A PROJECT REPORT

ON

"DESIGN ANALYSIS AND FABRICATION OF FOLDABLE BICYCLE"

Submitted by

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In partial fulfillment for the award of the Degree

Of

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Of

Prof. NAFE MOMIN

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"**DESIGN ANALYSIS AND FABRICATION OF FOLDABLE BICYCLE**"

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This is to certify that the thesis entitled

"DESIGN ANALYSIS AND FABRICATION OF FODABLE BICYCLE"

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ABSTRACT

Petrol In the present day lifestyle man is not able to dedicate specific time for his health, importance is least given to exercise and body fitness due to time shortage and stressful life. To cope with time deficit, we can utilize the time spent on commuting efficiently to exercise by using bicycles, thereby also contributing to pollution control. But regular bicycles occupy sufficient space to park, are not easy to carry around and are probable to theft. Transport has been one of the most important issues to be dealt with in the present day situation as commuting from place to place within the city has become a tedious and an expensive task. It is very difficult to reach the nearest public transport facility and in many cases the destination will be very far from the main roads where the public transport might not be able to commute or it might be very expensive. To overcome a common problem faced by the society, an idea is conceptualized to design and fabricate a foldable bicycle. We already have seen many foldable bicycles in the global market but the main idea of this project is to provide a foldable bicycle which is light & sleek yet rigid & safe, easy to handle and easy to maintain. Unlike the conventional cycles, this bicycle will occupy very less space and also is very easy to be carried around. The main objective is to design and develop a foldable bicycle which is comfortable to ride and economical. Regarding to the point that some people for solving this problem use bicycles as a transportation .We decided to design a bicycle that is folding design. It can be folded when is needed. In this way it can be placed in a small bag .Another important point about it: Doesn't need for any external electrical supply and fossil fuel. This report is aimed for our client which came to ask us to make a remodeled version of the folding bike with the most important difference, which is: a lower production costs (approximate 75%).successful design of folding bicycle should take into account the function, material properties, and fabrication process. There are some other factors that should be considered in anticipating the behavior of materials for folding bicycle. In order to understand the relationship between material properties and design of a folding bicycle and also for the future direction in new materials with new design, a comprehensive study on the design under different conditions are essential. Therefore, a systematic study on the relationship between material properties and design for folding bicycle has been performed. The advantages and disadvantages matrix between conventional bicycle and folding bicycle is presented for better understanding of the materials properties and design. It was found that the materials properties of the folding bicycle frame such as fatigue and tensile strength are the important properties for the better performance of the frame. The relationship between materials properties and design is not straight forward because the behavior of the material in the finished product could be different from that of the raw material. The swing hinge technique could be a better technique in the design for the folding bicycle frame.

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CHAPTER – 1 INTRODUCTION

Global warming is one of the most highlighted sectors over which the concentration and dilemma of human beings have shifted in past recent years. It is only due to the harmful effects of this global warming phenomenon which has caused disaster to our mother nature and to us. Effects like global warming, depletion of ozone layer etc are very prominent in now a days. The main cause of these harmful effects is greenhouse effect which is mainly caused due to the production of carbon di oxide, Sulphur di oxide, nitrous oxide etc. From the studies of year 1896 to the present age, one thing is clear that major production of these gases takes place from our mode of transportation. They create a large amount of these types of harmful pollutants and release them into the atmosphere which in turn causes greenhouse effect and leads to such harmful conditions. So in order to reduce and restrict this, the main focus is to reduce the production of those harmful pollutants from vehicles, and in order to meet this, research innovations and studies are conducted on the modes of transportation such as cycles which produces nearly 0% pollutants. From the very ancient time, cycle is always an important mode of transportation in our world. It is not only the transportation mean but also a very effective equipment for achieving and maintaining a good physical and mental health. Apart from this, it is the cheapest mode of transportation as it requires no fuel or source of energy and it requires no maintenance .It is also the most eco-friendly mode of transportation ever invented in this world as it produces 0% pollution. Besides this it is very economical and easily available mode of transportation. Folding bicycle is the modified and evaluated version of the cycles .It is the type of the cycles which is taking the legacies of the cycles to the new heights. It's characteristics and properties like light weight, easy to carry ,portable, less space requiring ,low maintenance needed, are making them more popular and first choice of cycle riders, mountaineers etc. The most important things in folding bicycle are the joints, material used and the type of joining techniques such as welding, brazing etc. done for the fabrication of the folding bicycle. This report consist of the important data with the fabrication of four fold- carry foldable bicycle. A folding bicycle is a bicycle designed to fold into a compact form, facilitating transport and storage. When folded, the bikes can be more easily carried into buildings and workplaces or on public transportation (facilitating mixed-mode commuting and bicycle commuting), and more easily stored in compact living quarters or aboard a car, boat or plane. Folding mechanisms vary, with each offering a distinct combination of folding speed, folding ease, compactness, ride, weight, durability and price. Distinguished by the complexities of their folding mechanism, more demanding structural requirements, greater number of parts, and more specialized market appeal, folding bikes may be more expensive than comparable non-folding models. The choice of model, apart from cost considerations, is a matter of resolving the various practical requirements: a quick easy fold, compact folded size, or a faster but less compact model.

CHAPTER NO-2 LITERATURE REVIEW

2.1 History of folding bicycle

In this work, the existing foldable bicycles have been evaluated to understand the limitations in it. Generally, in a typical product development process, the product is evaluated based on a specific set of design criteria. The design criteria are framed with regard to cost, functionality, safety, maintenance, durability in addition to a specific set of criteria depending upon the product being considered. In this study a specific set of criteria is formulated for the foldable bicycle and the existing bicycle designs are evaluated to understand their limitations.

Depending upon the shortcoming of the existing product for the criteria, new designs are proposed to overcome the limitations. The formulated criteria for the foldable bicycle in this work for evaluation are based on: the folding methods, portability, ease of transportation, compactness (during travel and storage) material used, tire size, weight and quickness to fold etc. The shortcomings of the existing designs in satisfying the formulated set criteria have strengthened the need for a new design in foldable bicycle, to overcome the limitations. The limitations in the existing foldable bicycles for the specific set of formulated design criteria are presented in this study. The weight of the currently existing foldable bicycles are found to be more than 15 kg., which is on the higher side considering the fact that it may be needed to be carried for long distances. The cost of the bicycle is also not affordable to average customers. The ease of fold ability is also found to be less because the existing bicycles can only be a folded into two fold.

The proposed design in this study eliminates all the limitations in the existing ones by enhancing the design feature besides adding some additional features The conceptual design is said to be a rough idea about the design to be proposed. It is considered to be a skeleton structure of the design, to which the flesh and body are added in the embodiment design stage which follows it. Analysis the limitation in the existing product, from which the opportunity to develop a new design is created. The second phase, conceptual design deals with the generation of as many solutions as possible to evaluate it to select the best concepts.

Generally the concept solutions are conceived as ideas which are represented by free-hand sketching. Once the concept solutions are generated, the best concepts are selected by techniques like Pugh chart and weighted matrix which evaluate the concepts based on the specific criteria which the customer would consider while purchasing the product. The conceptual design stage is followed by the embodiment design stage which deals with the selection of suitable materials to the components, along with its dimensions. The detail design stage, which follows the embodiment design stage deals with the detailed drawings and specifications of the components in the product.

The CAD tools are extensively used in this stage. The analysis and optimization of the design concepts are done using various CAD/CAE packages. In the current study a few foldable bicycle concepts are proposed. Some heuristics and line of thumb have also been developed by researchers to lighten the cognitive load that such design problems impose. Literature review of electronic media, journal publications, books and technical reports explain various inventions of foldable bicycle. The literatures are used to understand the past inventions of foldable bicycle.

In 1986, Nishimura et al invented a foldable bicycle frame which has a vertical center tube at a mid-portion of the bicycle frame. The front half of the bicycle frame can be folded or extended. Beech invented a portable cycle-type exercising device capable of being easily erected for use and compactly folded for convenient storage in a relatively small area during periods of non-use. In 1986, Chiu invented a mini foldable bicycle which has a single front wheel for steering and a pair of adjacent wheels at rear for propelling the bicycle. The bicycle is small and light, and is made foldable so that it can be reduced to a very small package for the convenience of being transported.

In 1990, Huppe invented the invention provide extended at an angle from a rear- wheel fork, pedal crank can be placed on a higher frame or adjustable vertically upwards to avoid rocks and bushes in mountain riding or downwards for lower obstacles in street riding.

In 1995, Ching-Tsung invented a foldable bicycle with many links that are made to join the components of the bicycle such as handlebar, seat tube, top tube, head tube and down tube. In 2000, Herder invented a foldable bicycle frame member with first and second shafts connected pivotally at one end and a locking unit for retaining releasable.

In 2001, Ibarra invented a novel bicycle which combine a skateboard and bicycle. The bicycle is provided with normal bicycle handle bar and the rear side of the bicycle is attached with the skateboard. There is no chain drive. Manual pull energy is the source of power to move.

In 2007, Sanders invented a foldable frame assembly with hinge.

The hinging action allows the bicycle to get foldable as well as provide a rigid structure while riding. The aesthetical appearance is also good.

In 2010, Yi-Cheng Lin invented a laterally moving foldable bicycle consisting of the mechanical components like a sleeve, upward directed notch, support tube, auxiliary wheel and threaded lever. In all above invention, the role of joints and links are observed to be important. Some of the journals about bicycle frame joints and links are reviewed.

In 1988 Zane et al, invented the clamp, which is releasable and has a secured lock to a foldable bicycle frame.

In 1996 Pan, used a joint for the bicycle frame. The joint includes a composite material which has a first tubular member, and a metal second tubular member fitting with a laterally extending insertion portion. There are a variety of inventions of the foldable bicycle so far. Hence, in the present paper an attempt has been made to design and develop a foldable bicycle by employing a systematic approach conceptual design and embodiment design methods.

2.2 Review from survey

Here an attempt is made to review the status of literature in folding bicycle based on various criteria. The work done by various authors are explained below.

Hajime Ishida (1977*):* This invention, which provides a folding bicycle, comprises a foldable frame structure including a front support assembly having handlebars and arranged to be rearward foldable. According to the invention, the user can very quickly and easily fold by manually rearward folding the front support assembly which includes upper and lower section interconnected by hinge.

Robert D. Shomo (1981): The author has put forward the concept of folding bicycle, As the folding bicycle of the present invention comprises a large-wheel folding bicycle which exactly duplicates the looks, and feel, rigidity, strength, weight and ride quality of a conventional and popular l0/l2speed touring bicycle. The folding bicycle of the present invention includes a compact frame which is foldable, with the front half of the frame being rotatable about a hinge means to position it against the rear half of the bicycle for easy and efficient transportation. The folding bicycle of the present invention is adapted to be inserted into a carrying bag, if desired. The handlebars employed with the folding bicycle of the present invention are foldable into a collapsed position and the pedals are reversible.

Kao P. Cheng, Changhu Taiwan (1994): An improved locking hinge for use in a folding bicycle is equipped with a lever arm which is in pivotal connection to a locking hook at the bottom end thereof. The looking hook also pivotally mounted onto the handlebar of a bicycle has a retaining recess which is made to engage with a locking pin mounted onto the steering stem of the bicycle so as handlebar which is put in linear alignment with the to get a folding bicycle in use as long as the lever arm is pushed toward the erected steering stem already. Besides, a securing spring plate is used to retain the lever arm in place so as to prevent the locking hook from disengagement from the locking pin as the bicycle is in use. To get the bicycle folded, the Securing spring plate is lifted upwardly too permanently to permit the lever arm to pried outwardly, resulting in the locking hook disengaged with locking pin. Then the handle bar and the steering stem are separated with each other and put side by side in a folding manner.

Jaime Herder, Perth, Australia (1998): A folding bicycle in which all the pivoting members have horizontally pivot axes and all the members are indirectly connected to a single collar that slides up and down a seat post. In order to achieve an open or closed state, the collar is made to slide along the post and is then secured by tightening a quick release lever on the collar. Two front tubes mending between the Steering head and the lower Part Of the seat post are parallel.

2.3 Gaps in literature

- The weight of the bicycle is more.
- Difficult to carry in bag.
- As compare to conventional bicycle has a less rigidity.
- Joint used in bicycle is hinged which is less reliable than compact joint.

2.4 Objectives of research

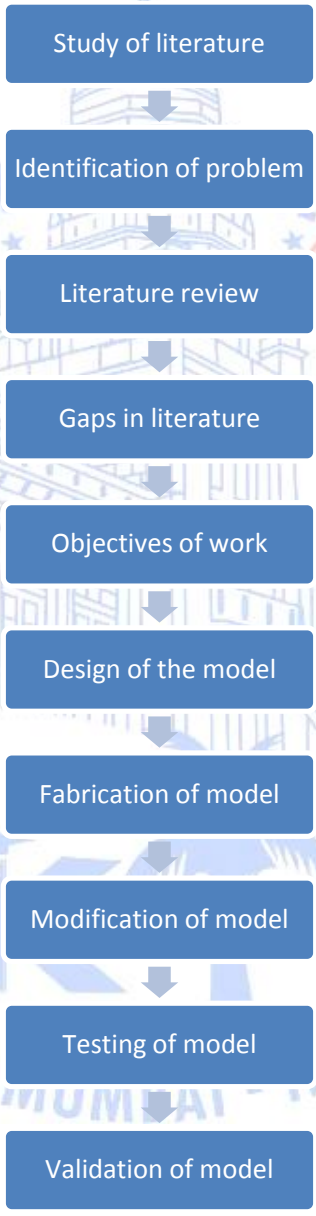
The objectives of research are as follows:

- Portability is a term which means any object or project can be easily port. Portability play very important role in every filed Such as machines, construction sides etc.
- The bicycle design must be a portable so that it can be easily carrying from one place another place.
- Weight can be calculated by product of mass & gravity. Weight plays a very important in a folding cycle which is generally used for carry it from one place to another place.

- If the weight of the bicycle is not maintained properly, then it will provide lots of difficulties for the portability of folding bicycle Factors which are consider for reducing the weight of material, of the bicycle are design of bicycle and its dimensions.
- In India cost factor plays an important role, so the cost of the cycle should be in the budget of the common people.
- To use optimum material to make the cycle affordable to each and every class of people.

CHAPTER NO-03 METHODOLOGY

The methodology used for research work is summarized in figure

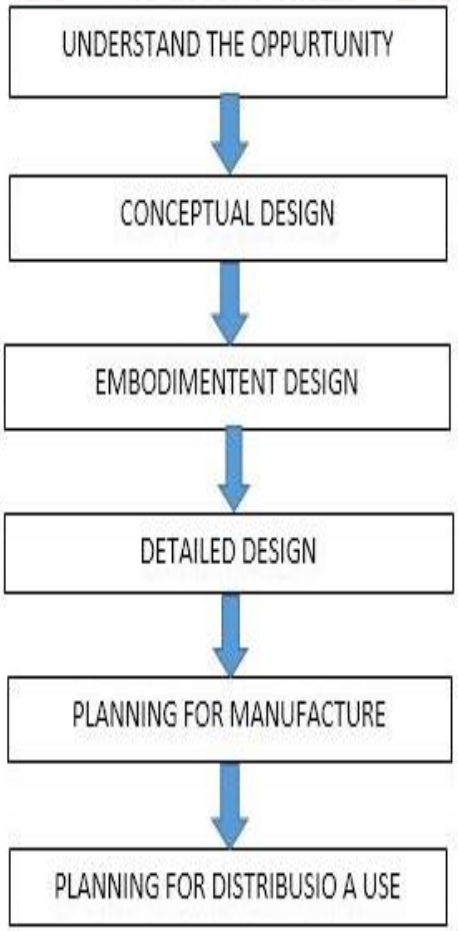


CHAPTER NO-04 METHODS AND PROCESSES

In this chapter the details about construction of each and every part of the Foldable bicycle are given. This chapter provides brief description of every component along with the materials used for every element of the system.

4.1 Design

4.1.1 Stages of design



The stages in the product development process are classified based on the type of technical activities performed in it. The flow chart in Figure-1 represents the sequence of activities performed in a typical product development process. The first phase, understanding the opportunity deals with developing a vision for new product. It analyses the limitation in the existing product, from which the opportunity to develop a new design is created. The second phase, conceptual design deals with the generation of as many solutions as possible to evaluate it to select the best concepts. Generally the concept solutions are conceived as ideas which are represented by free-hand sketching. Once the concept solutions are generated, the best concepts are selected by techniques like Pugh chart and weighted matrix which evaluate the concepts based on the specific criteria which the customer would consider while purchasing the product. The conceptual design stage is followed by the embodiment design stage which deals with the selection of suitable materials to the components, along with its dimensions.
The detail design stage, which follows the embodiment design stage deals with the detailed drawings and specifications of the components in the product. The CAD tools are extensively used in this stage. The analysis and optimization of the design concepts are done using various CAD/CAE packages. In the current study a few foldable bicycle concepts are proposed. Some heuristics and line of thumb have also been developed by researchers to lighten the cognitive load that such design problems impose.

4.1.2. Existing design and its evaluation

In this work, the existing foldable bicycles have been evaluated to understand the limitations in it. Generally, in a typical product development process, the product is evaluated based on a specific set of design criteria. The design criteria are framed with regard to cost, functionality, safety, maintenance, durability in addition to a specific set of criteria depending upon the product being considered. In this study a specific set of criteria is formulated for the foldable bicycle and the existing bicycle designs are evaluated to understand their limitations. Depending upon the shortcoming of the existing product for the criteria, new designs are proposed to overcome the limitations. The formulated criteria for the foldable bicycle in this work for evaluation are based on: the folding methods, portability, ease of transportation, compactness (during travel and storage) material used, tire size, weight and quickness to fold etc. The shortcomings of the existing designs in satisfying the formulated set criteria have strengthened the need for a new design in foldable bicycle, to overcome the limitations. The existing foldable bicycle designs are shown in Figures 2 and 3 [4]. The limitations in the existing foldable bicycles for the specific set of formulated design criteria are presented in this study. The weight of the currently existing foldable bicycles are found to be more than 15 kg., which is on the higher side considering the fact that it may be needed to be carried for long distances. The cost of the bicycle is also not affordable to average customers. The ease of fold ability is also found to be less because the existing bicycles can only be a folded into two fold. The proposed design in this study eliminates all the limitations in the existing ones by enhancing the design feature besides adding some additional features.

Fig:- 1 Existing Bicycle

4.1.3 Conceptual design

The conceptual design has the following stages in it as shown in Figure-4. The conceptual design is said to be a rough idea about the design to be proposed. It is considered to be a skeleton structure of the design, to which the flesh and body are added in the embodiment design stage which follows it.

Generation of sub functions

In this stage of concept generation various sub functions that are needed to accomplish the overall function are identified. This is generally identified by function structure diagram. Each sub function can be accomplished by different ways which are called as concepts. In the current study the following sub functions are identified based on the functional diagram.
They are: **1.** Frame shape **2.** Frame, **3.** Drive mechanism, **4.** Front wheel/back wheel, **5.** Tube interfaces, **6.** Joints, **7.** Links, **8.** Dynamic interfaces, **9.** Forks and steering. The sub function identified is contributions to the accomplishment of the overall function of the product.

Generation of methods to accomplish the sub Functions

The next stage in product design is to develop as many concepts as possible for each sub function. To accomplish each sub function a variety of options would be available. The available options for each sub function are then identified as real devices or sub components. These sub components which represent the sub functions are arranged in a logical manner to accomplish the

main overall function. In the current study the subcomponents needed for the formulated sub functions like frame shape, drive mechanism, tube interface etc. have been determined.

Construction morphological matrix

The representation of a variety of subcomponents for achieving each sub function is represented in a chart called morphological chart. The morphological chart contains rows and columns which resemble a matrix form. Each row has a particular sub function and the different methods in which it can be accomplished. Once completed The morphological chart gives a variety of possible sub components that could be used to achieve each product sub function. Further, any sub component under a particular sub function could be combined with other sub components in the other rows by various combinations to result in a wide range of product configurations to accomplish the overall function of the product.

Concept generation through sketching

Generally in the conceptual design stage the product concepts are drawn in paper using pencil as free hand sketches. CAD systems are too rigid and not as flexible as freehand sketching. The initial free hand sketches roughly describe the possible numerous solution concepts for the identified problem. The paper and pencil work are intensively used in the conceptual design stage whereas CAD applications are used for detail design like modelling of parts, FEA, etc. The pencil work allows the flexibility of speed that is needed during the conceptual design stage. Drawing and free hand sketching are the two efficient methods to develop an idea or thought to solve a definite problem and to express the ideas of the produce that are to be designed. Drawing and free hand sketching can be considered as a symbolic language used by the designer during the conceptual design stage. Generally the sketches start as a valuable idea or a solution to a problem and it is continuously evolved by adding some minute details to enhance the features of design by successive iteration.

Concept sketches play an important role in product design and development process [5]. The initial sketches that are drawn may sometimes be used as a tool to generate new ideas. The sketching in the product development process acts as a bridge between an idea as a thought and a physical representative of the idea as an object. The free hand sketch gives the flexibility in producing concepts and facilitates easy manipulation of the concepts, and they don't have any geometrical and topological constrains etc.

In this study, as many solutions as possible to a given design problem have been generated by means of sketching. Generally the CAD packages slow the ease and speed with which sketches can be created. The concept sketches provide quicker communication and retrieval at an early stage of design

Fig:- 2 Rendered Design Image

Fig:- 3 Rendered First Fold

Fig:- 4 Rendered Second Fold

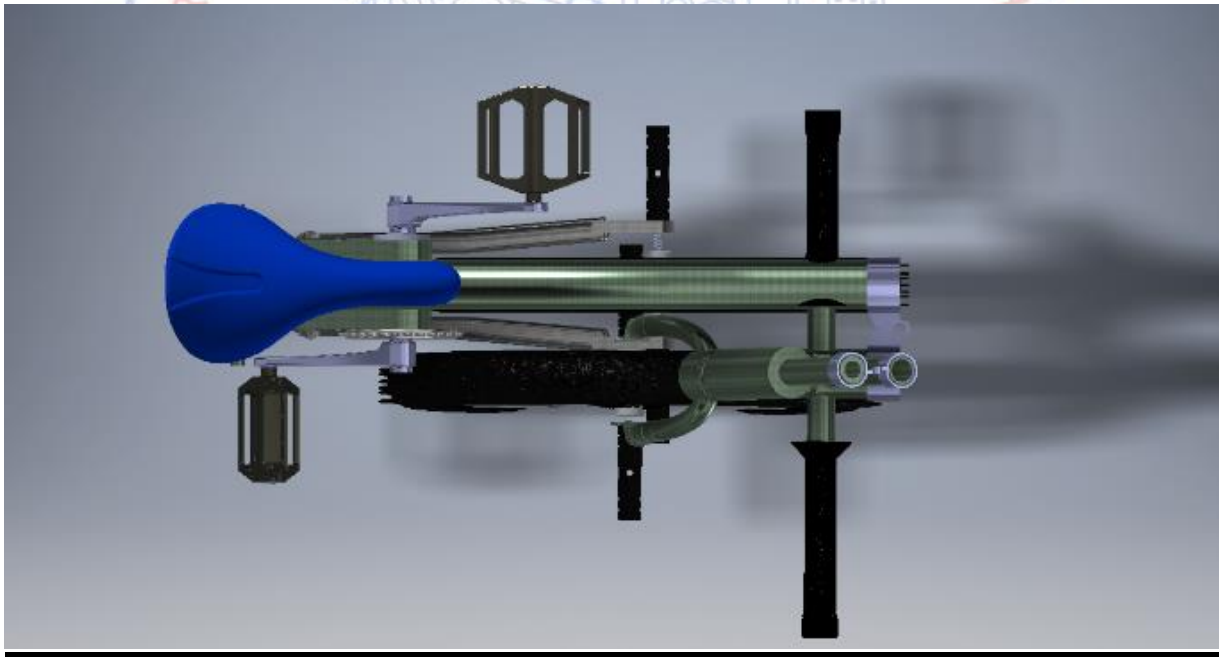


Fig:- 5 Rendered Complete Folded View

4.1.4 Dimension table

SR. NO.	PART NAME	DIMENSION (inches)
1	Top tube	20
2	Down tube	11
3	Seat tube	7
4	Head tube	6
5	Seat stays	12
6	Chain stays	12
7	Forks	12
8	Handle height	9
9	Handle width	20
10	Spoke	17
11	Stem	2

Table 1:- Dimensions

4.2Material selection

4.2.1 Materials Properties of Folding Bicycle Frame

Properties determine the usefulness of the engineering material. Therefore, it is important to use properties of the materials before any decision on a particular design . Table 2 shows the properties of the selected materials those are suitable for folding bicycle frame. It can be seen that the titanium alloy is more suitable for this particular application The major required properties of materials for the use of frame is discussed below.

Tensile Strength. Tensile strength is the basic measurement of strength of a material. It is specifically a measurement of the force required to pull apart a material. In frame design, the higher the tensile strength the better the performance of the frame. More strength allows less material to be used thus saving weight.

Fatigue Strength. Fatigue strength is the measurement of how far and how many times a material can bend before it breaks. Higher fatigue strength is essential for higher durability and more safety reason. Certain materials such as steel and titanium actually have a threshold value of the fatigue strength and after proper design it can be used for an infinite number of times without failure.

Yield Strength. Yield strength (YS) measures how much force it takes to permanently bend a material. As with tensile and fatigue strength, higher YS is expected from the materials for the use of frame. The higher strength level of titanium (typically 800-1080 MPa) allows material to be used less which in term reduces the weight of the structure.

Toughness. Toughness is the property that defines exactly how much a material can stretch before failing. Titanium is an incredibly tough material. Aluminum has good toughness as a raw material with some extra care during manufacturing of the aluminum frame to make sure not let the tube walls get too thin. Toughness is the Achilles heel of carbon fiber composites. If carbon receives an indentation, fibers have most likely been severed, strength has been reduced, and the possibility of further fracture has seriously increased.

Density. Density is simply the weight of a material for a given volume such as pounds per cubic inch or grams per cubic centimeter. The density of the carbon fibre composite showed the lowest density (hence lightest weight) with the approximate value of 1.8 g/cm3 followed by aluminum (2.71 g/cm3). However, titanium showed the highest density (4.43 g/cm3). The density of a material certainly is an important factor in materials evaluation; especially it is more important consideration for bicycle application compared to its strength and durability. Table 2: Properties of the selected materials those are suitable for folding bicycle frame.

Corrosion Resistance. Corrosion (or the lack thereof) plays a key role in the life expectancy of the bicycle and influences the amount of care or maintenance that must put into the bicycle to keep it in good shape. Fresh water, salt water, sweat, hot, cold, ultra-violet light and infrared light are the factors and materials are susceptible to corrosion. However, there will have very minimum effect if titanium alloy is used for folding bicycle frame as this material has very high corrosion resistance properties.

Material	Fatigue strength (Mpa)	Yield strength (Mpa)	Density (kilogram/cubicmetre)
Titanium	612	1085	4430
Mild steel	120	240	7850
Carbon fibre	402	700	1800
Aluminium	98	280	2710

Table 2 :Material properties

4.2.2 Effect of Material Properties on the Design

The frame of folding bicycle has to incorporate with certain design features which introduce changes in its cross-section. Figs 4 and 5 show the factors (primary and anticipated respectively) those should be considered in design of folding bicycle frame. The figures also showed clearly about the factors that affect the behavior of materials in folding bicycle frame design. The relationship between material properties and design is complex because of the behavior of the material in the finished product which might be quite different from that of the stock or original raw material.

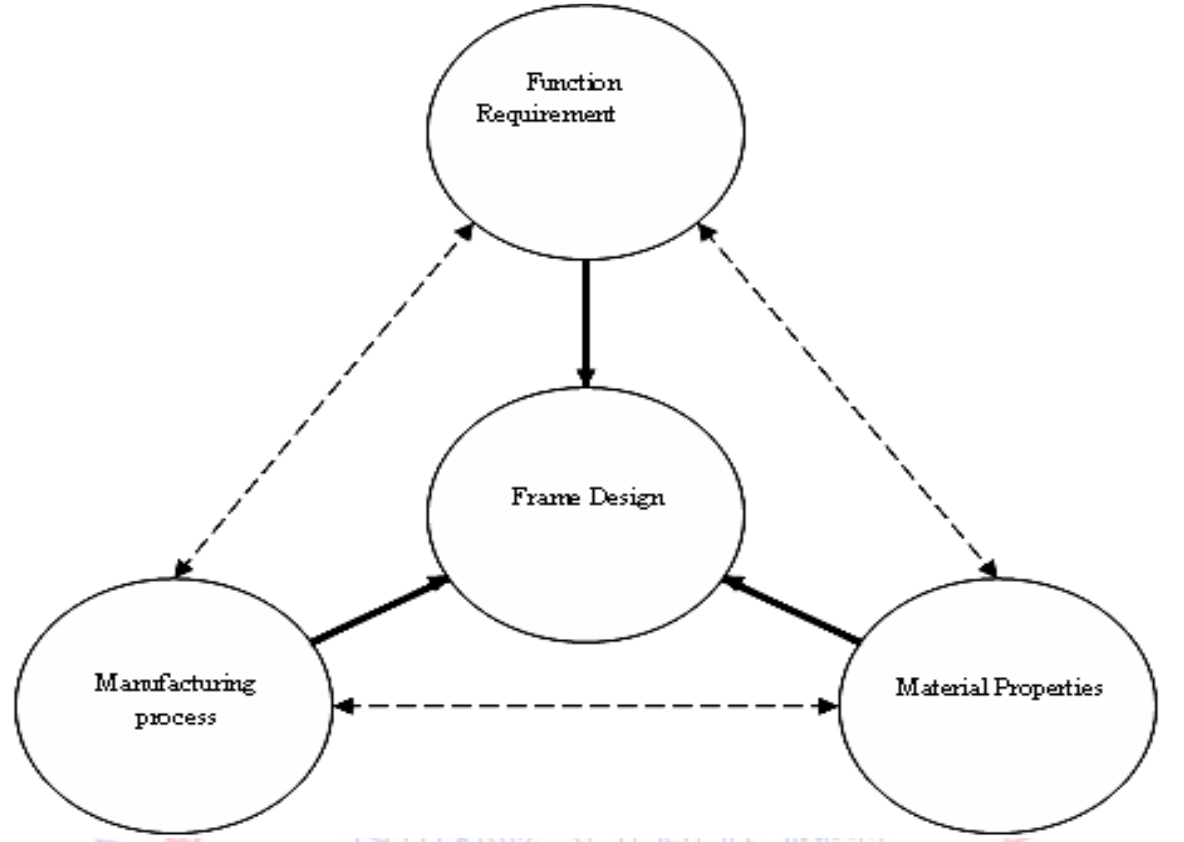


Fig. 6 Factors that should be considered in folding bicycle frame design.

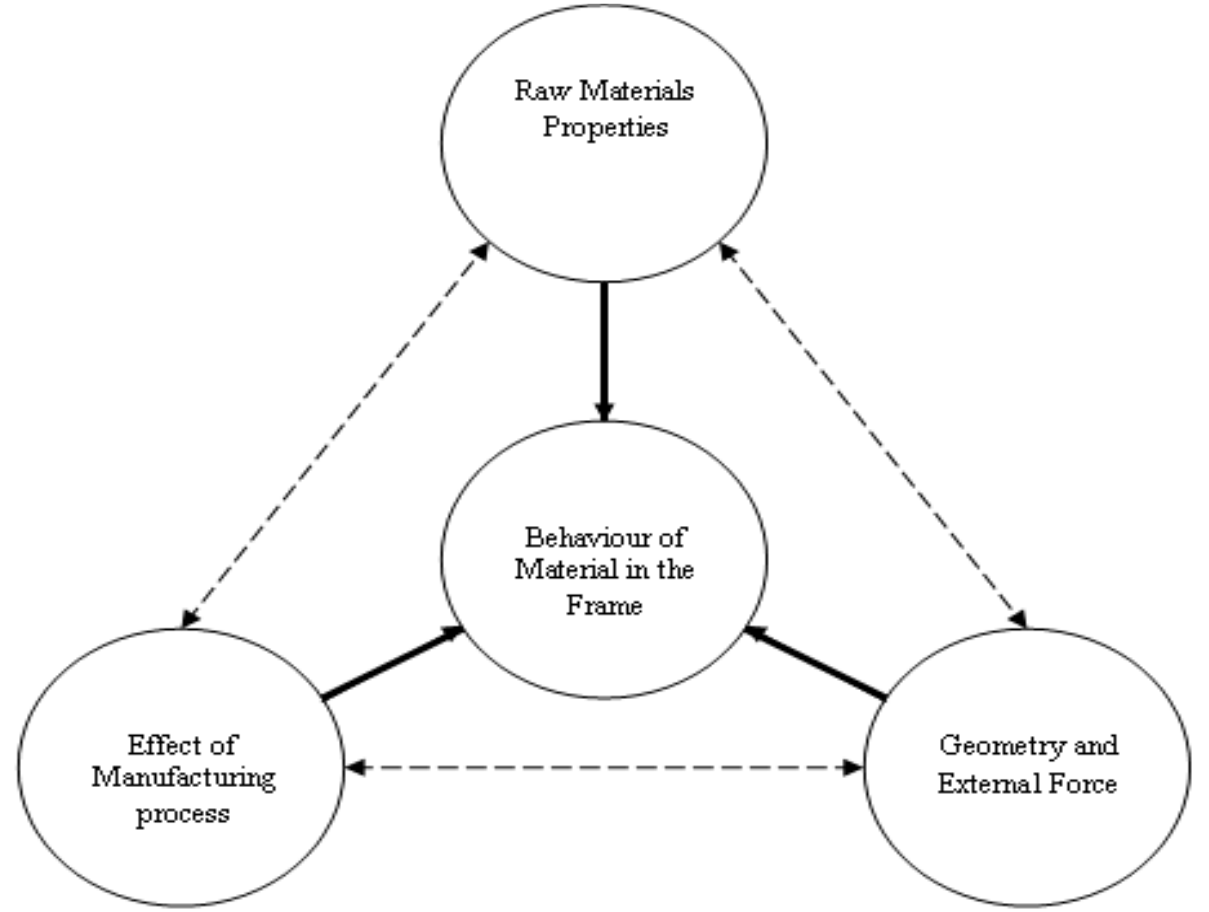


Fig. 7 Anticipated factors that affect the behavior of materials in folding bicycle frame design.

4.2.3 Conclusion of Material selection

The study on the aspects of materials properties and design of folding bicycle frame was performed. In conclusion, the folding bicycle is an important design in human history, thus it brings benefits to make life easier than before. The fatigue problem (which might extend the life cycle of the folding bicycle frame) is always considered as main problem regarding the properties of the materials. The relationship between materials properties and design is not straight forward because the behavior of the material in the finished product could be different from that of the raw material. Additionally, the properties like fatigue and tensile strength are the important properties for the better performance of the frame. The coated swing hinge in folding bicycle is considered as a better joint technique in the design and carries benefits to the user to fold the bicycle since it overcome the limited lifecycle and moreover is simple and cost effective.

Mild steel seemed the best material having enough strength tom withstand the various loads and stresses. The cost and the density of the mild steel is optimum for its use in manufacturing of foldable bicycle. The study on materials concluded mild steel the best material for fabrication.

4.3 Analysis

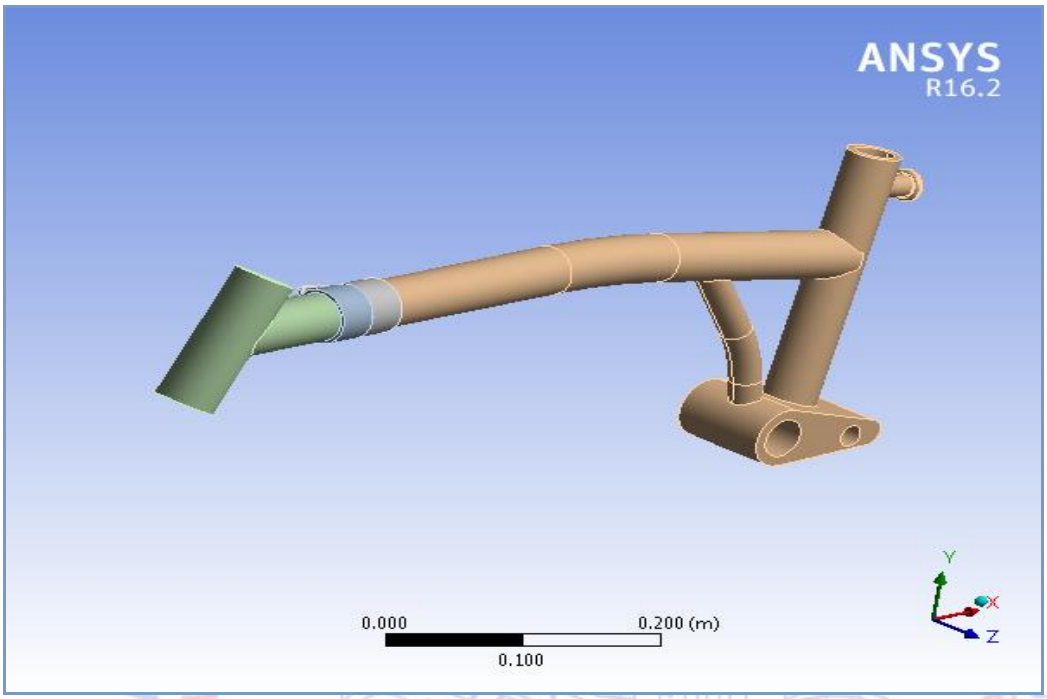


Fig:- 8 ANSYS Frame Design

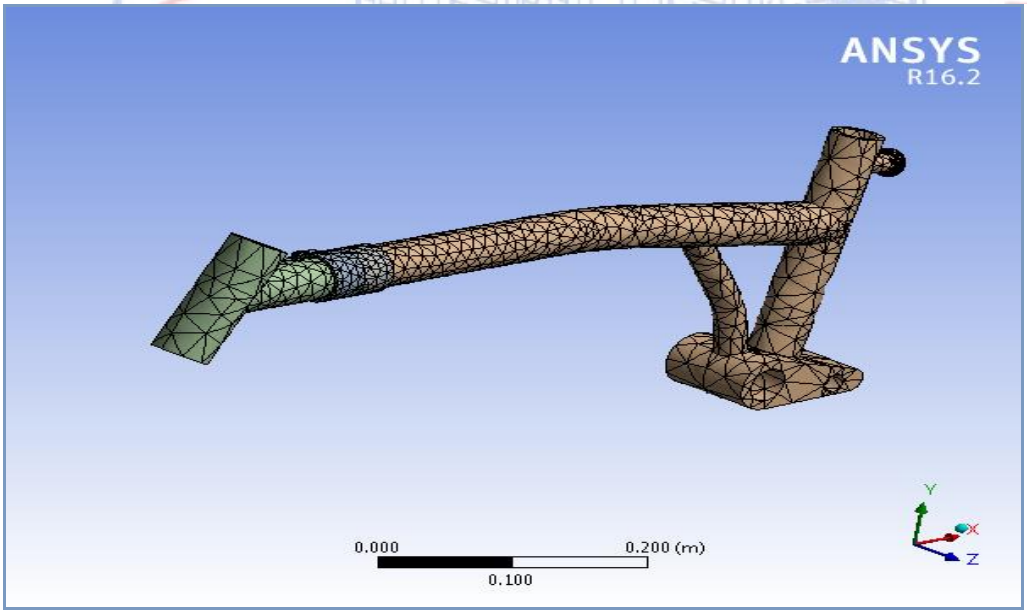


Fig:- 9 ANSYS Frame Meshing

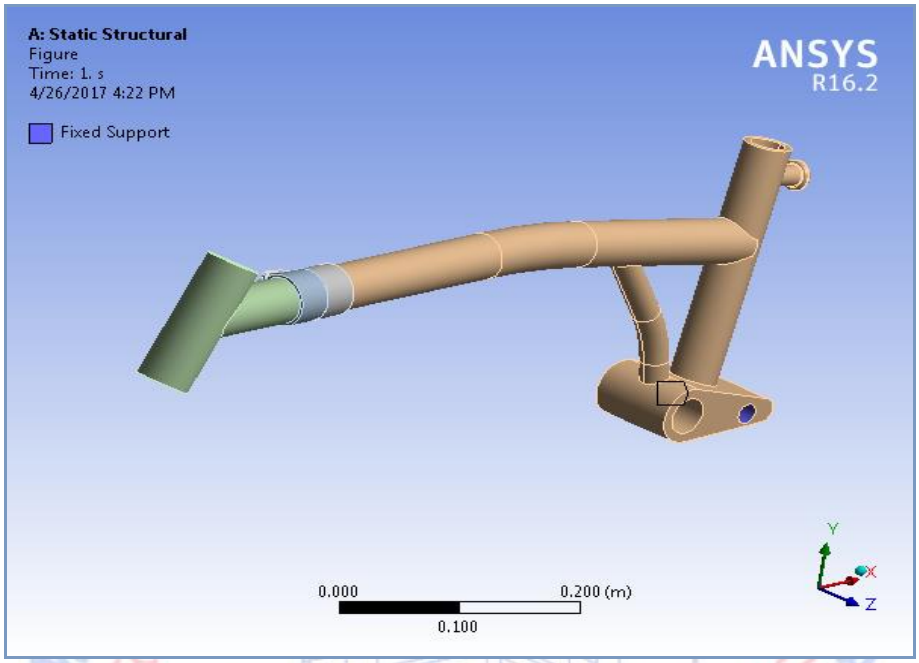


Fig:- 10 ANSYS Frame Fixed Supports

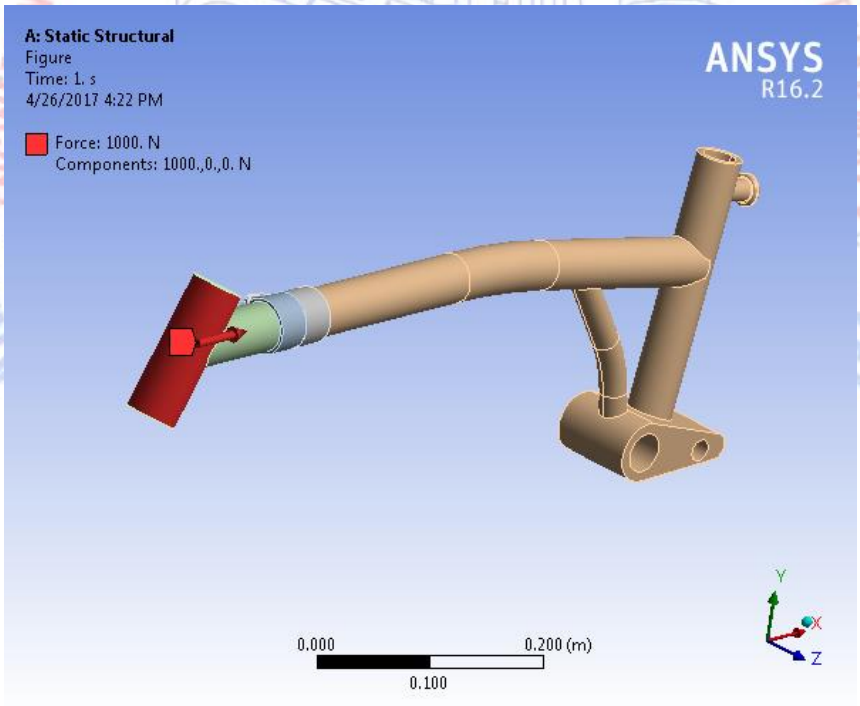


Fig:- 11 ANSYS Frame Loading

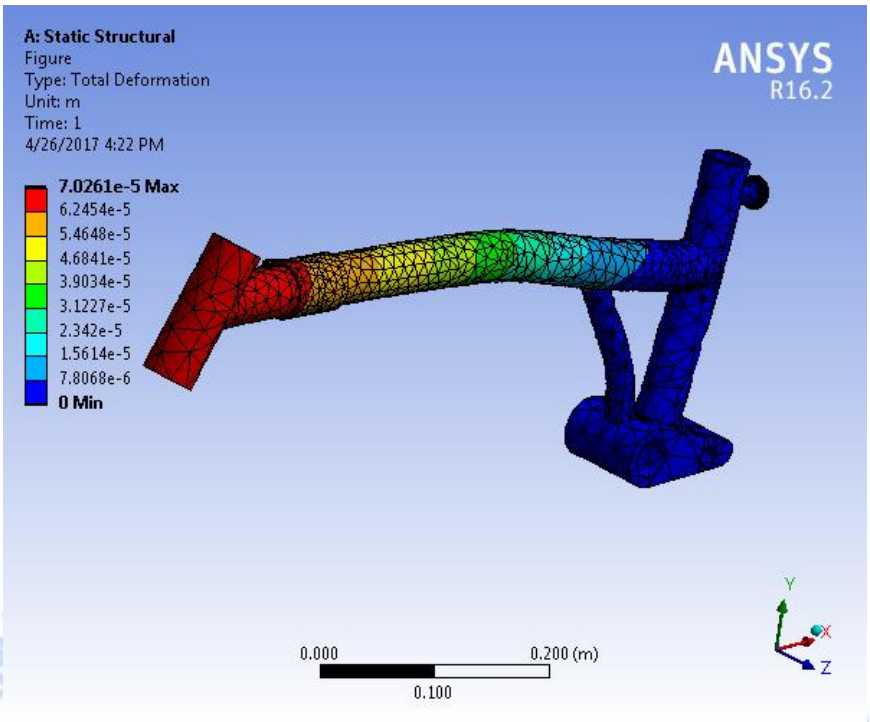


Fig:-12 ANSYS Frame Equivalent Stress

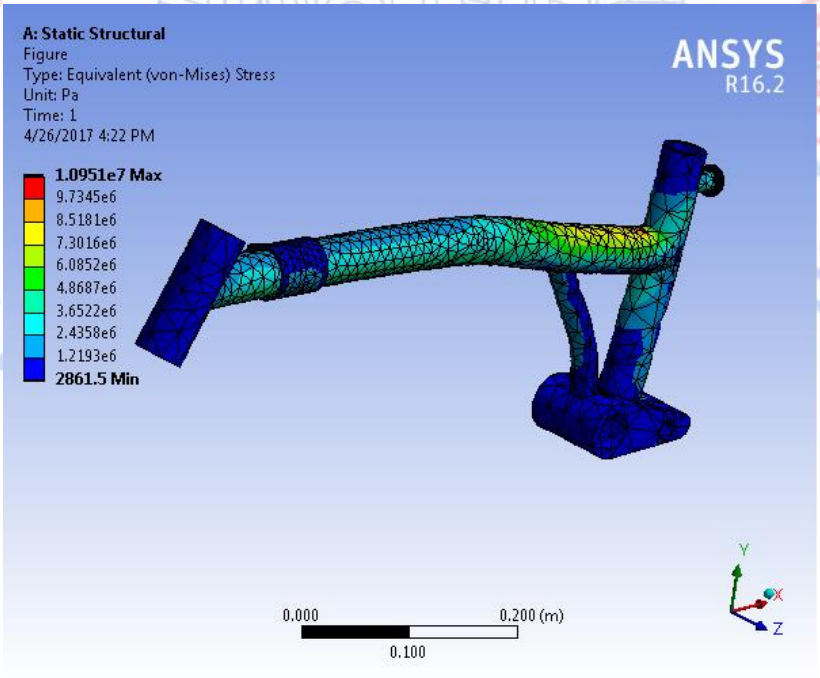


Fig:- 13 ANSYS Frame Deformation

4.3 Fabrication

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1st Fold: Folding of front frame

In this fold the front member of the bicycle i.e. the handle and front fork gets turned by 180 degrees to the left side of the bicycle body, this is done by cutting the frame from 4 inches from front handle tube. Then this joint is fitted with a screw locking hinge, this permits easy locking and unlocking of the fold and thereby is rigid enough to sustain the load. In this step, open the frame clamp of folding bicycle and the main frame or folding body of the folding bicycle is folded in such manner that the horizontal axis of the front wheel and the horizontal axis of the back wheel are come in a same axis.

Fig:- 14 First Fold

2nd Fold: Folding of rear wheel assembly

It is the most important type of fold of the bicycle. It uses a pivot fitted at the bottom of the sprocket assembly. This permits the rotation of the rear tire assembly in 180 degree along the axis of the larger sprocket this needs to be perfect because during the rotation the distance between the sprockets changes if this radius increases beyond the limits the chain may get dis located from the rear sprocket, this is not desirable where there is need of quick folding and unfolding. For this special care is taken to decide the position of the pivot so that radius between the sprockets does not get changed. This is done by pivoting half inch below the sprocket by thus radius is manipulated by half an inch which does not affects the chain and the chain remains on both the sprockets.

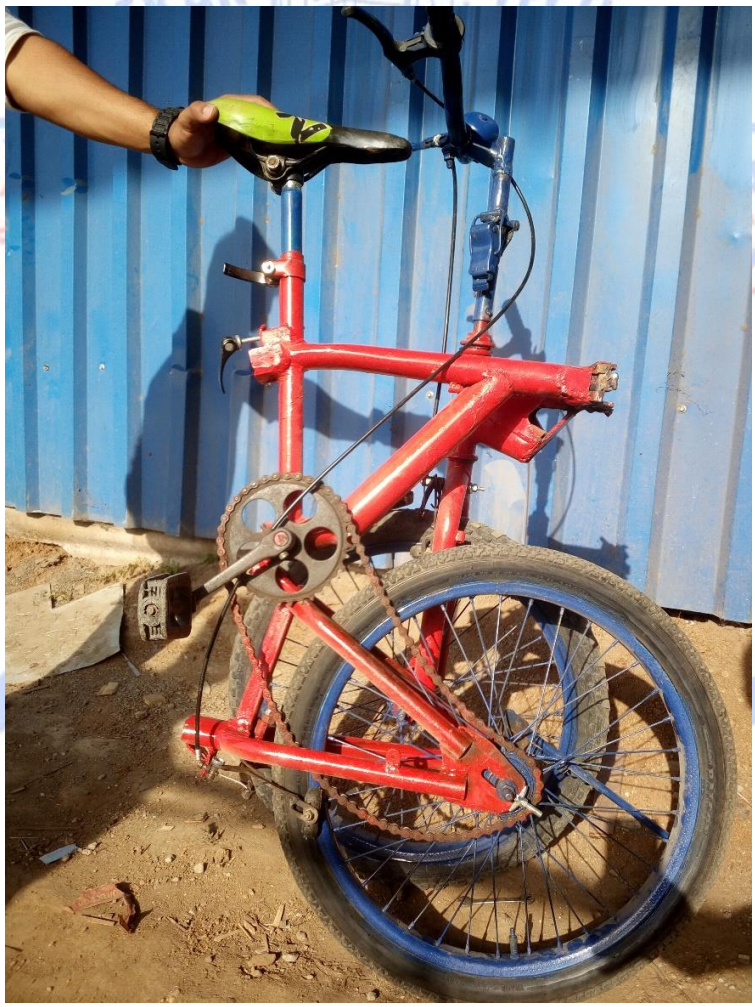

Fig:- 15 Second Fold

3rd Fold: Adjustment of Seat

It is the fold provided in the seat bar of the bicycle, it is used to raise or lower down the height of the seat according our need. It is provided with a clamp interlocking system. This reduces the overall vertical space needed for the bicycle. Adjustment of Seat In this step of the folding bicycle, open the seat clamp and allow to the adjusting seat of the folding bicycle as show in figure. The Saddle, Undo the lever, push the saddle right down, and re-clamp the lever. During this action, it is because of this that the rear frame remains folded, in turn retaining the front wheel in its folded position.

Fig:- 16 Third Fold

4th fold: Folding of Handle

This folds allows thee handle coloumn of the bicycle to get folded by 180 degrees. this is done by providing a locking and clamping hinge joint. This reduces the vertical height of the bicycle by 30%.In this step of the folding bicycle, open the handle clamp and allow folding the handle of the folding bicycle as show in figure. Handlebar Undo the hinge clamp at handlebar stem. Swing the handlebars down to lie alongside the front wheel, and push home so that the nipple, engages in the clip, simply let the handlebars drop into position

By all the four folds the size of the bicycle gets reduced by 65%. This is a great saving of space and the weight of the bicycle is reduced considerably making it more portable.

Fig:- 17 Fourth Fold

4.4 Modification

4.4.1 Cam locking Hinges

Hinges were used to permit folding and cam locks were used to easy locking and unlocking

Fig 18 Cam Lock

Fig 19 Cam Lock With Hinge

4.4.2 Welding

Electric Welding was done in order to join the modified parts throughout the structure.

Fig 20:- Electric Welding

4.4.3 Grinding and finishing

Surface grinding is used to produce a smooth finish on flat surfaces. It is a widely used abrasive machining process in which a spinning wheel covered in rough particles (grinding wheel) cuts chips of metallic or nonmetallic substance from a workpiece, making a face of it flat or smooth.

4.4.4 Painting

We used spray paints to improve the asthetics of our foldable bicycle. Red and blue colour combination was used to paint the cycle. Spray painting is a painting technique where a device sprays a coating (paint, ink, varnish, etc.) through the air onto a surface. The most common types employ compressed gas—usually air—to atomize and direct the paint particles. Spray guns evolved from airbrushes, and the two are usually distinguished by their size and the size of the spray pattern they produce. Airbrushes are hand-held and used instead of a brush for detailed work such as photo retouching, painting nails or fine art. Air gun spraying uses equipment that is generally larger. It is typically used for covering large surfaces with an even coating of liquid. Spray guns can be either automated or hand-held and have interchangeable heads to allow for different spray patterns. Single color aerosol paint cans are portable and easy to store.

Fig 21:- Spray Painted Cycle

CHAPTER NO-05 RESULT AND DISCUSSION

5.1 Advantages

- Multi Modal Transport – A folding bike can be taken on the bus, the tube, or the train, which can seriously improve door-to-door times for commuters and casual cyclists alike.
- Security – A folding bike is far less likely to be stolen because its owner can fold it down and carry it anywhere, reducing the need to leave it locked outside in public places.
- Convenience – Because of its compact nature a folding bike can be taken on long excursions, even plane journeys, which allows the owner to enjoy the bike in a wider range of locations than is possible with a traditional bike.
- Storage – A folding bike takes up very little space and can be stored indoors at home in order to avoid rusting.

5.2 Factors for switching to foldable bicycle

You can't take it with you when you go

But here's the thing: With a folding bike you can, and there's less chance it will be stolen by bicycle thieves. Most compact folding bikes are small enough that they will remain virtually unnoticed either beside or under your desk, and your colleagues won't even notice it's there.

But even if you do have to leave it locked up somewhere, folding bikes are still such a niche product that most thieves won't try for them, let alone know what to do with them. It's a nice feeling not to feel like you have to go all the way back down to the bottom floor just to check your bike is still where you left it, because all you have to do is look over into the corner of your office. It's also great not to be lugging a 100 lb chain around with you all the time. I remember one time, the thief hadn't been able to get my actual bike away from the railings I'd left it hooked into, so he just took the two $800 wheels and the saddle instead.

Folding bikes will make you look cool

Put it this way, you aren't going to look like a trainee circus act in a suit when you commute to work, which let's be honest, is normally the first thing you think about when you think about people riding folding bikes. But nothing could be further than the truth especially when you look at the ever expanding range currently available. That said, for the uninformed, there is still a

stigma attached to owning on; like somehow a folding bike is not a real bike and it'll be a b**** to ride anywhere on. But the truth is that it all depends on what you want your bike to do.

There's no way I'd want to take one down a black run in the Rockies for example, but if you'd like to get to the office with some dignity attached and know your bike will still be yours at the end of the day, then I can't help but recommend one to you.

Once you know how to fold your bike down and up with your eyes closed, you will also look like a boss when you collapse your folding bike in less than 20 seconds, pick it up and walk into the office, swiftly bypassing the other cyclists wrestling with their chains and padlocks and dismantling saddles and wheels in an effort to make sure no one steals them.

Accelerate off the line like Usain Bolt

It's just physics. Most folding bikes have smaller wheels than their grown up counterparts. This means you'll never outpace some guy with big ordinary wheels over distance, you can take off like you're entering Hyper-Space.

It's the small wheels, you see, it takes less effort to get those small ones going fast. Trust me on this. There is no better feeling in the world of leaving head to toe covered spandex 'pros' on their racing bikes with their mouths wide open in shock as you sprint away from them with next to effort at all.

Folding bikes are extremely practical

You can hop on the subway if it suddenly starts to rain or you have an important meeting to get to but you can't chance getting all sweaty before you show up but still fancy wanting to ride home at the end of the day.

That's perhaps the 2nd best thing about folding bikes after security concerns about folders, they are multi-modal: I know, it's the lamest sounding term I've ever come across as well, but that doesn't make it any less true.

Hopping on and off public transport at will gives you freedom and independence from having to be an unwilling participant in the daily commuter rat race, and get wherever you want to get to in the city quicker than you ever thought possible.

Folding bikes are convenient and save space, on the Subway and in the home

Whether you live in London, New York, or Tokyo, folding bikes are the ultimate space saver. Most folders can pack down so small you can fit them in the trunk of a car, and pretty much take them anywhere. The flipside of this is that you can store them anywhere as well, which can be a perfect solution for those living in apartment buildings where space is at a premium.

Even if you do have space to spare, being able to stow your folding bike away in the cupboard under the stairs where it doesn't have to face everything Mother Nature can throw at it out in the open, night after night, will mean even less maintenance than with a normal bike.

Low maintenance cost

Make sure your tyres have air in them, your lights are charged, and your chain is oiled, and that's pretty much it for looking after a folding bike. You don't have to rent out parking spots, pay insurance, buy gas, and should you ever need a bike mechanic, you'll find that:

- Most of them are trustworthy.
- It's tougher for them to try and pull a fast one on you as you will in all probability know exactly what's wrong with your bike.
- A bike service by a fully qualified bike mechanic is laughably cheap. Happy days all round.

Commuting to work on a folding bike is better for your lungs than sitting in your car

Fresh air is good for you. That is a scientific fact and common sense. You'll inhale more exhaust fumes sitting in a car than you will on a bike, even in rush hour. That is also a scientific fact. Cars and buses are not the self-sealed hermetic emission free bubbles think they are, especially in traffic.

Studies have shown that drivers and passengers are subjected to more air pollution than cyclists and walkers. It stands to reason. Nose to tail gridlocked cars suck in the fumes and vapour from the cars in front and around them. I'll leave that one to just sit with you for a few moments while I get on and write the rest of this article.

It's a conversation starter

People will think you have made life altering conscious decisions and think you have got the whole life work balance thing sorted out if you commute by folding bike. Every time you break open or break your bike down, people will probably just come up and ask you about the

contraption you have in your hands. It's actually quite surprising to begin with, and if you're anything like me, never gets boring either.

Commuting by bike will make you fitter than going to the gym: Get fit without thinking about it! Think about that

That is at least according to this study. But you don't need to read a study to just know that makes sense. You also don't need a folding bike, either, just a bike. You don't need a bike either, really. You just need be active. This is one of those universal truths, and I may be preaching to the converted here, but I'm going to do it anyway.

Working out in your free time probably isn't going to keep you fit and healthy. The recommended daily physical activity time for adults is 90 minutes a day. Walking from your desk to the coffee machine in work doesn't count!

And if you're anything like me then the last thing you want to do at the end of a long day is head to the gym to get shouted at by my personal trainers. I'm kidding, Sven is a stand-up guy, no really…

So what are you going to do about it? Are you going to hit the gym every night to get the pounds to drop off, or are you going to commute to work and get fit and stay thin without really having to think about it?

That's one of the real benefits of commuting by folding bike, or any bike for that matter, it's an automatic benefit that requires little thought on your part. Once it's a part of your utilitarian routine, it's not an effort to get fitter, because your commute to work is necessary, it's a habit you have no choice about. It

Folding bikes are very easy to use

Practice. That's it. There's nothing special about folding bikes that can't be learned in half an hour. The only learning curve is the folding and unfolding of them, and that you can become competent with very quickly.

All you have to do is practice. Don't try and learn how to do it at the entrance to the Subway, or when the bus is waiting on you, because then you might begin to feel frustrated and upset at your mechanical incompetence.

Folding bikes don’t depreciate in value

That’s right, folders have a really high resale value. They just don’t lose money, not really. When the day comes and you either want to upgrade to a full sized bike, or have decided to go live in a rainforest, you can sell your bike on and only lose about a $100.

In that respect, buying a folder is like a mini investment. Don’t ask me why they don’t go down in value, they just don’t.

5.3 Demerits

Customization

Unless you live near a shop that specializes in folding bikes, you may have to special order accessories from the manufacturer according to the Chicago Bike Blog. Many common accessories sold at your local bike shop, such as bike racks, baskets and fenders, won't fit a folding bike, and spare parts will be hard to find. If you have trouble finding bikes that fit you because of height or weight, a custom folding bike will cost more than a custom non-folding bike.

Off-Roading

Folding bikes are more compact because they have much smaller wheels than non-folding bikes. That means you'll feel the bumps and irregularities in the street more acutely. The Folding Society notes that as a general rule, larger wheels are better suited for very muddy or sandy conditions, which makes most folding bikes difficult to ride on an off-roading trail. Some companies sell folding bikes with 26-inch wheels, but they give the bike less portability.

Appearance

Folding bikes and electric cars face a common image dilemma. The style conscious may find folding bikes embarrassing to ride because of their small wheels or, in some instances, their unconventional frame shape. Commute by Bike comments that some attempts at overly modern or cool frame shapes end with "ridiculous results."

Considerations

There are some other concerns with the bikes. Folding Society claims many manufacturers aren't accurate about how long it takes to fold or unfold one. They can be cumbersome to carry around, and tough to steer. Some manufacturers may also take advantage of the term "folding" and require you to remove parts, such as the handlebars or a wheel, before it can be put away.

CHAPTER NO-06 CONCLUSION

Four fold foldable bicycle is of great use. It can be used for both town sides and for villages. It is the most efficient vehicle in the terms of fuel efficiency as the input fuel requirement is zero as it works on the human power and because of this no pollution (Air Pollution) is caused by the bicycle which makes it very environmental friendly Besides this it acquires very less maintenance charges as it does not installs any electrical, electronic or any costly mechanical device. Thus it is suitable for every class of the society. It's variable handle and padded seat height makes it available for use to every user irrespective of their age, sex etc. because the user can adjust the handle and the padded seat according to his requirement. Moreover it's property of very less space requirement and easily to carry makes it first choice in the field of interest of cycle riders, cycle mountaineers.

- There is significant interest in folding bicycle among park-and-riders provided they can take their bike on the train.
- There is significant interest in folding bicycle among people with regular-sized bike who already take their bicycle on the train.
- Improved bicycle infrastructure is positively and significantly correlated with higher rates of commuting by bicycle that could include promotion of folding bicycles.
- Most people understand the general concept of a folding bicycle but do not recognize the overall value of improved product designs given that few people are willing to pay for additional costs.

CHAPTER NO-07 COST ESTIMATION

Table for Cost Estimation of Project

SR NO	NAME OF COMPONENT	QUANTITY	PRICE
1.	Bicycle from market	1	1500/-
2.	Locks and hinges	4	800/-
3.	Accessories	-	800/-
4.	Miscellaneous	-	1000/-
5.	Painting	-	400/-

Total Estimates cost = 4500/-Rs

CHAPTER NO-08 FUTURE SCOPE

Kinetic Energy Reservoir System

Kinetic energy of the cycle can be stored and later it can be utilized whenever the user feel tired, exhausted or when he wants to use it .The kinetic energy can be store in any reservoir type device such as batteries. Besides this flywheel attached to the rear wheel is also an important mechanical device which can be used to store the kinetic energy for the future use.

Installation of Electronic Gadgets

Various types of electronic gadgets like mobile charger, music pods charger etc. can be installed easily on the 4 fold foldable bicycle. They will draw energy for them through the kinetic energy of the wheels of the bicycle and this will be conducted and initiated with the help of the transducers. These Equipment will make the riding experience of the user enjoyable and fun loving.

Use of more lighter materials

By using lighter material like aluminium, aluminium alloys and carbon fibre etc , the weight of the cycyle can be further reduced and by mass production the cost can also be further reduced.

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