powered energy system in the production phase of the life cycle. Compared to radios powered with primary batteries, the average environmental'return on investment time' of the human powered energy system was over 2 years [4].

Fig. 3 Aladdin power by Nissho engineering Co.

One of the human powered products, now available on the market is the Aladdin power (Fig 3).When squeezing at 90 Hz, the output power will be approximately 1, 6 Watt, sufficient for

some cellular phones. Push button squeeze turn handle ride bike small radio Walkman TV remote cell. Phone video 8lap top TV

Human powered system application

Fig. 4 Interactive storyteller and bedside projector, Philips Design and Olivetti Italy

Fig. 4 Interactive storyteller and bedside projector, Philips Design and Olivetti Italy The interactive storyteller and bedside projector are results from the combined Philips and Olivetti project called Vision of the Future. One of the ideas was that children should have just as much pleasure winding up their toys as when they are watching the projected images. Fig. 5 Wind-up shaver by MOY concept and design.

Fig. 5 Wind-up shaver by MOY concept and design

DISCUSSION

Human power offers a range of opportunities as presented in Fig. 2, in this figure the main directions for the application of human power were identified. These directions will be explored in projects by Delft University of Technology in corporation with industry, as in the mentioned Volvo project. From the analysis of existing products we conclude that human power also provides challenges to industry; improve on energy conversion techniques in order to achieve a higher efficiency and find ways to produce human powered energy systems with less pollution.

Green marketing will have to emphasise the environmental advantages of human powered energy systems. Designers will have to take a way existing prejudices against human powered products by strengthening the fun factor in these products. “Human power is green, it’s fun and it can be done”.

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