International Journal on Emerging Technologies 2(1): 109-113(2011) ISSN : 0975-8364

Rest Pause Cycle Using Ergonomic

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(Received 10 January, 2011 Accepted 10 February, 2011)

ABSTRACT : In this paper an effort is made to experimentally study the effect of varying workloads on heart viz... (i) At rest (ii) During exercise with respect to varying speeds and loads using a self designed and fabricated bicycle ergometer by leg pedaling at constant room temperature and humidity. It has been found that there is an increase in heart rate as exercise begins and as the work load becomes heavy, the heart rate increases immediately and continuous to increase till the exercise ends. On conducting experiment on people with different weight group, it has been found out that the rest pause required per person is different & depends upon his/her capabilities [1]. It has also been observed that with an increase in load there is marginal increase in rest time required.

Keywords : Heart beat rate, work cycle, ergometer.

I. INTRODUCTION

In an economically poor country like India bicycle is the cheapest means of transport. On the average an Indian plies about 10 kilometres on a bicycle everyday. Fatigue studies on bicycle have not been extensively done in our country. A bicycle is one of the simplest and widely used machines. A machine may consist of virtually any type of physical object, device, equipment, facility that people use in carrying out some activity which is directed to achieve a purpose of function. It is the interaction of one or more physical components that brings about desired output from given output in a machine. A convenient apparatus for studying and measuring the physiological responses of human beings during exercise is termed as an “ergometer”. In the 1950s Dr W von Döbeln developed a principle for accurate determination of the brake power of the bicycle ergometer [2]. Its main requirement is that it should permit prolonged exercise at moderate rates by a subject at constant rate. The grades of exercise should be fixed, fixed, reproducible and, chosen with ease. Different types of ergometers are practically possible, namely electrical pedaling ergometer, friction type mechanical ergometer. To avoid of the factor of uncertainly in the output due to heat loss in a dynamo and the temperature coefficient of resistance of copper winding the electrical pedaling ergometer is not chosen and instead a simple mechanical friction braking pedaling ergometer is chosen [3]. Moreover it is simple in construction and more suitable for prolonged exercise for different grades of work with a satisfactory degree of reliability and responsibility. The physiological cost of work is measured through changes in heart rate at various levels of work and the simple relationship between them is established through practical readings. To achieve this aim the pedaling ergometer has been designed and fabricated.

II. COMPONENT LIST

List of components that were used during experimental work is as follows :

S. No.	*Name*	*Qty.*	*Parts*
1.	Frame	1	Std
2.	Seat	1	Std
3.	Chains	1	Std.
4.	Wheel	1	Std. (Small)
5.	Fork	1	Shaped to fit
6.	Pipes (MS)	4	as per reqt.
7.	Pedals	2	Std.
8.	Handle	1	Std.
9.	Pedal Axle	1	Std.
10.	Chain Rollers	2	Std.
11.	Chain Roller Support	1	Std.
12.	Roller Bearing	2	Std.
13.	Ball Bearing	as per reqt.	Std.
14.	Nut & Bolts	as per reqt.	Std.
15.	Plain washers and Lock washers	as per reqt.	Std.
16.	Belt	1	Shaped to fit.
17.	Hook for slotted weights	1	Shaped to fit.
18.	Electronic Sensor’s (Speedometer, Heart Beat Sensor, and Timer)	1	Std

III. DESIGNING CONSIDERATIONS

1. Design of front platform

Assuming that the front supporting (2) rods are carrying 300 N force and load on each rod = 150 N.

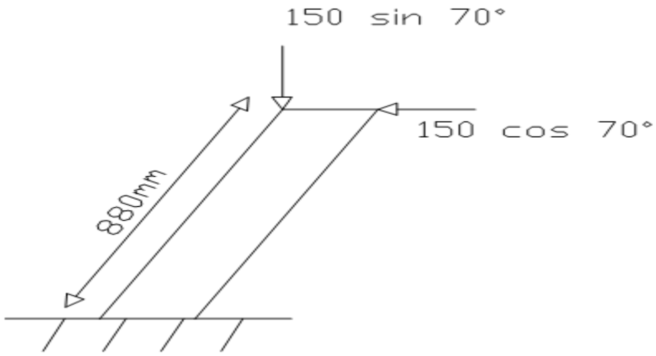


Fig. 1.

Total stress

sinduced $= \sigma_a + \sigma_b$

$= -F/A + MZ$

$F_1 = 150 \sin 70°$

$A = \pi/4\ (d_0^2 + d_1^2)$

where d_0 is outer diameter of the pipe = 95 mm and d_1 is inner diameter of the pipe = 90 mm.

$A = 726.5$ mm^2, $M = F_2 \times L = 150 \cos 70° \times 880 \sin 70°$

$Z = \pi d_0/ = 90/95 = 0.947$, $Z = 16475$ mm^3

$= -150 \sin 70°/726.5 + 150 \cos 70° \times 880 \sin 70°/16475$

$= -0.194 + 3.24 = 3.05$ N/mm^2 (sallowable = 80 N/mm^2)

Hence, design is safe.

2. Design of back platform

Assuming that the back supporting (2) rods are carrying 300N force and load on each rod = 150N.

$$K = 0.947,\ \sigma_a = -F/A;\ \sigma_b = 0$$

$\sigma_{induced} = -150/726.5 = -0.206$ (Compressive) N/mm^2

($\sigma_{allowable} = 80$ N/mm^2), hence, design is safe.

3. Design of coupler

$$\Sigma M_B = 0,\ R_A \times 430 = 150 \times 180,\ R_A = 62.7\text{N}$$

$$R_A + R_B = 150\text{N},\ R_B = 87.2\text{N}$$

Maximum bending moment, $M = 62.7 \times 250 = 15{,}675$ N-mm

$$Z = \pi d_o^3/32(1 - \text{K4})$$

$$K = 0.9$$

$$Z = 4747 \text{ mm}^3$$

$$\sigma_a = 0;\ \sigma_b = \text{M/Z}$$

$\sigma_{induced} = 15675/4747 = 3.33$ N/mm^2 ($\sigma_{allowable} = 80$ N/mm^2)

Hence, design is safe.

4. Design of Hook

$$\sigma_{induced} = M/Z = (F \times L \times 32)/(\pi d^3)$$

$$d = 6 \text{ mm}$$

$$L = 17.5 \text{ mm}$$

$$F = 50\text{N} = (50 \times 17.5 \times 32)/(\pi \times 256)$$

$$= 41.26 \text{ N/mm}^2 \text{ (sallowable = 80 N/mm}^2\text{)}$$

Hence, design is safe.

5. Maximum load which plate can carry

P = Area × Stress

Assume tensile stress = 70 N/mm^2

$$= \pi R^2 \times 70 = \pi \times 9 \times 70 = 1979.2 \text{ N}$$

Therefore, permissible tensile strress

$$\sigma_t = 70/1.2 = 58.33 \text{ N/mm}^2$$

Assume shear stress = 56 N/mm^2

$$\sigma_s = 56/1.2 = 46.66 \text{ N/mm}^2$$

IV. FABRICATION AND ASSEMBLY

For the design of rest pauses, we require an apparatus which should have the facilities to change the load conditions to measure the heart beat of the person working on it, to measure the voltage generated during experimentation & to measure speed by speedometer. We fabricate this apparatus by modifying the simple bicycle. A frame of cycle is mounted on a strong framework of M.S. to carry loads upto 150 Kg. M.S. Beams are welded at an angle, with the help of a M.S. Fork in the front and straight on back side. One end of the belt is connected to the spring balance which in turn is attached to the base. The other end is kept free on to which various loads can be attached. For measurement of heart beats we have two options (1) either by a stethoscope or (2) by an electronic sensor. Amidst these we use the electronic sensor. This sensor is not only capable of measuring the heart rate but also measures the speed of the cycle. It also has an in built stop watch for time measurement.

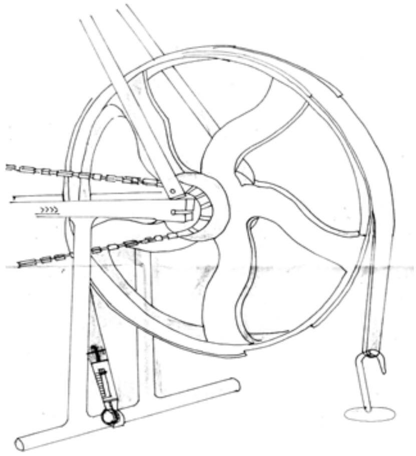


Fig 2. Isometric view of Fly wheel assembly.

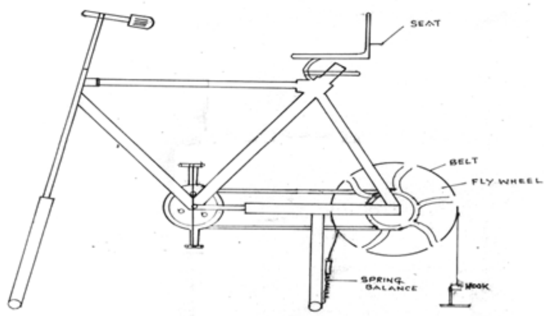


Fig. 3 Rest-Pause cycle using Ergonomics.

V. EXPERIMENTAL WORK

1. Object: To establish relation between heart rate of a person and rate of energy expenditure at work and calculation of rest pauses.

2. Apparatus Required:

[*a*] Ergocycle

[*b*] Electronic Sensor (Heart Beat Sensor, Speedometer, Timer)

[c] Spring balance.

[d] Weights.

3. Description of Apparatus: This ergocycle has a wheel which can be operated by paddles. The load on the wheels can be applied by the belt attached to the rear wheel. The load can be varied by varying the tension of belt by application of suitable weights or by changing angle of lap of belt with wheel. (Fig. 2 and 3).

4. Theory: Rest pauses are very essential for worker to overcome the fatigue developed during work. The rest pauses are best utilized if they are given at the times when they are needed most. Duration of rest pauses also plays a very important role is overcoming fatigue and metal tension[4]. It is observed that heart beating rate when worker is at rest the rate of energy expenditure while at work and the heart rate at work bear some relation.

5. Procedure for Experimentation: The method of determining the variation of heart beat rate of person during physical work which consists of allowing the operator to carry out the given physical work in our case it is cycling at constant speed and at constant load. The heart beat rate of operator is measured after every minute and a graph in plotted between time and heart rate at a particular load. The same is followed for different loads. The heart rate is to be measured conveniently and accurately. See graph 1 and 2. The counting of heart beats is done by heart beat sensor. The heart rate so obtained is used to calculate oxygen consumption, energy expenditure and total rest time required.

Subject: 1

Weight category = 80-90 kgs, Load = 5 Kg

Heart beat at rest — 70 (per min.)

Energy consumption –1.09 Kcal/Min

Time (in Min)	*Heart beat (per minute)*	*O_2 consumption (liters/Min)*	*Energy Kcal/Min*
1	110	1.09	5.45
2	118	1.282	6.41
3	115	1.210	6.05
4	120	1.330	6.65
5	122	1.378	6.89
6	128	1.522	7.61
7	128	1.572	7.61
8	126	1.474	7.36
9	130	1.570	7.85
10	124	1.426	7.13

K_{10} (sum of energy expenditure) = 69.019 KcaI/Min

K_{avg} (K_{10} / 10) = 6.9 KcaI/Min

$R = T(K_{avg} - S)/(K_{avg} - 1.5)$; where S = 5 Kcal/min

R = 3.51 Min = 212 Sec

Subject: 2

Weight category = 80-90 kgs Load = 5Kg

Heart beat at rest — 74 (per min.)

Energy consumption –1.09 Kcal/Min

Time (in Min)	*Heart beat (per minute)*	*O_2 consumption (liters/Min)*	*Energy Kcal/Min*
1	115	1.21	6.05
2	120	1.33	6.65
3	124	1.426	7.13
4	139	1.786	8.93
5	141	1.834	9.17
6	141	1.834	9.17
7	150	2.05	10.25
8	150	2.05	10.25
9	150	2.05	10.25
10	151	2.074	10.37

K_{10} (sum of energy expenditure) = 88.22 KcaI/Min

K_{avg} (K_{10} / 10) = 8.822 KcaI/Min

$R = T(K_{avg} - S)/(Kavg - 1.5)$;

where S = 5 KcaI/min

R = 5.21 Min = 312 Sec

Subject: 3

Weight category = 60-70 kgs, Load = 3 Kg

Heart beat at rest — 75 (per min.)

Energy consumption –0.78 Kcal/Min

Time (in Min)	*Heart beat (per minute)*	*O_2 consumption (liters/Min)*	*Energy Exp. Kcal/Min*
1	110	1.09	5.45
2	108	1.042	5.21
3	108	1.042	5.21
4	111	1.114	5.57
5	111	1.114	5.57
6	112	1.138	5.69
7	114	1.186	5.93
8	111	1.114	5.57
9	113	1.162	5.81
10	113	1.162	5.81

K_{10} (sum of energy expenditure) = 55.87KcaI/Min

K_{avg} (K_{10} / 10) = 5.587 KcaI/Min

$R = T(K_{avg} - S)/(K_{avg} - 1.5)$;

where S = 5 KcaI/min

R = 1.42 Min = 85 Sec

Subject: 3

Weight category = 60-70 kgs

Load = 5Kg

Heart beat at rest — 71 (per min.)

Energy consumption –1.09 Kcal/Min

Time (in Min)	*Heart beat (per minute)*	*O_2 consumption (liters/Min)*	*Energy Exp. Kcal/Min*
1	109	1.066	5.33
2	133	1.642	8.21
3	142	1.858	9.29
4	152	2.098	10.49
5	148	2.002	10.01
6	148	2.002	10.01
7	152	2.002	10.49
8	154	2.146	10.73
9	150	2.05	10.25
10	152	2.098	10.49

K_{10} (sum of energy expenditure) = 95.4 KcaI/Min

K_{avg} (K_{10} / 10) = 9.54 KcaI/Min

$R = T(K_{avg} - S)/(K_{avg} - 1.5)$; where S = 5 KcaI/min

R = 5.64 Min = 339 Sec

Sample calculation

Subject: 2 Wt. category: 80-90 Kgs

Load: 5 kg Heart beat at rest: 74 Speed: 3.5 km/hr (Avg.)

1. Energy consumption

$$(T_1 - T_2) \times V / 75$$

T_1= 5 kg, T_2 = 1.5 Kg , V = 3.5/1.67 miles/hr

0.097 Hp = 1.09 kcal/min

2. O_2 consumption

For 1st minute heart beat = 115

O_2 consumption = –1.55 ± (0.024 × 115) = 1.21 Lit/mm

3. Energy expenditure (k)

For 1st minute

=1.21 × 5 = 6.05 Kcal/min

4. Total energy exp. in 10 mins (K_{10})

(6.05 + 6.65 + 7.13 + 8.93 + 9.17 + 9.17+10.25 + 10.25 + 10.25 + 10.37) = 88.22 Kcal/min

5. Avg. Energy exp. (K_{avg}) = 8.822 Kcal/min

6. Total rest reqd. in minutes

$$= T \times (K_{avg} - S) / K_{avg} - 1.5)$$

= 10 (8.822-5) / (8.822 – 1.5) =5.21 minutes or 312 seconds.

VI. CONCLUSION

The current interest in human factors arises from the fact that technological developments have focused attention on the need to consider human beings in ergonomics developments. Such developments were the beginning of what we now call human factors that is the design of things and facilities so that they can reasonably well serve human needs. The project work deals with consideration of human characteristics, expectations and behavior in design of rest pause in their work and lives. In simple world human factor has been referred to as designing for human use with its full efficiency in most effective manner. The entire experiments are carried out on erog bicycle to find out the energy expenditure during the energy expenditure during the work. To measure the general physiological status and from all these experiments we find that

(1) Heart rate is reasonably inductive of the effects of heart stress and emotional stress but is also related to individual factors (*i.e.* constitution physical condition sex. etc.). And is therefore less suitable as an absolute index

of the load imposed various types of work than is oxygen consumption [5].

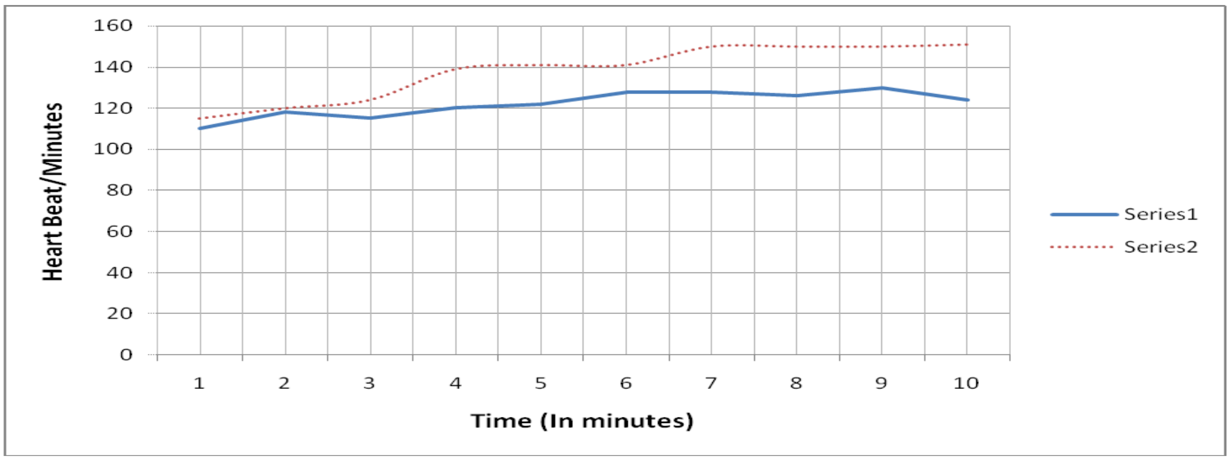
(2) The oxygen debt For example is the amount of Oxygen that required by the muscles after the beginning of work over and above that which is supplied to them by tile circulatory system during their activity. This debt needs to be "repaid alien tile cessation of work and is reflected in the elevated rate (*i.e.* above resting level) of oxygen consumption in recovery process.

(3) The approach that is discussed in this project work is definitely helpful [hr developing proper data for the management this will helpful to provided right information about the all human factor. For designing their rest pause after particular activity and hence useful for increasing the productivity by using maximum efficiency of labour with more scientific manner.

Graphs:

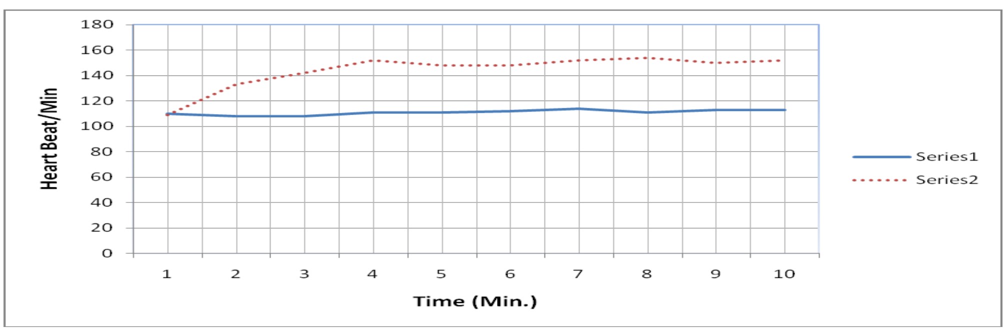
(1) Comparison between SUBJECT– 1(Series-1) & SUBJECT– 2 (series-2) at 5 Kg Load

Observation: Difference in heart beat between subjects of same wt. category



(2) Comparison between SUBJECT – 3 at 3 kg (Series-1) & at 5 kg (series-2) Load

Observation: Difference in heart beat between subjects of different Load Conditions



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