Fabrication and Cost Optimisation of Elliptical Bicycle

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Abstract— Ellipti Move is a tool used in training by fitness enthusiasts and athletes to improve their performance with an innovative engineering concept that combines the motion of running, bicycling and elliptical machine. Elliptical cycling is for people who want to get physically fit, achieve their fitness goal and recover from hip and knee injuries. Its unique mechanism encourages maximum people to use this bike. Our aim is to design the elliptical bicycle in an optimized manner by reducing it's weight and cost in a such a way that it has low impact, high performance, exciting outdoor workouts and has an significant role in human welfare. Modification in design is a trend for developing a bicycle in recent years. Thus, the comfort of riding a bicycle is an important factor that should be paid much attention to while developing a bicycle. From the viewpoint of ergonomics, the concept of "fitting object to the human body" is designed into the bicycle frame in this study. Firstly the important feature points like frame design, wheel size, materials required, method of fabrication and troubleshooting are discussed. Further this study proposes a detailed of design of elipticle bicycle and methodology of fabrication which is helpful for the designer to develop an elliptical bicycle in an efficient and economical manner.

Keywords: Elliptical Bicycle, Fabricated Model, Ellipti Move

I. INTRODUCTION

The ElliptiMove is an elliptical bicycle. By modifying the elliptical trainer motion and combining it with the functionality of a bicycle, the ElliptiMove bicycle delivers a high performance workout experience that closely mimics running outdoors while eliminating the impact. It provides the most comfortable, fun and efficient way to get out and stay active.

ElliptiGO co-founder and former Ironman tri-athlete Bryan Pate was inspired to create the world's first elliptical bicycle after injuries plagued him to the point where he could no longer run for fitness. Although he was an experienced cyclist, Pate chose instead to use the elliptical trainer to stay fit because it was more comfortable than sitting on a bike. Unsatisfied with the experience of working out in a gym, however, Pate had a vision of creating a product that would allow him to have both the outdoor "running experience" and the low-impact workout of the elliptical machine. In 2005, Bryan partnered with ElliptiGO co-founder Brent Teal, a mechanical engineer and ultra-marathoner, to design and develop the world's first elliptical bicycle. Five prototypes and thousands of test miles later, the ElliptiGO was born.

The ElliptiMove is perfect for anyone who wants to get a great cardiovascular workout outdoors without damaging their body. It is particularly well-suited for runners who want to enjoy a running-like experience while giving their knees and joints a break from the wear and tear caused by running. The ElliptiMove is also ideal for cyclists who want to get the experience of cycling without the discomfort caused by sitting on a conventional bike seat or riding in a hunched-over position.

The ElliptiMove is easy to ride and more stable than it looks. Riding an ElliptiMove requires the same amount of balance as is required to ride a traditional bike or scooter. Like anything new and different, it takes some getting used to, but we've found that most people get comfortable within 5 minutes of riding it.

ElliptiMove is very different from a traditional bicycle. Traditional bicycles usually have a big seat with a back rest whereas the ElliptiMove has no seat at all. The traditional bicycle rider pedals with the legs parallel to the ground while the ElliptiMove rider's legs are perpendicular to the ground standing up and pedaling and rider stands for the whole time. The traditional bicycle rider's visibility is usually limited because they are lower to the ground making it, both harder to see them and herder for them to see around obstacles like cars, busses, trucks etc. In contrast, the elliptical rider's visibility is unusually good because their line of sight is elevated.

Cruising speed on an ElliptiMove is around 24 kmph, but a really strong rider can reach speeds in excess of 40 kmph on level ground. The ElliptiMove climbs, descends, accelerates and maneuvers similarly to a bicycle, so anywhere you can take a road bike, you can take an ElliptiMove, including up and down steep hills and along twisty sections of road. The ElliptiMove shares many of the most desirable benefits of an indoor elliptical trainer, including a low-impact workout, a natural pedaling motion, a weight-bearing position, and the ability to deliver a high-intensity exercise experience, with one major difference – it can be used outdoors.

Because ElliptiMove is designed to be aerodynamically efficient, road bicycles have uncomfortable ergonomics. The ElliptiMove is designed to emulate the natural running movement, so the rider stands upright in a very comfortable position and propels the ElliptiGO using a very comfortable motion. Moreover, the most complained-about element of road biking is the seat, which causes significant pain and numbness for a majority of riders and has proven links to erectile dysfunction and other urological ailments. By enabling a seatless cycling experience, the ElliptiGO solves one of the most important and challenging problems facing the road bicycling industry.

II. OBJECTIVE OF THE PROJECT

- To design and fabricate an elliptical bicycle for cost optimization as compared to actual ElliptiGO, conventional bicycles and other fitness equipments.
- To design and fabricate an elliptical bicycle for weight optimization as compared to actual ElliptiGO, conventional bicycles and other fitness equipments.
- To provide the rider a workout experience while eliminating the impact on the joints of the human body

caused during running, bicycling or working on an elliptical trainer in the gym, with the use of ElliptiMove.
- To provide comfortable and better ergonomics to the rider as compared to conventional cycle in order to eliminate the pain caused by constant cycling, with the use of ElliptiMove.
- Developing a fitness tool with the feasibility to explore the nature. To allow the rider to enjoy the outdoors and benefit from the utility of using an ElliptiMove to travel from one place to another for purposes of commuting, running errands, and general recreation.

III. METHODOLOGY

A. Material Selection

In the fabrication of the Bicycle, the material used is M.S Rod of 38 mm diameter. Mild Steel is the least expensive of all steel and the most common steel used. Used in nearly every type of product created from steel, it is weldable, very hard and ,although it easily rusts, very durable. The mechanical properties of mild steel is of carbon and iron content, with much more iron than carbon .In fact, at most steel can have about 0.16-0.18% of carbon. Mild steel is one of the most commonly used construction materials. It is very strong and can be readily available natural materials. It is known as mild steel because of its relatively low carbon content.

This type of steel of steel is able to magnetise and in almost any project. Its Structural strength prevents it from being used to create load bearing girders and structural beams, automobile chassis, motorcycle frames etc.Structural steel sections are usually used for construction of buildings, buildings, and transmission line towers (TLT), industrial sheds and structures etc. They also find in manufacturing of automotive vehicles, ships etc.Steel exhibits desirable physical properties that make it one of the most versatile structural materials in use. Its great strength, uniformity, light weight, easy of use, and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers, and other structure.

- Elasticity: steel follows hooks law very accurately.
- Ductility: A very desirable of property of steel, in which steel can withstand extensive deformation without failure under high tensile stresses, i:e., it gives warning before failure takes place.
- Toughness: Steel has both strength and ductility.
- Additions to existing structures: Example: New bays or even entire new wings can be added to existing frame buildings, and steel bridges may easily be widened.

As per the material survey the best suited material is mild steel (MS). The mentioned materialwas chosen as the material for bicycle frame due to its low density, compatible yield strength, easy of fabrication, cost and ease of availability. This material was chosen for designing the frame by comparing its results with different materials as alloy steel, EN8 etc.

B. Optional Materials:

- Al-6061-magnesium and Silicon Major Alloying Element-density 2.70g/cm3.
- Al-7005-Zinc-density-2.78g/cm3 depending on the temper, may be slightly stronger.

IV. DESIGN OF MODEL

A. Part Modeling Steps:

Following are the part modeling steps to generate the modeling of component.

Starting Out in Part Mode: Describes how to start creating a part with Solid works.

- Sketcher: Describes how to create sketches in a stand-alone Sketcher mode.
- Datum: Describes how to create datum features: datum planes, datum points, datum curves, datum axes, coordinates features, graphs, evaluate features.
- Sketching on a Model: Describes how to create 3-D sections in the process of feature creation.
- Feature Creation Basics: Describes how to create extruded and revolved protrusions.
- Sweeps, Blends, and Advanced Features: Describes how to create sweeps, blends, and advanced features.
- Construction Features: Describes how to create construction features, such as holes, slots, and cuts.
- Rounds: Describes how to add rounds to part geometry.
- Tweak Features: Describes how to create tweak features, such as draft, local push, and section dome.
- Creating Surface Features: Describes how to create surface features.
- Creating Advanced Surface Features: Describes how to create advanced surface features.
- Working with Quilts: Describes operations that you can perform on quilts.
- Freeform Manipulation: Describes how to dynamically manipulate a surface of a part or quilt.
- Patterning Features: Describes how to pattern features.
- Copying Features: Describes how to create and place groups of features, and how to copy features.
- Modifying the Part: Describes how to modify and redefine the part.
- Regenerating the Part: Describes how to regenerate the part and resolve regeneration problems

V. HEALTH BENEFITS

In 2015, the American Council on Exercise (ACE) commissioned an independent study to determine the effectiveness of a workout on the Ellipti bicycle and how it measures up to accepted fitness industry guidelines for improving cardio respiratory fitness and body composition.

For the study, researchers from the University of Wisconsin, LaCrosse, had 16 healthy female and male volunteers between the ages of 18 and 45 participate in three 15- to 20-minute practice sessions on the Ellipti bicycle before completing a graded maximal exercise test on a treadmill and a 30-minute exercise session on the Ellipti bicycle. During the graded exercise test, expired air and metabolic responses were measured, in addition to recording each participant's ratings of perceived exertion (RPE) at the end of each stage of the test. During the 30-minute exercise session, which was only conducted after the researchers deemed the participant

proficient on the Ellipti bicycle, heart rate and oxygen consumption was recorded each minute as the subjects exercised at a self-selected pace; session RPE was also recorded. ACE's study findings concluded that exercising at a self-selected intensity on the Ellipti bicycle met the guidelines on both accounts. The study subjects exercised at an average of 84 percent of HRmax and 75 percent of VO2max during the 30-minute exercise session.

VI. FUTURE SCOPE

In this project, we present an approach that solves the problem by offloading the low-level cognitive requirements from a biker to her bicycle. To support this approach, we enhance a standard bicycle with sensing and computational capabilities to create a Cyber-Physical bicycle system. The core goal of this system is to provide accurate and timely detection of rear-approaching vehicles to alert the biker of the pending encounter, through the cross-cutting application of mobile sensing, computer vision, and audio processing techniques.

Most of the people use fitness equipments for workouts and to stay fit, however as the fitness equipments are placed in closed/confined spaces, unfortunately the user ends up working out in an artificial environment and misses the opportunity to explore the nature. Another problem associated with fitness equipments is, the person using the fitness equipment has to perform a single exercise and is committed to that workout until it gets completed. So the aim of our project is to develop an elliptical bicycle or a fitness tool in minimum cost, which allows the user to work out as well as carry out his chores, commute from one place to another and can be used for general recreation.

The central goal of this work is to reduce the cognitive overhead of a biker to allow her to focus attention on bicycle handling and the roadway ahead. Evaluating this is a challenging problem as it requires thorough coverage of different biker skill levels, riding styles, roadway and route characteristics, environmental conditions, and user interface issues. As such, we acknowledge the importance and need for a full user study and plan to conduct one in the future as a separate, but related piece of research.

A. Fabrication of the Model:

After successful analysis of the model on the analysis software for different loads and environmental conditions, the frame is fabricated successfully according to the design specifications. Fabrication techniques included arc welding, bending, cutting, grinding, punching, forging and assembly of various parts required.

Fabrication was carried out in two phases, namely phase-I which included initial spot welding of all the joints for assuring proper shape of the frame and phase-II included complete welding of all the joints in the frame, along with custom paint job and finally the assembly of all the parts.

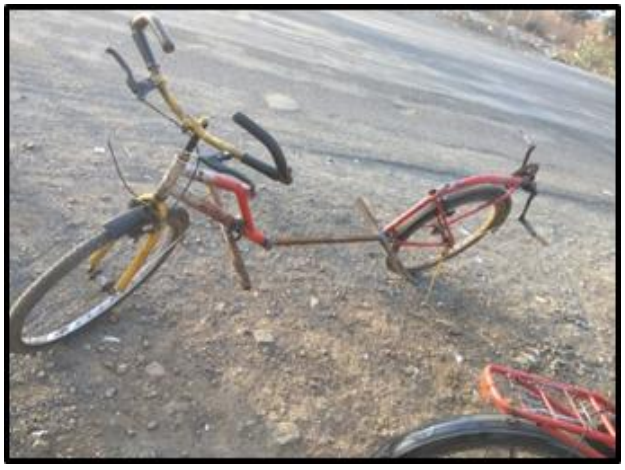

Fig. 2.12: Fabrication phase –I started

The above figure shows the commencement of fabrication phase-I which includes bending of pipes, spot welding of basics joints while taking care of distortion caused during welding

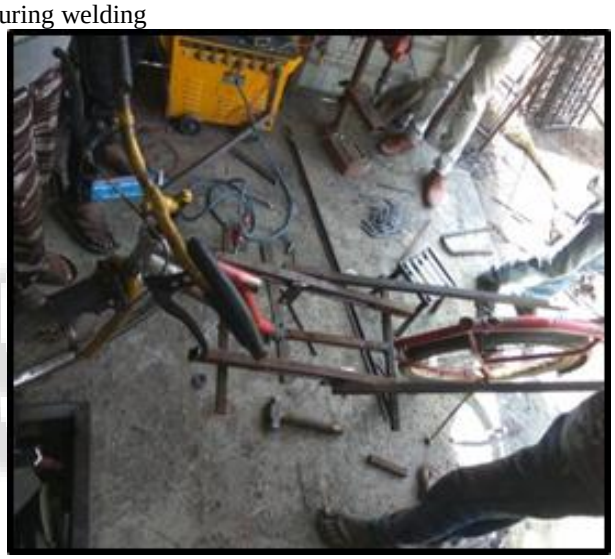

Fig. 2.13: Fabrication phase-I completed

The above figure shows the completion of fabrication phase-I, which includes spot welding of complete frame and assembly of tires and handle to ensure the frame is fabricated properly.

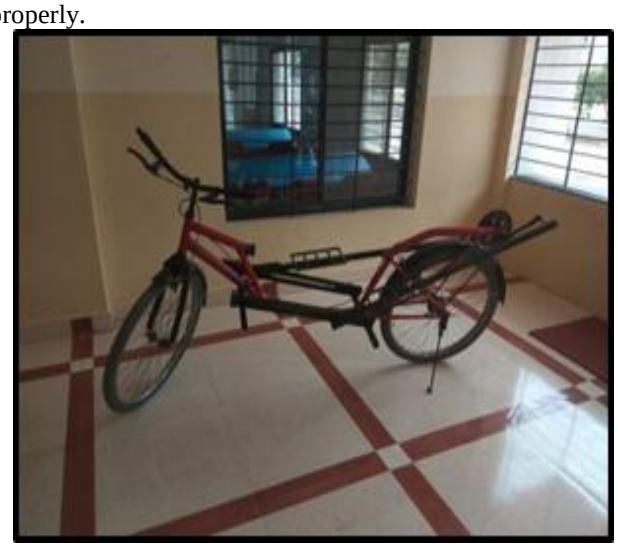

Fig. 2.14: Final look of EllipticMove after completion of fabrication phase-II

The above figure shows the final look of ElliptiMove after the completion of fabrication phase –II which included assembly of all the essential components and a custom paint job.

B. Testing of the Fabricated Model:

Followed by the fabrication of the actual model, the model has been tested for different road, different load and various environmental conditions to identify any defects or flaws in the design or fabrication processes, and eventually no defects or flaws where noticed or observed. The model was tested on smooth, rough, dirt and uneven road surfaces to observe the behavior of the bicycle on the above mentioned road conditions, and fortunately the bicycle behaved in a well-mannered way, hence eliminating any chances of misbalance or mishap.

C. Troubleshooting:

In case, if any defects or flaws are found in the fabricated model during the course of its future use the defects or flaws will be corrected/rectified by taking suitable steps. The rectification steps will include the change in chain length in case of falling of chain from the chain ring, change in the center distance between the chain ring and sprocket in case of tight or slack chain to avoid failure of chain, chain ring or sprocket, and lastly adjustment of the handle height according to the riders comfort.

VII. CONCLUSIONS

Thus we conclude that ElliptiMove is designed and fabricated with the 80% cost optimization hence satisfying our aim of the project which was to design and fabricate the model while optimizing the cost which is successfully achieved with an added advantage of introducing this concept in the Indian market. ElliptiMove is designed in such a way that we have also achieved weight optimization up to 1 kg. ElliptiMove provides the rider a workout experience while eliminating the impact on the joints of the human body caused during running, bicycling or working on a elliptical trainer in the gym. The comfortable and better ergonomics of ElliptiMove ensures that the rider workouts with ease eliminating the pain caused due to constant cycling during the use conventional bicycle.

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