DESIGN AND MANUFACTURING OF A HUB CENTER STEERING SYSTEM MOTORBIKE

A PROJECT REPORT

Submitted by

ABHAY TRIPATHI [RA1611011010200]
ABHISHEK MISHRA [RA1611011010219]
PRITAM GHOSH [RA1611011010224]

Under the guidance of

Mr. G. Jesu Rajendran
(Assistant Professor (S.G.), Department of Automobile Engineering)

in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

AUTOMOBILE ENGINEERING

of

FACULTY OF ENGINEERING AND TECHNOLOGY

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be **University** *u/s 3 of UGC Act, 1956)*

S.R.M. Nagar, Kattankulathur, Kancheepuram District

MAY 2020

SRM INSTITUE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

BONAFIDE CERTIFICATE

Certified that this project report titled "**DESIGN AND MANUFACTURING OF A HUB CENTER STEERING SYSTEM MOTORBIKE**" is the bonafide work of " **ABHAY TRIPATHI [RA1611011010200], ABHISHEK MISHRA [RA1611011010219], PRITAM GHOSH [RA1611011010224] ,** ", who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE	**SIGNATURE**
Mr. G. Jesu Rajendran **GUIDE** Assistant Professor (S.G.) Dept. of Automobile Engineering	Dr.M.Leenus Jesu Martin **HEAD OF THE DEPARTMENT** Dept. of Automobile Engineering
Signature of the Internal Examiner	Signature of the External Examiner

ABSTRACT

Hub Center Steering (HCS) is a type of front-end suspension/steering mechanisms used in motorbikes. Hub center steering consists of a swing arm that extends from the bottom of the engine/frame to the center of the front wheel instead of two telescopic fork suspension system. Hub center steering systems use an arm, or arms, on bearings to allow upward wheel deflection, meaning that there is no stiction or under braking. Braking forces can be redirected horizontally along these arms, or tie rods, away from the vertical suspension forces, and can even be put to good use to counteract weight shift. Finally, the arms typically form some form of parallelogram which maintains steering geometry over the full range of wheel travel, allowing agility and consistency of steering that telescopic fork suspension system currently cannot get close to attaining. With the rise in popularity in motorbikes, and the acknowledged problems of a front fork suspension, Jack Difazio saw a need for alternative steering systems. In 1968 there was a copyright made on the Difazio hub center steering concept. Difazio proposed the model for Hub center steering mechanism. This project is aimed at incorporating the Difazio Hub Center Steering system in a small displacement motorbike at a low cost.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my guide, Mr. G. Jesu Rajendran for his valuable guidance, consistent encouragement, personal caring, timely help and providing me with an excellent atmosphere for doing research. All through the work, in spite of his busy schedule, he has extended cheerful and cordial support to me for completing this research work.

Author

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS

HCS Hub Center Steering

LIST OF SYMBOLS

m	Kerb mass of motorbike with rider, kg
b	Wheelbase of the bike, mm
$N_{\mathbf{A}}$	Normal reaction at the front wheel, N
$N_{\mathbf{B}}$	Normal reaction at the rear wheel, N
τ	Shear stress, MPa

CHAPTER 1

INTRODUCTION

1.1 Hub Center Steering (HCS) System

Hub Center Steering system is one among many different types of front-end steering/suspension mechanisms used in motorbikes and bicycles. A typical Hub Center Steering system has the steering pivot points inside the hub of the wheel instead of them conventionally being above the wheel in the headstock. Most hub center arrangements make use of a swingarm that extends from the base member of the engine/frame to the center of the front wheel, as shown in Figure 1.1. There are various advantages of using a HCS system over a conventional front fork suspension. The major advantage being that hub-center steering ends the inter-dependency of the steering, suspension and braking functions.

When fork suspension is used, the braking forces are transmitted through the suspension, which leads to the compression of the suspension and thus a large amount of suspension travel is used up. This results in difficulty in dealing with road irregularities such as bumps and potholes. The steering geometry of the motorbike changes when the forks dive which results in the motorbike becoming more nervous, and on acceleration the motorbike tends to become lazier.

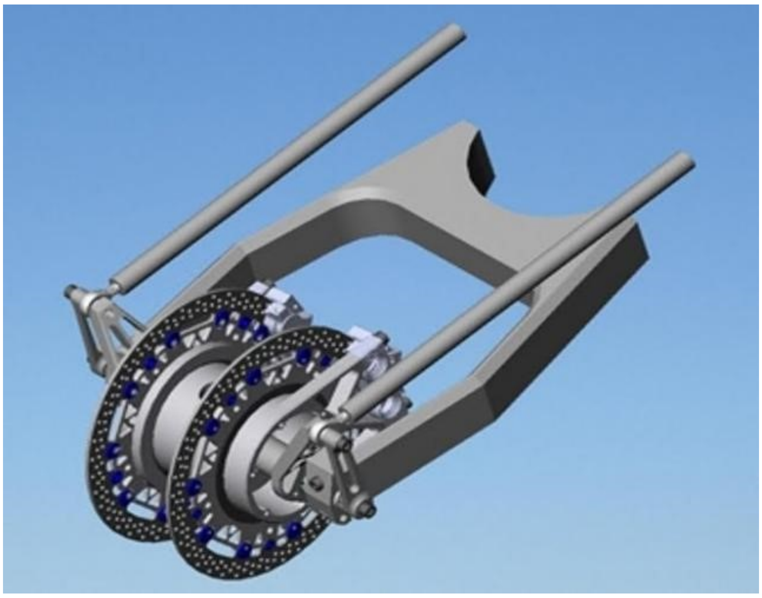


Figure 1.1: Hub Center Steering System

Also, having the steering working through the telescopic fork suspension system causes problems with stiction, decreasing the effectiveness of the suspension. The length of the typical motorbike fork means that they act as large levers about the headstock requiring the telescopic fork suspension system, the headstock, and the frame to be very robust and thus contributing in an overall increase to the total dry weight of the motorbike.

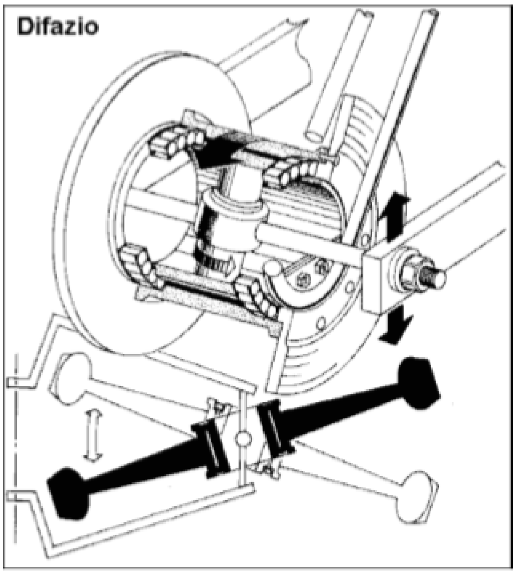


Figure 1.2: Difazio's HCS System

1.1.1 Need for HCS

- HCS system offers independency of front suspension, steering and braking from each other.
- Independency from braking decreases nose dive by a considerable amount.
- Overall vehicle handling also increases notably due to absence of bump steering.

1.1.2 Methodology

- Front swingarm will be mounted to the existing chassis of the motorbike.
- Front monoshock suspension will connect chassis and front swingarm.
- Wheel hub will be designed and manufactured and will be connected to the existing rim via custom spokes.
- Steering linkages will be connected between the hub and the handlebar.

1.1.3 Existing Design Iterations

1. NER-A-CAR

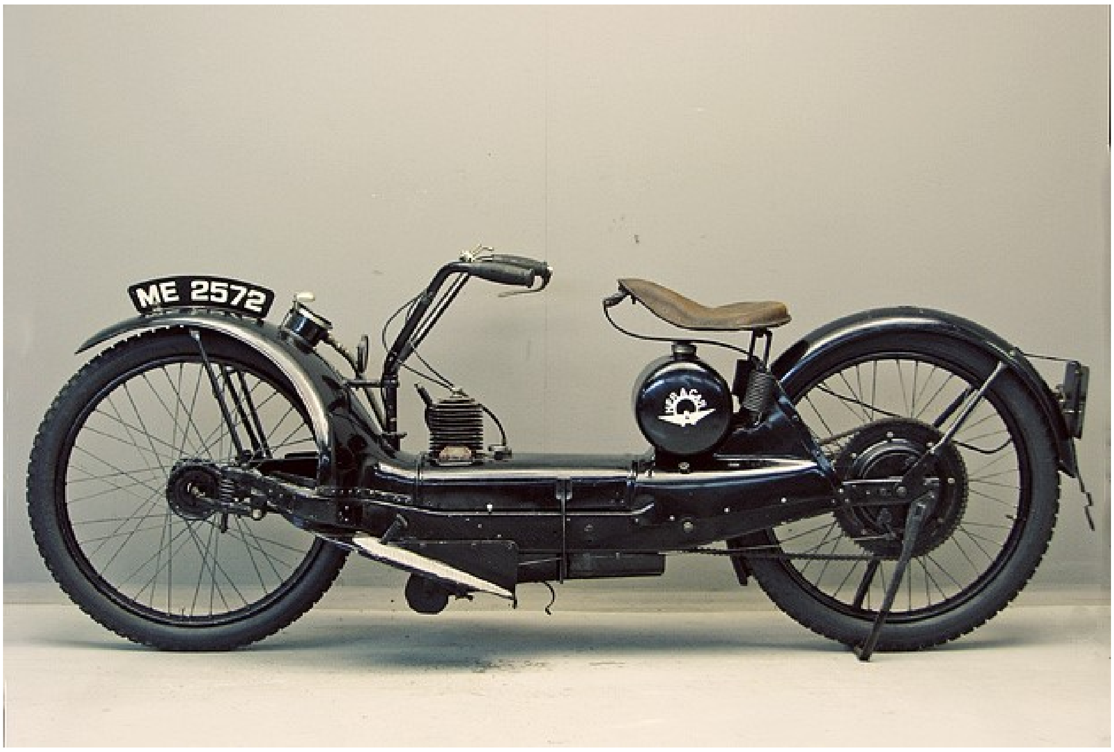


Figure 1.3: Ner-A-Car

2. CHIQANE AND ZEPPELIN WORKS

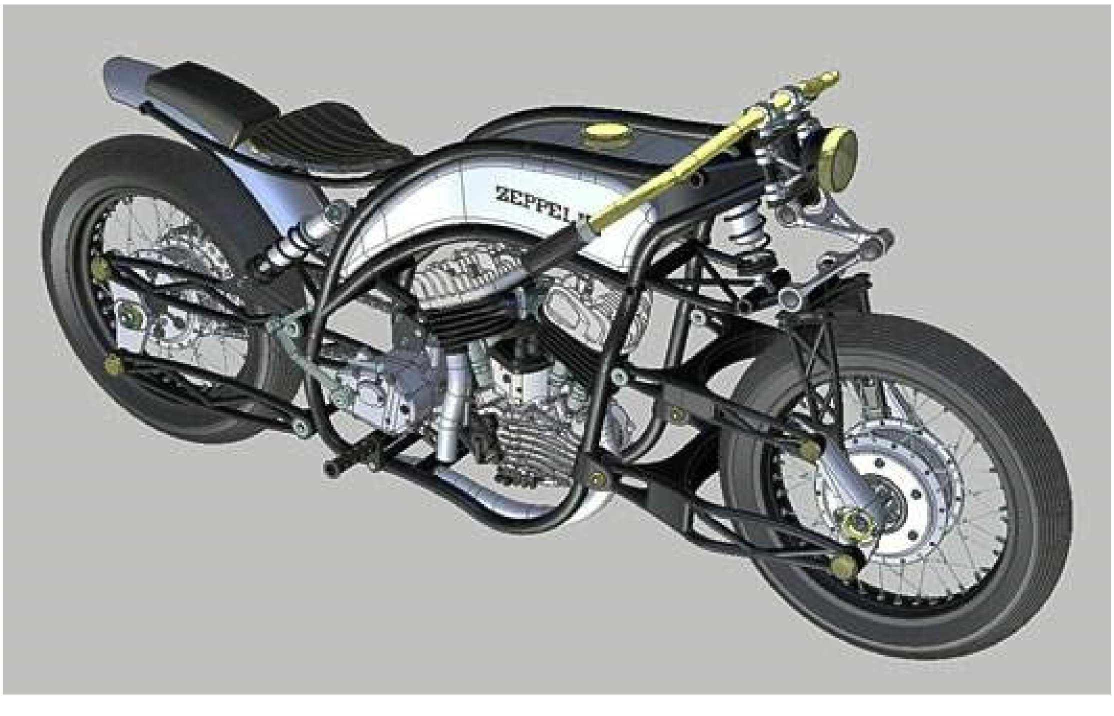


Figure 1.4: Zeppelin

3. BIMOTA TESI 3D

Figure 1.5: Bimota Tesi 3D

4. VYRUS 985

Figure 1.6: Vyrus 985

CHAPTER 2

LITERATURE SURVEY

Conventionally, motorbikes used two telescopic front suspensions for steering and suspension. The two major problems faced by current front suspension systems are:

1. Lateral displacement of the wheel and,
2. Difficulty in maintaining control during braking and cornering. Gautam Jodh (2014)

Gautam Jodh (2014) also discusses the construction and working of HCS. HCS puts in use a swingarm that is attached to the base member of the engine or frame on one end and to the center of the front wheel on the other. HCS systems use linkage arms attached to bearings to enable upward wheel deflection, thus reducing the stiction to zero, even under the application of brakes. Braking forces are directed horizontally along these linkage arms and are led away from vertical suspension forces. Finally, the linkage arms form a parallelogram which helps in maintaining steering geometry, thereby giving the rider more control. This can never be achieved by the conventional system. Generally, a steerable but non-rotating hub of large diameter is mounted on a king-pin. Another hub which is of a larger diameter and is attached to the the rim, is mounted onto the first hub. The steering axis is defined by the center line of the king-pin, so the tyre can only be allowed to deflect away from this axis due to the flexure in the wheel and the hubs themselves.

Davis (2012) studied the benefits of HCS and Wadibhasme et al. (2014) studied the limitations of fork suspension which are elaborated upon in the following sections.

2.1 Benefits of HCS

- The lateral displacement is reduced at the source.
- Braking efficiency increases due to the even spread of braking loads between the swingarm and the steering links.
- HCS ends the inter-dependency of steering, braking, and suspension.
- The overall ride quality of the motorbike has improved and better suspension performance is achieved by the use of a monoshock suspension.

2.2 Limitations of Fork Suspension

2.2.1 Effects of Braking on Fork Suspension

When a fork is used, the force produced due to braking gets directed through the suspension, which results in the suspension getting compressed and thus a large amount of suspension travel gets used up. This results in difficulty in dealing with road irregularities such as bumps and potholes. The steering geometry of the motorbike changes when the forks dive which results in the motorbike becoming more nervous, and on acceleration the motorbike tends to become lazier. The force exerted at the steering head of the motorbike while braking is shown in Figure 2.1. Not only does the conventional setup need a larger frame in order to resist these forces, but sometimes these forces can result in a moment around the wheel causing the motorbike to flip over resulting in injuries to the operator which can prove fatal in some cases.

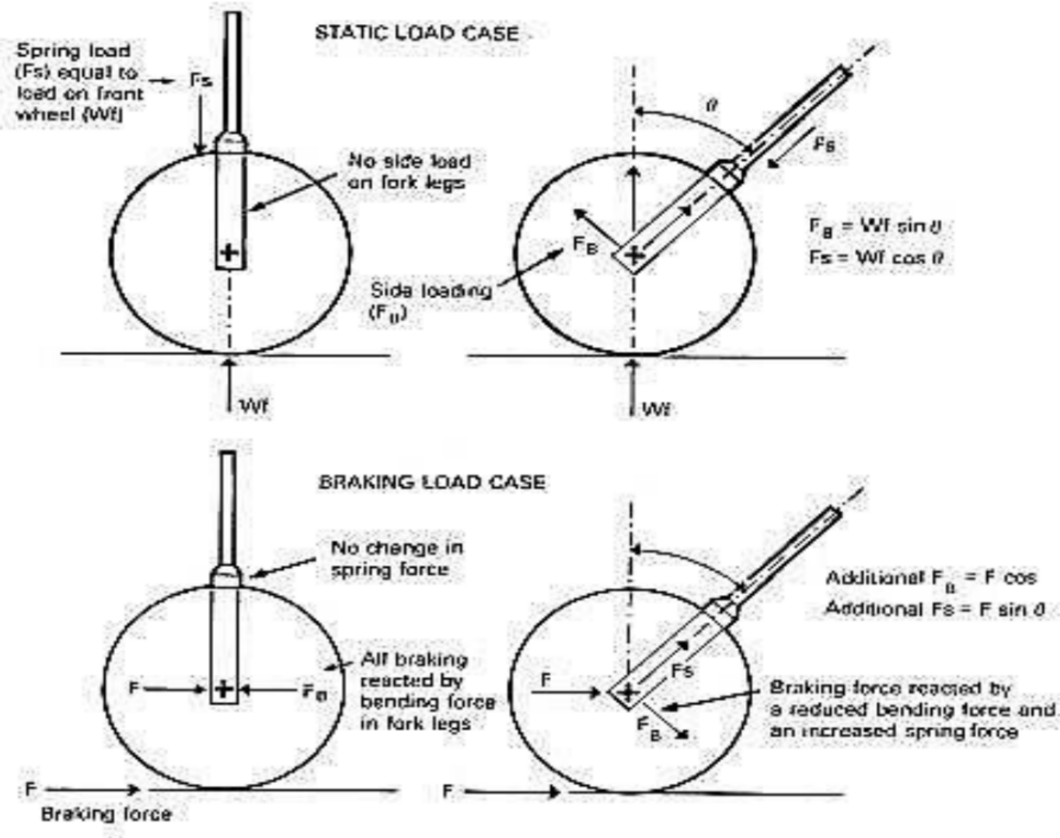


Figure 2.1: Force Exerted during Braking

2.2.2 Effects of Turn on Fork Suspension

Due to lateral flex in the forks the patch of tire in contact with the ground moves away from the steering axis resulting in tire wobble and the rider losing control. Lateral forces resulting in tire wobble are depicted in Figure 2.2

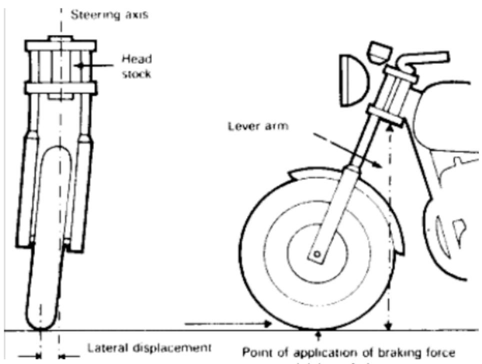


Figure 2.2: Force Exerted during Braking

Liu (2017) studied the multi-link front suspension. This suspension mechanism has four locating arms. There are two arms on either side of the cycle. They are mounted in such a way that they lie in the horizontal plane, one on top of the other, and are symmetric across the cycle. Each arm is attached to the rear end of the frame, and at the front end to the lower fork or front wheel carrier.

Kumar and Choudhry (2015) studied the development of plastic triple tree/yoke for motorbike. A triple tree is used to attach the fork tubes to the frame via steering head bearings, allowing the fork assembly to pivot from side to side, and so steer the motorbike. It was found out that when fork tubes with single action damping are employed, triple trees need to be reinforced more than when the forks shared both damping roles because the rigidity of the triple trees helps in distributing the forces within the forks without flex. The said design featured two vertical clamps for mounting the handlebar on the top of triple tree. This research was an attempt to redesign handlebar clamps which have been integrated with the triple tree. In an attempt to integrate the clamps, they are fixed to the base plate of the triple tree.

Sangamesh Bhure (2012) devised an alternative front suspension for motorbikes. The system is designed based on the studies conducted on the previous models that where in use. Major studies were done on the two present designs, i.e. the Hub Centre Steering, and the double link.

The Hub Centre Steering is much more complicated and is more expensive as it requires special joints and a large curved swing arm to accommodate the steering. The double mechanism was also studied in detail. The process of achieving the desired motion was more complicated as the system demands more accurate and precise geometry, which should not change with the motion of system. This is more difficult as the dynamic environment is unpredictable.

The design was done by using a modified double link mechanism in which one of the links take both the swinging as well as the steering effort. This system is further refined by including a slotted bar and sliding mechanism. Figure 2.3 shows a double link front suspension mechanism

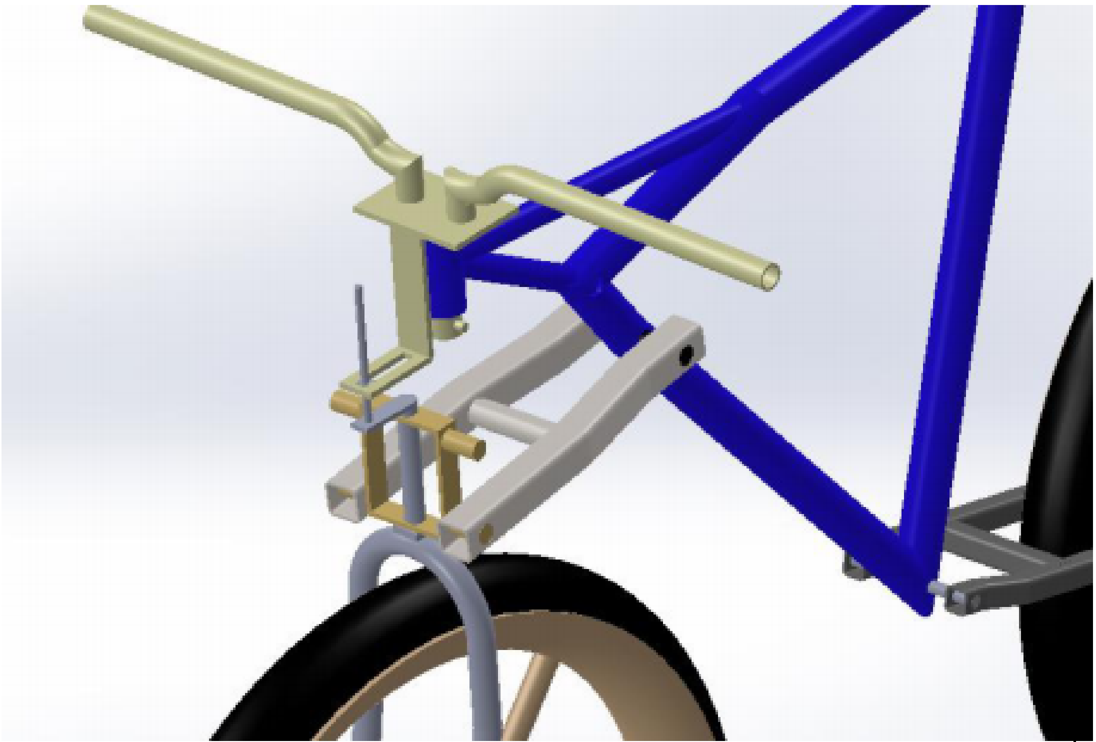


Figure 2.3: Double Link Front Suspension

Rankhambe and Nhaichaniya (2017) studied the swingarm and suspension requirements. A motorbike suspension serves two roles, providing the operator control over braking and steering functions and damping bumps and other road irregularities to provide a comfortable ride. Fork tubes on the front of the motorbike and a swingarm in the rear are the major suspension components. There are two types of swingarms found on motorbikes.

Typically, most motorbikes have a monoshock swingarm. In said design, a coil over shock is attached to a linkage arm that is connected to the motorbike frame and the H-shaped swingarm itself. A more recent development is the single-sided swingarm. This type is identical to the H-shaped swingarm in function, except that one side has been removed which aids in tyre change.

CHAPTER 3

DESIGN CALCULATIONS AND CONCEPT DESIGN

3.1 Design Calculations

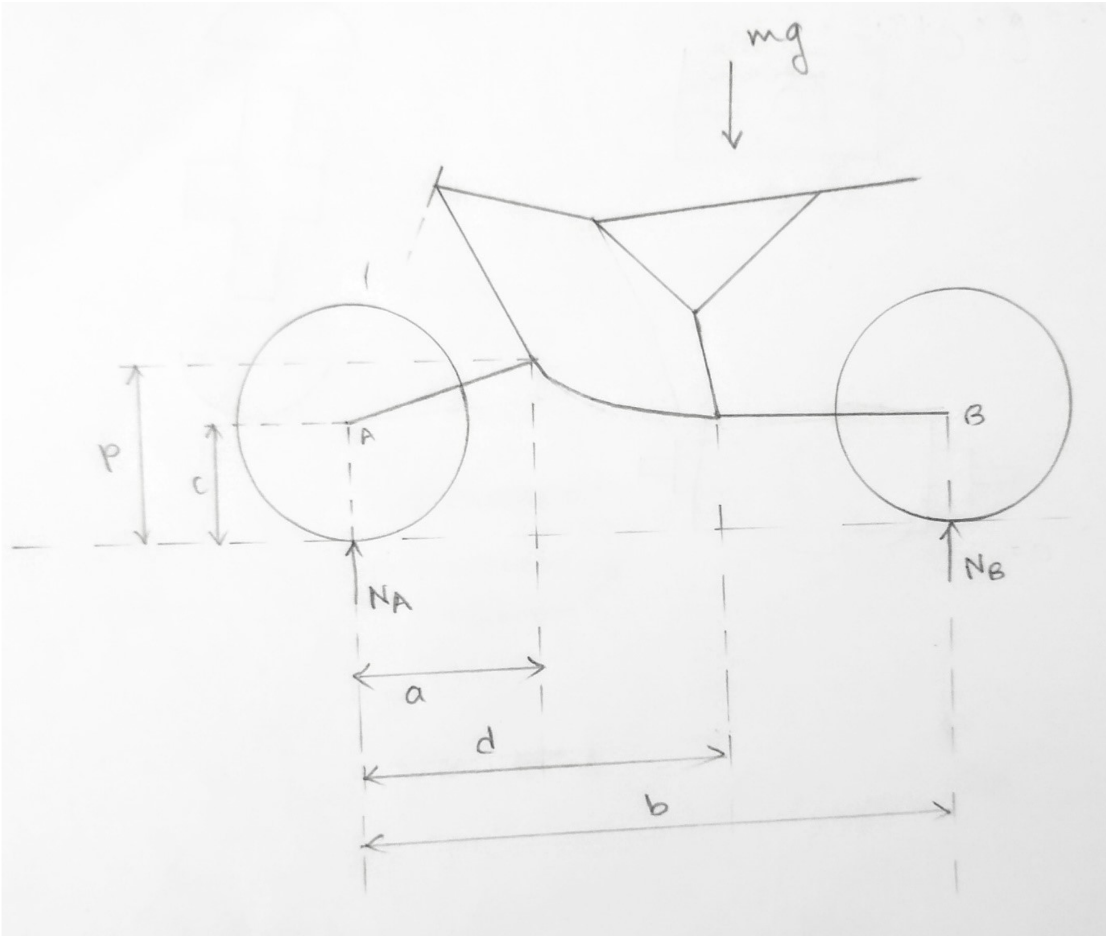


Figure 3.1: Force Resolution Diagram

The force resolution diagram of a concept hub center steering motorbike has been shown in Figure 3.1. This diagram helps in understanding the various forces acting on the frame of the motorbike and being transmitted through to the hub. Calculations have been done to find out the maximum force that the hub would be subjected to under normal operation, as well as under worst case conditions, i.e. when the front wheel is dropped from a height of 2 feet. The weight of the motorbike has been chosen as the average wet weight of a 100cc motorbike and the rider weight has also been factored into the calculations. The torque being applied at the mounting point of the hub has been calculated. The stopping torque required has thus been obtained and assuming pure kinetic energy, the force acting on the hub has been found.

3.1.1 Force resolution

$m = 200kg$ (along with rider weight)

$a = 570mm$ (horizontal distance between center of front wheel to front swingarm mounting point)

$d = 890mm$ (horizontal distance between center of front wheel and rear swingarm mounting point)

$c = 320mm$ (vertical distance between ground and center of front wheel)

$p = 380mm$ (vertical distance between ground and front swingarm mounting point)

Assume normal reaction at B to be 0. Then,

$N_{\text{A}} = mg = 1962N$

Torque at A from rider sitting on bike,

$mg \times a = 1118.34Nm$

Stopping force required to create moment about front wheel,

$F = \sum ma = 0$

$\equiv (F \times c) - (T \times d) = 0$

$\equiv F = 3110.38kg - f$

Torque created by stopping force on mounting point/joint,

$T = F \times p = 1181.95kg - m - - - [i]$

Assuming pure kinetic energy, stopping speed is verified, $KE = 0.5mv2$

$\equiv 1181.95 = 0.5mv^2$

$\equiv v = 3.44m/s \approx 12.4km/h$

Worst case scenario:

The front wheel of the bike being dropped from 2 feet above ground level. Then,

Velocity of the bike from 2 ft (0.61 m)

$v = \sqrt{(2gh)} = \sqrt{(2 \times 9.81 \times 0.61)}$

$= 3.46m/s$

Kinetic energy produced from hitting the ground,

$KE = 0.5mv^2$

$= 0.5(200)(3.46)^2$

$= 1197.16J$

$\approx 1197.16/g = 122.04kg - m$

3.1.2 Design of Center Pin

From equation [i],

Maximum torque,

$T = 1181.95kg - m$

$= 11594.89 \times 10^3 N - mm$

Considering material of pin as Steel ASTM A514,

Ultimate Strength $= 760MPa$

Factor of safety $= 2$

$\therefore$ Shear Stress induced, τ = Ultimate stress/factor of safety

$= 760/2$

$= 380MPa$

Diameter of pin (d) is calculated,

$\tau = (16 \times T)/(\pi \times d^3)$

$380 = (16 \times 11594.89 \times 10^3)/(\pi \times d^3)$

$d = 54.75mm$

Length of pin (L) is calculated,

$L = 1.5 \times d = 82.12mm$

Due to bearing dimensional constrains, the base diameter of pin, d, hereby is chosen as 50 mm.

And therefore, length of pin,

$L = 1.5 \times 50 = 75mm$

Now the horizontally protruded part of the center pin is a design feature necessary for the thrust bearings to sit on. So, the diameter of the protruded part will be decided by the outer diameter of the thrust bearing. The outer diameter of the thrust bearing we could find/procure for a bore of 50mm is 70 mm. So, the diameter of the protrusion of center pin is 70 mm.

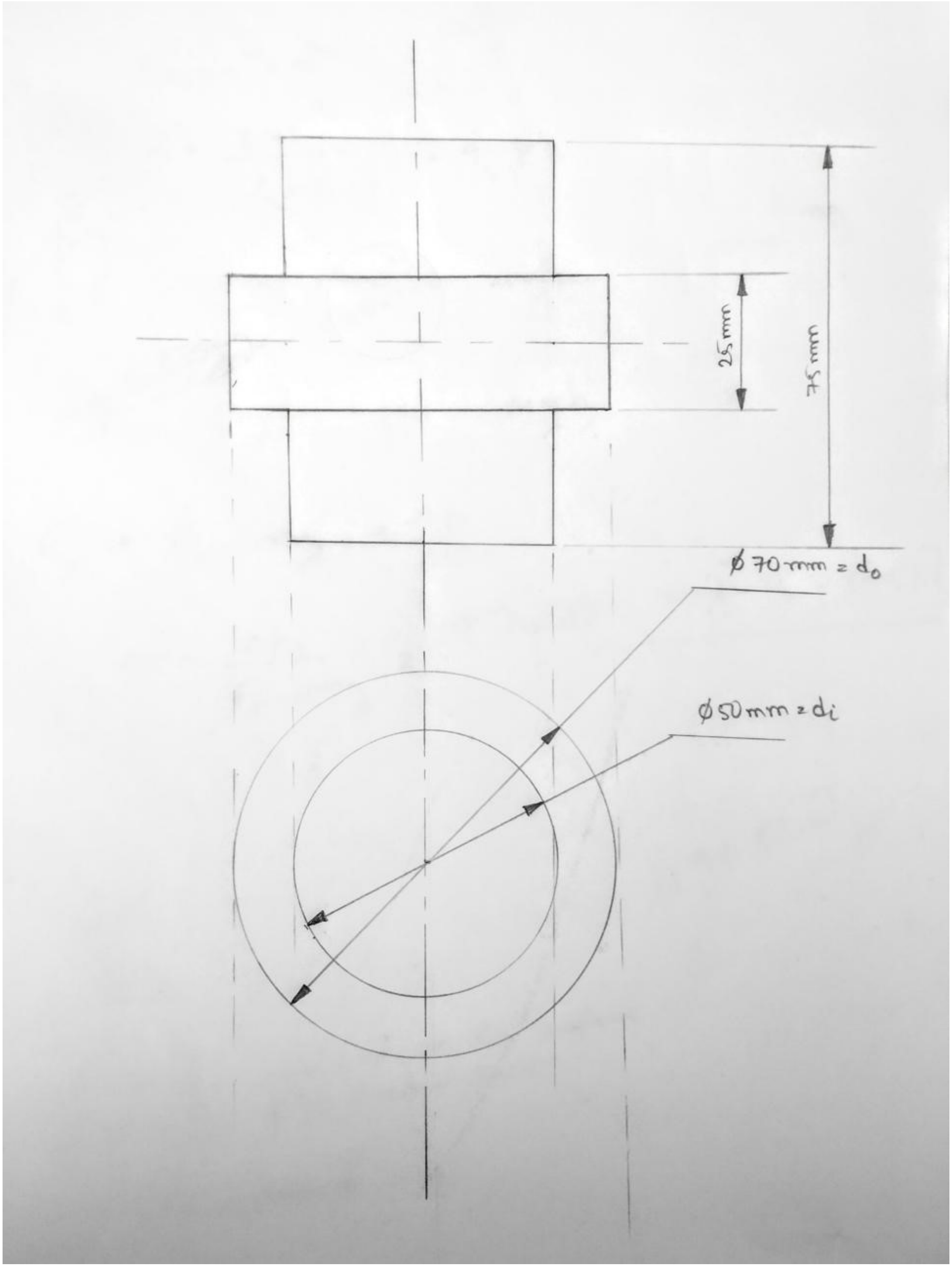


Figure 3.2: Center Pin Dimensions

3.1.3 Dimensions of Thrust Bearing

The inner diameter/bore, D1 of the thrust bearings will be equal to the base diameter of center pin is 50 mm.

For a 50mm bore, the outer diameter, D of the thrust bearing we could find/procure is 70 mm.

Height, H provided in this bearing is 14 mm.

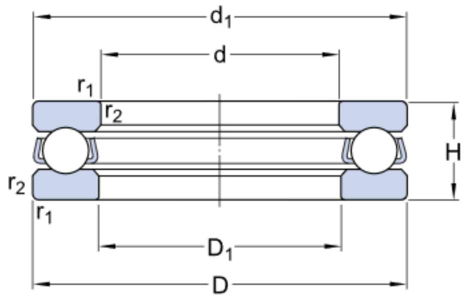


Figure 3.3: Thrust Bearing Dimensions

3.1.4 Dimensions of Roller Bearing

The length of pin will be a decisive factor in choosing the inner diameter/bore of the radial bearing. Providing clearance for the top end caps, each of height 12 mm, total 24 mm for two, the inner diameter, d of the radial bearing is chosen as, $75 + 24 = 98 \approx 100mm$

Now the width of the radial bearing has to be equal to or more than the diameter of the horizontally protruded part of the center pin i.e., 70 mm. We found a suitable bearing of 100 mm bore having a width, B of 73 mm, which satisfies our requirement.

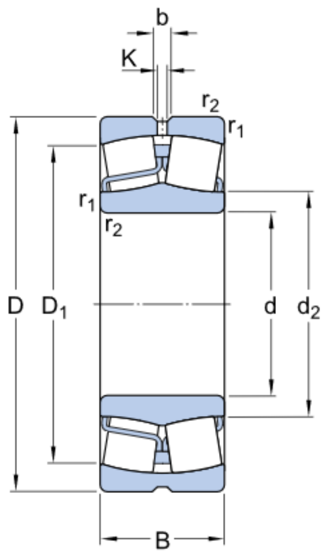


Figure 3.4: Dimensions of Roller Bearing

The dynamic load bearing capacity of both the bearings chosen above exceeds well over 5-10 times the weight of the motorbike. So, no further calculations are necessary for load bearing criteria as custom-made bearings are well beyond the scope of this project.

3.2 Concept Design

A basic concept design of the hub and all its major parts was first sketched on paper to get an idea of space and packaging restraints. Direct inspiration was taken from Difazio's mechanism. After going over all the existing iterations of the hub center steering system, the best elements of each design were chosen and incorporated into one also keeping in mind the cost restrictions and availability of raw materials as well as built units.

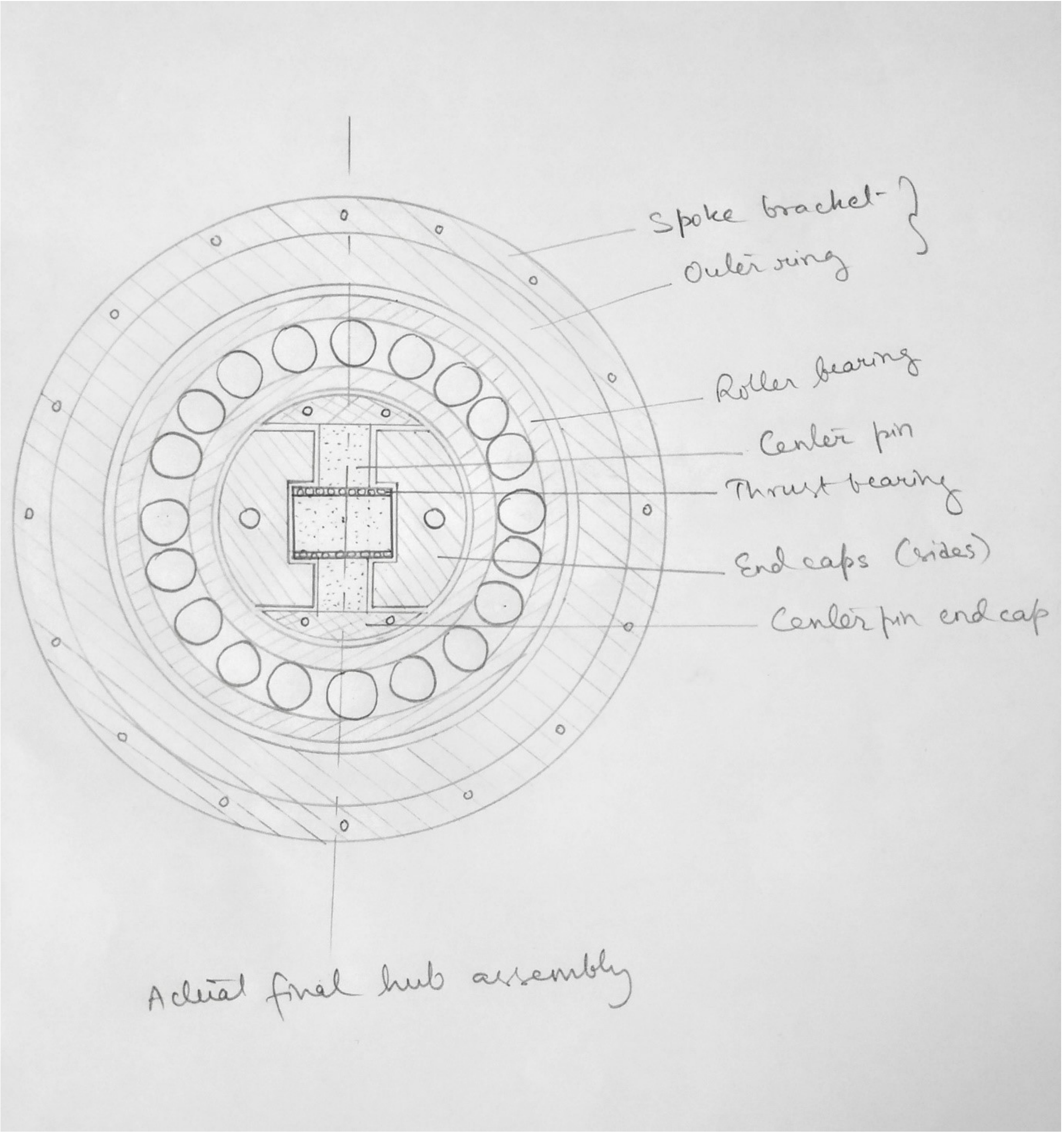


Figure 3.5: Concept Sketch of Hub Assembly

As Figure 3.2 illustrates, the concept hub assembly consists of a center pin, two thrust bearings, two side end caps, two center pin end caps, a roller bearing and a casing for the hub which includes an outer ring as well as a spoke bracket to attach the hub to the rim.

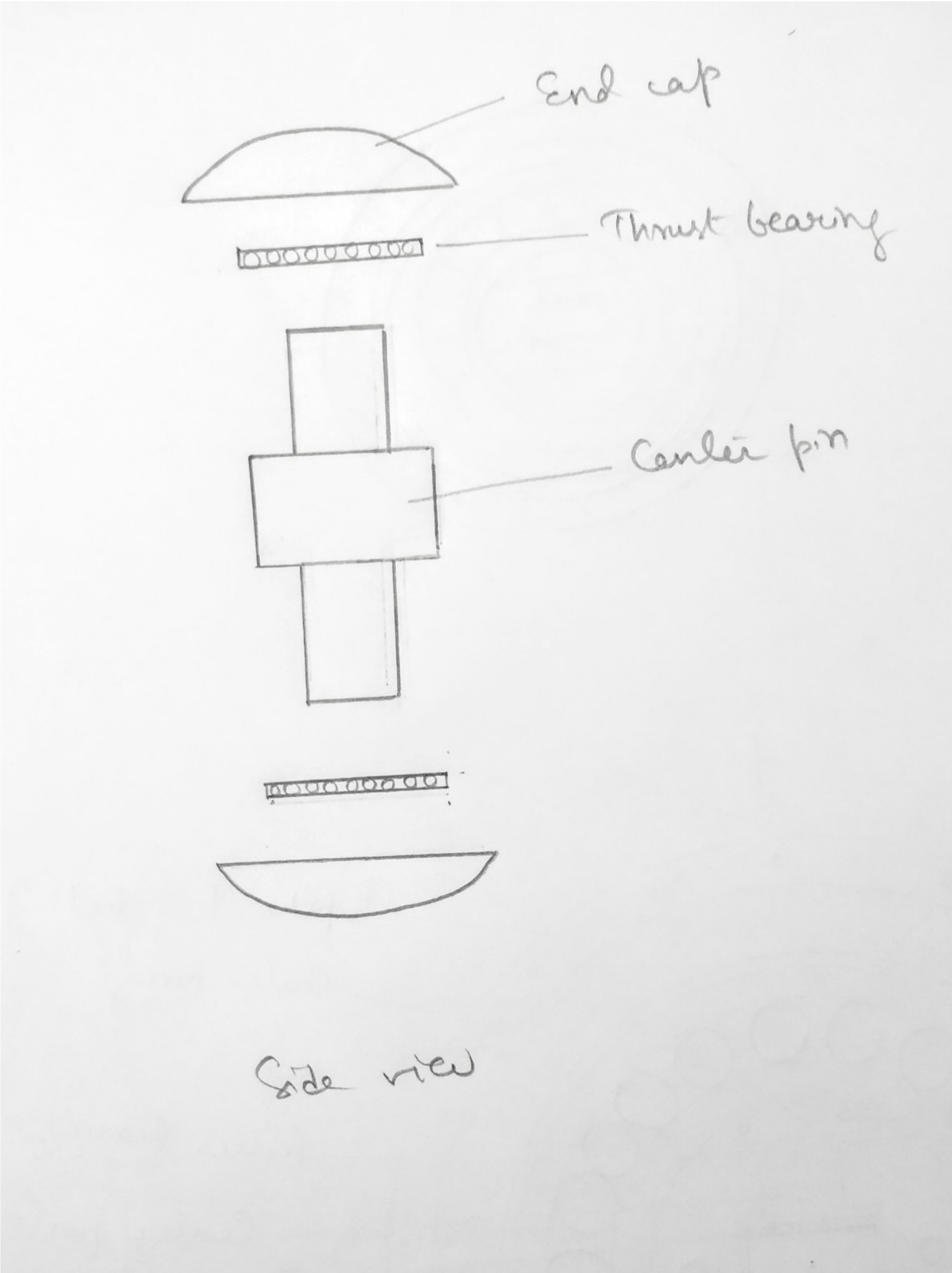


Figure 3.6: Concept Sketch of Center Pin

Figure 3.3 illustrates the center pin and the two thrust bearings along with it. The ends of the center pin are secured by one end cap each on either side which restrict the vertical motion of the thrust bearings.

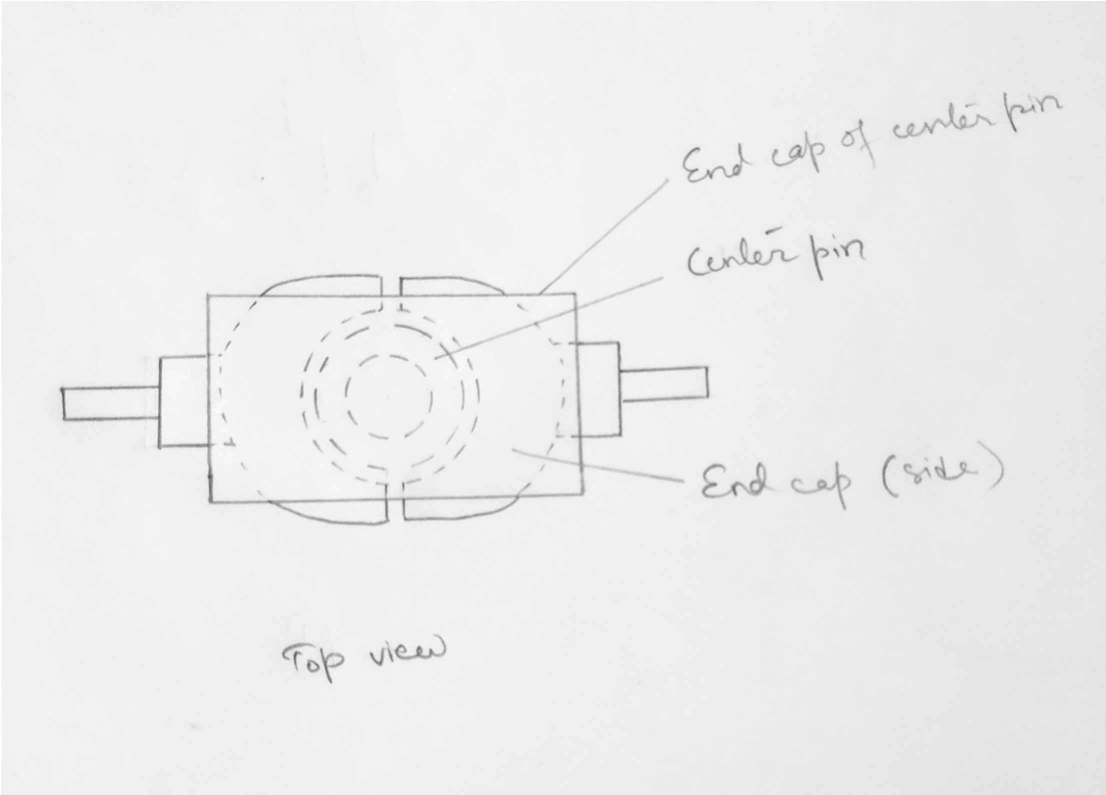


Figure 3.7: Concept Sketch of Center Pin (Top View)

3.2.1 Steering Mechanism

The end caps will be fixed to the front swingarm. The end caps are attached to the center pin via thrust bearings, so the center pin is free to rotate about its axis. The center pin is press fitted to the the top caps and the top caps are press fitted to the radial roller bearing which is further press fitted to the entire wheel hub. Therefore, if the centre pin is free to rotate, then the entire assembly can rotate along with the center pin, leading to the steering of the wheel. Through holes/slots provided in the top caps which lead to the hub cover, solid linkage rods can be attached which link the triple clamp connected to the handlebar, so the wheel can be steered conventionally via these solid linkage rods. These linkage rods will be used just for steering and will not bear any loads.

CHAPTER 4

CAD MODELLING AND FINAL ASSEMBLY OF HUB

4.1 Components of Hub Assembly

The Hub consists of:

1. Outer Hub Assembly
   - Spoke bracket
   - Roller bearing
2. Inner Hub Assembly
   - End caps
   - Thrust bearings
   - Center pin

The outer hub consists of a spoke bracket that is used to attach the final assembly to the rim via spokes and a roller bearing to facilitate the circular motion of the wheel. Refer Figure 4.1.

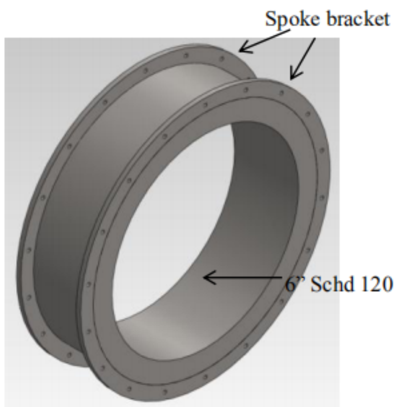


Figure 4.1: Outer Hub Assembly

The inner hub consists of the center pin, end caps to cover the thrust bearing and thrust bearing for free rotation of pin inside the hub. Refer Figure 4.2.

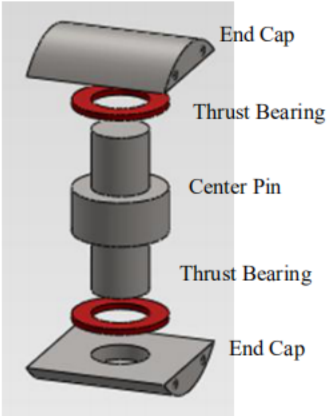


Figure 4.2: Inner Hub Assembly

The inner hub assembly is pressed into the inner side of the roller bearing. Once the inner assembly has been press fitted, the spoke bracket is then pressed onto the outer cover of the roller bearing, thus completing final hub assembly as shown in Figure 4.3.

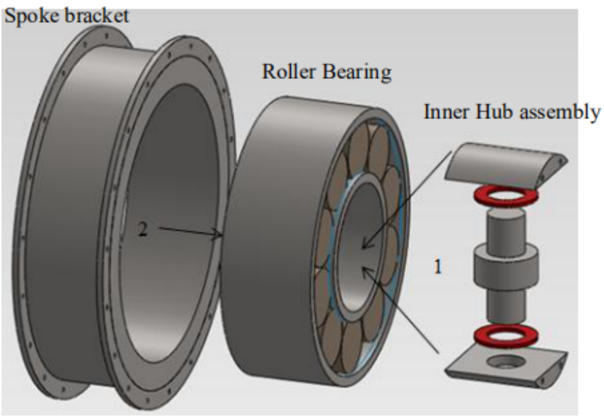


Figure 4.3: Assembly of Hub Mechanism

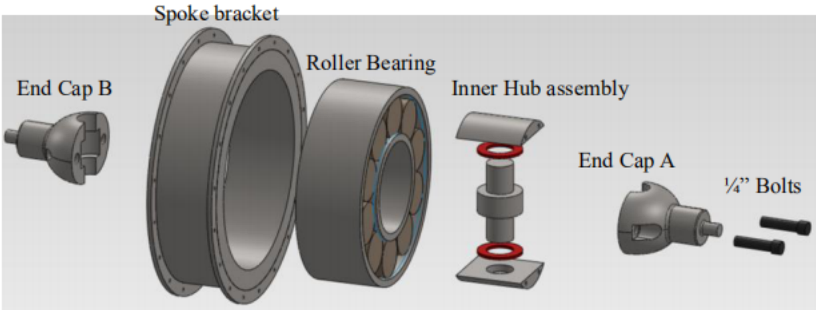


Figure 4.4: Final Hub Assembly

4.2 CAD Modelling using PTC Creo Parametric

A CAD model of the major components of the hub was made using PTC Creo Parametric.

A final assembly of all the components was also done and is shown below in Figure 4.5 and so forth.

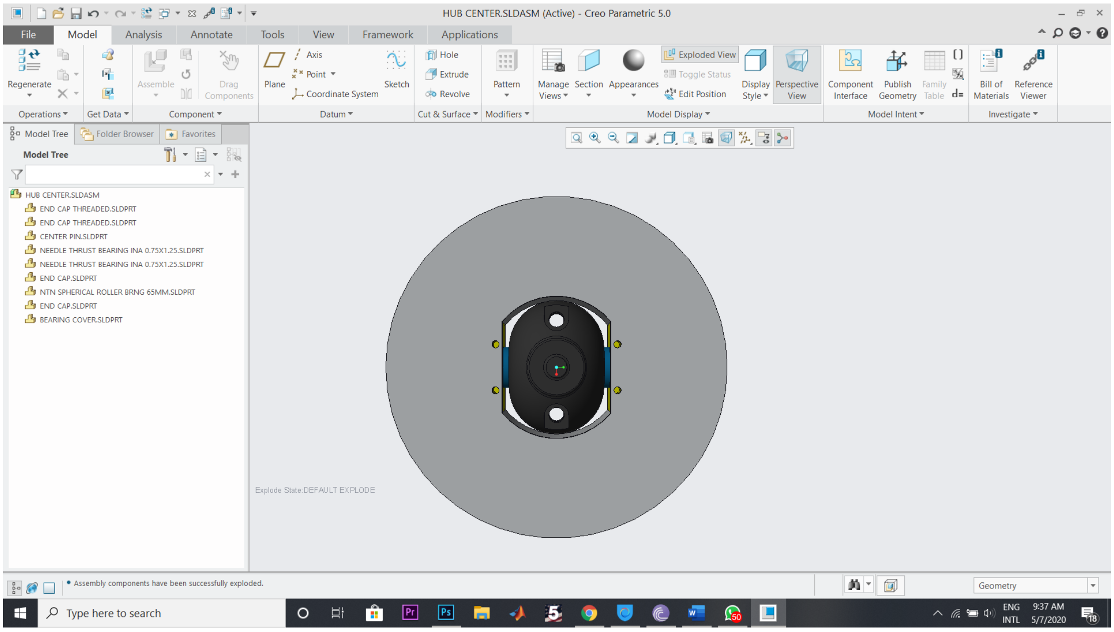


Figure 4.5: Front View of Hub Assembly

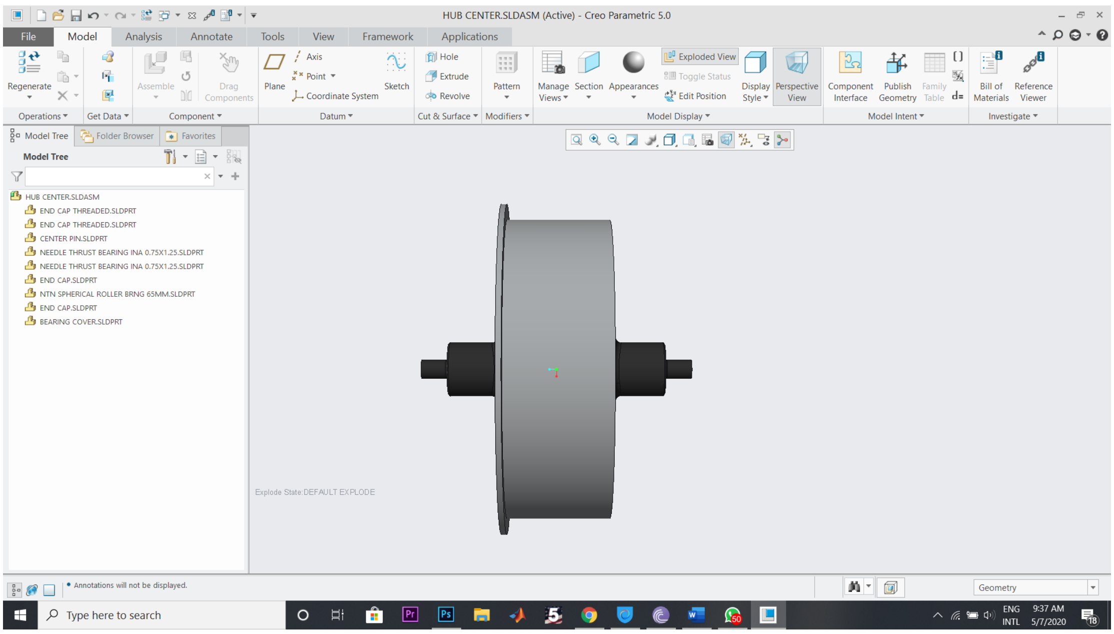


Figure 4.6: Side View of Hub Assembly

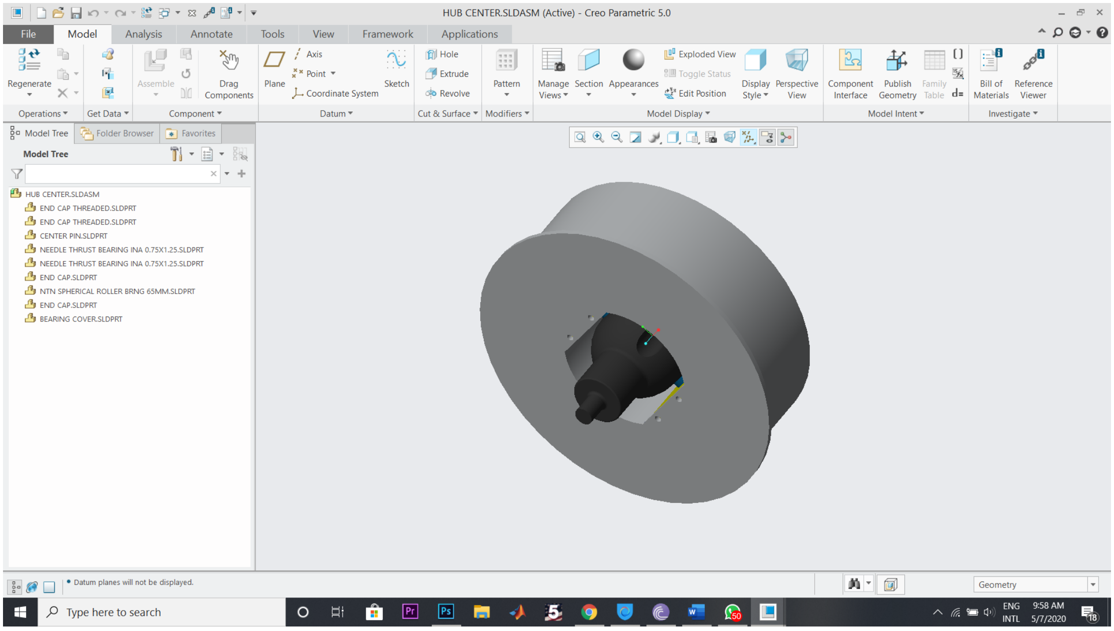


Figure 4.7: Isometric View of Hub Assembly [1]

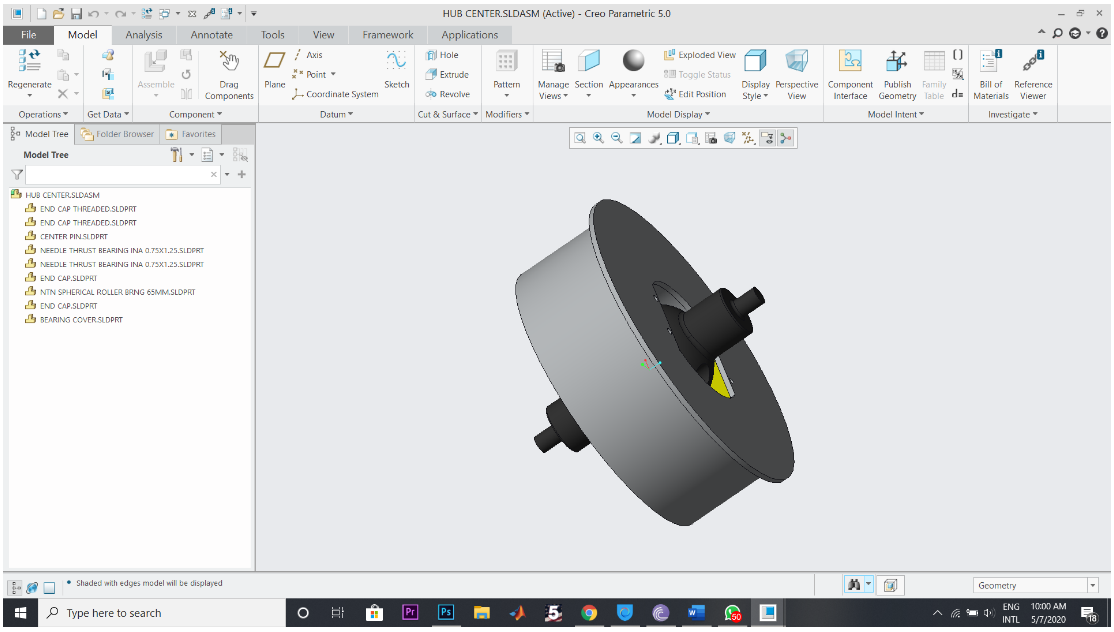


Figure 4.8: Isometric View of Hub Assembly [2]

The end cap design is shown in Figure 4.9 and so forth.

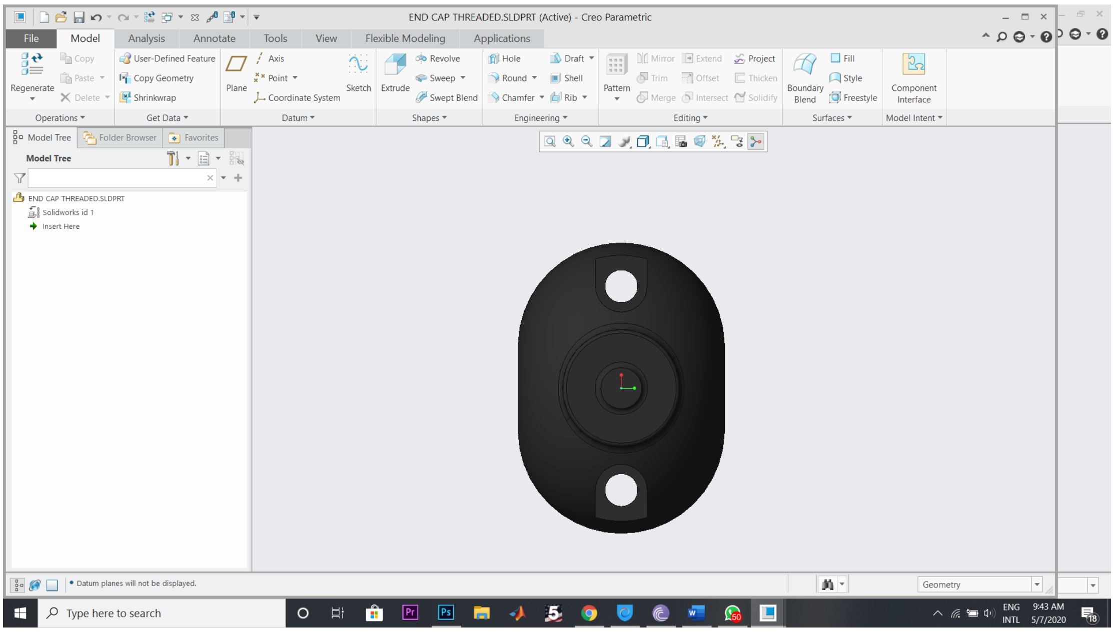


Figure 4.9: Front View of End Cap

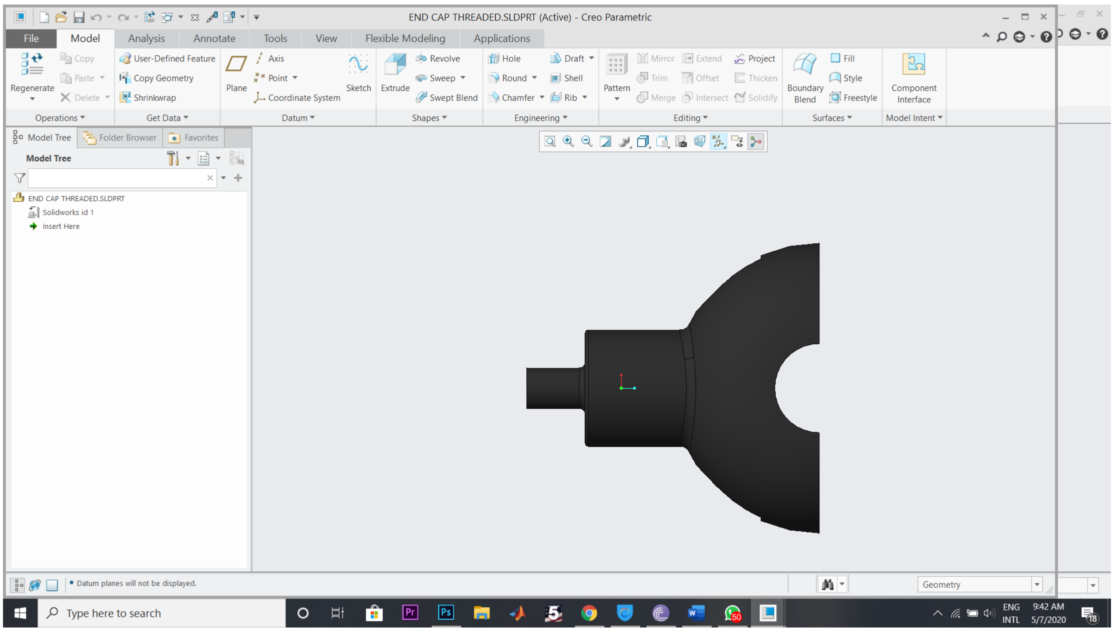


Figure 4.10: Side View of End Cap

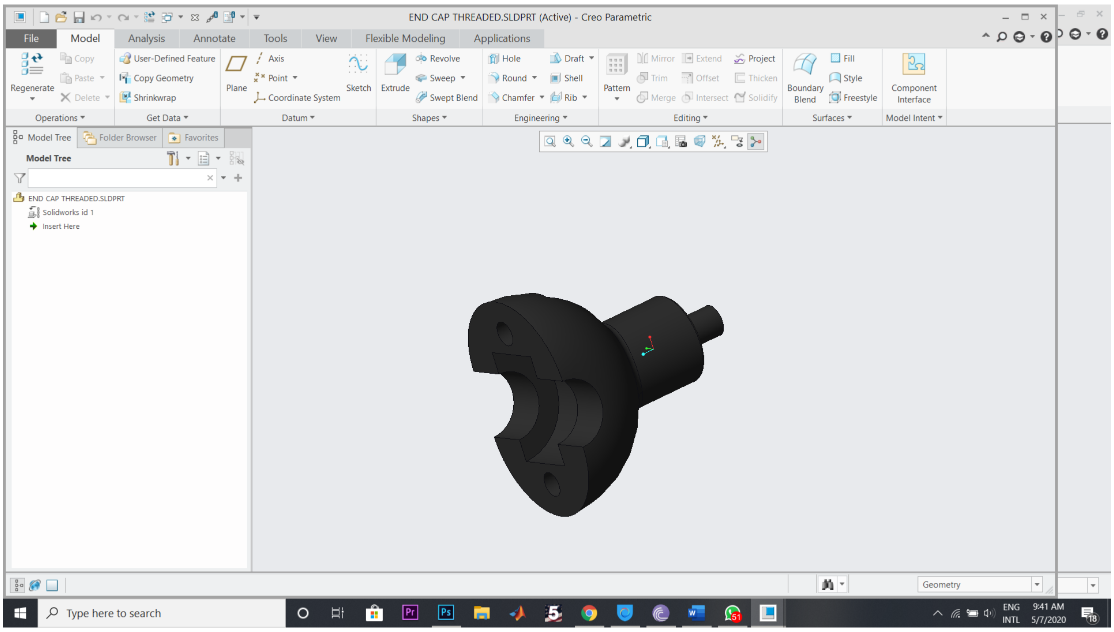


Figure 4.11: Isometric View of End Cap

The center pin design is shown in Figure 4.12 and so forth.

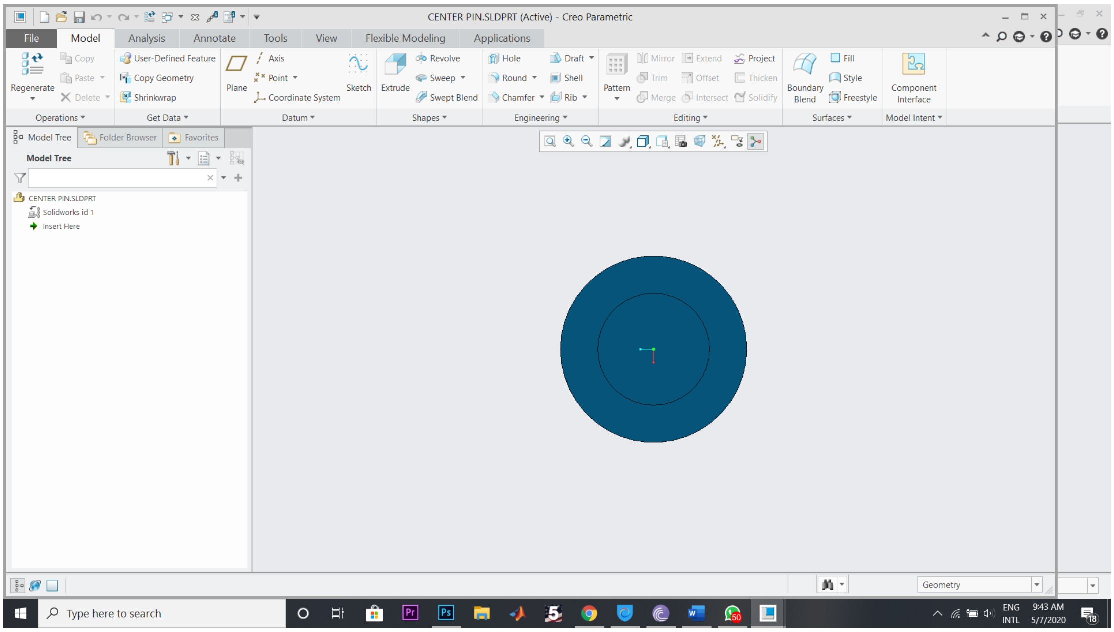


Figure 4.12: Front View of Center Pin

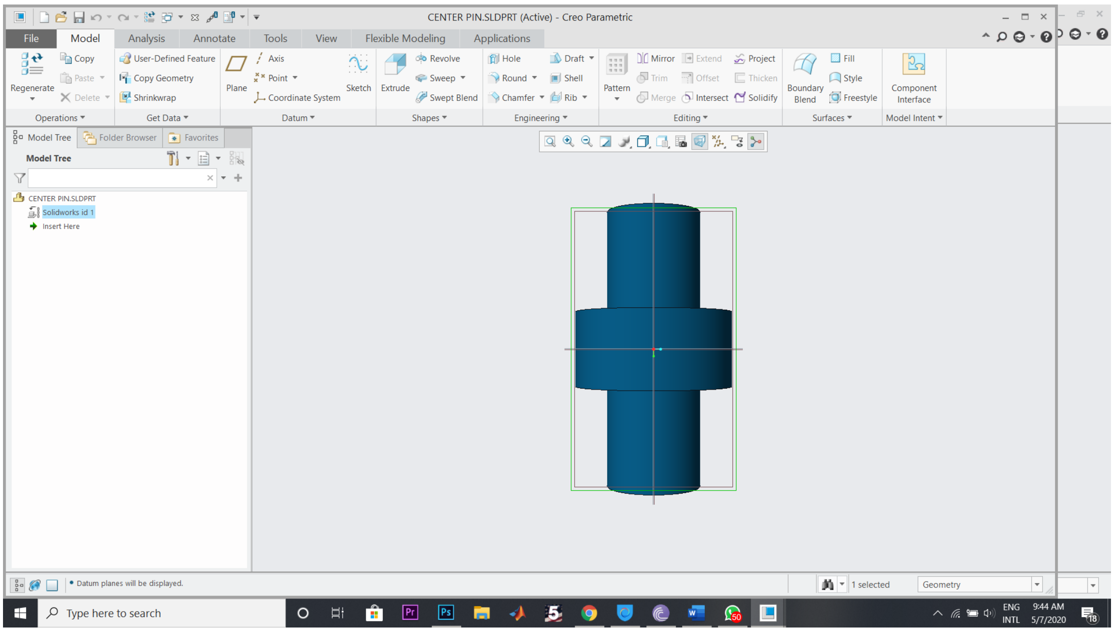


Figure 4.13: Side View of Center Pin

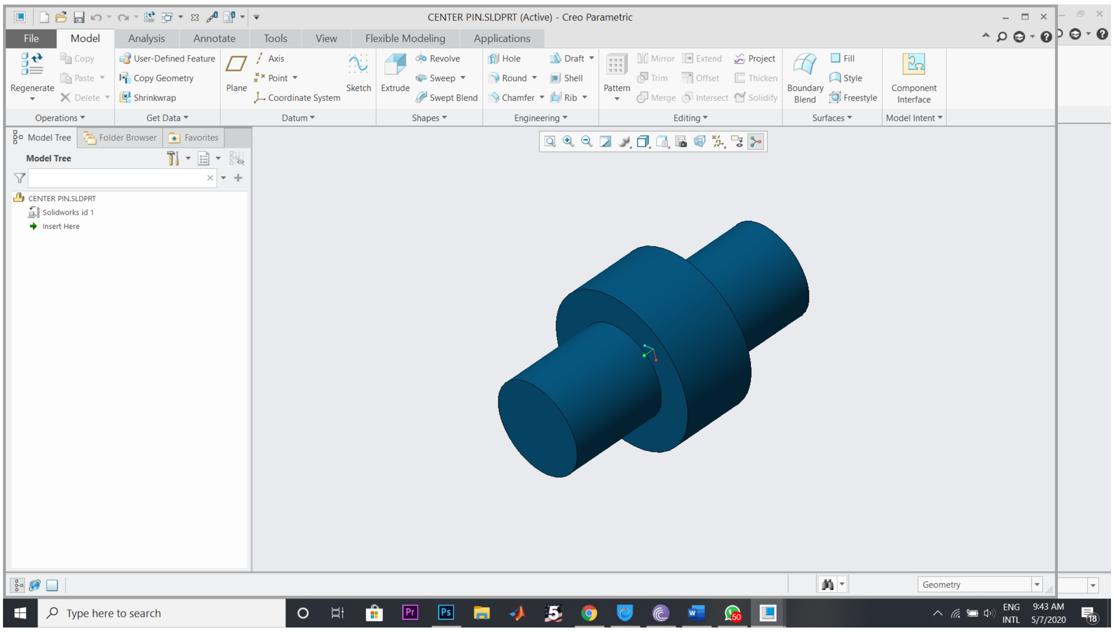


Figure 4.14: Isometric View of Center Pin

The thrust bearing design is shown in Figure 4.15 and so forth.

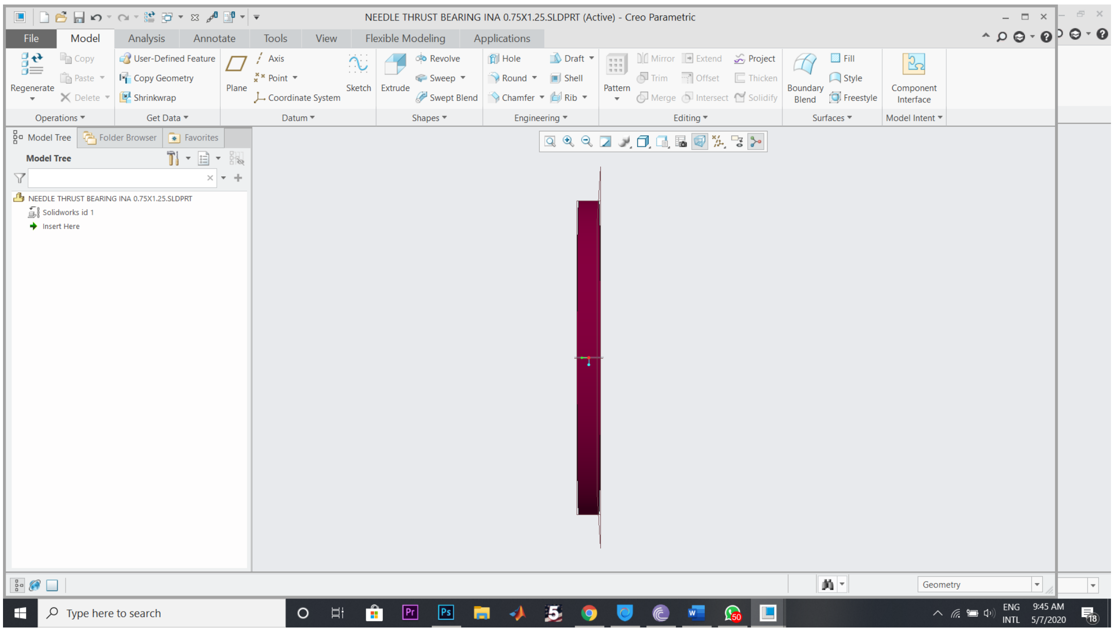


Figure 4.15: Front View of Thrust Bearing

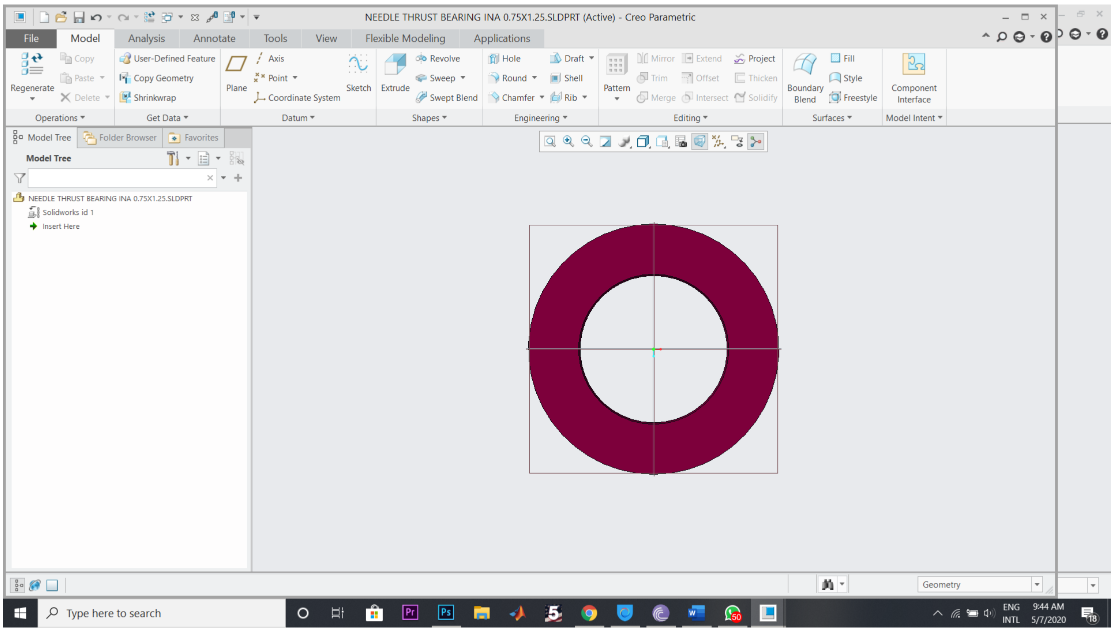


Figure 4.16: Side View of Thrust Bearing

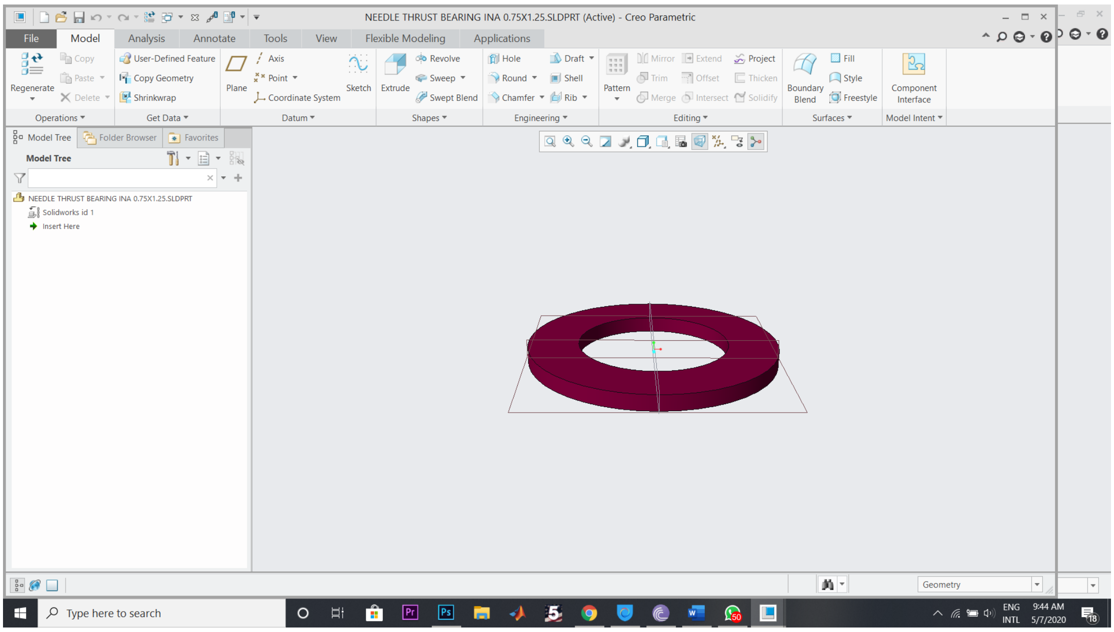


Figure 4.17: Isometric View of Thrust Bearing

The top cap design is shown in Figure 4.18 and so forth.

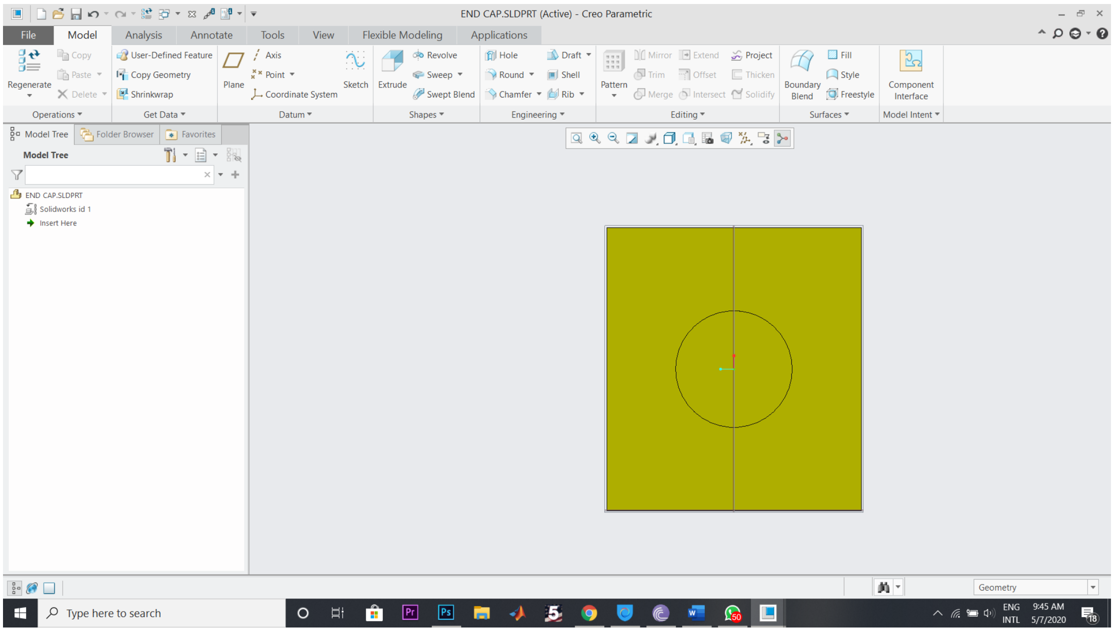


Figure 4.18: Front View of Top Cap

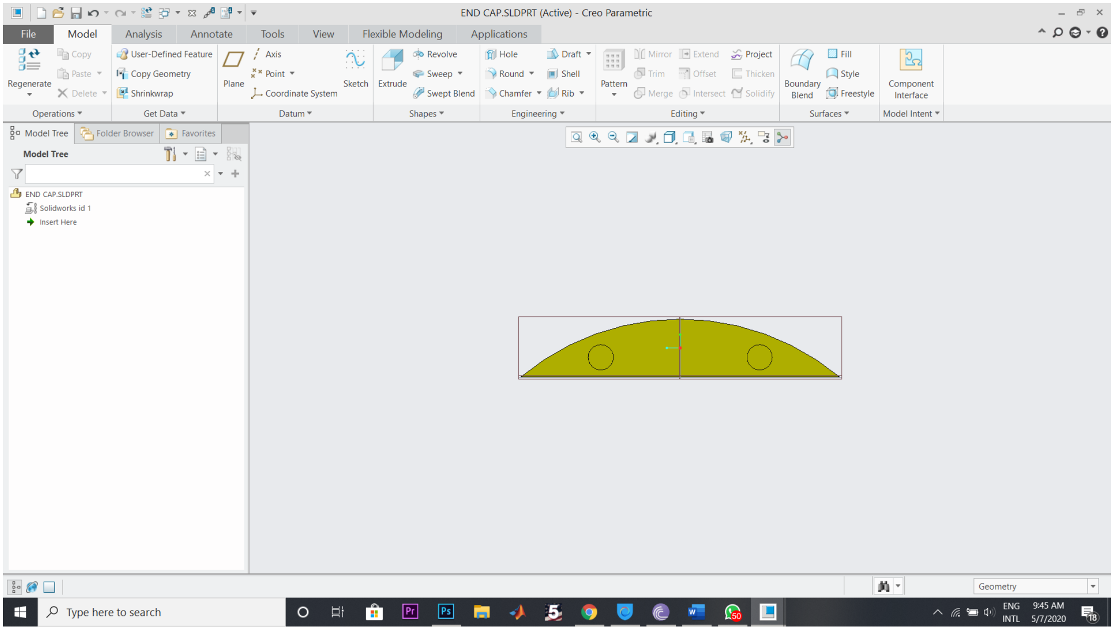


Figure 4.19: Side View of Top Cap

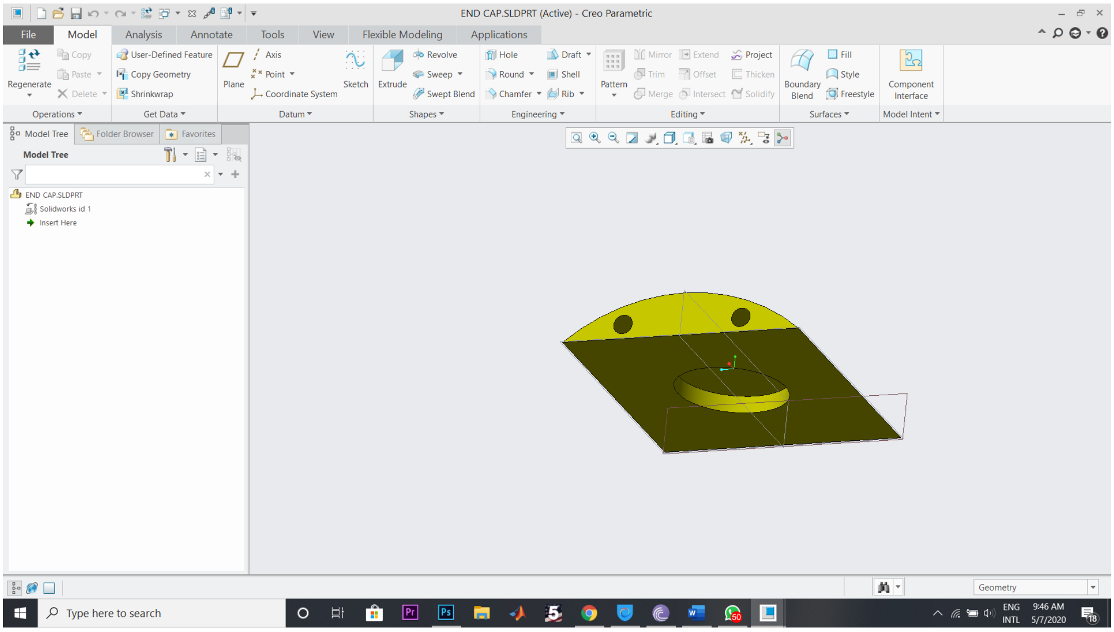


Figure 4.20: Isometric View of Top Cap

The roller bearing design is shown in Figure 4.21 and so forth.

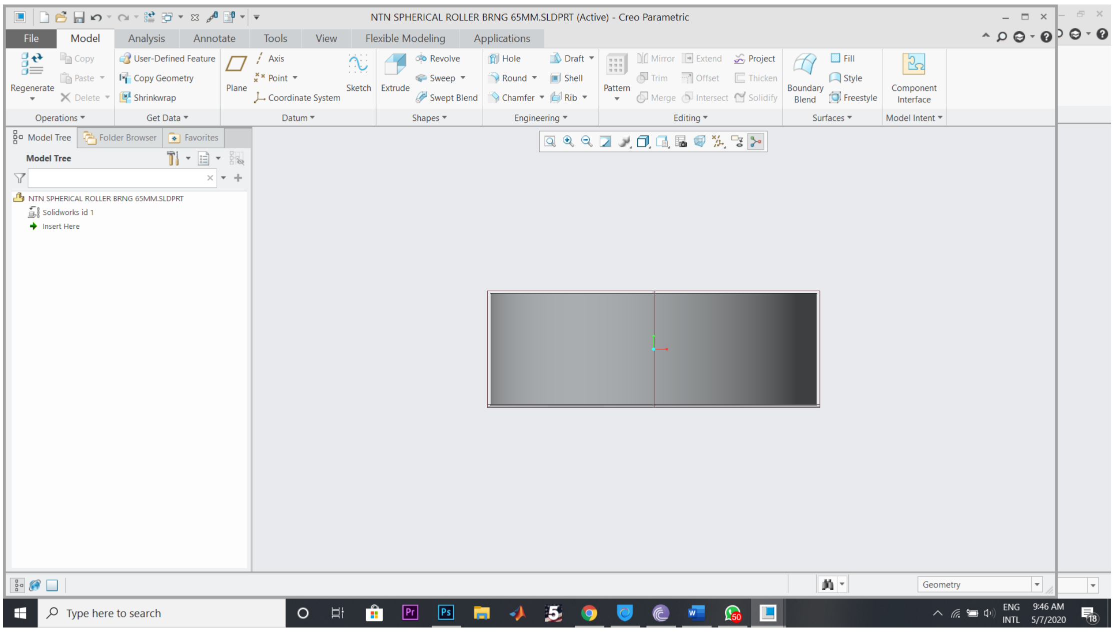


Figure 4.21: Front View of Roller Bearing

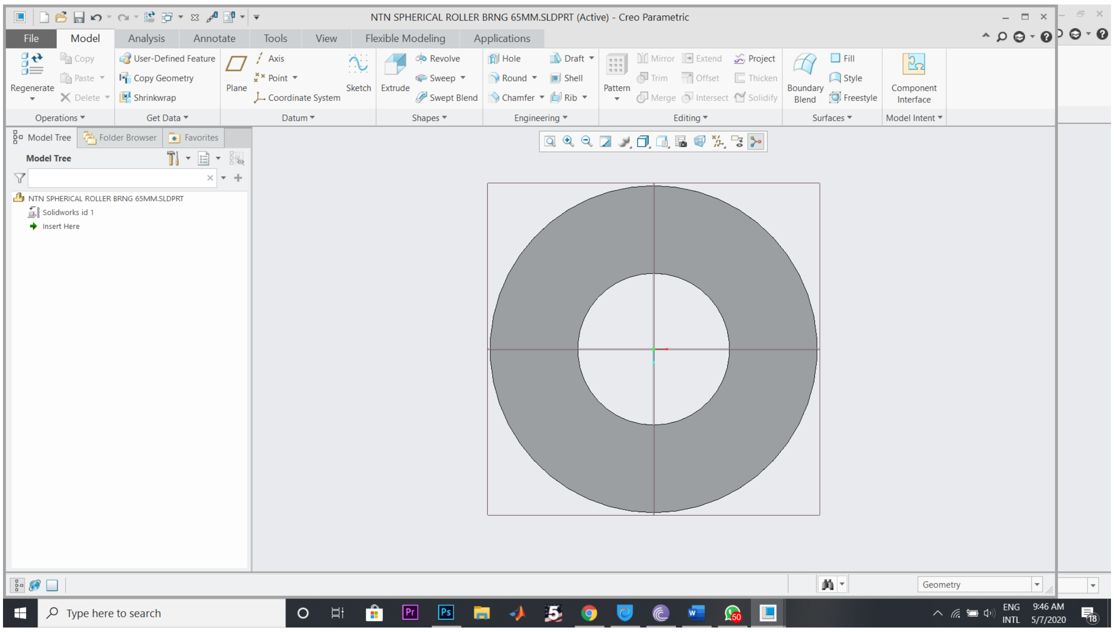


Figure 4.22: Side View of Roller Bearing

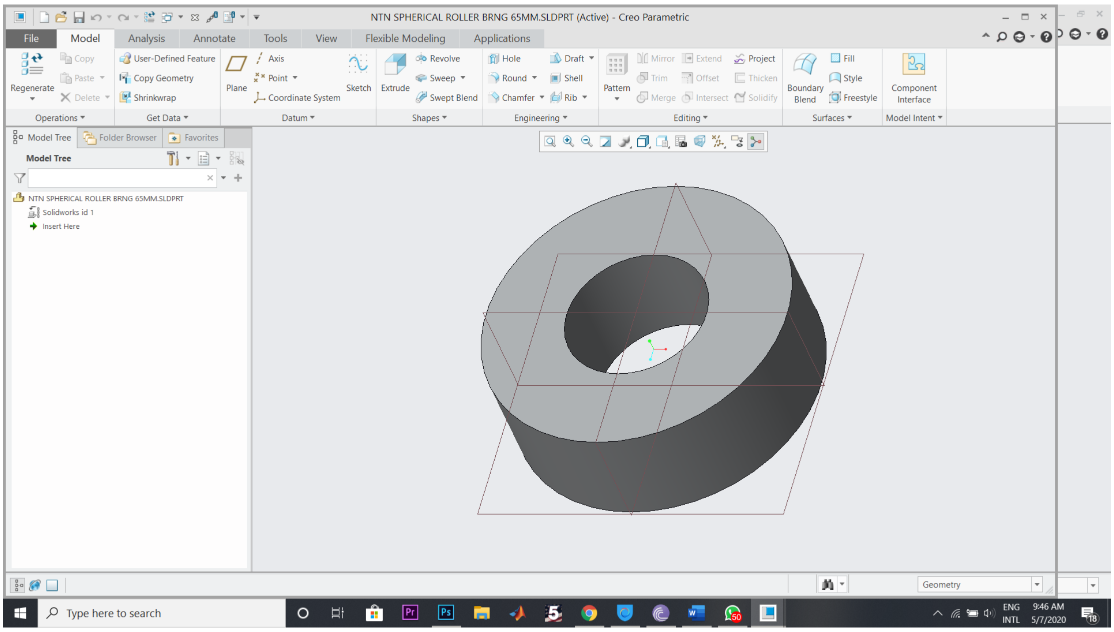


Figure 4.23: Isometric View of Roller Bearing

The roller bearing cover design is shown in Figure 4.24 and so forth.

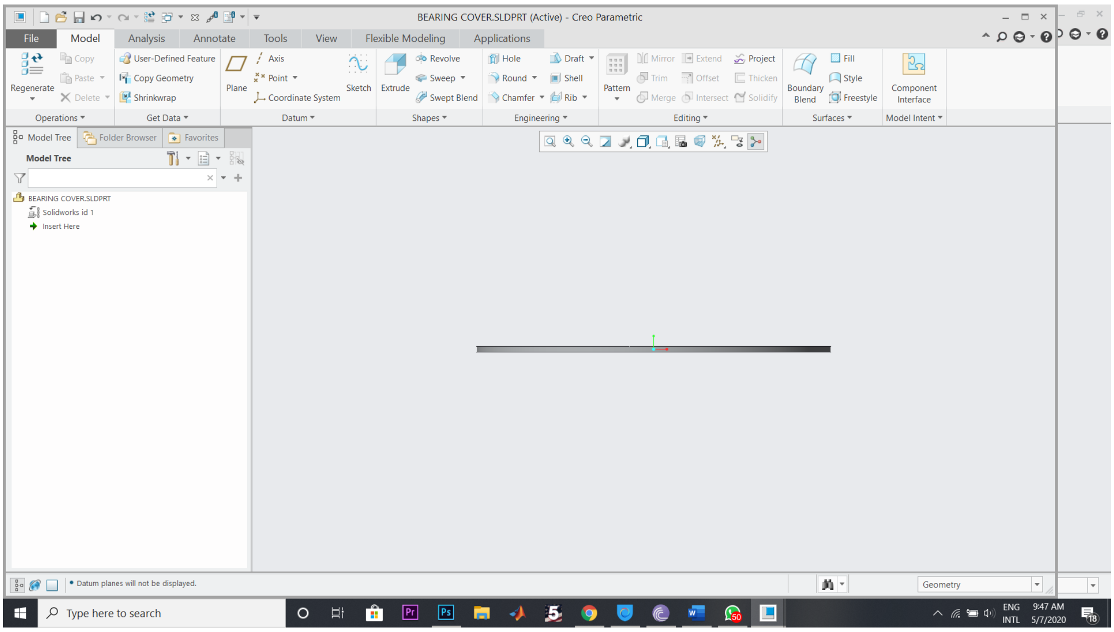


Figure 4.24: Front View of Bearing Cover

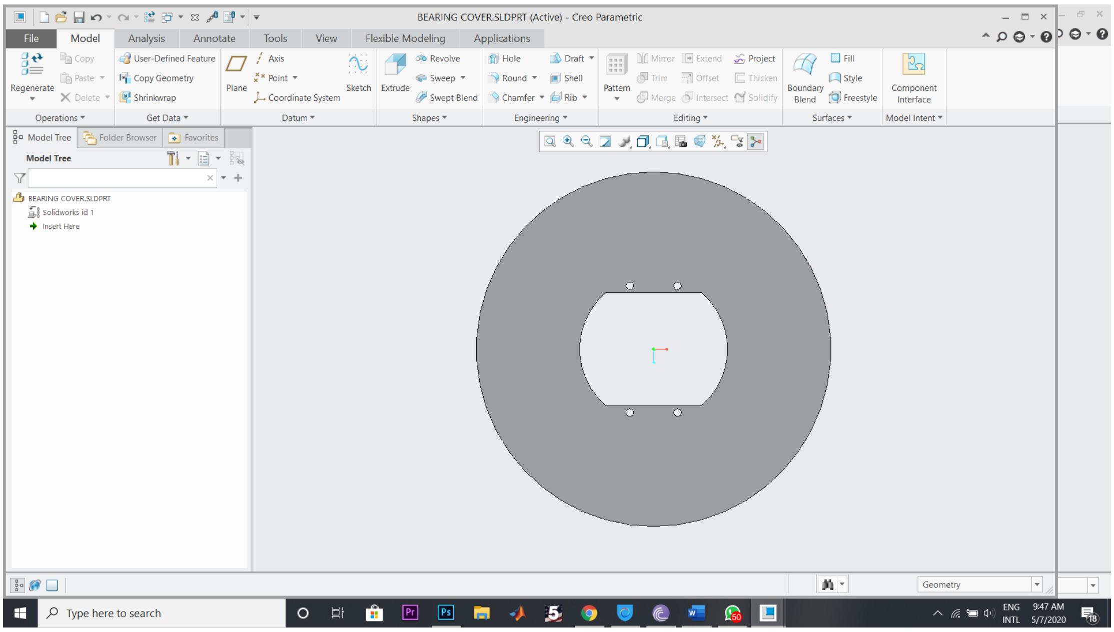


Figure 4.25: Side View of Bearing Cover

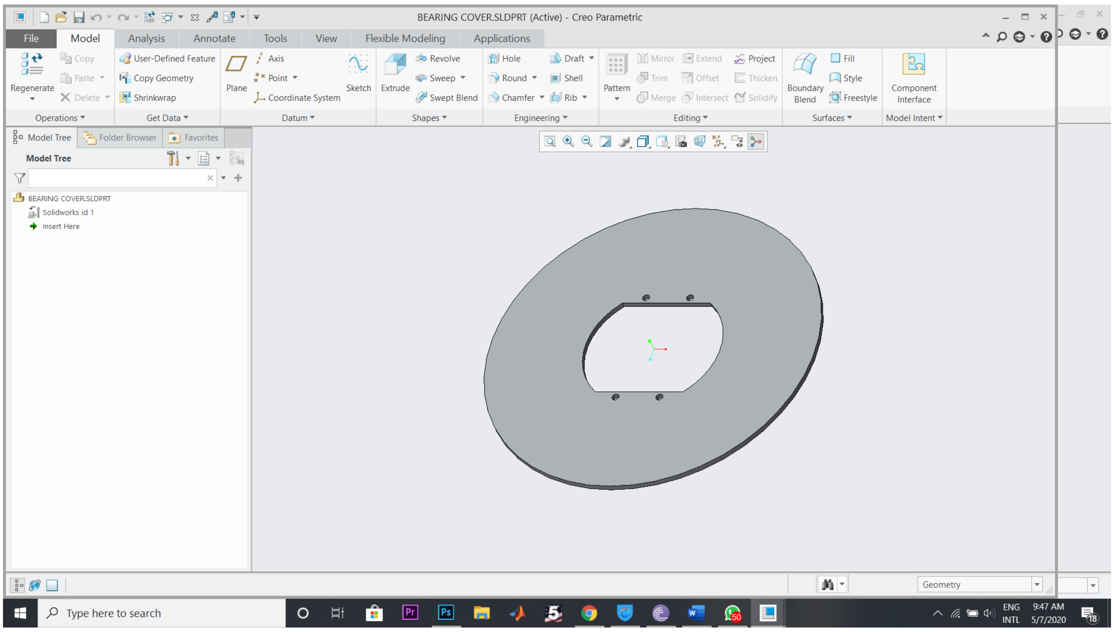


Figure 4.26: Isometric View of Bearing Cover

4.3 Analysis of Hub Components

The major load bearing components, the center pin and the end caps, were analysed using DS Solidworks. The analysis results were satisfactory.

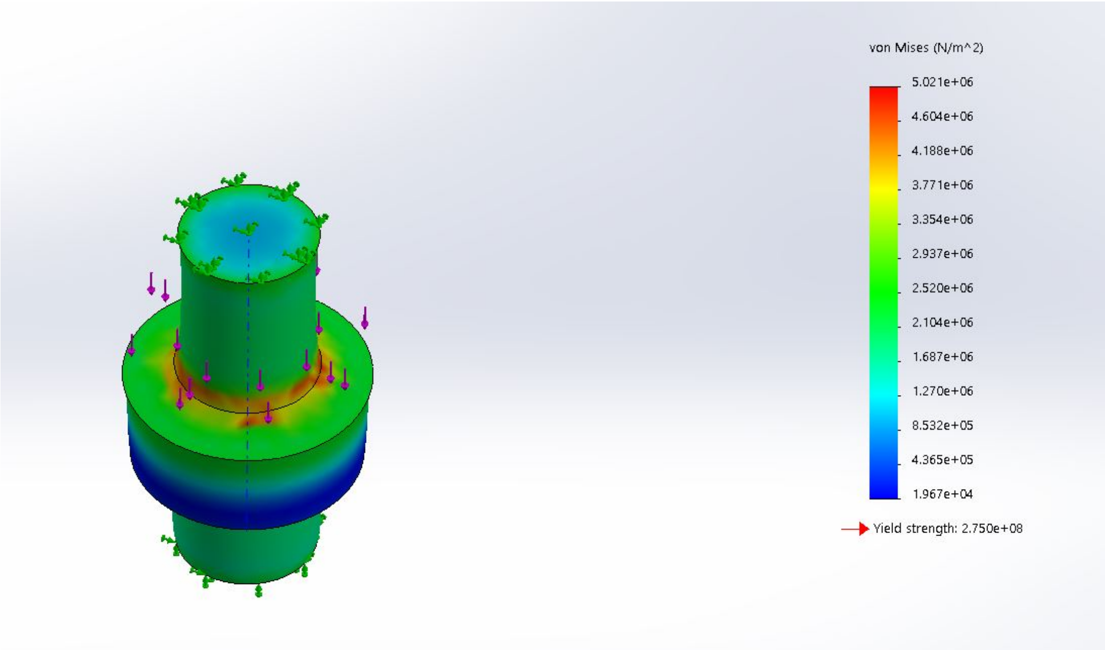


Figure 4.27: Analysis of Center Pin [1]

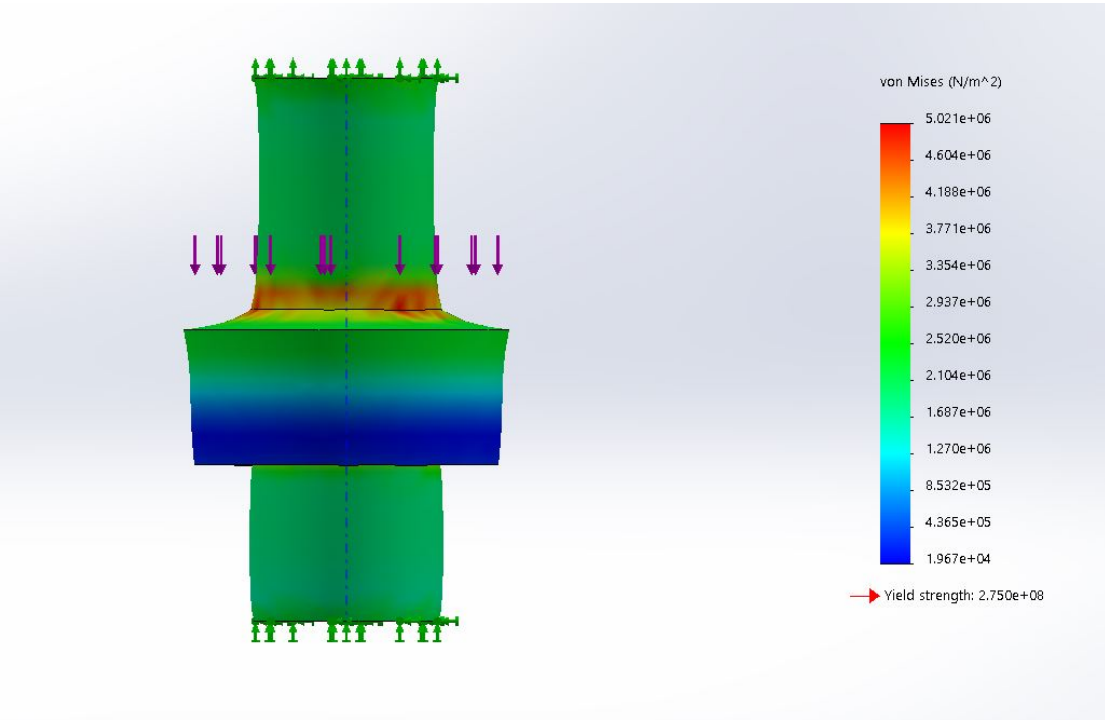


Figure 4.28: Analysis of Center Pin [2]

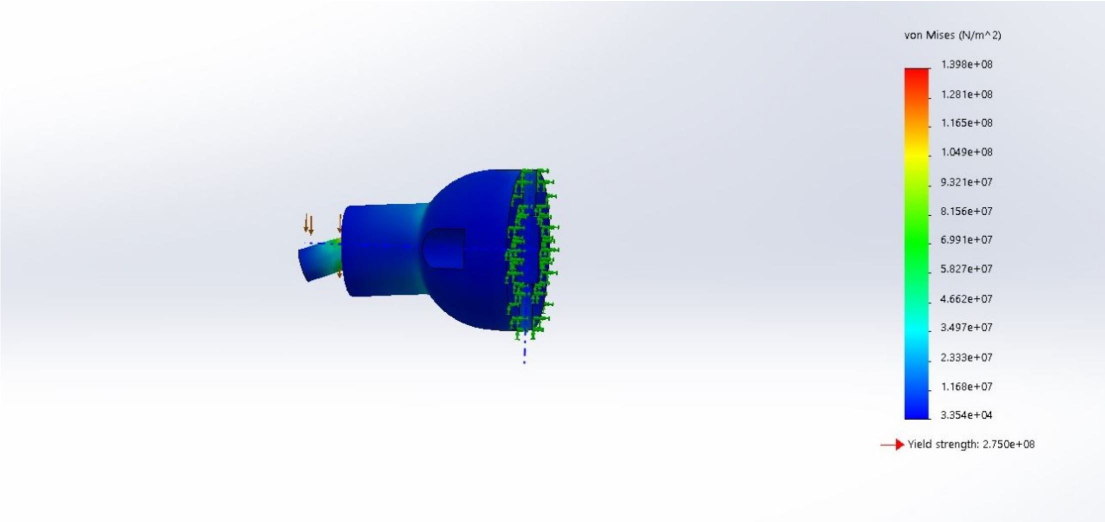


Figure 4.29: Analysis of End Cap [1]

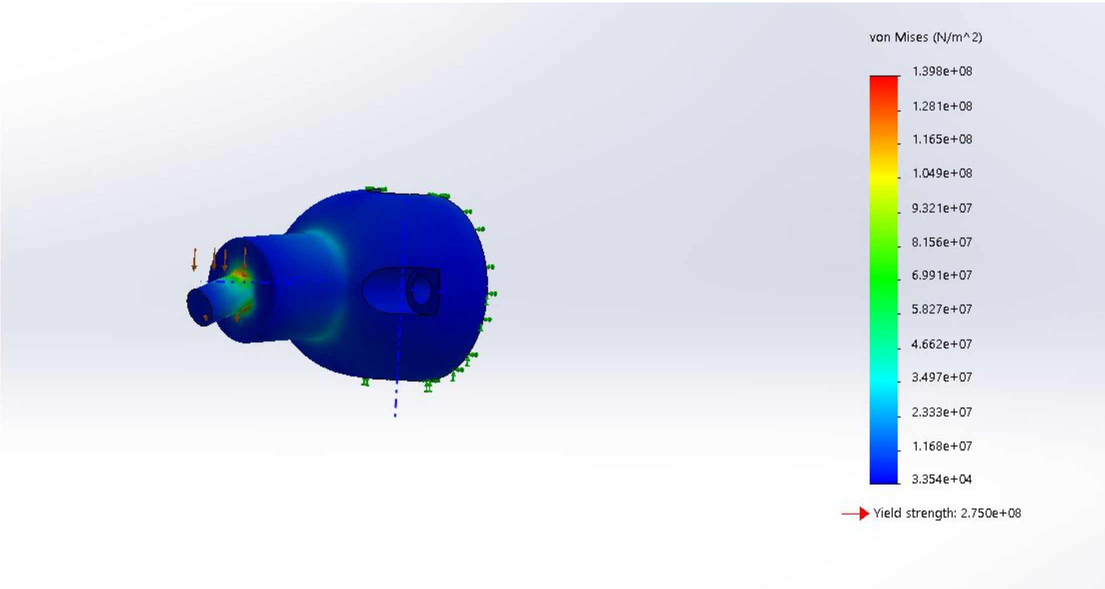


Figure 4.30: Analysis of End Cap [2]

CHAPTER 5

EXPERIMENTAL PROCEDURE

5.1 Procurement of Materials

After an extensive study of the properties of various metals and alloys, Aluminum 6063 (AA 6063) was chosen to be used for machining of all hub components except the center pin. The properties of AA 6063 can be seen in Figure 5.1. Some of the factors that influenced this choice were the high corrosion resistance, good surface finish, good machinability and ease of anodisation of AA 6063. An additional benefit of using this alloy is that it is readily suited to welding which makes resolution of minor faults easy, less time consuming and economical.

Sl.No.	Properties	
1	Density	2.68 g/cm^3
2	Poisons ratio	0.33
3	Young's modulus	75 GPa
4	Elongation	16%
5	Yield strength	75 MPa
6	Hardness	25 BHN
7	Tensile Strength	126 MPa

Figure 5.1: Properties of AA 6063

Raw AA 6063 was to be procured in billet form from Arihant Aluminium Agencies (10 G Mookernallamuthu Street, Parrys, Chennai, Tamil Nadu 600001)

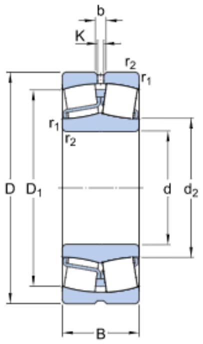
ASTM A514 steel was chosen to be used for machining of the center pin. This decision was influenced by the fact that the center pin is the main load bearing component of the assembly and requires a greater yield strength. Steel has a greater yield strength when compared to aluminum. ASTM A514 is also adequate for machining purposes which adds to its advantages. The properties of ASTM A514 are shown in Figure 5.2.

Physical Properties	Unit	Value
Density, ρ	kg/mm^3	7.9E-6
Elasticity constant, E	N/mm^2	210000
Tensile strength, Ultimate	N/mm^2	800
Tensile strength, Yield	N/mm^2	620
Poisson Ratio, v		0.3
Shear modulus	N/mm^2	80769

Figure 5.2: Properties of ASTM A514

SKF 22320 was chosen to be the roller bearing for the outer hub assembly. This choice was based on design parameters as well as budgetary restrictions. The SKF 22320 bearing was to be procured from Jinan Maolei Bearing Co. (Shandong, China) for a price of 45 USD.

Figure 5.3: SKF 6019



DIMENSIONS

d	100 mm
D	215 mm
B	73 mm
d_2	≈ 130 mm
D_1	≈ 184 mm
b	11.1 mm
K	6 mm
$r_{1,2}$	min. 3 mm

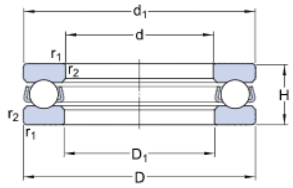
Figure 5.4: Roller Bearing Dimensions

Basic dynamic load rating	C	847 kN
Basic static load rating	C_0	950 kN
Fatigue load limit	P_u	88 kN
Reference speed		2400 r/min
Limiting speed		3000 r/min

Figure 5.5: Roller Bearing Data

SKF 51110 was chosen to be the thrust bearing for the inner hub assembly. This choice was also based on design parameters as well as budgetary restrictions. The SKF 51110 bearing was to be procured from Jinan Maolei Bearing Co. (Shandong, China) for a price of 4 USD per pair.

Figure 5.6: SKF 51110



DIMENSIONS

d	50 mm
D	70 mm
H	14 mm
d_1	≈ 70 mm
D_1	≈ 52 mm
$r_{1,2}$	min. 0.6 mm

Figure 5.7: Thrust Bearing Dimensions

Basic dynamic load rating	C	27 kN
Basic static load rating	C_0	75 kN
Fatigue load limit	P_u	2.8 kN
Reference speed		4300 r/min
Limiting speed		6300 r/min

Figure 5.8: Thrust Bearing Data

5.2 Workflow

The manufacturing and assembly workflow is described below:

- The components of the hub assembly are machined using CNC milling techniques.
- The various components of the hub assembly are assembled together.
    1. The inner hub assembly including the center pin, thrust bearings and the top caps is assembled first.
    2. This assembly is then press fitted to the internal surface of the SKF 6019 roller bearing.
    3. The roller bearing along with the inner hub assembly is then attached to the bearing cover using bolts.
    4. The end caps are fitted thus completing the final assembly.
- Drilling operation is used to drill holes into the bearing cover for spokes to attach.
- Spokes are used to attach the hub to the rim.

CHAPTER 6

RESULTS

The CAD model of the HCS assembly was designed on PTC Creo Parametric and the major load bearing components were subjected to analysis on DS Solidworks.

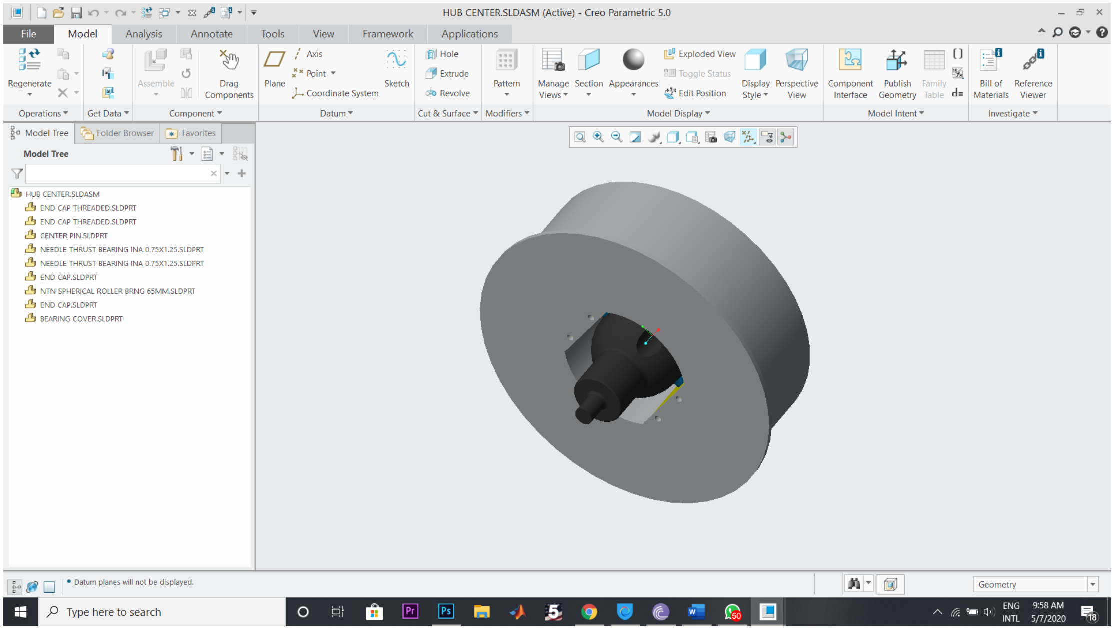


Figure 6.1: HCS Assembly

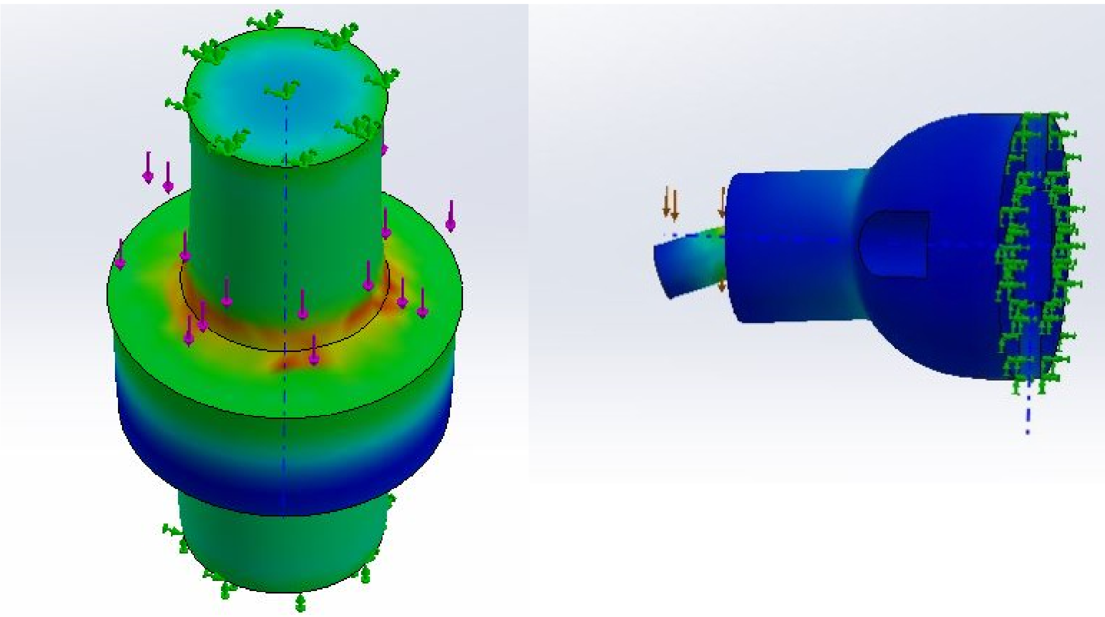


Figure 6.2: Analysis Results

CHAPTER 7

CONCLUSION

- Previous HCS iterations were studied and analysed.
- Concept designs for all major hub components were drafted.
- Design calculations to find dimensions of major hub components were done.
- CAD models of all hub components were made and a final assembly was prepared on PTC Creo Parametric.
- The major load bearing hub components were subjected to analysis on DS Solidworks.
- The material choice and procurement details were finalised keeping in mind design and budgetary restrictions.

REFERENCES

1. Davis, C. (2012). "Hub centre steering." *Bachelor of Science University of Cincinnat*.

2. Gautam Jodh, Kaustubh Gothe, S. K. D. T. V. P. (2014). "Design, modeling simulation of hub center steering mechanism." *International Journal Of Research In Aeronautical And Mechanical Engineering*.

3. Kumar, A. and Choudhry, S. (2015). "Design and development of plastic triple tree/yoke for motorcycle.

4. Liu, C. (2017). "A multibody dynamics model of a motorcycle with a multi-link front suspension.

5. Rankhambe, T. and Nhaichaniya, G. K. (2017). "Topology optimization of motorcycle swing arm.

6. Sangamesh Bhure, Amrinder Singh, S. R. A. (2012). "Design and analysis of alternative front suspension for motorbikes." *Conference Paper - VIT University, Vellore*.

7. Wadibhasme, S., Ladekar, A., and Paunikar, R. (2014). "Hub centre steering." *Discovery*.

D6

ORIGINALITY REPORT

5%	4%	1%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	clingonforlife.blogspot.fr Internet Source	2%
2	ijtir.hctl.org Internet Source	2%
3	en.wikipedia.org Internet Source	1%
4	Yaowei Chen, Masmi Iwase, Jun Inoue, Shoshiro Hatakeyama, Atsusi Suyama. "Realization of A Deformable Wheel Adapting to Running Conditions", Journal of Physics: Conference Series, 2020 Publication	<1%
5	Form Structure and Mechanism, 1992. Publication	<1%
6	Hailong Cui, Yang Wang, Hong Yang, Liang Zhou, Hai Li, Wei Wang, Chunjiang Zhao. "Numerical analysis and experimental research on the angular stiffness of aerostatic bearings", Tribology International, 2018 Publication	<1%