# Design and Development of Lever Operated Wheelchair

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**Abstract -** *The design and construction of a lever wheelchair can be improved. There are a large number of people with disabilities due to accidental injuries. Various methods are used to create a wheelchair to help those people. These methods change the existing design but there are many people who cannot afford an improved model. Therefore, in this deign we change the chain-linking mechanism with a ratchet pawl machine to transfer the wheelchair power.*

*The wheelchair is designed in such a way that it requires little user effort to operate and be economically accessible compared to other high-quality wheelchairs.*

***Key Words***: **Lever Wheelchair, Wheelchair Design, Active Wheelchair Design, Ratchet and pawl mechanism**.

## 1.INTRODUCTION

Wheelchairs are an excellent tool for these patients, empowering them to live a normal life by allowing them to do most of their daily activities. This can range from being able to move from one place to another to compete in sporting events. Wheels of bicycle are used instead of push edges. The wheels will be rotated with the help of lever which will be used to propagate further with ease and less efforts.

The wheels will be rotated with the help of a lever that will be used for continuous distribution with minimal effort. by using Ratchet and pawl mechanism which used in normal bicycles help to reduce efforts applied by patient wheels of bicycle are used instead of push edges. The wheels will be rotated with the help of lever which will be attached to wheels by means of lever operated mechanism. The main motto of this project is to give the replica which will require less effort than the conventional wheelchair and it will have low cost in comparison with the advanced wheelchairs available in the market. There are people who cannot buy the Automatic power wheelchairs for daily use. So, this wheelchair will be the better option for those people.

## 2. PROBLEM STATEMENT

Modern wheelchairs for people with physical disabilities are difficult to operate. This requires great strength to move forward.

For the disabled person living in a developing country, wheelchairs are not to be missed as they reduce the user's level of space and smoothness.

The proposed Lever wheelchair system can be used to move it with very little power.

**Fig. 1**: Traditional wheelchair

## 3. SURVEY

According to the 2011 Census, in India a population of Cr 121, 2.68 Cr people are 'disabled' which is 2.21% of the total population.

Among people with disabilities 56% (1.5 Cr) are men and 44% (1.18 Cr) are women. In the general population, men and women make up 51% and 49% respectively. The majority (69%) of people with disabilities live in rural areas (1.86 Cr people with disabilities in rural areas and 0.81 Cr in urban areas). In terms of population again, 69% come from rural areas and the remaining 31% live in urban areas.

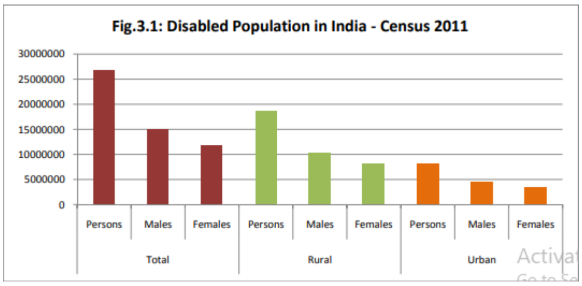


**Chart -1**: Disabled population in India 2011

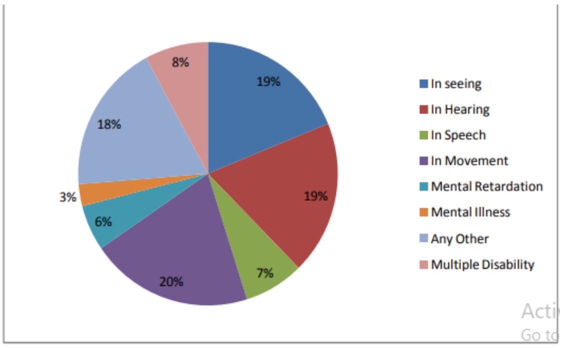


**Fig. 2**: Disabled population by type of disability 2016

Types of disability The Census 2011 revealed that, In India, 20% of the disabled persons are having disability in movement, 19% are with disability in seeing, and another 19 % are with disability in hearing. 8% has multiple disabilities.

About 69% of the overall disabled Indian population lives rural areas. This tells us that 37,51,410 locomotor disabled people live in rural areas. Only about 16,85,416 locomotor disabled people live in urban areas.

## 4. OVERLOOK OF MECHANISM PROPOSED

### Mechanism of 4 bar linkage

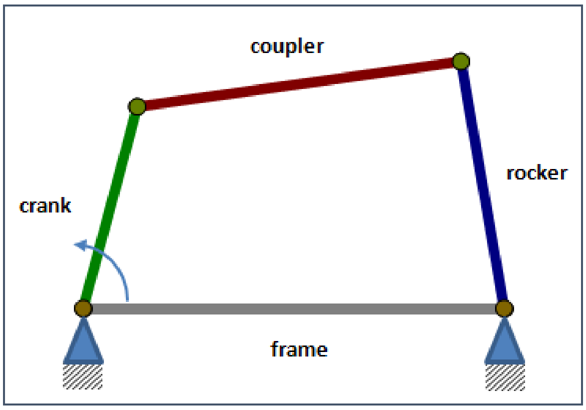


**Fig. 3**: Mechanism of 4 bar linkage

Input: Reciprocal Link

Output: Rotating link (wheel hub)

The connection of the four bars, also called the four bars, is a simple portable connection closure. It consists of four bodies, called bars or links, attached to a loop by four joints. Typically, members are arranged so that the links travel on the same plane, and the assembly is called a planar four-bar linkage.

Four-line connections can be used for many mechanical purposes, including: converting rotational movements into repetitive movements (e.g., pumpjack models) converting repetitive movements into rotating movements (e.g., bicycle models) rotating movements (e.g., knee models and suspensions).

### Ideal condition for such mechanism:

Input link: Rotary

Output link: Reciprocating

So, this mechanism is discarded as it may fail sometimes while performing motion. It may get stopped.

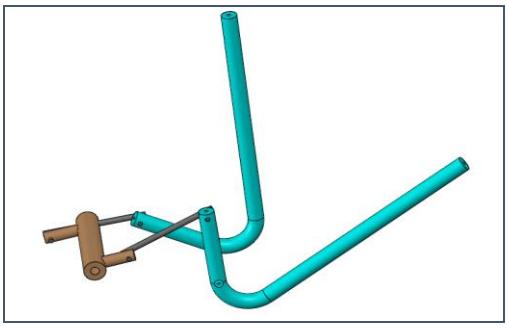

**Fig.4**: CAD model of 4 Bar Mechanism designed in Solid works

### Ratchet and Pawl mechanism

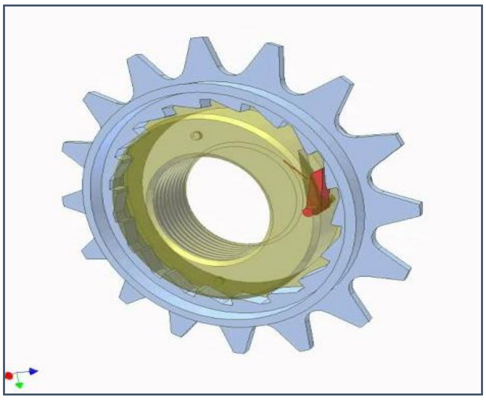

**Fig.5**: Ratchet and pawl mechanism

There are ratts on some screw drivers that allow the user to effortlessly turn to one side and back without turning the screw.

When the gear shifts in one direction, the pawl slides up and over the gear teeth, sending the pawl into place before the next tooth. The pawl has been tightened against the pressure between the gear teeth, preventing any backward movement.

Ratchet machines are very useful devices that allow direct or rotating movement on only one side.

Typical examples of ratchet watches, jackets, and hoists.

**Forward Stroke:**

Pawl allows forward motion of sprocket.

**Backward Stroke:**

Pawl does not allow backward motion of sprocket.

Red portion - Pawl

Hence, to and fro motion of lever results in travelling forward distance.

**Reason to choose Ratchet and pawl mechanism**

The ratchet and pawl mechanism is preferred for this project because during the process of connecting the motion 4 bar it may be suspended or reversed when power is applied. A practice similar to a sewing machine may be possible.

But on the ratchet and pawl movements will be given only one side.

## 5. ROUGH SKETCH

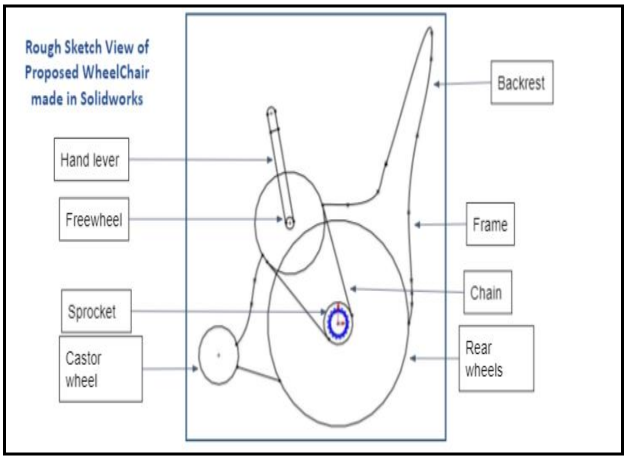


**Fig. 6:** Rough sketch of design for lever operated wheelchair

## 6. LITERATURE REVIEW

7 healthy male volunteers (Unskilled Wheelchair users):

- Mean height: 175.8 (+/-) 4.11 cm
- Mean mass: 72.62 (+/-) 5.88 kg
- Mean age: 26.0 (+/-) 3.46 years

4 disabled male volunteers (Skilled Wheelchair users)

- Mean height: 173.75 (+/-) 7.68 cm
- Mean mass: 67.75 (+/-) 11.76 kg
- Mean age: 42.5 (+/-) 8.58 years

**Standard wheelchair sizes:**

- Drive wheel size in diameter - 24'' (61 cm)
- Caster wheels - 4'' to 6'' (10 to 15 cm)
- Propulsion Torque (Rear-wheel torque of the Wheelchair).
- Maximum propulsion torque:
- Heavy- fast condition: Unskilled - 19.21 (+/-) 1.99 Nm, Skilled - 15.98 (+/-) 2.25 Nm
- Light-slow condition: Unskilled - 12.47 (+/-) 1.08 Nm, Skilled - 9.23 (+/-) 1.13 Nm

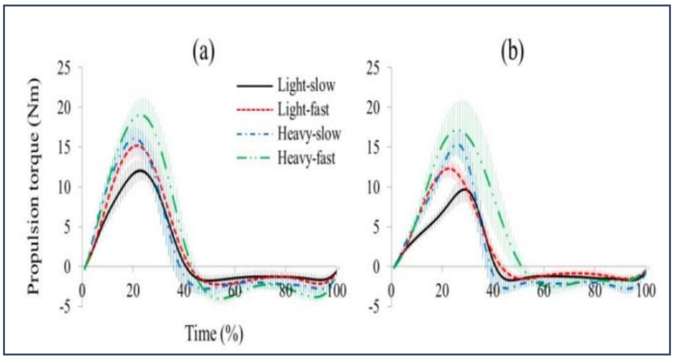


**Fig. 7:** Mean propulsion torques for (a) unskilled and (b) skilled groups during manual wheelchair propulsion under four different conditions

## 7. CALCULATIONS FOR DESIGN

**Force calculation**

There are three forces resisting the motion of wheelchair:

- Rolling resistance force
- Inertial force
- Aerodynamic force (neglected)

For rolling resistance force, Fr = μ * N

Therefore, Fr = μ * mg

where, μ is the coefficient of rolling resistance

m is the total mass of body (mass of person + mass of wheel chair)

Generally, μ is in the range of 0.015 to 0.02 for wheels.

Fr = 0.02 * (70+15) * 9.81

--- ( mass of person = 70 kg, mass of wheelchair = 15 kg)

Fr = 16.677 N

For inertial force of wheelchair:

Facc. = m*a

Range of acceleration = 1.33 m/ sec2

Therefore, Facc. = (70 + 15) *1.33

Facc. = 113.323

Aerodynamic force is neglected because Fa = 0.5* ϱ* A* $v^2$

where, ϱ is the density of surrounding medium

A is the frontal area, v is the velocity of moving body

So, total resisting force (F) = Fr + Facc.

F = 16.677 + 113.323, F = 130 N

**Torque calculations**

For traditional wheel chair:

Torque (τ) = F * Rw

$\tau_1$ = 130 * 0.28

$\tau_1$ = 36.4 Nm

For lever operated wheel chair:

Torque (τ) = (L*F) / (D2/D1)

D2 is the diameter of bigger sprocket

D1 is the diameter of smaller sprocket

$\tau_2$ = (L*F*D1)/ D2

$\tau_2$ = (0.6*130)/ 1.4

$\tau_2$ = 55.7142 Nm

Therefore, % increase in torque for same amount of force = Δ τi

Δ τi = (($\tau_2$ – $\tau_1$)/ $\tau_1$ )* 100

Δ τi = (55.7142 – 36.4)*100/ 36.4

Δ τi = 53.061 %

**Speed calculations**

The relation between speed and diameter of sprocket:

ω1*D1 = ω2*D2

Velocity (v) = R. ω

($v_{chair}$/ $v_{hand}$) = (D2*Rw)/(D1*L)

D2 = diameter of larger sprocket

D1 = diameter of smaller sprocket

($v_{chair}$/ $v_{hand}$) = (1.4* 0.28)/ 0.3

($v_{chair}$/ $v_{hand}$) = 1.3066

The relation between speed and diameter of sprocket:

ω1*D1 = ω2*D2

Velocity (v) = R. ω

($v_{chair}$/ $v_{hand}$) = (D2*Rw)/(D1*L)

D2 = diameter of larger sprocket

D1 = diameter of smaller sprocket

($v_{chair}$/ $v_{hand}$) = (1.4* 0.28)/ 0.3

($v_{chair}$/ $v_{hand}$) = 1.3066

**Designing and drawing a Sprocket**

| | |
|---|---|
| **P** = Chain Pitch<br>**N** = Number of Teeth<br>**Dr** = Roller Diameter ( See Table) | **yz** = $Dr\left[1.4\sin(17° - \frac{64}{N}) - 0.8\sin(18° - \frac{56°}{N})\right]$ |
| **Ds** = (Seating curve diameter) = 1.0005 Dr + 0.003 | **ab** = 1.4 Dr |
| **R** = Ds/2 = 0.5025 Dr + 0.0015 | **W** = $1.4\ Dr\ \cos\frac{180°}{N}$ |
| **A** = $35° + \frac{60°}{N}$<br>**B** = $18° - \frac{56°}{N}$ | **V** = $1.4\ Dr\ \sin\frac{180°}{N}$ |
| **ac** = 0.8 x Dr | **F** = $Dr\left[0.8\cos(18° - \frac{56°}{N}) + 1.4\cos(17° - \frac{64°}{N}) - 1.3025\right] - .0015$ |
| **M** = $0.8 \times Dr\cos(35° + \frac{60°}{N})$ | **H** = $\sqrt{F^2 - (1.4Dr - \frac{P}{2})^2}$ |
| **T** = $0.8 \times Dr\sin(35° + \frac{60°}{N})$<br>**E** = 1.3025 Dr + 0.0015 | **S** = $\frac{P}{2}\cos\frac{180°}{N} + H\sin\frac{180°}{N}$ |
| **Chordal Length of Arc xy** = (2.605 Dr + 0.003) $\sin(9° - \frac{28°}{N})$ | **PD** = $\frac{P}{\sin\left[\frac{180°}{N}\right]}$ |

**Fig. 8.** Calculation table

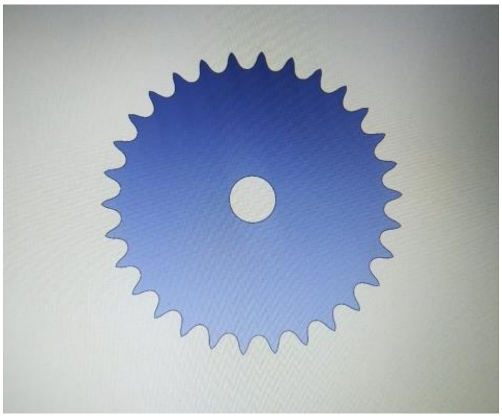

**Fig. 9**: Sprocket design

**Smaller sprocket design**

| | | | | |
|---|---|---|---|---|
| P=Chain Pitch | N=No of Teeth | | Sprocket Calculations | |
| 15.875 | | | | |
| Change B3 value | 21 | | Dr = Roller Diameter | |
| | | Dr | 9.525 | |
| | | | Ds = Seating curve Diameter | |
| | | Ds | 9.5327625 | |
| | | R | 4.76638125 | 4.7878125 |
| A | 37.85714286 | A | 37.85714286 | |
| B | 15.33333333 | B | 15.33333333 | |
| | 13.95238095 | ac | 7.62 | |
| | | M | 6.016320314 | |
| Different N | 41 | T | 4.676354336 | |
| | 45 | E | 12.4078125 | |
| | 31 | xy | 3.310643402 | |
| | 36 | yz | 1.200285417 | |
| | 50 | ab | 13.335 | |
| | | W | 13.18605907 | |
| | | V | 1.987478619 | |
| | | F | 7.882514222 | |
| | | H | 5.744651792 | |
| | | S | 8.705040605 | |
| | | PD | 106.51341 | |

**Fig. 10:** Smaller sprocket calculations

**Bigger sprocket design**

| | | | | |
|---|---|---|---|---|
| P=Chain Pitch | N=No of Teeth | | Sprocket Calculations | |
| 15.875 | | | | |
| Change B3 value | 21 | | Dr = Roller Diameter | |
| | | Dr | 9.525 | |
| | | | Ds = Seating curve Diameter | |
| | | Ds | 9.5327625 | |
| | | R | 4.76638125 | 4.7878125 |
| A | 37.85714286 | A | 37.85714286 | |
| B | 15.33333333 | B | 15.33333333 | |
| | 13.95238095 | ac | 7.62 | |
| | | M | 6.016320314 | |
| Different N | 41 | T | 4.676354336 | |
| | 45 | E | 12.4078125 | |
| | 31 | xy | 3.310643402 | |
| | 36 | yz | 1.200285417 | |
| | 50 | ab | 13.335 | |
| | | W | 13.18605907 | |
| | | V | 1.987478619 | |
| | | F | 7.882514222 | |
| | | H | 5.744651792 | |
| | | S | 8.705040605 | |
| | | PD | 106.51341 | |

**Fig. 11**: Bigger sprocket calculations

## 8. MATERIAL SELECTION

The most common uses in the frame / wheelchair structure are:

Solid Steel (AISI 1018 Mild / Low Carbon Steel):

The density is 7.87 g / cc and the cost is estimated at Rs. 60 / kg.

Strength = 370 MPa and Modulus of Elasticity = 205 GPa

Aluminum (Al 6061 - T6):

The density is 2.7 gm / c.c. and the cost is Rs. 275 / kg.

Strength = 276 MPa and Modulus of Elasticity = 68.9 GPa

Titanium (Ti - 6Al - 4V) (Grade 5) alloy:

The density is 4.512 g / cc and the cost is estimated at Rs. 1600 / kg.

Strength = 862 MPa and Modulus Elasticity = 110 GPa

## 9. CAD MODEL OF DIFFERENT PARTS

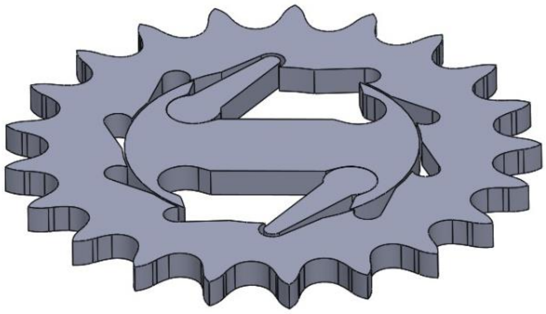

**Fig. 12.** Ratchet Pawl Mechanism

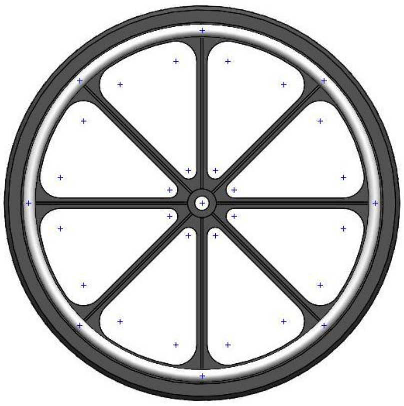

**Fig. 13.** Free Wheel

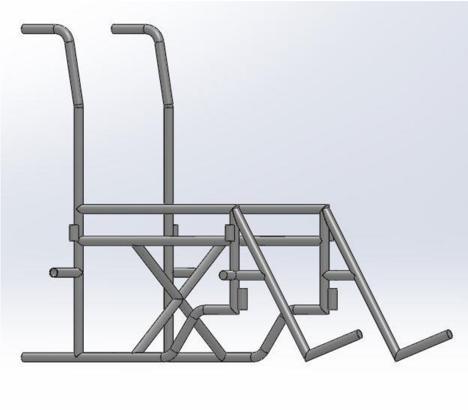

**Fig. 14.** Frame

**Fig. 15.** Chain

**Fig. 16.** Wheelchair Model

### 10. ANALYSIS USING ANSYS

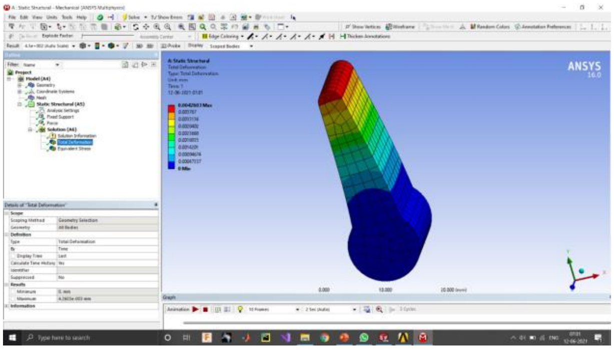

**Fig. 17.** Total Deformation

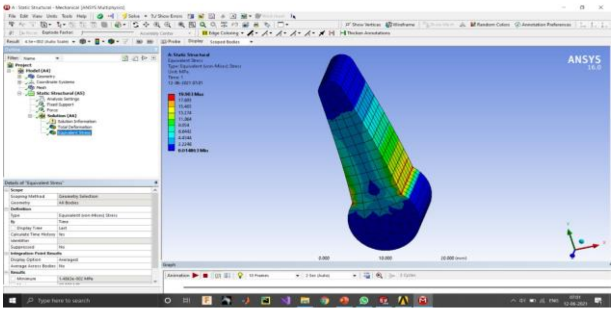

**Fig. 18.** Equivalent Stress

- For the analysis of pawl, it is considered as a cantilever beam.
- Radius of internal teeths = 38 mm.
- Torque on sprocket = 40 Nm.
- So, Force on one pawl = 520 N.
- Therefore, Mb = 520 * 0.026 = 13.52 Nm
- Shear stress = F/ A

= 520/ (0.003 * 0.0061) = **28.415** MPa

### 11. FINAL WORKING MODEL

**Fig. 19.** Developed wheelchair

## 12. COST ESTIMATION

| SR.NO. | PART NAME | QUANTITY | COST(PER UNIT) | TOTAL COST |
|---|---|---|---|---|
| 1 | HAND LEVER | 2 | 60 | 120 |
| 2 | FREEWHEEL | 2 | 400 | 800 |
| 3 | SPROCKET | 2 | 250 | 500 |
| 4 | CASTOR HEEL | 2 | 150 | 300 |
| 5 | REAR WHEEL | 2 | 300 | 600 |
| 6 | CHAIN | 2 | 100 | 200 |
| 7 | FRAME | 1 | 700 | 700 |
| 8 | BACKREST | 1 | 100 | 100 |
| 9 | SITTING MAT | 1 | 100 | 100 |
| 10 | BEARING | 2 | 150 | 300 |
| 11 | HAND RESTING PADS | 2 | 100 | 200 |
| 12 | GRIPS | 4 | 40 | 160 |
| 13 | FOOT RESTING PADS | 2 | 150 | 300 |
| | | | TOTAL COST | 4380 |

## 13. CONCLUSIONS

1. Design is feasible, it can be scaled up.
2. Cost effective, simple and efficient.
3. It saves human efforts which is very essential especially for disabled.
4. The increase in speed and torque in percentages is 53 % and 40. 35 % respectively for this wheel chair as compared to traditional wheel chair.
5. Mechanism is purely mechanical, hence reliable.
6. Universal design makes it application oriented.
7. It can be used on different terrains if some more modifications are done in this wheel chair such as using hydraulics for the launch of wheel chair.

## ACKNOWLEDGEMENT

The aim of this project is to provide a clear and complete presentation of theoretical and practical information on the construction of a wheelchair. To achieve this goal, team members have never worked alone as these ideas are built on the comments, suggestions and acceptance provided by PROF. G.D. KORWAR Mechanical Engineering Department.

Thanks PROF. G.D. KORWAR's guidance, support and input into this study project would not have been possible without it.

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