Engineering Change Request – Morning Walker

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Abstract -- **The morning walker is an aerobic exercise device inspired by the goldfish locomotion principle, enabling users to simulate walking motion while lying in a supine position. However, clinical feedback from users and physiotherapists revealed significant drawbacks, including joint discomfort and limited therapeutic benefits. Detailed mechanical and biomechanical analysis identified two primary causes: (*i*) lateral oscillations (xx direction) generating vibrations that stress the anterior and posterior cruciate ligaments and (*ii*) the cantilever effect of the leg with the knee as a fixed joint, resulting in high bending moments and pain. To address these limitations, a novel cam-based mechanism was developed, producing motion in the vertical plane (yy direction). The proposed cam profile is derived from the superimposition of a constant-velocity profile and a cycloidal profile. This hybrid approach ensures uniform walking-like motion (constant velocity) while reducing jerk and impact forces at extreme displacement points (cycloidal transition). By combining kinematic smoothness with biomechanical compatibility, the redesigned system aims to minimize vibration-induced stress and enhance user comfort during prolonged exercise sessions.**

Keywords: *Morning walker, Cam profile design, Goldfish motion, Constant velocity profile, Cycloidal profile, Biomechanical analysis*

I. INTRODUCTION

(*i*) Morning walker, an aerobic exercising machine of a goldfish movement, by which we can do Morning Walk lying on the bed itself.

(*ii*) By using Morning walker for 15 minutes is equal to 10000 steps of brisk walk and 8 km in terms of oxygen benefit.

(*iii*) Morning walker moves the entire body, most importantly; it is moving the largest muscle group in the body i.e. our legs.

(*iv*) The swinging motion causes your blood to circulate efficiently in the whole body. In turn every cell absorbs oxygen and the toxins are removed.

(*v*) By using Morning walker,we do not get a 10 km run kind off workout which makes us sweaty and exhausted. Instead we lie down, relax while having a workout and our entire body is rejuvenating within these few minutes of workout.

(*vi*) Morning walker consumes just 50 watts of power.

Figure 1.

II. BENEFITS OF MORNING WALKER

Following benefits are claimed by the company manufacturing the Morning Walker:

(*i*) *Strong Bones and Joints:* The rhythmic swinging movement of Morning walker exercises bones and joints of the whole body. Improved blood circulation due to increased oxygen absorption can alleviate the paralysis and pain of arthritis and rheumatism caused by oxygen deficiency.

(*ii*) *Reduced Muscle Fatigue:* When exercising or working too hard, muscle fatigue is likely to occur. By exercising with Morning Walker, it increases the body metabolism which helps to eliminate muscle fatigue.

(*iii*) *Enhanced Internal Organ Function:* The swaying motion of the Morning walker can massage internal organs to help peristalsis, prevent constipation, and alleviate vulnerability of disease. Also, the overall effect of its aerobic exercise especially on the waist and belly region, can lose weight and dissolve excess fat.

(*iv*) *Balanced Autonomic Nervous System:* The Autonomic Nervous System is responsible for controlling the body's metabolism. An unbalanced Autonomic Nervous System can cause nervousness, anxiety, peristaltic disease, fatigue, and constipation. Morning walker improves the body's metabolism, thus prevents many of these problems.

(*v*) *Increased Breathing Capacity:* Aerobic exercise with Morning Walker enhances the oxygen carrying ability

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of the blood, activates cells and urges metabolism by increasing blood circulation and delivering blood to peripheral nerves.

(*vi*) *Improved bodily fluid base-acid equilibrium:* Perfect physical condition s achieved when fluid has a weak alkaline content. The fluid base equilibrium varies according to food, exercise, climate and environment. Exercising with Morning Walker can help one attain a good fluid base-acid equilibrium.

(*vii*) *Strengthened Spinal Column:* The vertebra is the most important support system of the human body. Frequently, the vertebra (which controls the Automatic Nervous System) and the nervous system cannot operate properly due to trauma, scoliosis, or other spinal problems. Morning walker can help strengthen the muscles around the spine and therefore help prevent injury and disease. Morning walker can help prevent costly trips to a chiropractor by helping the body naturally re-align the vertebra.

III. METHODOLOGY

Basic Ergonomics of the Machine

Following are the methods through which the machine can be operated for maximum benefits:

(*i*) Operating a Morning Walker is very easy. All you have to do is plug it on and rest your legs on the leg support provided on the machine.

(*ii*) Now to obtain maximum benefits there are various postures in which you can use the machine to achieve maximum benefits.

(*iii*) To improve blood circulation, cardiovascular function, relief fatigue and lie down with two palms facing up and by the legs in a relaxed manner.

(*iv*) To relieve migraine, bony spur, headache, gout, arthritis, spinal deformity: Lie down with both hands placed under the head.

(*v*) To reduce weight, balance nerve system, relieve mental strain: Lie down with both hands stretched upwards. For quick results to reduce weight, contract belly and buttocks while breathing normally.

(*vi*) To improve breathing capacity, lung function, relieve back pain: Lie down with both arms surrounding the head.

(*vii*) To relieve from indigestion, constipation, frequency of micro nutrition, strengthen excretory system: Lie down with both hands placed on abdomen.

(*viii*) To increase oxygen supply, promote body growth (especially for children): Lie down with both hands spread sideways and palm facing down.

IV. MECHANISM USED IN THE MORNING WALKER

- It's a simple 4-bar mechanism with the following dimensions:
- Fixed link: 120 mm
- Side links: 87 mm
- Slider link: 140 mm
- For providing motion, a cam profile has been used in the vertical slot provided in the slider link.
- Cam is mounted on the motor shaft which has been powered by the power supply.
- The mechanism used in the machine is a double rocker mechanism which is responsible for the motion.
- It has a motor of 50-watt power.
- The outer section of the model consists of a leg support used for supporting the legs when the machine is working.
- The leg support is directly mounted on the upper section of the four bar mechanism

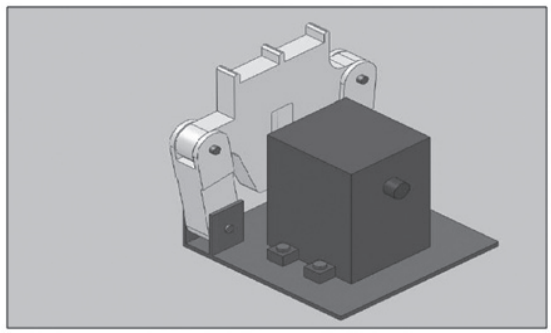

Figure 2.

V. BEGINNING WITH THE ECR MORNING WALKER

The major problems faced by the users of Morning Walker are as follows:

(*i*) Back aches.

(*ii*) Pain in the knee.

(*iii*) Shooting pain in the body.

These problems were first reported to us by Dr. H.K. Sahjwani (H.O.D, Applied Science) IEC-CET. He was a constant user of the machine and noticed above mentioned problems. After hearing from him, we searched through the internet to get the views of the other users of the machine and found that every second person is reporting the same problems.

Few quotes are mentioned below to validate our study:

Evidence No.1

Walk lying down:

I have experienced the product a couple of days back. The timer was set at 10 minutes and I was asked to lie down flat on my back on mattress and prop my legs (ankles) up on a double U shaped contraption positioned on top of the machine. When the machine started, it was like nothing I expected in my wildest dreams. The lower portion of my body was horizontally swung from side to side with my hip acting as the pivot. 10 minutes of this action was in hindsight a form of pleasant torture.

I am diabetic, hypertensive and suffer from back pain. The back pain did not manifest itself through the afternoon and evening after the season. The next day some muscle groups (*e.g*. back of thigh) had a dull ache. The back pain had also returned. Whether the violent swinging action of the lower part of the body has any cardiac benefits is not for me to judge since I did not feel the heart pumping harder like after jogging or skipping. There may be benefit for diabetics since the lower body is violently exercised and hence vascular condition may improve.
From:
Sumit Majumdar (Sumitmajumdare.com)

Evidence No.2
Morning Walker Damaged my Knee: Posted on Jul 07, 2009 under General
The heavily advertised Morning Walker and the TV advertisement encouraged me to buy it. I am 45 and my Mom 80. I used it 5 min for the 5 days. I then used it 15 min for the next 10 days. My knees began to hurt. I called in the company. They said they had never had any complaints. I am surprised, I checked around and discovered others too were having problems with their knee and some kinds at the Ankles.

My mother had 'tingling sensation' even 5 hrs later. She is fitter than most of her age. She can walk 4 Km each morning and ever since it rained she stopped. But she was on the Morning Walker. This probably damaged her knee too.
The side to side oscillation is unnatural for the knee. This is verified by a Orthopedic Surgeon too. Products such as these definitely have a problem. Are there other users who have the similar problem?

VI. CAUSES OF THE PROBLEM

After thorough study, we concluded that following points could be responsible for the problem faced by the users:
The portion below the knee acts as a cantilever beam while exercising on the Morning Walker with knee acting as a fixed joint and the point load acting on the ankle. It is well known that the maximum bending moment in case of cantilever beam acts at the fixed joint which in this case is knee, causing trouble for those who are suffering from arthritis.

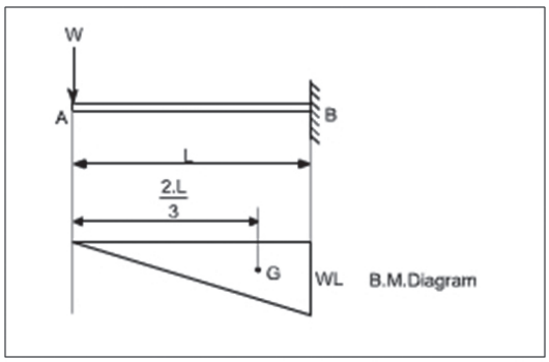

Figure. 3

As the Morning Walker generates vibration which travel across the foot and causes stress at the cruciate ligament in addition to the bending moment that can cause the tearing of ligament if used for long period.

In addition to this, there is a problem of double momentum at the point of time when the machine returns from its extreme position. At the time of returning at one point of time the walker has velocity in one direction which all of sudden changes in other direction resulting into the double momentum problem.

VII. RESULTS AND DISCUSSION

Need statement: To convert gold fish movement into *y-y* direction movement.

I. Solution Offered
Converting cantilever beam problem to uniformly distributed load problem can avoid problems by providing support up to knee. All the effect that has been causing problem in the knee so far can now be transferred to thigh and butt joint which is strong enough no such muscle or ligament that can tear easily. Additionally, by providing some accessories along with support like cloth roll at the back of knee hamstring muscle can be strengthened.

II. Doctors review about the project:
(i) Dr. Siddarth Saran (M.S. ORTHO): Result of y-y is better than *x-x* due to following reasons. Active movement Generalized muscle exercise.
(ii) Dr. B.K. Dhaon (M.S. ORTHO): Can give his views only after seeing the model.
(iii) Dr. Ashish Jain (MBBS, General Physician and Diabetologist): Motion of Morning Walker is an unnatural motion. Motion of our machine is more beneficial as it will help in burning more calories and can also help us in improving the metabolism of the body. Since the motion used is that of walking, it will always be beneficial to the body without affecting it.
(iv) Dr. Supriya (Physiologist): She helped us to improve our machine and has shown keen interest in the project.

Mechanism to change the motion:
Following mechanisms were considered to achieve the desired y-y motion:
A five-link straight-line mechanism.
Cam-and-follower mechanism.

Cam-Follower Mechanism: In this mechanism a cam-and-roller follower arrangement is used. The cam-profile is designed in such a way that it will give the constant velocity motion and the jerks at the extreme position will be minimized. So a cam-profile is obtained by superimposing two cam-profiles. One profile is of the constant velocity nature and the other one is of cycloidal nature. These two profiles are superimposed because

constant velocity profile will give the linear displacement profile which resembles with the natural walking-motion and the cycloidal profile will minimize the jerks at the extreme positions. Five link straight line mechanisms were rejected because of its complexity and huge size of machine and due to the simplicity of cam-follower design, it was used in the project.

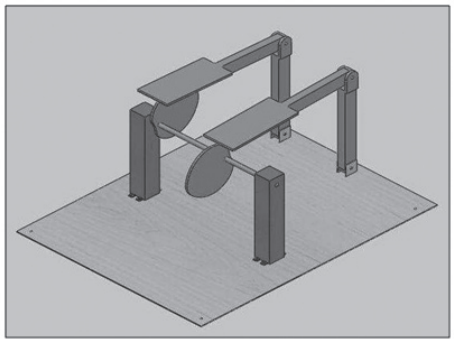

Figure 4.

IV. PROCEEDINGS

Following are the software design of the two cam profiles used in this mechanism:

Constant velocity profile with the following specifications:

Base circle radius: 30 mm Rise angle, Dwell angle, Fall Angle, and Dwell angle as 160˚, 20˚, 160˚, 20˚ respectively.

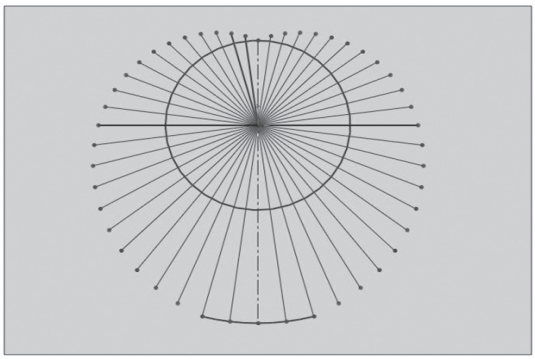

Figure 5.

Here is the displacement diagram of the constant velocity cam profile:

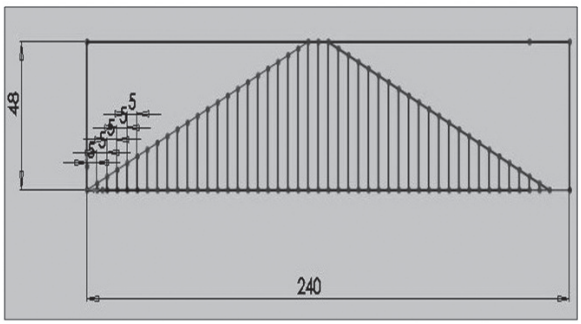

Figure 6.

Horizintal line: 240 mm

Vertical line: 48 mm

Horizontal line divided into 48 equal parts of 5 mm.

- Cycloidal Profile with the following specifications:
- Base circle radius: 30 mm Rise angle, Dwell angle, Fall Angle and Dwell angle as 160˚, 20˚, 160˚, 20˚ respectively.

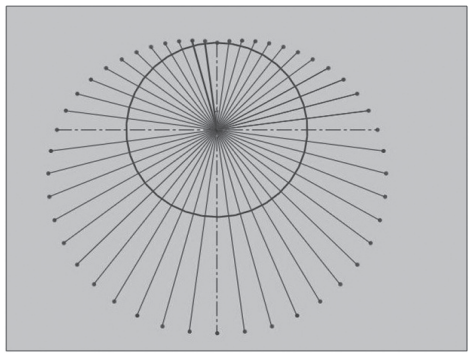

Figure 7.

Here is the displacement diagram of the cycloidal profile:

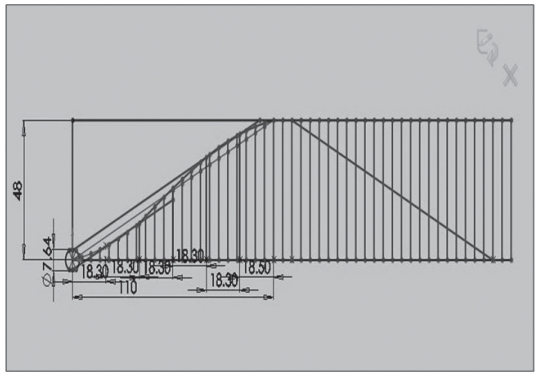

Figure 8.

Horizontal line: 240 mm

Vertical line: 48 mm.

Horizontal line divided into 48 equal parts of 5 mm

The final profile is obtained by superimposing the above two profiles.

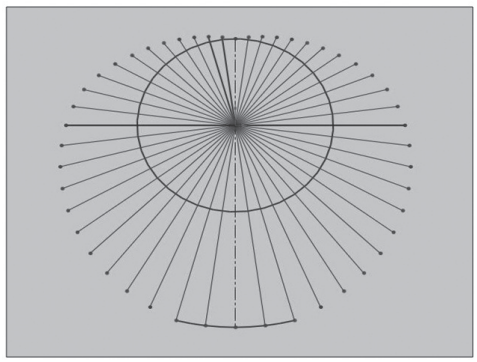

Figure 9.

VIII. CALCULATIONS

Mathematical proof that the cycloidal profile has the minimum jerks at the extreme points than the other profiles. Here we are comparing this profile with the simple harmonic.

The Jerk Function of the Simple Harmonic Motion is given by the equation:

$J= -\pi^3 h\sin(\pi\theta/\beta)/2\beta^2$

And the Jerk Function of the Cycloidal Motion is given by the equation:

$J= 4\pi^2 h\cos(2\pi\theta/\beta)/\beta^2$

where, β = total angle of any segment rise, fall or dwell (degrees or radians)

θ = camshaft angle (degrees or radians)

For the following assumed data the above two equations of jerk function will give the following result:

Let, h= 10 units, $\beta= 60^\circ = \pi/3$ and $\theta=90^\circ=\pi/2$

J= -21.65 units (for the simple harmonic motion)

J= -360 units (for the cycloidal motion).

IX. CONCLUSION

After converting the horizontal motion of the Morning Walker into *y-y* vertical motion with the help of two superimposed cam profiles and follower mechanism, its drawbacks are overcome. Now all the negative effect that has been causing problem in the knee so far can now be transferred to thigh and butt joint in place of knee joint alone which is strong enough to tolerate any kind of load as there are no muscles or ligaments that can tear easily. In this mechanism, a cam and roller follower arrangement is used. The cam profile is designed in such a way that it will give the constant velocity motion and the jerks at the extreme position will be minimized. A cam profile is obtained by superimposing two cam profiles. One profile is of the constant velocity nature and the other one is of cycloidal nature. These two profiles are superimposed because constant velocity profile will give the linear displacement profile that resembles with the case natural walking motion and the cycloidal profile will minimize the jerks at the extreme positions.

Figure 10. Present Model in which the superimposed profile is used.

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