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Design and fabrication of mono bike

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ABSTRACT

When it comes to self-balancing personal transportation devices, it looks like the Solo wheel, Honda U3X, Uno, and Segway could all be in for a little competition. A monowheel/bike is a one-wheeled single-track vehicle similar to a unicycle. Instead of sitting above the wheel as in a unicycle, the rider sits either within the wheel or next to it. Usually driven by smaller wheels pressing against its inner rim. Most are single-passenger vehicles, though multi-passenger models have been built. The goal of this project is to design, analyze, and build a self-balancing single wheel bike for use as a transportation tool for someone traveling short distances. The project consists of a research phase in which similar systems have been investigated to help determine a sensible design approach and to establish appropriate design specifications; a design phase in which a model was designed with certain assumptions to meet the aforementioned specifications and a construction phase, in which the vehicle was built and tested. Monowheel looks like something out of a science fiction movie, but monowheel is, in fact, real, today, mono wheels are generally built but from the 1860s through to the 1930s, they were proposed for use as serious transportation. The idea may sound extreme, but the science behind monowheels is solid, at present, because of the surging consciousness of pollution and energy shortage crises, automobiles and motorcycles are no longer the best for transportation. As the price of petroleum products growing nowadays, there is a need for a cheaper and more efficient form of transport.

Keywords: *Construction of Monowheel, Specification, Luggage Carrying Capacity*

1. INTRODUCTION

A Mono bike (Monowheel bike) is a single-track vehicle consisting of a single crawler (Wheel). The main aim of Mono bike is that it reduces space occupied when a single occupied vehicle is necessary and for transportation of short distances. This may sound fictional but as going through history.

The first mono bike designs appeared as early as the 1860s. In 1869 the Craftsman Rousseau of Marseilles built the first monocycle. Several of these featured a seat for a rider with pedals connected to the outside wheel. The rider pedals the small wheel, creating motion even at that time, the monowheel was recognized as a difficult means of transportation. The project proposes a monowheel bike, which was the serious mode of transportation back in the 1800s to 1900s.

So we have chosen this idea of a vehicle because of a very simple thought of that, -" The technology revolves around itself "- for example, Back in the days when the mobile phones where invented, the size of the phones where same as the size which we are using today and who would have thought that hoverboards will be the future replacing the roller skates. The very common thing we can notice in these inventions is, the design stayed at the origin but the performance and the high-power output increased in terms of 100 times better. This makes us believe in what are we doing now.

So, with the adaptive idea of design, we have built a compact, efficient, powerful and cheaper version, with our design and fabrication – The Indian version of the mono bike. We have made this mono bike in an extremely affordable budget where every Indian can get hands-on it. It is cheap, efficient and can be built within a short time, making its production rate also can be higher, than any other corporate company is manageable with.

2. LITERATURE REVIEW

A. History

A **monowheel** is a one-wheeled single-track vehicle similar to a unicycle. Instead of sitting above the wheel as in a unicycle, the rider sits either within the wheel or next to it. The wheel is a ring, usually driven by smaller wheels pressing against its inner rim. Most are single-passenger vehicles, though multi-passenger models have been built.

Hand-cranked and pedal-powered monowheels were patented and built in the late 19th century; most built in the 20th century have been motorized. Some modern builders refer to these vehicles as **mono vehicles**, though that term is also sometimes used to describe motorized unicycles.

Today, monowheels are generally built and used for fun and entertainment purposes, though from the 1860s through to the 1930s, they were proposed for use as serious transportation. The world speed record for a motorized monowheel is 98.464 km/h (61.18 mph).

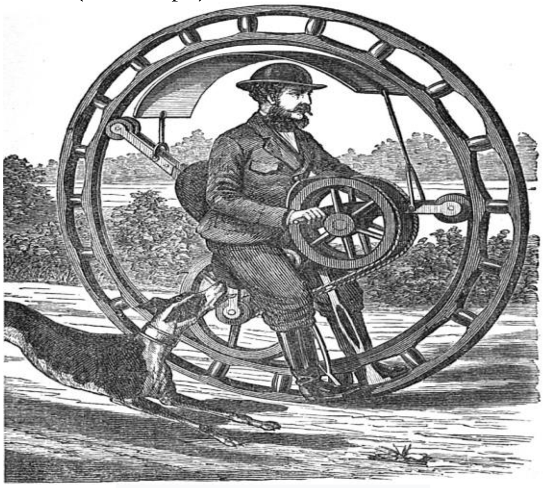

Fig. 1: Hemming's Unicycle

Hemming's Unicycle, or "Flying Yankee Velocipede", was a hand-powered monowheel patented in 1869 by Richard C. Hemming.

B. Steering

In a two-wheel mode of transportation, two systems (wheels) affect motion. Typically one wheel provides the force to control speed, while the other handles changes in direction: steering. For a monowheel, both direction and speed are controlled through the same physical apparatus; this generally makes steering more difficult. In a majority of systems, change in direction is effected by the rider shifting their weight, or in the sudden movement creating a shearing force between a handhold and the axis that the driver is settled on. Better control can usually be achieved at lower speeds. Because of the steering problem, monowheels have never caught on as a widely accepted mode of transportation.

3. CONSTRUCTION PLANNING PROCESS

Fig. 3: Block Chart of Mono bike

The selection of this concept bike is one of our craziest ideas. Later on, we developed the design by reverse engineering method ie., the Adaptive engineering method (Adaptive manufacturing systems achieve intelligence and adaptation capabilities through the close interaction between mechanics, electronics, control, and software engineering. The results, achieved by applying the method in reengineering a module of an automotive sensor manufacturing line, are finally presented). Therefore the selection of materials that play a crucial role helps the chassis weight through material characterization. And then setting up a plan according to the schedule. Mapping for 2 stroke engine and crawler(tire) is in repair condition so we turn into working condition state. After this as per planning, we need to manufacture Transmission drum, Rollers, and Fabrication of Chassis and the final step is to assemble all of these components into one.

3.1 Diagrammatic Construction And Working

The side elevation of a self-balancing mono bike following the present invention as shown in Fig. In this illustrative embodiment, the self-balancing monobike includes a handlebar, a Fuel tank, Seating, a Crawler 265*R17, a C-frame, a Transmission drum, a 2 Stroke Engine, a Rollers, shock absorbers, a Chain Sprocket, and Chassis facilitates holding, moving, or loading the monobike. A foot platform disposed on a side of Rollers.

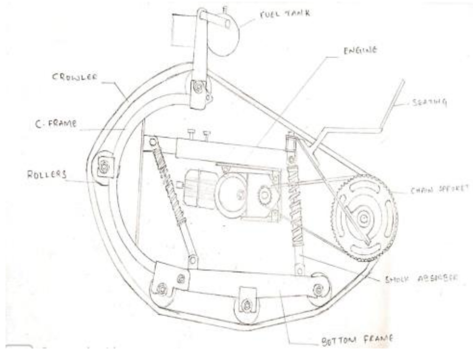

Fig. 2: Schemetic View of Mono bike

3.2 Components of Mono Bike

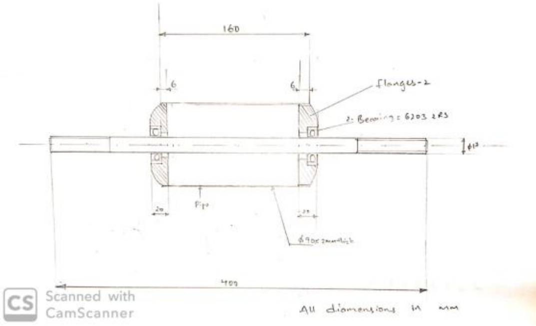

Fig. 4: Roller

3.2.1Rollers

<u>Dimensions</u>

- HOLLOW PIPE LENGTH = 160 mm
- SHAFT ROD = 400 MM ; DIA = Ø 17
- RUBBER STEEL BEARING = 6203
- FLANGE THICKNESS = 20 mm
- FLANGE INSERT DEPTH = 6 mm

In this project we have used IDLER type of rollers, We made these rollers by taking a hollow 90mm mild steel round pipe and cutting them into 5 equal pieces over a length of 160mm and then we have created flanges at both ends and drilled to 18mm and bore to the length of 40mm and press-fitted Deep groove ball bearings 6203 2 RS 17x40x12mm at both ends of 5 pieces with hydraulic press fit and welded the flanges at the ends of the roller. Then we inserted deep groove cut to ensure that it is locked with an external circlip of Diameter 17mm at the ends to an MS rod of Diameter 17mm and length of 400mm into the roller and threaded from end to the middle for the length of 80mm.

3.2.2 C- Fame

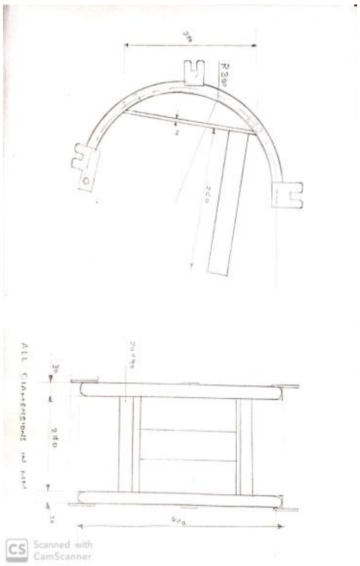

Fig. 5: C- Frame Chassis

Dimensions

1. C- FRAME RADIUS= R30˚ ; DIA= 30 mm
2. SQUARE BOX PIPE LENGTH= 250 mm ; 40*40 THICKNESS = 5 mm
3. RECTANGULAR BOX PIPE= 270 mm ; 20*40 : THICKNESS= 5 mm
4. ENGINE PLATE LENTGH = 270 mm : WIDTH= 60 mm ;THICKNESS= 10 mm
5. U SHAPED HOLDER= W= 50 mm
6. H= 60 mm
7. HOLE RADIUS = R17 FROM MID AXIS

The c-frame will be the frontier part of a mono bike where the three (3) rollers will be placed making it a crucial part of the chassis The c-frame is usually built by a process called bending, on a machine called ROLL BENDING MACHINE, where the curvature radius is about 300mm and the distance between two ends when bent 420mm whose OD is 30mm and ID is 24mm of 2 pieces. They are joined together by the two rectangular section pipes of length 270mm.

3.2.3 TRANSMISSION DRUM

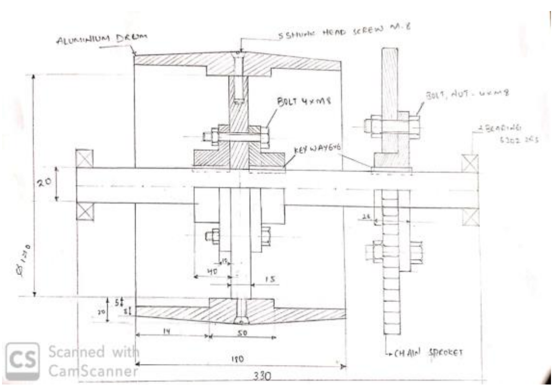

Fig. 7: Transmission Drum

Dimensions

1. ROTATING SHAFT DIA = 20 mm
2. TRANSMISSION DRUM = Ø190 :
3. LENGTH = 180 mm
4. TRANSMISSION DRUM TAPER TURNING THICKNESS = 8 mm
5. TOTAL LENGTH OF TRANSMISSION SYSTEM = 330 mm
6. FLANGE HUB DIA= 110 mm
7. DRUM PLATE DIA = 170 mm
8. DRUM PLATE THICKNESS = 15 mm
9. COUNTER SHUNK HEAD SCREW SIZE = M8
10. HEXAGONAL BOLT = M8
11. PILLOW BLOCK BALL BEARING SIZE = 6302 RS
12. SQUARE KEY SIZE = 6*6 mm

The transmission drum is made up of aluminum by a process called casting. The drum rotates the crawler by the use of surface contact friction. It consists of a metal plate inside in it with the diameter of 170 mm and thickness of 15mm and a 40mm hole is drilled inside in it for placing a shaft of material EN 31 STEEL ALLOY with a diameter of 20mm and length of 330mm, to its both ends a ball bearing 6203 2 RS is connected which is fixed to the chassis. The metal plate is connected to the aluminum drum from the inside at the center, by using countersink screws M 8 of 5. In between the shaft, a sprocket and chain system are connected to the engine transmission system

3.2.4 Engine Frame

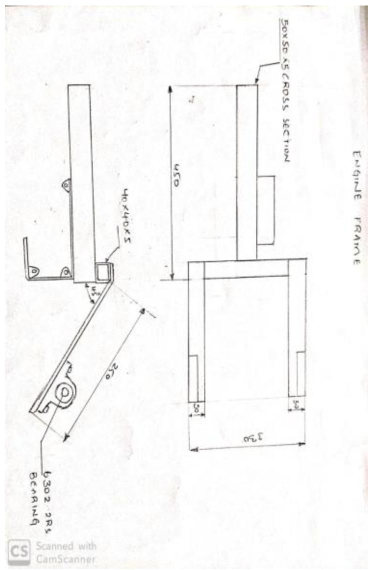

Fig. 6: Engine Frame

The engine frame consists of an adjustable system with box pipes of MS in which one end 40*40 mm is joined to c-frame and another end 50*50mm welded to the engine cover. It is a very significant element in the chassis where it holds the total seating arrangement, where the rider weight is directly applied to it. It is also a connection between the c-frame and supports the transmission system, making it a vital element.

Dimensions

1. SQUARE BOX PIPE = 50*50 mm : 40*40 mm
2. TOTAL LENGTH OF SQUARE BOX PIPE = 450 mm
3. THICKNESS OF PIPE = 5 mm
4. PILLOW BLOCK BALL BEARING = 6302 2RS
5. LENGTH OF PLATE ON BEARING FIXED = 250 mm
6. DISTANCE BETWEEN TWO BEARING FIXED PLATES = 330mm

3.2.5 Bottom Frame

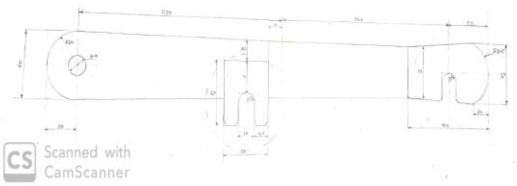

Fig. 8: Bottom Chassis Frame

The bottom frame carries two rollers in which it also connects the c-frame which is the frontier part of the mono bike. The suspension is connected to it. it completes the whole chassis.

Dimensions

1. PLATE THICKNESS= 5 mm
2. PLATE TOTAL LENGTH= 500 mm
3. PLATE START AND END RADIUS = 60 mm
4. U SHAPED HOLDER= W= 50 mm
5. H= 60 mm
6. HOLE RADIUS= R17 FROM MID AXIS

3.2.6 Engine Specification

Fig. 9: 2 Stroke Engine

Engine Type	2 Stroke Single Cylinder
Displacement	69.9 cc
Max Power	3.5 bhp @ 5000 rpm
Max Torque	5 Nm @ 3750 rpm
Cooling System	Air Cooled
Starting	Kick Start Only
Fuel Supply	Carburetor
Clutch	Centrifugal Wet Type
Ignition	Flywheel magneto 12V, 50W
Transmission	Automatic
Gear Box	Automatic
Bore	46 mm
Stroke	42 mm

The 2-stroke 69 cc (Cubic centimeter) auto transmission, which was not in the working condition when purchased and was replaced by the essential parts that made the engine alive by making it again into the working condition

4. CAD MODEL PREPARATION

AUTO CAD SOFTWARE is mainly used for detailed engineering of 3D models or 2D drawings of physical components, but it is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. So after completing the production drawing successfully, now it was the time to make a digital design output through CAD model preparation by AUTOCAD. These are the CAD images of the essential components of our project

4.1 Roller model

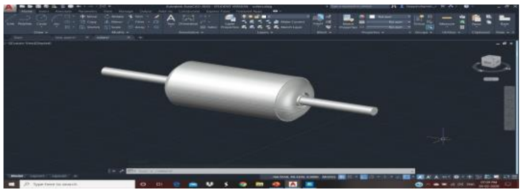

Fig. 10: Roller Cad design model

4.2 C frame model

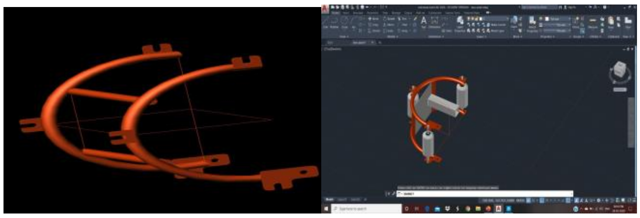

Fig. 11: C frame Chassis Cad design model

4.3 Bottom Frame

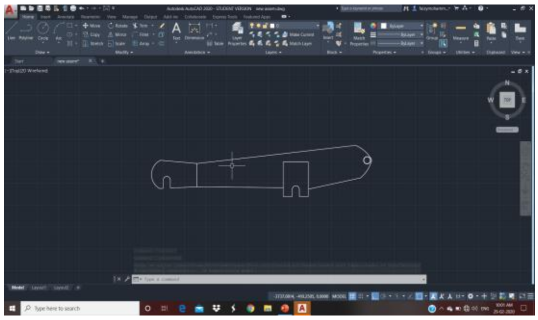

Fig. 12: Bottom Chassis frame Cad design model

4.4 Engine Model

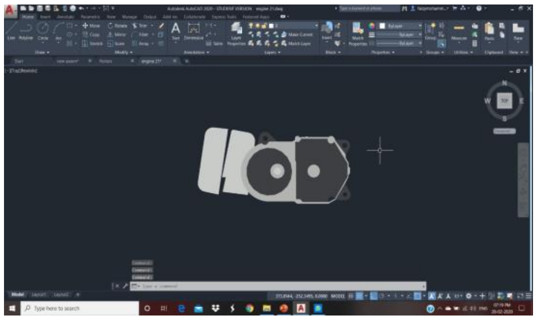

Fig. 13: Engine Block Cad design model

4.5 Transmission drum model

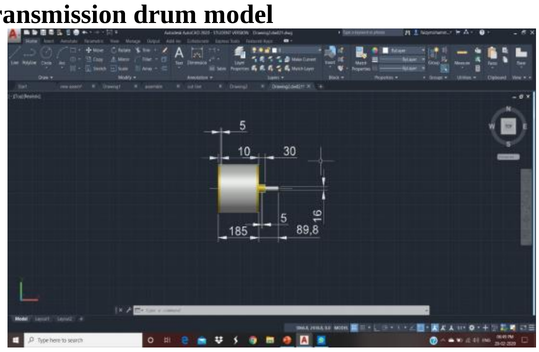

Fig. 14: Transmission System Cad design model

4.6 Assembly of all models

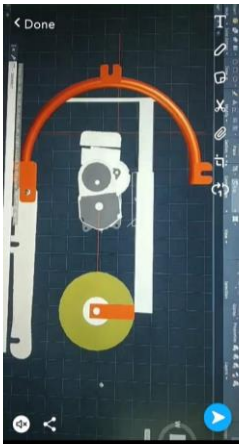

Fig. 15: Assembly Cad model

5. PROBLEM STATEMENT

5.1 Rollers calculations

From bending moment equation

$$\frac{M}{\sigma} = z \text{ where } z = \frac{\pi}{32}\left(\frac{d_0^4 - d_i^4}{d_0}\right)$$

M= bending movement = $\frac{wl}{4}$

$$\sigma = \text{bending stress}$$

Bending stress of steel pipe is 240 mpa

Tension in tire = 71612.7 N

The tire tension is acting as a load on a pipe so the Torque = Tension of tire * ½ of the length of pipe

Assuming length is 160 mm and outer dia is 90 mm

Torque = 5729.01 NM

$$\text{Bending moment M} = \frac{wl}{4} = \frac{5729.01*0.16}{4} = 229.1 \text{ Nm}$$

$$\text{Di} = \left(\left(\frac{M*32*d_0}{\sigma*\pi}\right) - d_0^4\right)^{\frac{1}{4}}$$

Di = 88 mm

$$\text{From hoop stress } \sigma_c = \text{T}\left(\frac{2(r_0)2}{{r_0}^2 - {r_i}^2}\right)$$

T = Torque

$$r_{0=outer\ radius=0.045\ m}$$
$$r_{i=inner\ \ radius=0.043\ m}$$

$$\sigma_c = 131.83\ \frac{KN}{m^2}$$

Longitudinal stress of a cylinder

$$\sigma_l = \text{T}\left(\frac{(r_0)^2}{(r_0)^2 - (r_i)^2}\right)$$

$$\sigma_l = 65.91 \text{ N/m}^2$$

So the longitudinal stress and hoop do not exceed the normal stress.

Hence design is safe

4.2 Calculating tension in tire

Tire dimension

w= 0.245 m

t = 0.02 m

l = 4.87 m

Density of rubber **ρ** = 1140 kg/m^3

Allowable stress in rubber σ = 15*10^6 N/m^2

Speed N = 837 rpm

Drum dia = 0.19n

$$\text{Velocity v} = \frac{\pi dN}{60} = \frac{\pi*0.19*837}{60} = 8.33 \text{ m/sec}$$

$$\text{Coefficient of friction } \mu = 0.54 - \frac{42.6}{152.67+v} = 0.275$$

θ the angle of contact between the belt and each pulley

$$\alpha = 2.61\ rad\ \theta = 2.07 \text{ rad}$$

Maximum tension in tight side of the belt

$$\text{T} = \sigma . a = 15 * 245 * 20 = 73500\ N$$

Mass of the belt per meter length

$$\text{M} = \text{a*l*ρ} = 27.20 \text{ kg/m}$$

Centrifugal tension

$$T_c = mv^2 = 1887.3 \text{ N}$$

Tension in tight side of belt

$$T_1 = \text{T} - T_c = T_1\ 71612.7 \text{ N}$$

We know

$$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta$$

$\frac{T_1}{T_2} = 2.758$ by Antilog

$$T_2 = \text{tension in slack sight of the belt}$$

$$T_2 = 25965.4 \text{ N}$$

Total tension in slack side

$$T_3 = 27852.7 \text{ N}$$

5.3 Engine frame calculation

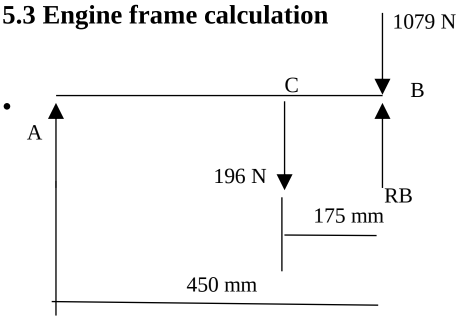

Fig. 16: Bending Movement

- The material used in the engine frame is mild steel
- The yield strength of MS is 248 mpa
- Assuming the factor of safety is 4
- The allowable stress σa = 65 N/mm2
- Assuming the engine frame as a simply supported beam
- From the diagram The Bending Movement M= 20.94*10 N/mm
- Area of cross-section A = 50-44 = 564 mm
- Movement of inertia I = 50-44/12 = 208.49*10 mm
- From bending equation

$$\text{M/I} = \sigma/\text{y}$$

σ= bending stress , y = 1/b = 25 mm, σ= m*y/I

σ= 20.94*10*25/208.49*10

σ= 2.51 N/mm

- Hence the bending stress is not exceeded then the allowable stress, so the design is safe

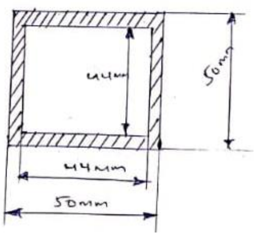

Fig. 17: Cross-section of frame

6. IMPLEMENTATION

While performing the project it was divided into stages of the procession. The stages are as follows:

1. Making a blueprint
2. Crawler
3. Manufacturing of Transmission components
4. Fabrication of Chassis
5. Fabrication of rollers
6. Fabrication of engine frame
7. Fabrication of bottom frame
8. Assembly

6.1 making a blueprint

Mentioned in fig [2]

6.2 Crawler

Fig. 18: Crawler (Tire)

265/65R17 these are the tire dimension we purchased in the second-hand spare market

6.3 Manufacturing of Transmission Drum

Fig. 19: Transmission Drum After Casting And lathe operations

The transmission drum is made up of aluminum by a process called casting. The drum rotates the crawler by the use of surface contact friction. It consists of a metal plate inside in it with the diameter of 170 mm and thickness of 15mm and a 40mm hole is drilled inside in it for placing a shaft of material EN 31 STEEL ALLOY with a diameter of 20mm and length of 330mm, to its both ends a ball bearing 6203 2 RS is connected which is fixed to the chassis. The metal plate is connected to the aluminum drum from the inside at the center, by using countersink screws M 8 of 5. In between the shaft, a sprocket and chain system are connected to the engine transmission system.

6.4 Fabrication of C-Frame

Fig. 20: C- Frame Chassis after fabrication -info [2.2.2]

6.5 Fabrication of rollers

Fig. 21: Fabricated Roller - info [2.2.1]

6.6 Fabrication of engine frame

Fig. 22: Fabricated Engine Frame-info [2.2.4]

6.7 bottom frame

Fig. 23: Fabricated Bottom Chassis Frame – info [2.2.5]

6.8 Transmission shaft assembly

Fig. 24: Transmission System – info [2.2.3]

6.9 After Assembling

Fig. 25: Assembled Output

7. APPLICATION

1) For sport and adventure purposes.
2) In bigger industries and companies.
3) It is used in Portland Police Department

8. CONCLUSION

Conclusion for the futuristic scope Monowheel or Monobike is a personal transporter that can carry a person to move from one place to another within large areas like industries, space centers, shopping complex areas, etc.

We have built a compact, efficient, powerful, and cheaper version with keeping budget in mind This Monobike is an extremely affordable budget variant and any person can get hands-on it. Since it has fewer components it can be easily dismantled and also less maintenance cost

9. FUTURE WORK

These are the most amazing innovative bikes, here we step into the future with those who love blending style and functionality with pioneering design and technology. They are designed from scratch to inspire awe, keeping production feasibility. Some of them may even hit the roads of reality in the coming future. It's not what we create and force on the market, it's how we allow ourselves to be changed by the act of creation.

An Engineer's passion is in how the culture we should be building now, might offer the same stability for a wider range of people and manufacturing these concepts into tangibility.

10. ACKNOWLEDGEMENT

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