DESIGN AND FABRICATION OF A PROTOTYPE TO GENERATE ELECTRICITY THROUGH SPEED BREAKERS ON BUSY ROADS

A Thesis

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by

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ABSTRACT

There is an increasing need for finding new and cheaper sources of energy owing to the persistent energy crisis in the country. This project is based on the idea that the kinetic energy getting wasted during the motion of vehicles on the roads can be utilized to generate power. We intend to develop a product that can replicate a speed breaker on the road, and by using the basic concepts of machine theory and design, produce electricity through a complex transmission that runs a DC generator while remaining cost effective. Extensive literature review of journal papers, conference papers and patents was carried out to aid the design process. SolidWorks was used to generate CAD models of the of the individual parts as well the complete mechanism for the product. Design optimization was ensured by the use of analysis software by putting the mechanism through in-service environment and constraints. Multiple iterations carried out during the design phase ultimately led to the fabrication of our final product. Finally, an extensive feasibility study has been carried out to determine the effectiveness and practicality of our product.

PREFACE

This thesis focuses on design and fabrication of a prototype which can produce electricity when installed as a speed breaker. It is a part of our Final Year Project (FYP) required for completion of our undergraduate degree at NUST SMME, Islamabad.

In this project report we have taken help from faculty at NUST SMME, Islamabad and also from experts in manufacturing industry. This project was started with extensive research and resulted in development and fabrication of a prototype.

ACKNOWLEDGMENTS

We would like to thank all the people who helped us in completing our project.

Firstly, we would like to thank our supervisors and faculty advisors for the unrelenting support they offered us with. Their technical guidance was very important in completing our work timely.

Secondly, we would like to thank the MRC staff for their guidance and support throughout the project. They shared their valuable industrial experience with us and their guidance was immensely useful in the manufacturing phase.

Thirdly we would like to thank the administration of our department NUST SMME, Islamabad which includes our principal Dr. Abdul Ghafoor and Head of Department Dr. Shahid Ikramullah Butt who provided us the opportunity to select this challenging project. Guidance and support in matters of FYP by Dr. Liaqat Ali, Col. Naveed and Dr. Mushtaq have been most welcome and much appreciated.

Fourthly, we would also thank all whose work we have used or taken help from in the completion of this project, without which this project would not have been possible.

ORIGINALITY REPORT

This document is our own work and has never been presented anywhere else for evaluation. We have taken extra care to cite and/or give proper credit to whoever's work we have taken help from.

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CONTENTS

INTRODUCTION

We are all aware of the persistent energy crisis facing Pakistan. With the demand for energy ever-increasing, the failure of the energy sector to increase production has brought adverse effects on the country's economy. The crisis has plagued all sectors ranging from industry, agriculture,social life, inflation to poverty and it is hampering national progress in a drastic manner. While much is being said and done about it at the governmental level, there is still a dire need to look for unconventional and localized solutions to this predicament. Moreover, with global warming due to the burning of fossil fuels fast becoming a serious threat, it is imperative that we shift our focus towards renewable sources of energy which are both clean and sustainable.

All the major roads in the bigger cities bear a dense load of traffic throughout the day. The vehicles moving on the road dissipate a vast amount of kinetic energy into other forms which is basically wasted. This is infact a huge resource of untapped energy which can be utilized for power generation. If executed on a large scale, it can certainly remove a considerable chunk of load from the national grid. A lot of research is being carried out in this regard all over the world. Many different mechanisms, both electrical and mechanical are being tested for this purpose. We came across multiple conference papers and some patents originating form India and the United States respectively, in our literature survey.

Our final year project, takes a step in this direction by a creating a system that can produce electricity from speed breakers on busy roads.Major objectives were:

- To produce a prototype that can replace a speed breaker on the road.
- And, can generate electricity using a complex mechanical arrangement.
- Provide a cost effective solution to the energy crisis.

The prototype was designed for the in-service conditions of a loaded motorcycleor a small car passing over the speed breaker.

om the conference papers and our own engineering knowledge.

LITERATURE REVIEW

The generation of electricity from roads is quite a popular topic among researchers in many countries. Different mechanisms have been proposed ranging from those utilizing the kinetic energy of the vehicles to even the pressure that they exert on the road surface during motion. We looked into multiple conference papers, some patents and of course the internet for inspiration. A brief review of the mechanisms that we found most relevant to our scope of work and related calculations carried out will follow. Some of the more important sources are mentioned below :

Conference paper/ patent title	Code, Year of Publishing, Authors
Generation of Electricity Using Road Transport Pressure	ISSN: 2319-5967 International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 3, May 2013 Md. Saiful Islam, Syed Khalid Rahman, Jakeya Sultana Jyoti

Power Generation Using Speed Breaker with Auto Street Light	ISSN: 2319-5967 International Journal of Engineering Science and Innovative Technology (IJESIT) Volume 2, Issue 2, March 2013 Amanpreet Kaur, Shivansh Kumar Singh, Rajneesh, Parwez, Shashank
A Revolutionary Technique of Power Generation Through Speed Breaker Power Generators	ISSN: 2278-0181 International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 8, August – 2013 Rajat Gupta, Suyash Sharma, Saurabh Gaykawad
Road Power Generation (RPG) by Flip plate Mechanism	International Journal of Science, Engineering and Technology Research (IJSETR) Volume 3, Issue 3, March 2014 Pranay Vijay Ashtankar, Pratik H. Bendle, Krunal Kene, Milind R. Kalbande, Pratik Makhe, Prof. S.M. Dhomne
Patent: Road Based Electricity Generator	**Patent #: US-8123431 B2**

REVIEW OF DIFFERENT MECHANISMS

Road Power Generation by Flip plate mechanism

IJSETR Volume 3, Issue 3, March 2014

The authors of this conference paper have proposed a mechanism that includes moving plates (flip-plates) installed on the road. Through a rack and pinion arrangement, the plates transfer even a small movement from the road to a flywheel system, developed to achieve a large moment of inertia in a small space . It has a method of driving one flywheel from another once it reaches a predetermined velocity. The pinion is mounted on a shaft which is attached to the frame via bearings. A flywheel is also mounted on the shaft which is connected with a pulley mounted on the DC generator through a V- belt. As the wheel passes over the flip plates, the ensuing downward movement of the rack provides torque to the pinion which in turn, transfers it to the shaft. The DC generator is powered by the shaft through a system of pulleys and produces electricity. The calculations that they carried out are mentioned below.

Assuming,

The weight of the two wheeler = 270Kg.

And, that the mechanism is installed at a toll booth.

Average speed of the vehicle = 20km/hr

Maximum height of the plate = 10cm

It is known that power is the product of a force on an object and its velocity.

Output Power calculations:

Let us consider,

The mass of a vehicle moving over the flip plate = 270 Kg.

Height of the plate from surface = 10 cm.

Work done = Force x Distance

Force = mass x acceleration due to gravity

=270x10 =2700N

Therefore, work done / sec

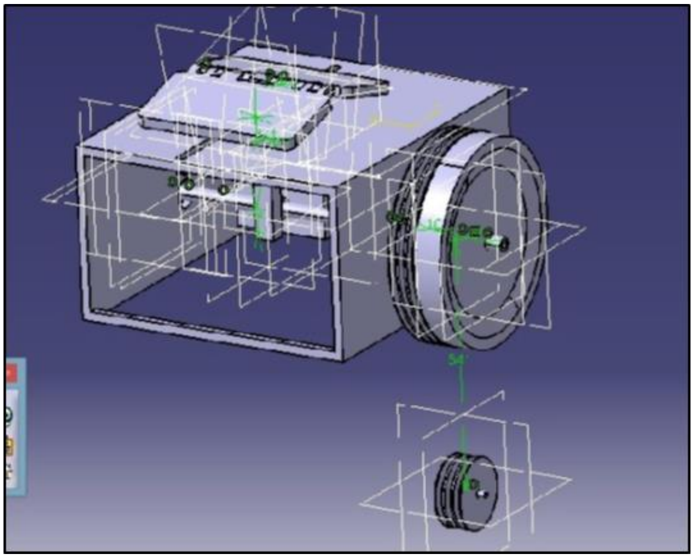
= (2700x 0.10/60)

= 4.5 watt (for one pushing force)

Therefore, power developed for 1 vehicle passing over the flip plate for one minute = 4.5 watt

and, the power developed for 60 min = 270 watt/hr

Therefore, power developed for 24 hrs = 6048 KW/day



Generation of Electricity Using Road Transport Pressure

IJESIT Volume 2, Issue 3, May 2013

This proposed mechanism essentially works on the same principle as the previous one. It needs to be placed under a specially disguised speed breaker. When a vehicle passes over the speed breaker, the pressure lever is pressed and the flywheel is rotated by a chain-sprocket mechanism. The DC generator will rotate and produce electricity since it is mounted on the same shaft as the flywheel. An advantage of this mechanism is that the gear trains that are being used which greatly increase the rpm and torque at the output.

Input power, Output power and efficiency calculations

When a 7 kg weight is applied on the pressure lever, it travels a distance of 0.152 meters (m) and the total time taken to travel this distance is 0.717 second(s). The RPM for one stroke is 1014. By one stroke, the sprocket gear moves three teeth from its original position.

Gear ratio between sprocket gear 01 & sprocket gear 02:

$$\frac{N_1}{N_2} = \frac{T_2}{T_1}$$

$$\frac{3/18}{N_2} = \frac{8}{18}$$

So the calculated N_2 becomes

$$N_2 = \frac{3}{8}$$

As sprocket gear 02 & gear 03 are on the same shaft

So revolution of sprocket gear 03, $N_3 = N_2 = \frac{3}{8}$

Now gear ratio between gear 03 & gear 04

$$\frac{N_3}{N_4} = \frac{T_4}{T_3}$$

$$\frac{3/8}{N_4} = \frac{17}{54}$$

$$So,\ N_4 = 1.19$$

As gear 04 & gear 05 are on the same shaft

So revolution of gear 05 becomes

$$N_5 = N_4 = 1.19$$

Gear ratio between gear 05 & gear 06

$$\frac{N_5}{N_6} = \frac{T_6}{T_5}$$

$$\frac{1.19}{N_6} = \frac{17}{54}$$
$So, N_6 = 3.78$

As gear 06 & gear 07 are on the same shaft

So revolution of gear 07 becomes
$N_7 = N_6 = 3.78$ Gear ratio between gear

07 & gear 08

$$\frac{N_7}{N_8} = \frac{T_8}{T_7}$$
$$\frac{3.78}{N_8} = \frac{17}{54}$$
$N_8 \;\; 12.01 \approx 12$

So the gear ratio between gear
01 &gear 08 $N_1 : N_8 = \frac{3}{8} : 12$

The flywheel, gear 08 & DC generator shaft are connected on the same shaft So RPM of DC generator shaft becomes
$= \frac{12 \times 60}{0.717}$

RPM=1004.1 We know,

Work done, W = F*S
Where, F = force & S = distance travel
W = mg*s
Where, m = mass & g = gravitational acceleration

W= 7* 9.81* 0.152 =10.43 Joule (j)

Input Power, P = Total work done / total time taken to do the work

So, P= W/t

Pi = 10.43/0.717= 14.55 Watt (w)

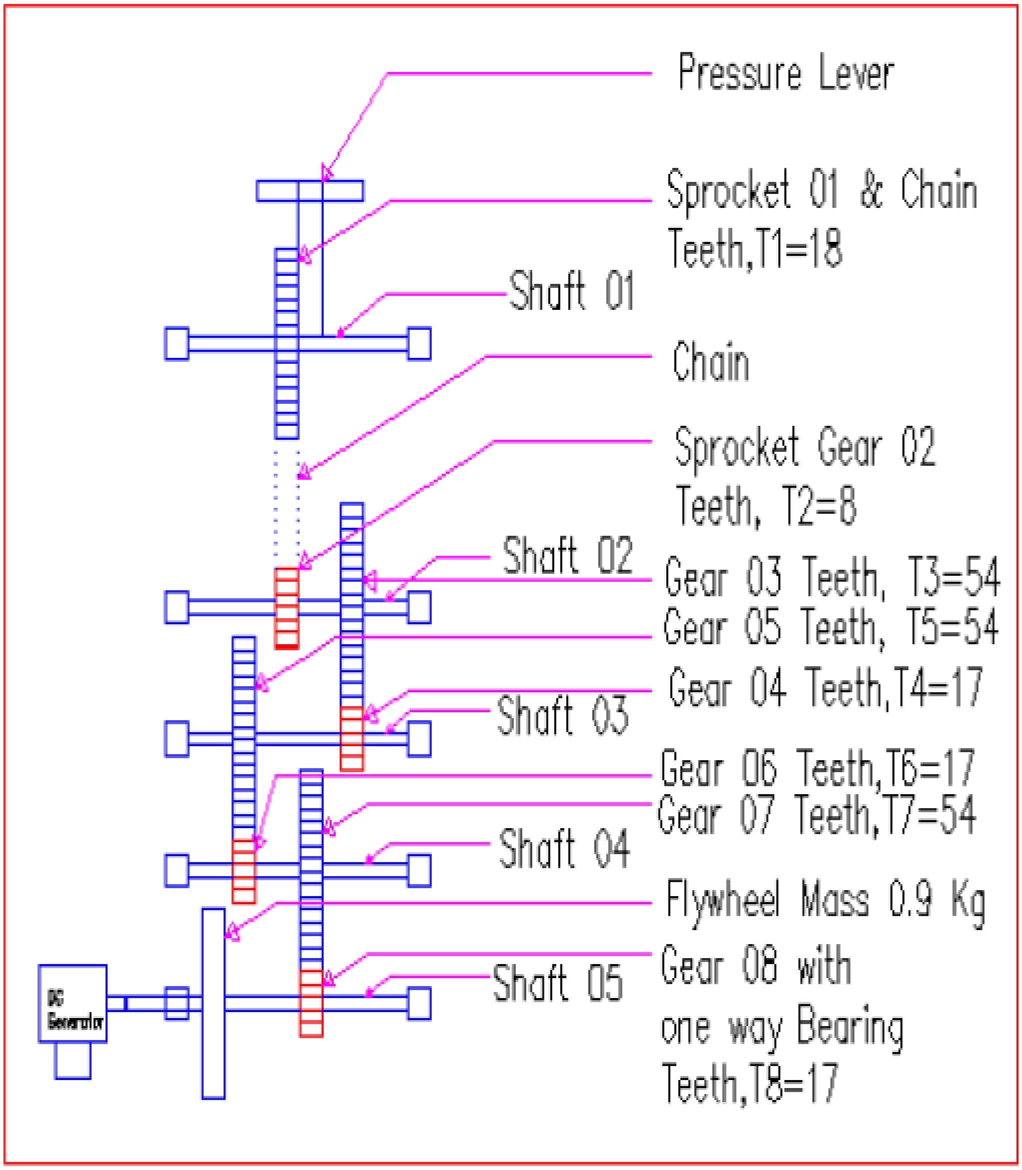
Output Power Calculation

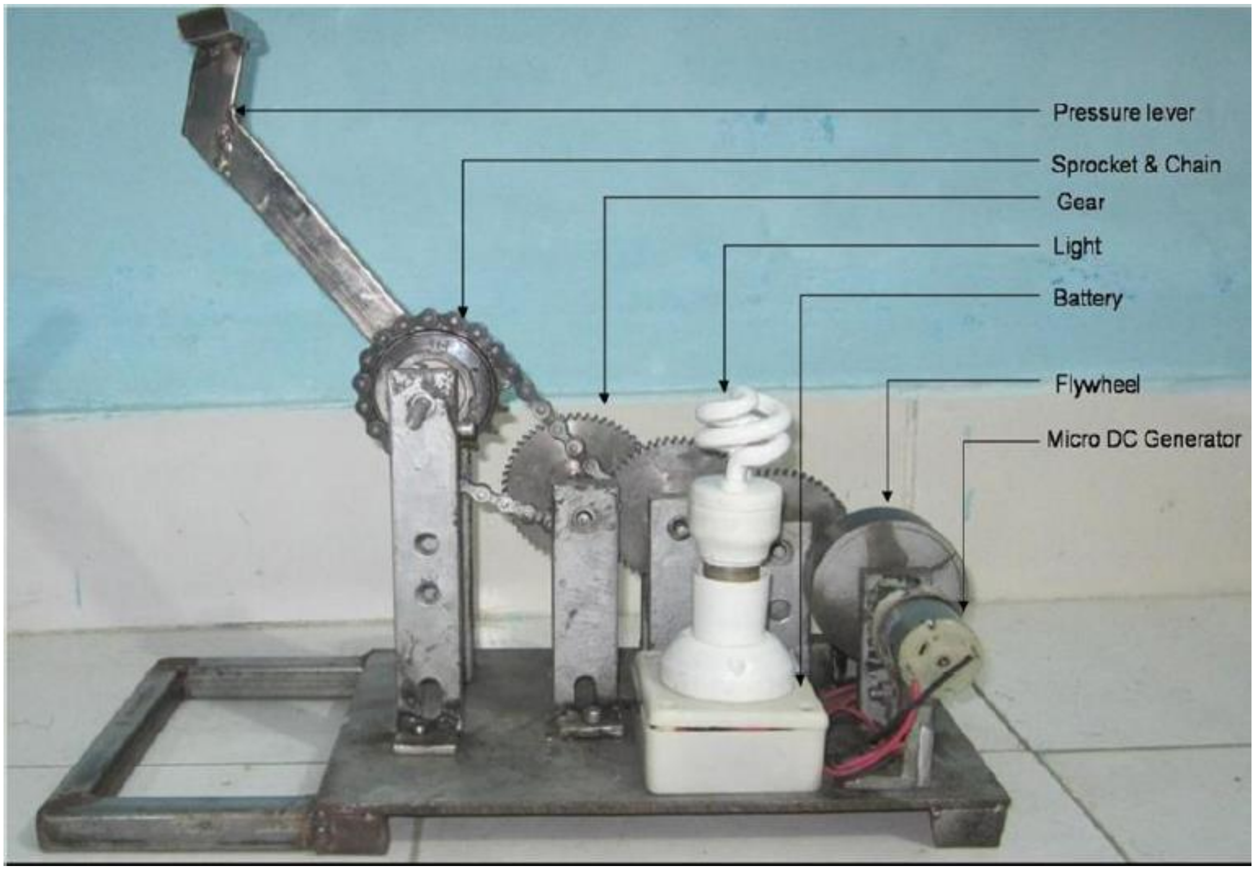
Output power, Po = Voltage*Current Output power, Po = V*I

=4.0*0.5 =2 Watt (W)

Efficiency Calculation

Efficiency = (Output Power/Input Power)*100 % Efficiency = (2/14.55)*100% =**13.75** %


Pressure Lever
Sprocket 01 & Chain
Teeth,T1=18
Shaft 01
Chain
Sprocket Gear 02
Teeth, T2=8
Shaft 02
Gear 03 Teeth, T3=54
Gear 05 Teeth, T5=54
Gear 04 Teeth,T4=17
Shaft 03
Gear 06 Teeth,T6=17
Gear 07 Teeth,T7=54
Shaft 04
Flywheel Mass 0.9 Kg
Gear 08 with
one way Bearing
Teeth,T8=17
Shaft 05
DC
Generator



Our focus was primarily on the generation of electricity from speed breakers. But we came across other clever techniques of utilizing the weight of passing cars for harvesting electricity. We think that they deserve mentioning as well.

Electricity Generation from Piezoelectric Effect

Piezoelectricity refers to the ability of some materials - most notably crystals and certain ceramics, including bone - to generate an electric potential in response to applied pressure. The word is derived from the Greek 'piezo' or 'piezein', which means to squeeze or press.

This method uses a generation device installed under the road surface. The device contains pressure plates that are covered in protective layers and placed under the roadbed. When a vehicle passes over the electrical generation device, the pressure plate is pushed downward by the weight of the vehicle. The downward displacement of the pressure plate is used to drive an electrical generator. The piezoelectric effect converts mechanical strain into electrical current or voltage and the system is expected to scale up to 400 kilowatts from a 1-kilometre stretch of dual carriageway. The generators are embedded between the superstructure layers, and usually covered with an asphalt layer.

Reference: http://www.hamariweb.com/articles/article.aspx?id=13390

Another ingenious alternative was proposed by a Mexican entrepreneur. The method makes use of small ramps made from a tough polymer are embedded in the road, protruding 5 cm (2 in) above the surface. The ramps are pushed downwards whenever a vehicle passes over them.

Consequently, air is forced through bellows that are attached to the underside of the ramp. That air travels through a hose, and is compressed in a storage tank. The stored compressed air is ultimately fed into a turbine, generating electricity. The amount of electricity generated electricity can increase with an increase in traffic density.

Reference: http://www.gizmag.com/vehicle-road-weight-electricity/29990/

Road Based Electricity Generator

Patent #: US-8123431 B2

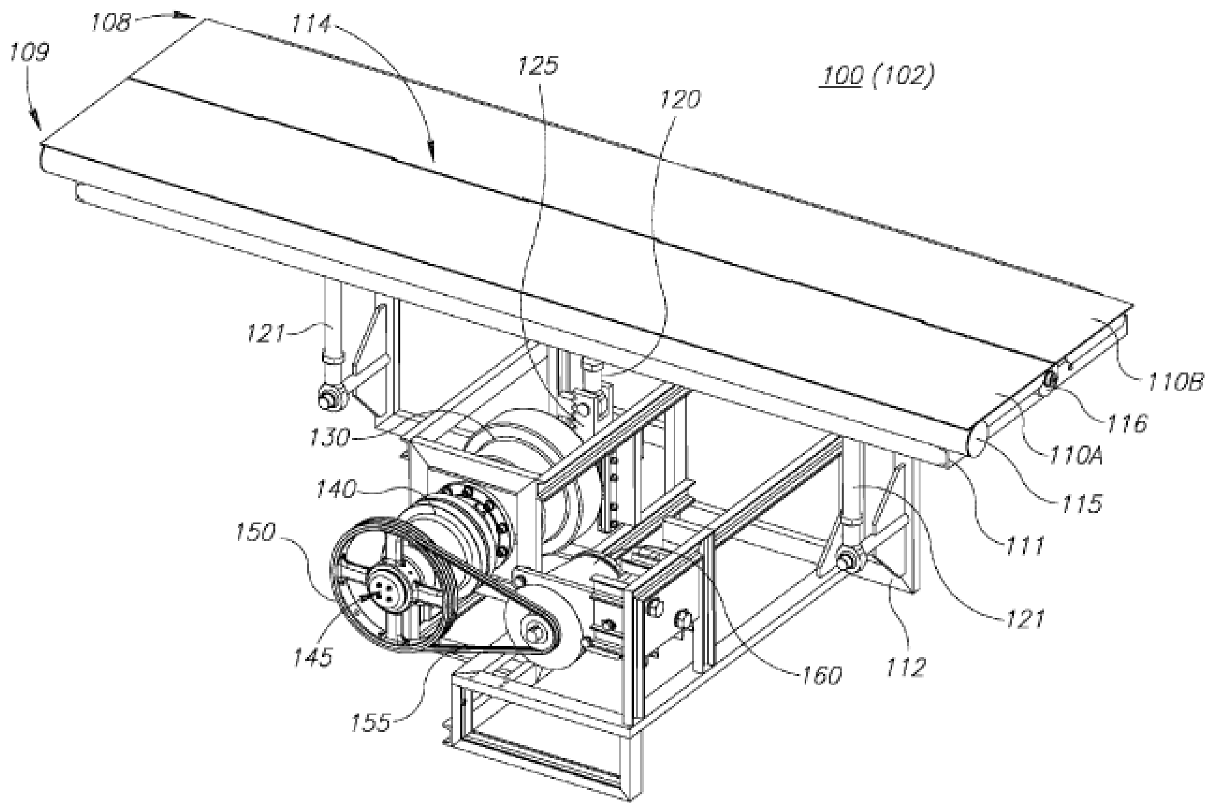
This patent was based on an electro-mechanical device that can perform the desired function when placed under a dome disguised like a speed breaker. The system has two configurations:

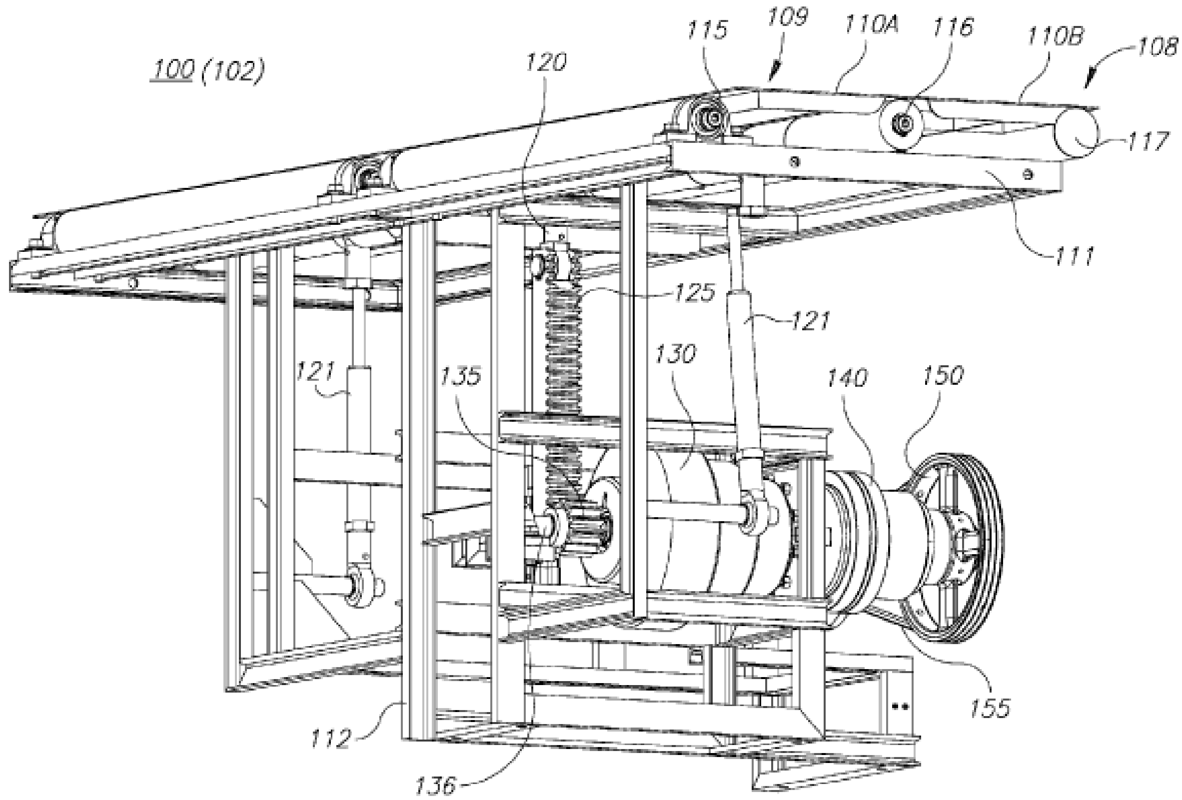
(i) a protruding state, in which the flaps is inclined upwards and the end of the flap at the middle is above road level

(ii) (ii) a level state, in which each flap is level with the road

The springs attached to the dome get compressed and the rack gets pressed downwards whenever a vehicle passes over the dome in a similar fashion as that of the previously described mechanisms. The linear motion of the rack is converted to rotary motion by the pinion which is mounted on a shaft. A flywheel is mounted on the shaft whose function is to regulate the fluctuation in the energy and to make the energy uniform. The shaft is connected to a generator through a belt drive.

An important feature of the system is a transmission that only transmits rotations to the output axis that result from the downward movement of the rack, and de-couples the input axis from the output axis for all rotations resulting from the upward movement of the rack, so that all the rotations are accumulated in one direction only. The generator produces electricity from the accumulated rotation of the flywheel.





100 (102)
120
115
109
110A
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110B
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117
111
125
121
130
121
135
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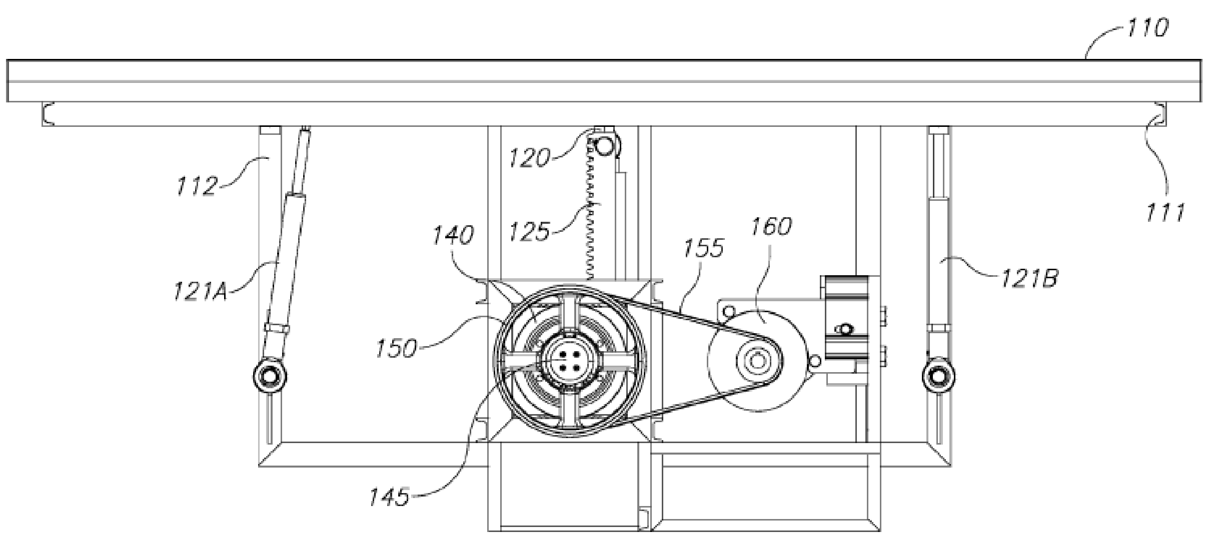
150
155
112
136



110
111
112
120
125
140
155
160
121A
121B
150
145

CALCULATIONS

Honda Civic (2014) Wheel Base = 2700mm

Car speed = 25 km/hr

Curb weight + driver's weight = 1325 kg

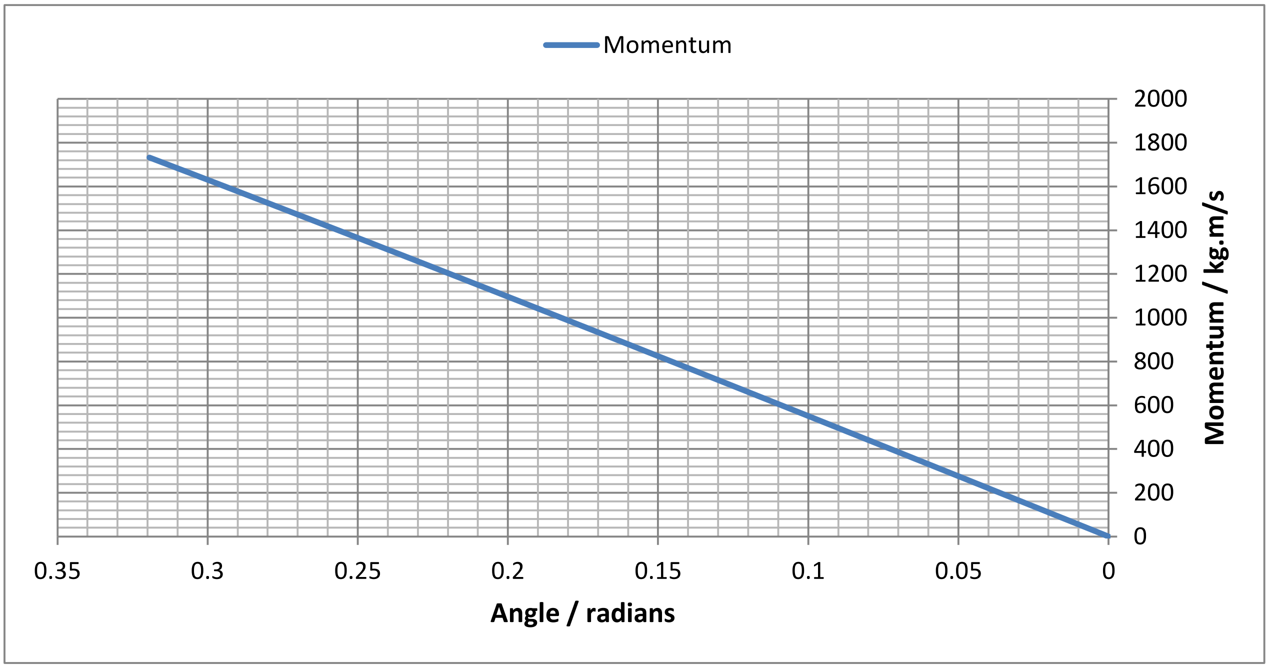
Vehicle weight distribution: 60% front, 40% rear

For front wheels:

The momentum of vehicle as it passes over the flap plates is not constant. It varies with the pressing down of the plates. The variation in momentum's magnitude is presented graphically below:

Average momentum = 866.2 kg.m/s (for two wheels)

Distance = 255 mm

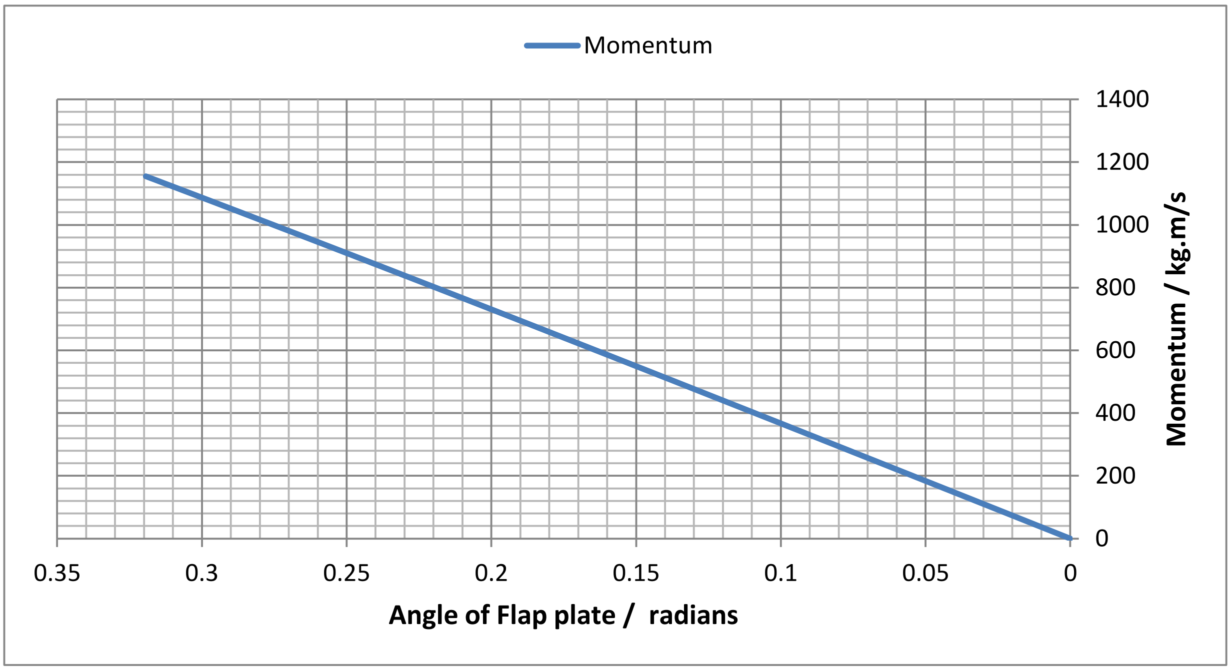


Speed, v = 6.94 m/s

Time, t = $\frac{0.255}{6.94} = \ 0.0367\ s$

$$\text{Force} = \frac{\Delta\,\text{Momentum}}{\Delta\,\text{Time}}$$

Average Force delivered = 23.6 kN (for two wheels)



For Rear Wheels:

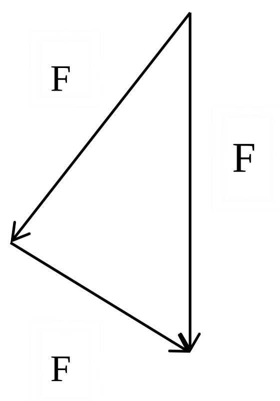
Momentum Variation:

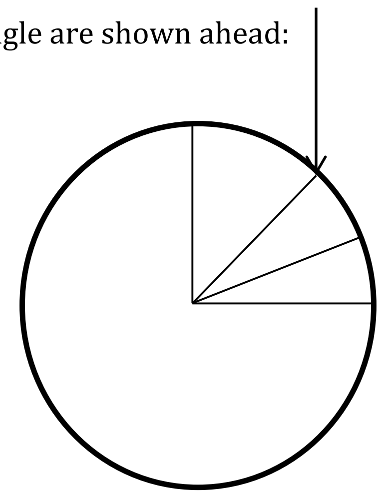
Average Momentum = 577.45 kg.m/s (for two wheels)

Average Force = 15.7 kN (for two wheels)

Ratchet Torque Calculations:

The pawl meshes with the ratchet at 44.5 degrees and transfers torques until the angel reaches 67 degrees. The vertical force is distributed into the radial and tangential components. The vertical force and force triangle are shown ahead:





From the force triangle we can calculate the range for F_T that is responsible for the torque production.

The pawl keeps contact for 22.5 degrees. The angle will vary from 44.5 degrees to 67 degrees.

21.7 kN $\geq F_T \geq$ 16.5 kN (on momentum transfer from front wheels)

15.7 kN ≥ F_T ≥ 14.4 kN (on momentum transfer from rear wheels)

Flywheel:

The flywheel has been designed to smoothen out the surges in rotational speed. It will store energy when demand is lower than available energy and release it during the rest of the operating cycle.

Design Constraints:

- Space
- Working Speed
- Material
- Cars pass a junction every 10 seconds

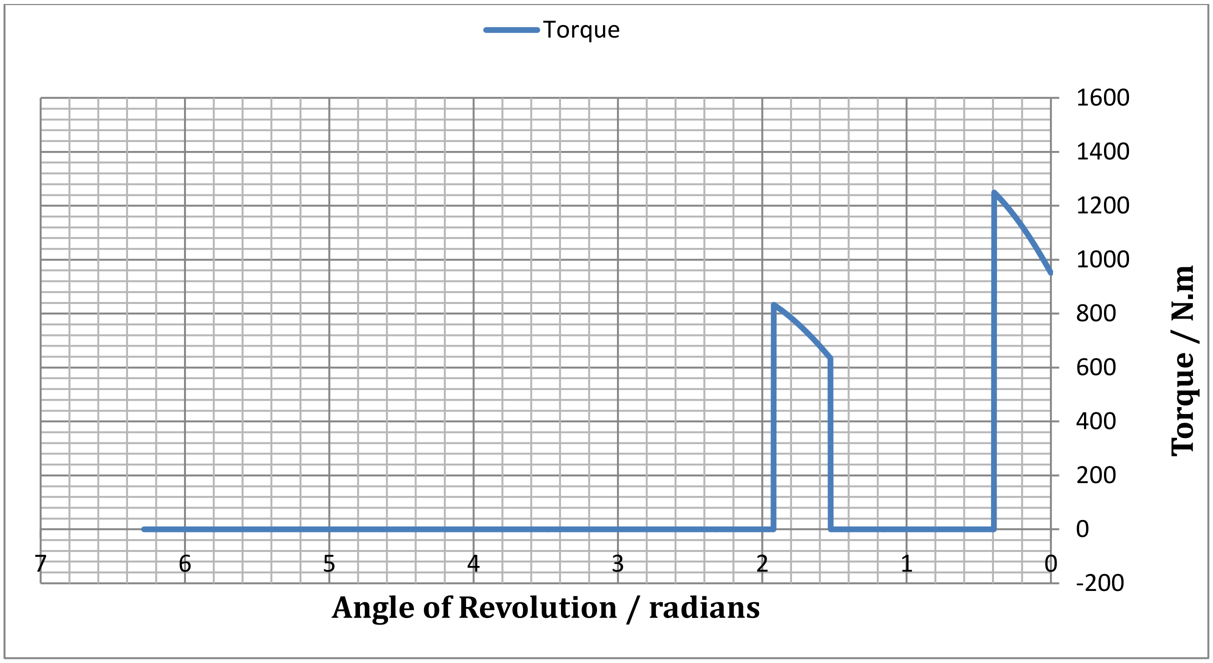
Calculations:

RPM required by the dc generator = 3000

Pulley ration = 80

Rpm required at the flywheel = 3000/80 =37.5 = 3.93 rad/s

The forces evaluated earlier are tabulated to provide the torque exerted over the range of pawl and ratchet contact. The torque v/s angle curve is drawn to evaluate the energy requirements for one cycle of flywheel operation.



The torque and angle curve is integrated to obtain the total energy of the cycle.

Total Energy = 729.5 J

Average Energy requirements = $\frac{729.5}{2\pi}$ = 116.1 J

Coefficient of variation of speed, $C_s = \frac{w_{max} - w_{min}}{w_{avg}}$

Pertaining to the large variation in the rotational speed of the flywheel the C_s is chosen to be 0.5

Moment of inertia, $J = \frac{U}{w_{avg}^2 C_s}$

$$\mathrm{j} = \frac{116.1}{3.93^2 \times 0.5} = 15.03\ \mathrm{kg.m^2}$$

Assuming that the moment of inertia of other components is 0.03 kg.m^2:

$J_{flywheel}$ = 15.03 – 0.03 = 15 kg.m^2

The mass of the flywheel is related to the moment of inertia and average radius through the given equation:

$$m = \frac{J}{r_a^2}$$

The space requirements come into play now as r_a has to be assumed. Different values of m and r_a are traded off to come to a suitable agreement between these two variables.

r_a = 370 mm

$$\mathrm{m} = \frac{15}{0.35^2} = 122.45\ \mathrm{kg}$$

Stress in Flywheel and Spokes:

Although there is no direct load acting on the flywheel, nonetheless, it is crucial for the design process that the stresses induced in the flywheel, i.e. in the rim and the spokes, be calculated.

The stress in rim is given by the equation:

$$\sigma = \frac{\rho r_a^2 w^2}{g}\left[1 - \frac{f_4}{3} + \frac{Ar_a}{3Z_r}\left(f_4 - \frac{1}{f_3\alpha}\right)\right]$$

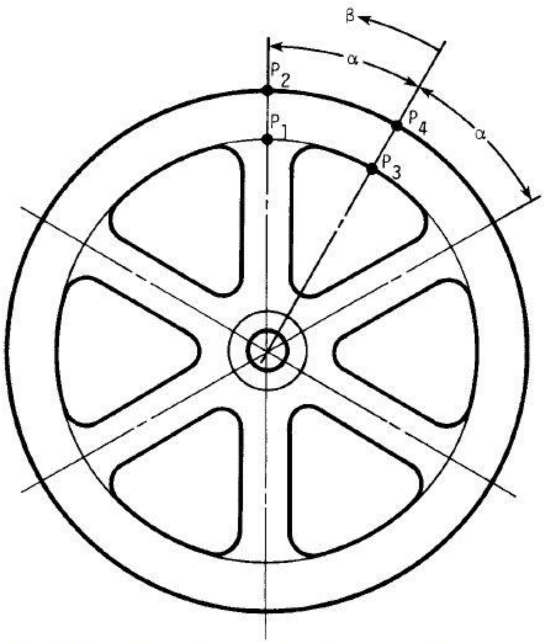


FIGURE 7.6 Rim-type flywheel. The angular position β is measured from the center line bisecting the adjacent spoke locations. Points P_1 through P_4 correspond to the values given in Table 7.5.

Where

$$f_1 = \frac{1}{2\sin^2\alpha}\left(\frac{\sin 2\alpha}{4} + \frac{\alpha}{2}\right)$$

$$f_2 = f_1 - \frac{1}{2\alpha}$$

$$f_3 = \frac{Ar_a^2 f_2}{I} + f_1 + \frac{A}{A_s}$$

$$f_4 = \frac{\cos\beta}{f_3 \sin\alpha}$$

Where;

Z_r is Section Modulus of rim;

A is cross sectional area of rim;

A_s is cross sectional area of spoke

<u>Data:</u>

r_a = 350 mm

hub radius = 120 mm

Z_r =6.302 x 10^{-5}

A = 6.875 x 10^{-3} m^3

$A_s = 1.5 \times 10^{-3}\ m^3$

$I = 1.733 \times 10^{-6}$

$f_1 = 0.9566$

$f_2 = 1.67 \times 10^{-3}$

$f_3 = 6.352$

$f_4 = 0.2727$

Stress, σ = 60592.5 Pa.

The stress in spokes is given by the equation:

$$\sigma = \frac{\rho r_a^2 w^2}{6g}\left(3 + \frac{4A}{f_3 A_s} - \frac{3r^2}{r_a^2}\right)$$

σ = 1405.2 Pa

The stresses induced at the hub/spoke connection have considerable effect on the integrity of the flywheel and, hence, are added into the spoke stresses to get the whole picture.

$$\sigma = \frac{T(r_a - r_h)}{Z_s N_s r_a}$$

σ = 78486.99 Pa

Total σ = 1405.2 + 78486.99 = 79892.1 Pa

The flywheel is subject to mild stresses which do not have any critical effect on the integrity of the flywheel. The reason for uncritical nature of the stresses is the operation of the flywheel, i.e. the flywheel is being used only to act as energy reservoir not as a tool to transfer torque ahead.

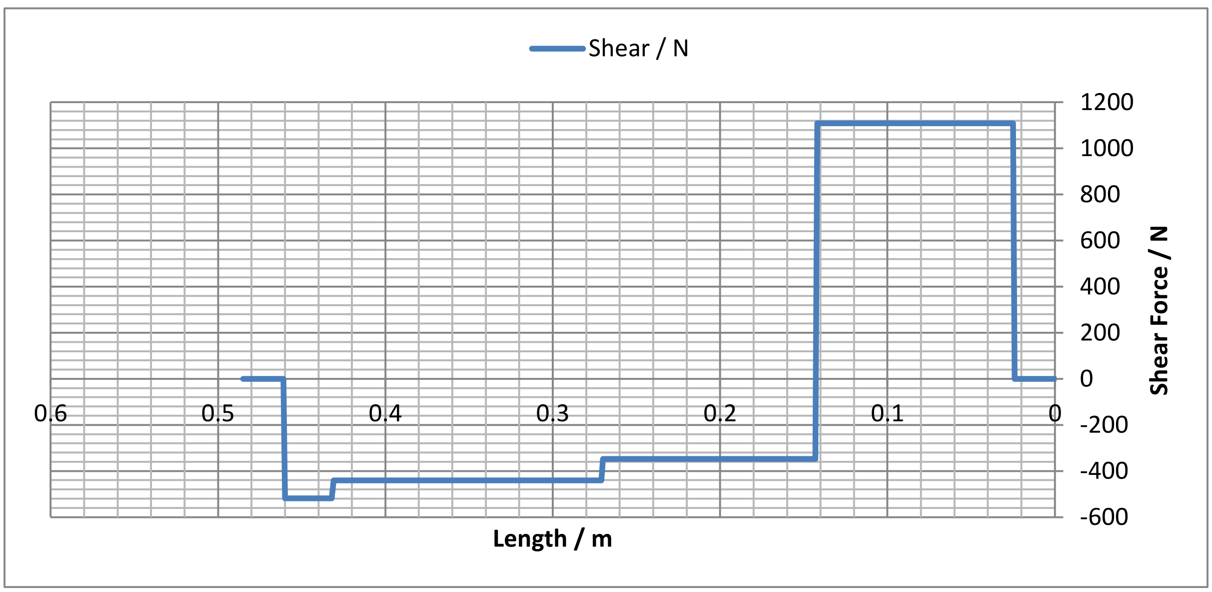
Shaft:

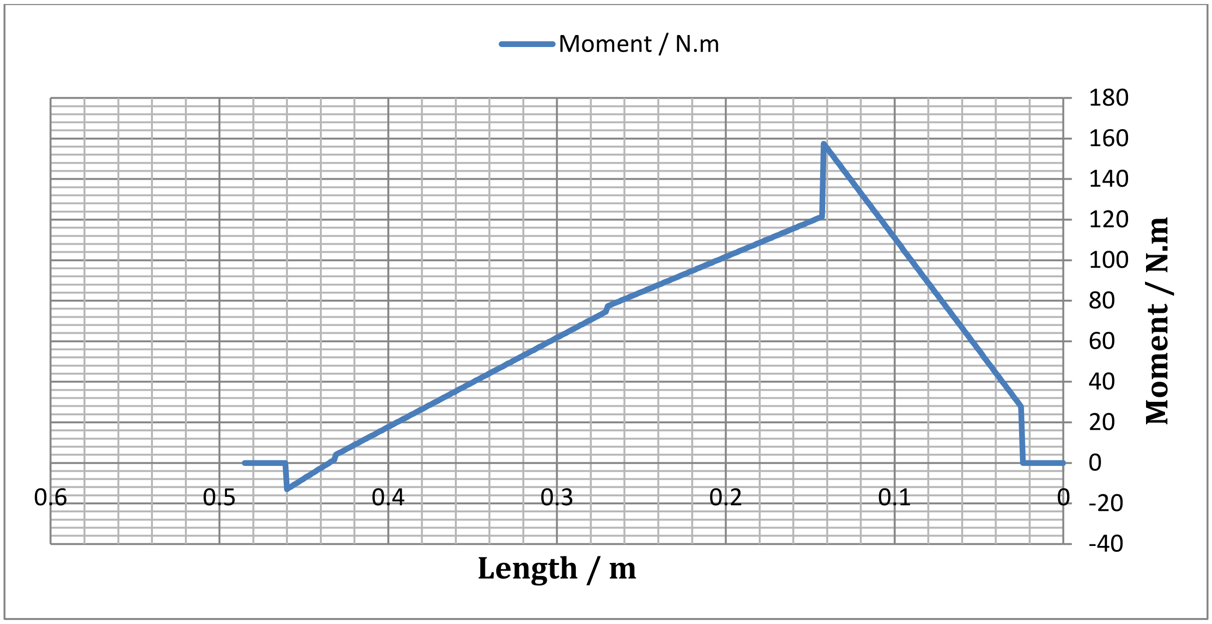
The main shaft has flywheel, ratchet and one of the pulleys pressed on it. It is subjected to combined bending and torsional stresses. The selection of appropriate diameter of the shaft is done on the bases of separate effect of each type of loading.

Material:

AISI 1018 Mild Steel

Bending:





$$\sigma_{max} = \frac{M_{max}R}{I}$$

$$I = \frac{\pi d^4}{64}$$

From the given equations we obtain:

$$d = \sqrt[3]{\frac{32M_{max}}{\pi\sigma_{max}}}$$

Factor of safety, N = 3 (chosen on the basis of type of loading conditions)

σ_y = 350 MPa

σ_{max} = 350/3 = 117 MPa

d = 23.9 mm

Now, the torsional calculations will be done to check the validity of the obtained diameter of the shaft.

Torsion:

$$\tau_a = \frac{16}{\pi d^3}\sqrt{(K_t T)^2 + (K_m M)^2}$$

K_t = 1.5

K_m = 2.0

Using d = 23.9 mm

τ_a = 399.88 MPa

This stress is greater than the yield strength of the material and will fail under the loading conditions. The required diameter should be greater than 23.9mm.

d = 40 mm

τ_a = 149.3 MPa

N = 2.34 (which is suitable for the given loading conditions)

Hence, shaft of diameter 40mm is used.

MATERIAL SELECTION

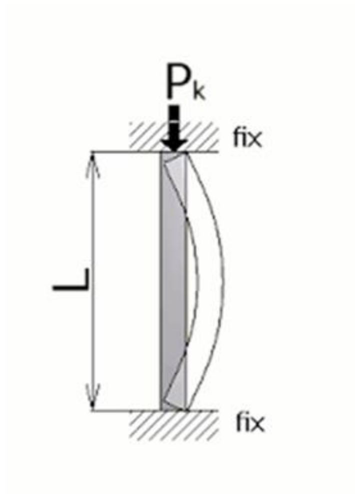
- The flap plates, frame, the pawl, flywheel and the shafts are all manufactured from AISI 1018 Mild/Low Carbon Steel. It has excellent machinability, weldability and offers a good balance of toughness, strength and ductility. It is the preferred choice for the manufacturing of general engineering components and machine parts, gears, pins, shafts and much more. It is cheap and very easily available in the market.
- The ratchet wheel takes a large impact load during operation. For this reason, it has been manufactured from AISI 1045 Medium Carbon Steel. AISI 1045 steel is characterized by good weldability, good machinability, and high strength and impact properties. It is widely used for all industrial applications requiring more wear resistance and strength. Typical applications include gears, ratchets, bolts, studs etc.

Reasons for using square tubing instead of angle iron for the frame:

- Tubing is a more efficient design because there is more moment of inertia available at the cross section which means that it is stronger than angle iron (maximizing design while minimizing weight). Moreover, angle iron has a tendency to buckle at the top rail in case of bending.
- Tubing is more aesthetically pleasing and it has torsional and tensional characteristics that angle iron does not have.

References: http://www.azom.com/article.aspx?ArticleID=6115

http://www.azom.com/article.aspx?ArticleID=6130



P_k
fix
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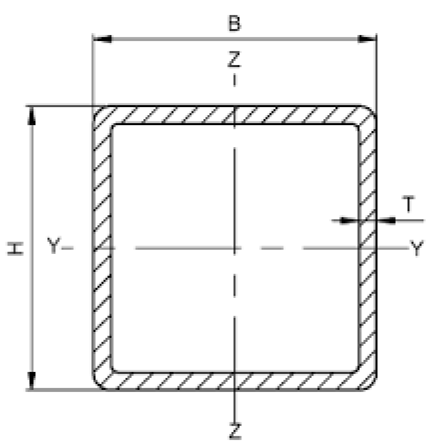

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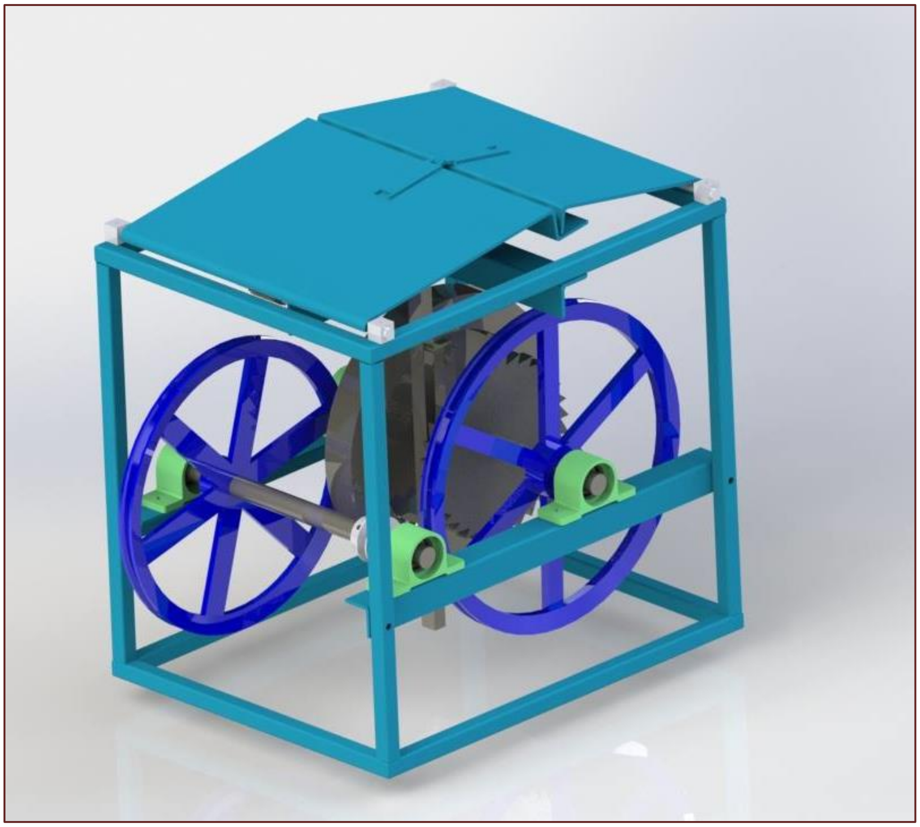
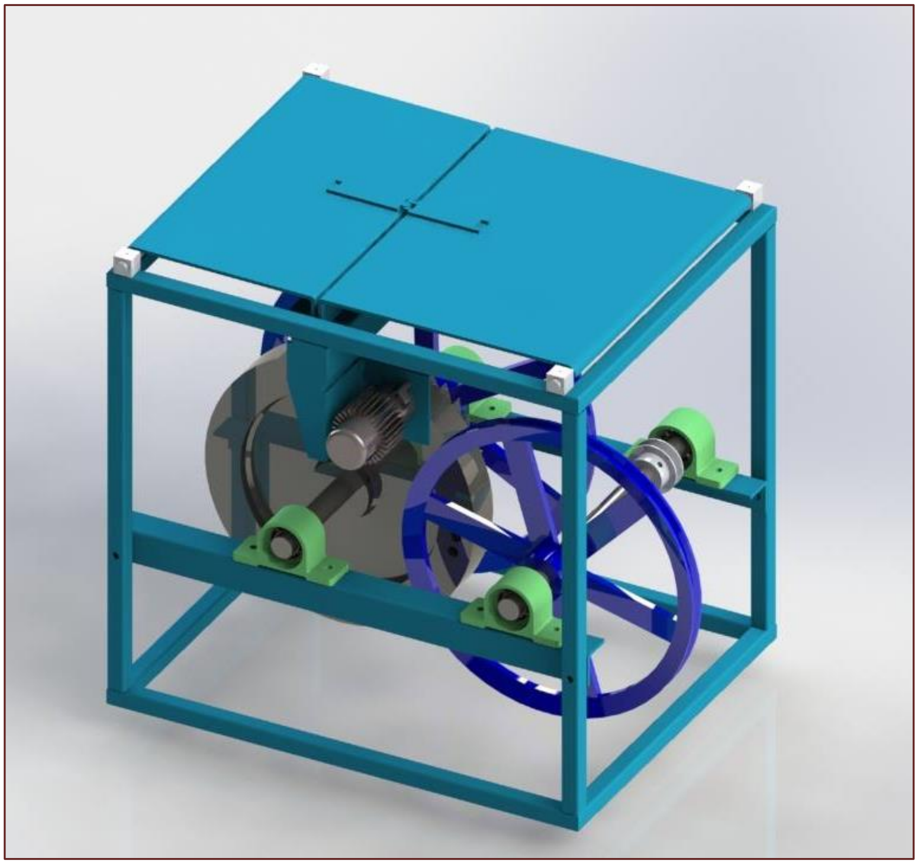
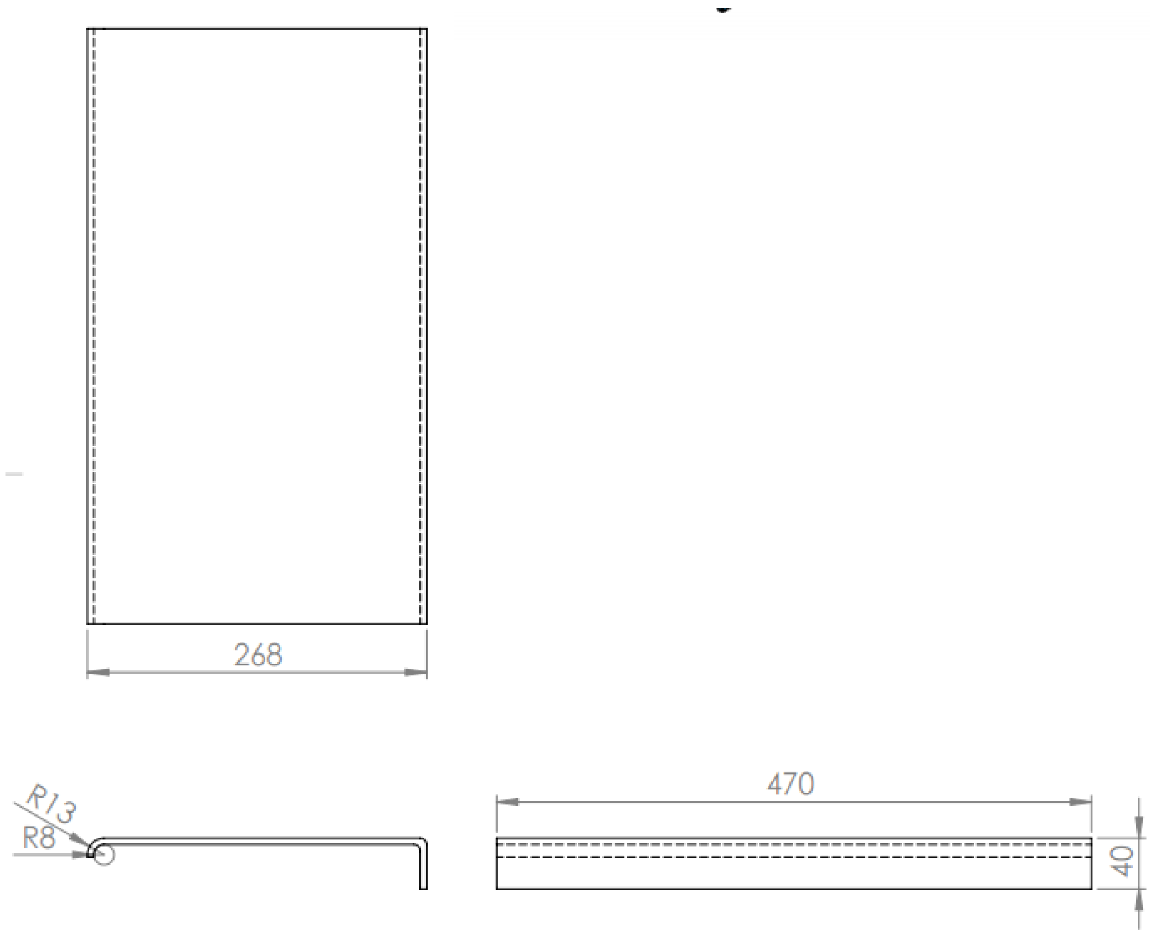
DESIGN OF PROTOTYPE



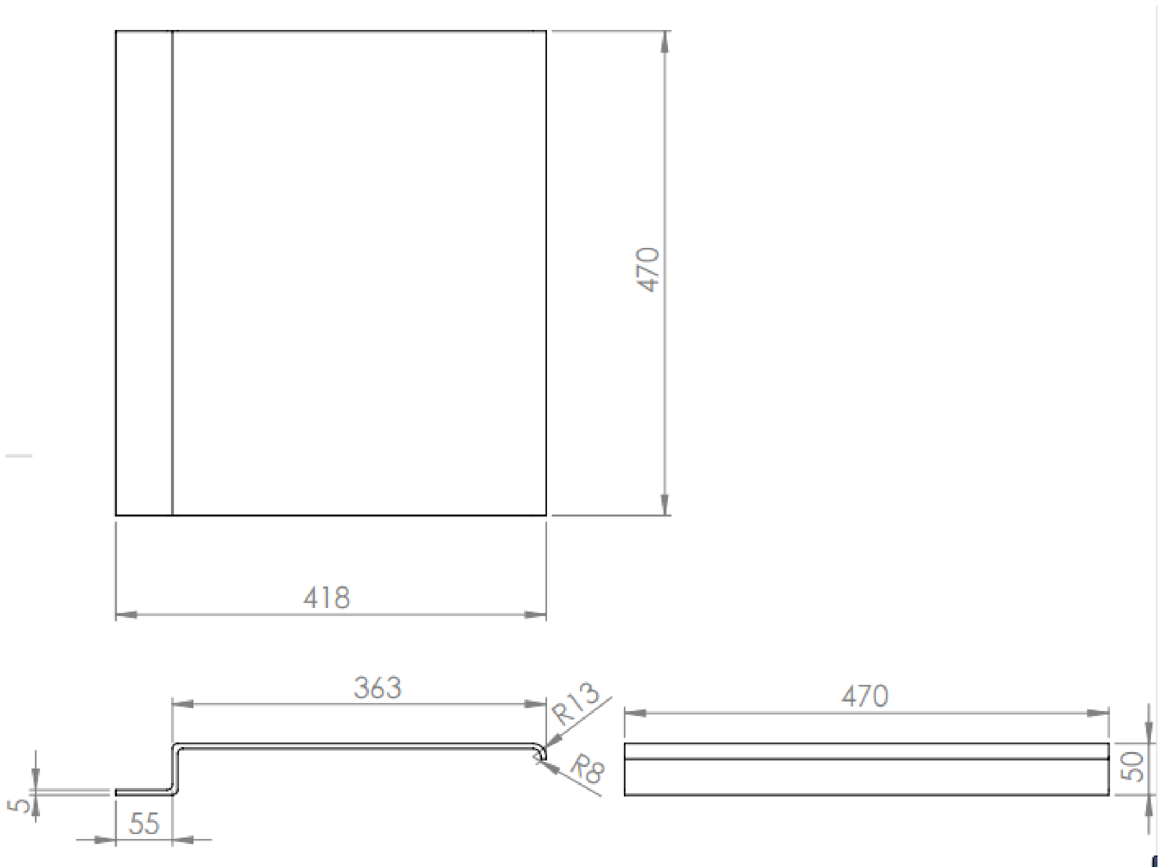


DRAWINGS

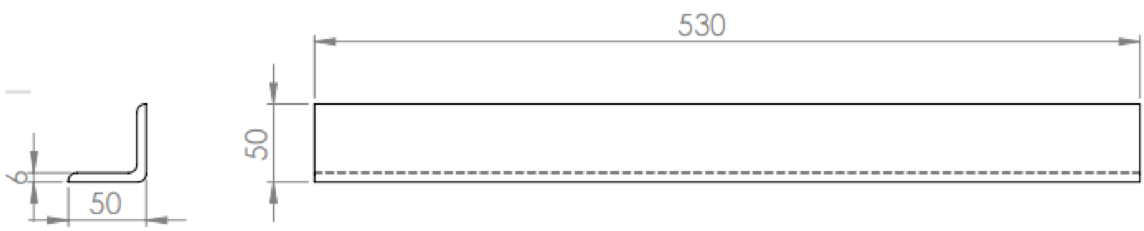
Flap Plate 1



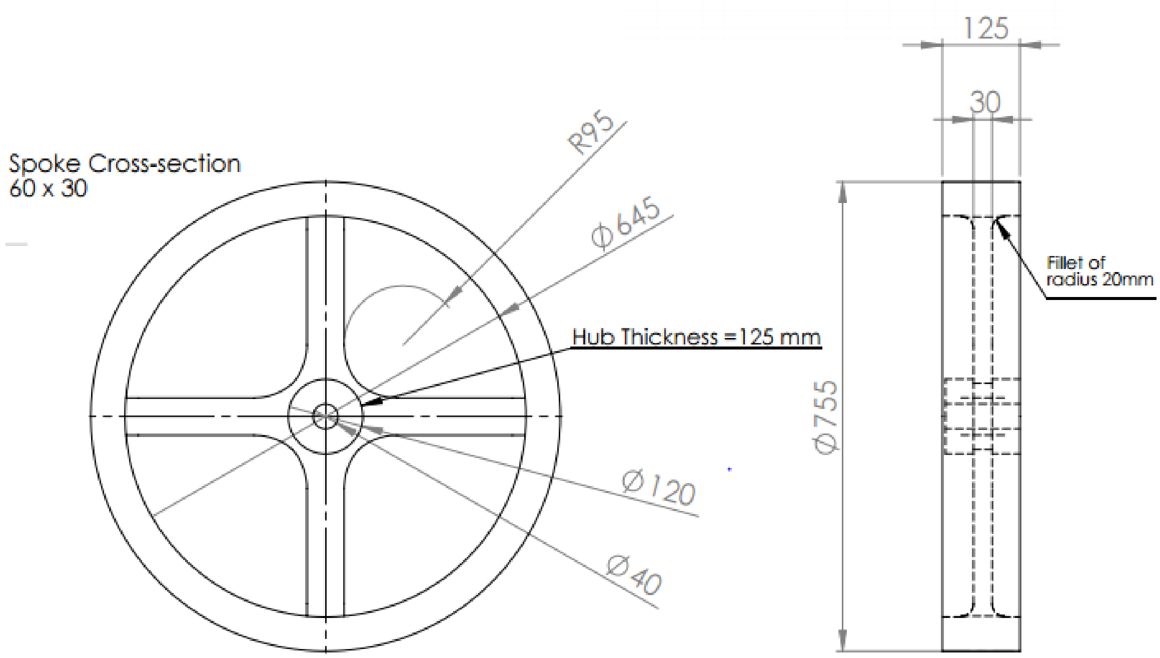
Flap Plate 2



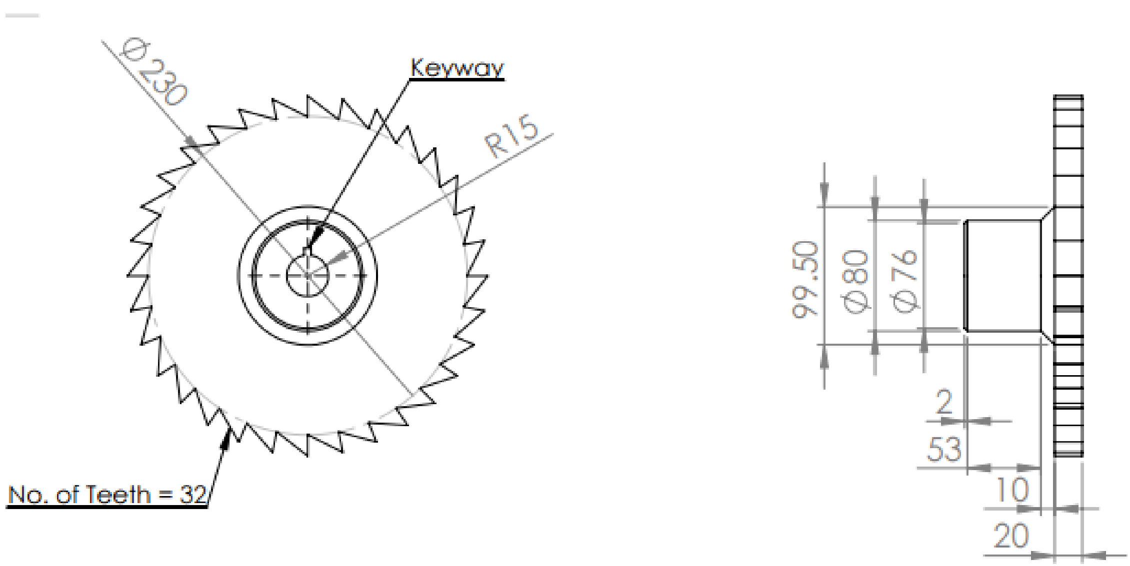
Flap Plate Angle Iron



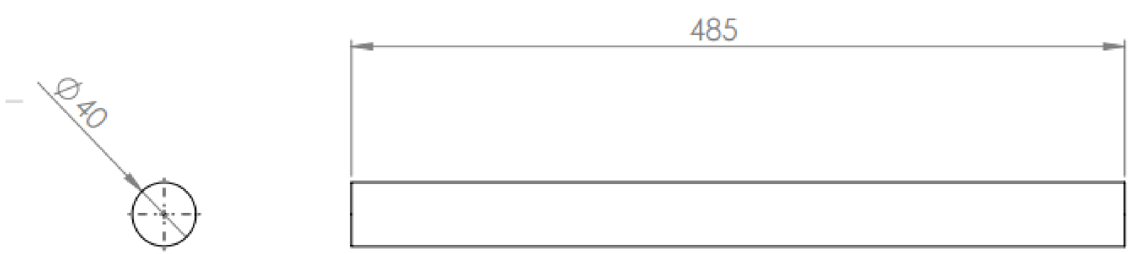
Flywheel



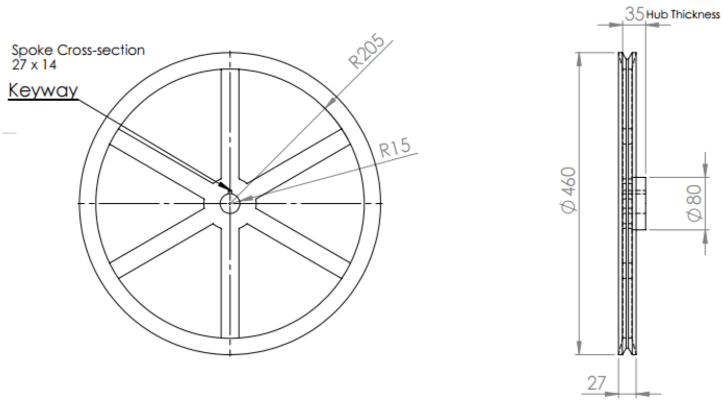
Ratchet



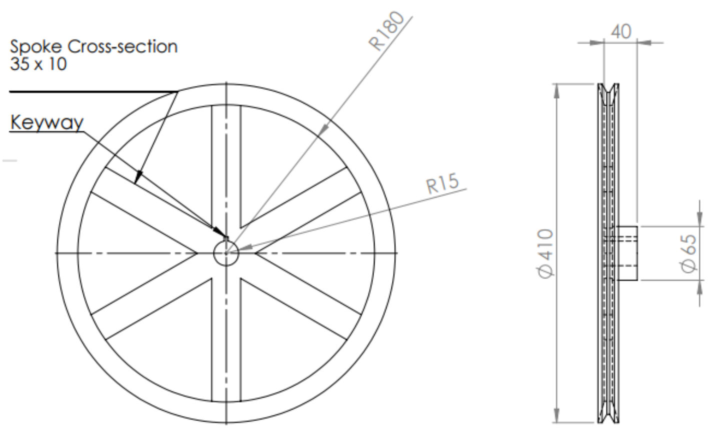
Shafts



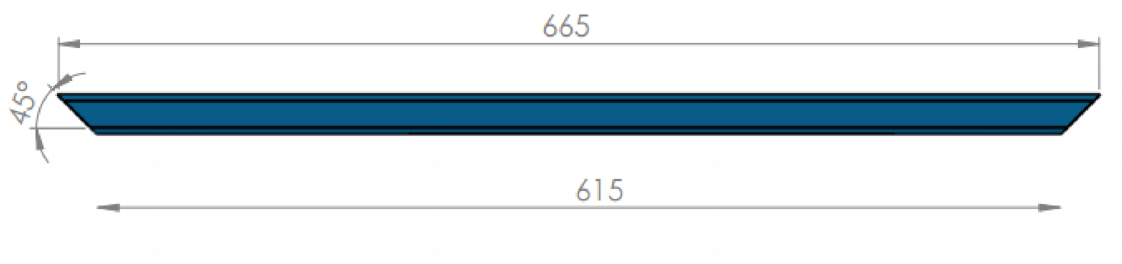
Pulley 1



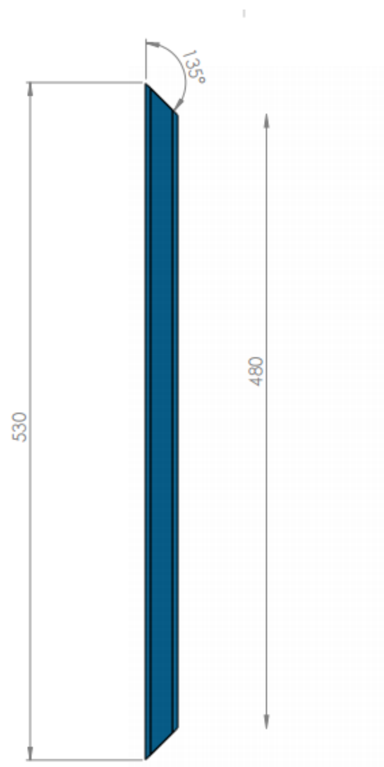
Pulley 2



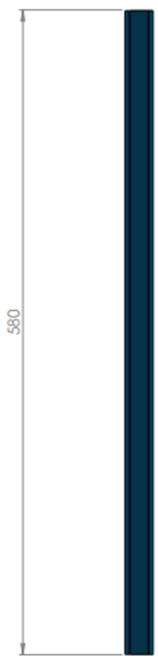
Longitudinal Tube



Latitudinal Tube



Vertical Tube



MECHANISM

Following the extensive literature survey, the design phase commenced. We took inspiration from the different types of mechanisms that we came across in our study. The project was designed using the fundamentals of engineering learned over past four years and a fair bit of intuition as well. A brief description of the operation and the major components of the prototype follows.

Flap Plates

The design quite similarly to the previously described mechanisms entails a pair of flap plates that have two states:

i. A protruding state in which the flaps are inclined upwards and the ends of the flaps at the middle are above road level.
ii. A level state in which the flaps are level with the road.

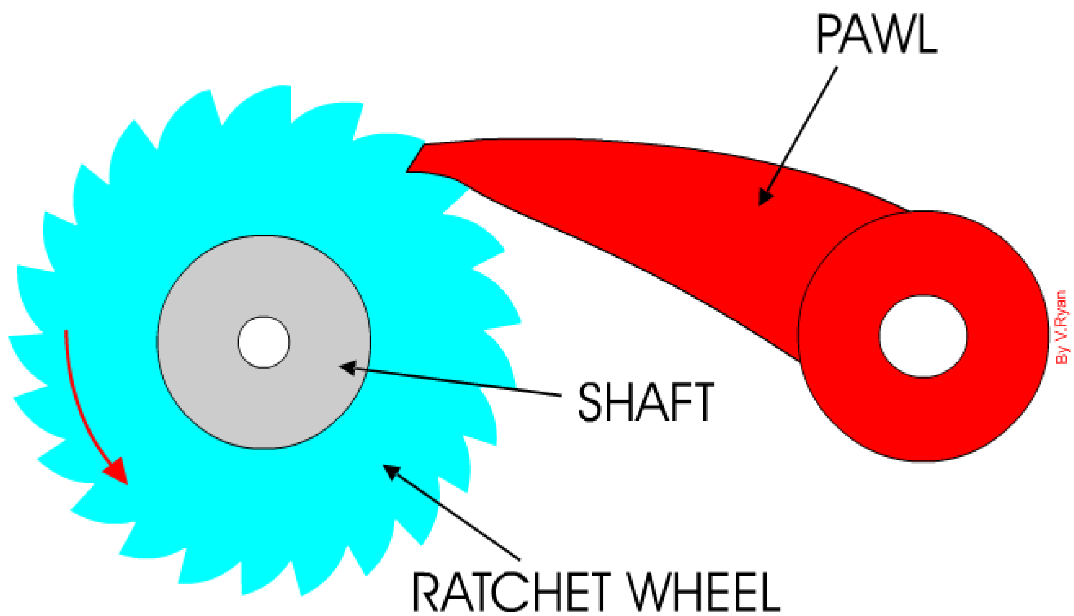
Ratchet and Pawl Assembly

It was necessary that the shaft of the DC generator rotate in only one direction for generating a proper DC pulse. For this purpose, a Ratchet and Pawl assembly was used.

The mechanism usually consists of a rotational gear with suitably shaped teeth (also known as the ratchet wheel) and a thin metallic piece known as the pawl which rests against the ratchet to restrict its motion in a particular direction (either clockwise or anticlockwise). The teeth on the ratchet wheel have edges with a sharp and a gentle slope. When moving in the unrestricted direction, the pawl slides along the gently sloped edge of the teeth and falls into the 'dip' between the ratchet teeth. In the restricted direction, the pawl slides along the steeply sloped edge of the teeth and locks the wheel to prevent any rotation.

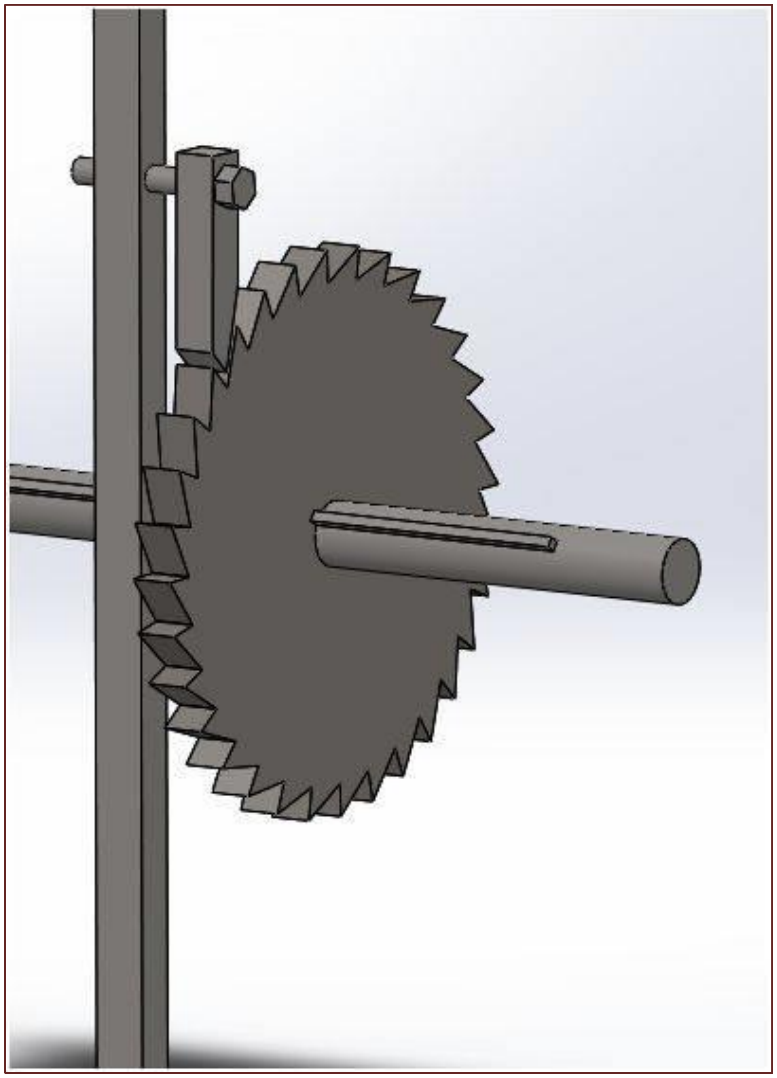
The pawl is usually spring-loaded which results in the clicking noises heard during its operation. In this prototype the pawl is not spring loaded. A piece of metal is welded to the pawl which allows it to fall into the 'dip' between the ratchet teeth simply because of the added weight.

The pawl is installed on a shaft of square cross section which is pushed downwards when a vehicle passes over the flap plates. This shaft is spring-loaded which allows the flaps to return to their original protruded state after the vehicle has passed over them.



References: http://www.technologystudent.com/cams/ratch1.htm

http://www.wmberg.com/products/Ratchet-Pawl-Gears.aspx



Ratchet and Pawl

Pulleys, Flywheel and Shafts

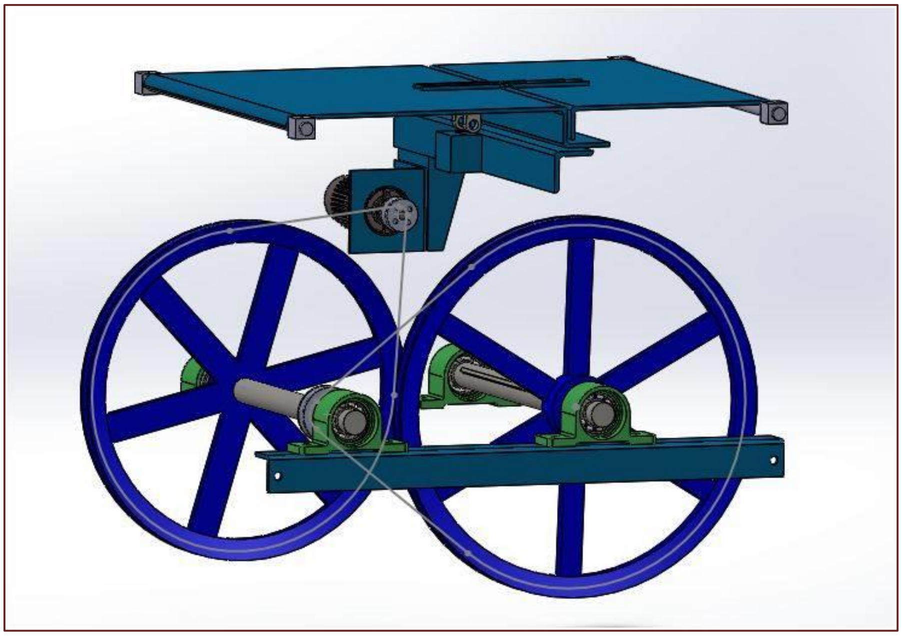
The ratchet wheel, a flywheel and a pulley are mounted on a shaft that is attached to the frame. Whenever a vehicle passes over the flap plates, it causes the rotation of the ratchet wheel and the shaft. A countershaft with a smaller pulley mounted on it, is driven by the first shaft through a belt drive. The smaller pulley on the countershaft in turn drives the shaft of a DC generator which produces electricity.

A flywheel is an energy-storage device with a significant moment of inertia. It absorbs mechanical energy by increasing its angular velocity and delivers energy by decreasing its velocity. Flywheels resist changes in their rotational speed, which helps steady the rotation of the shaft when a fluctuating torque is exerted on it.

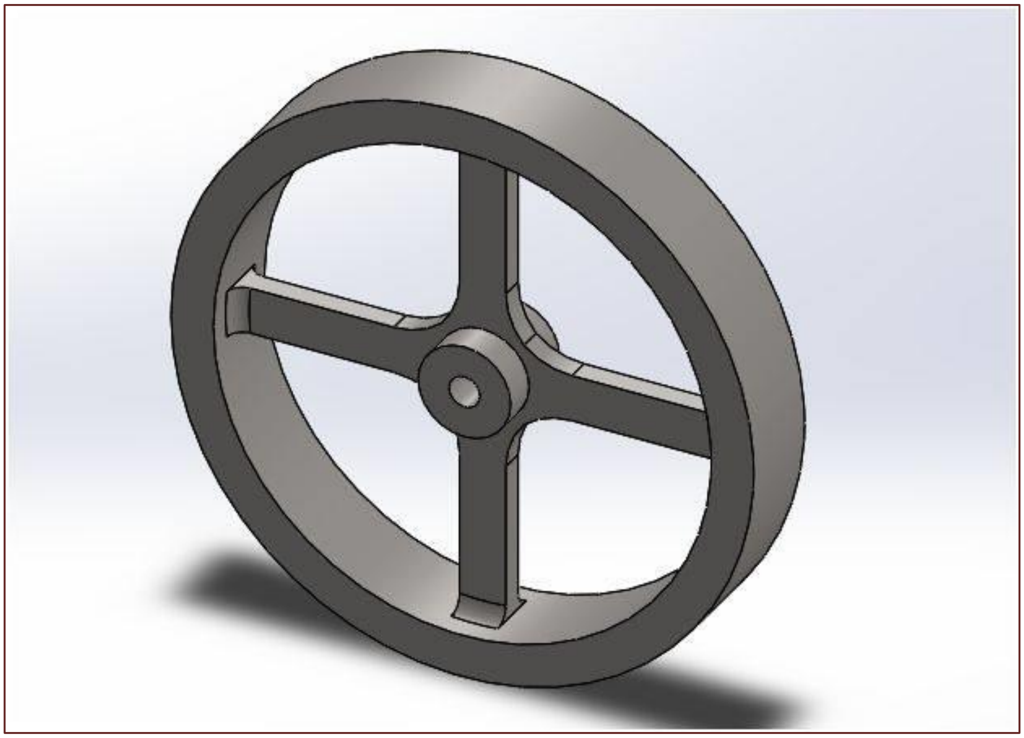
References: Shigley's Mechanical Engineering Design, Eighth Edition

The shafts are horizontal and each is attached to the frame via two Pillow block bearings. Pillow blocks are the most commonly used mounting units that provide shaft support where the mounting surface is parallel to the shaft axis. They are basically housings with a bearing fitted into them (ball bearing in this case) which prevents the need for purchasing the bearings separately. The housing is bolted to the frame via holes in the foundation.

Reference: http://www.thebigbearingstore.com/pillow-block-bearings/



Pulley assembly



Flywheel

DC Generator

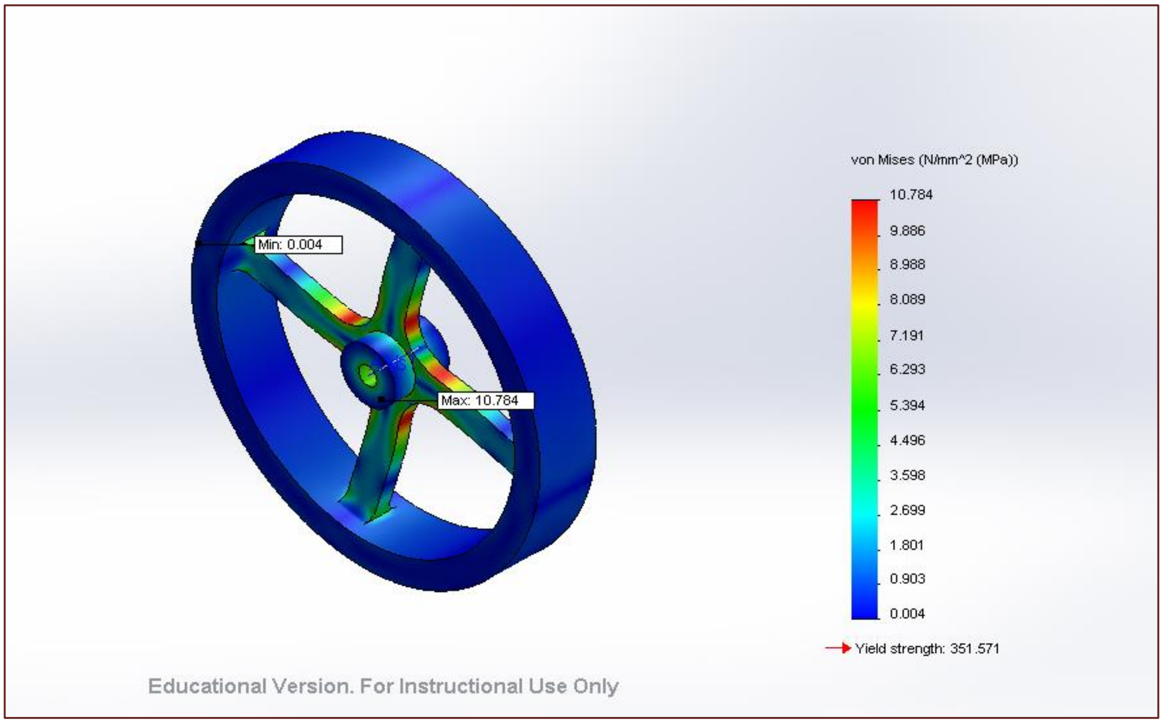
The final pulley is connected to a DC generator.

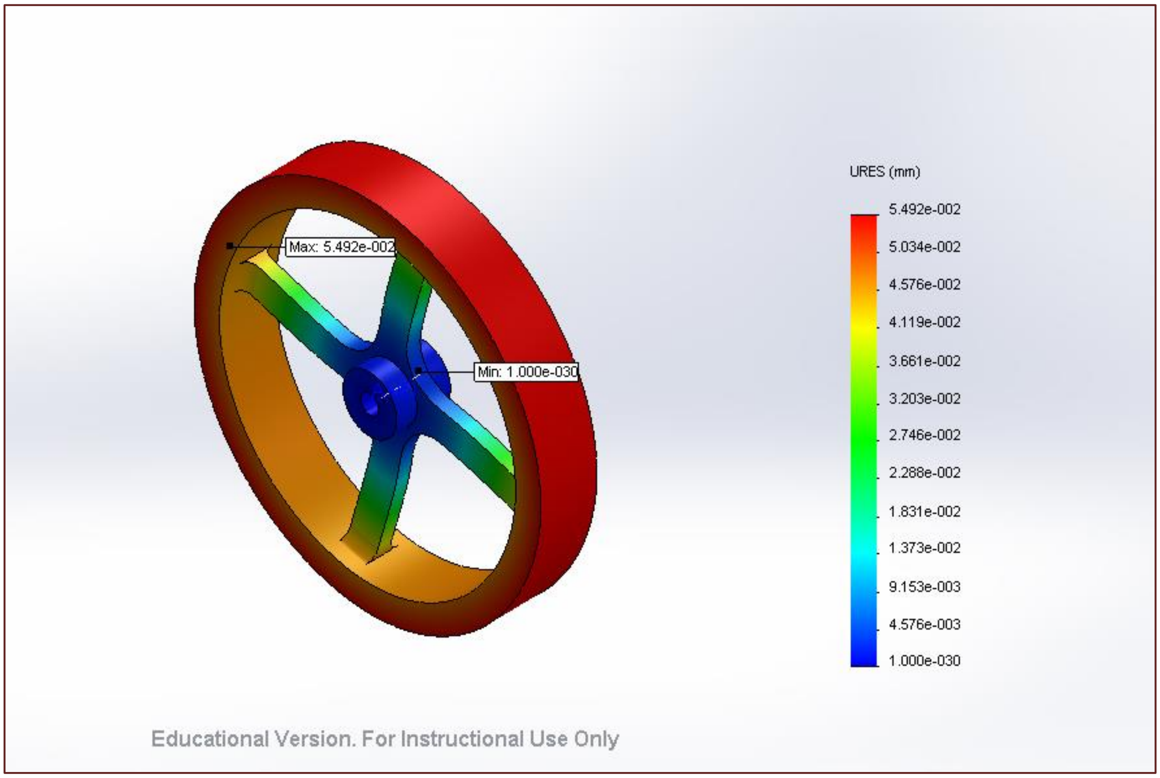
The Specifications of the DC generator are:

- Rated Output power 200W
- Rated Speed 3000 RPM
- Rated Voltage 75 V
- Rated Current 3.6 A
- Friction Torque 4.9 x 10^-2 Nm
- Mass 2.2 kg

FINITE ELEMENT ALALYSIS

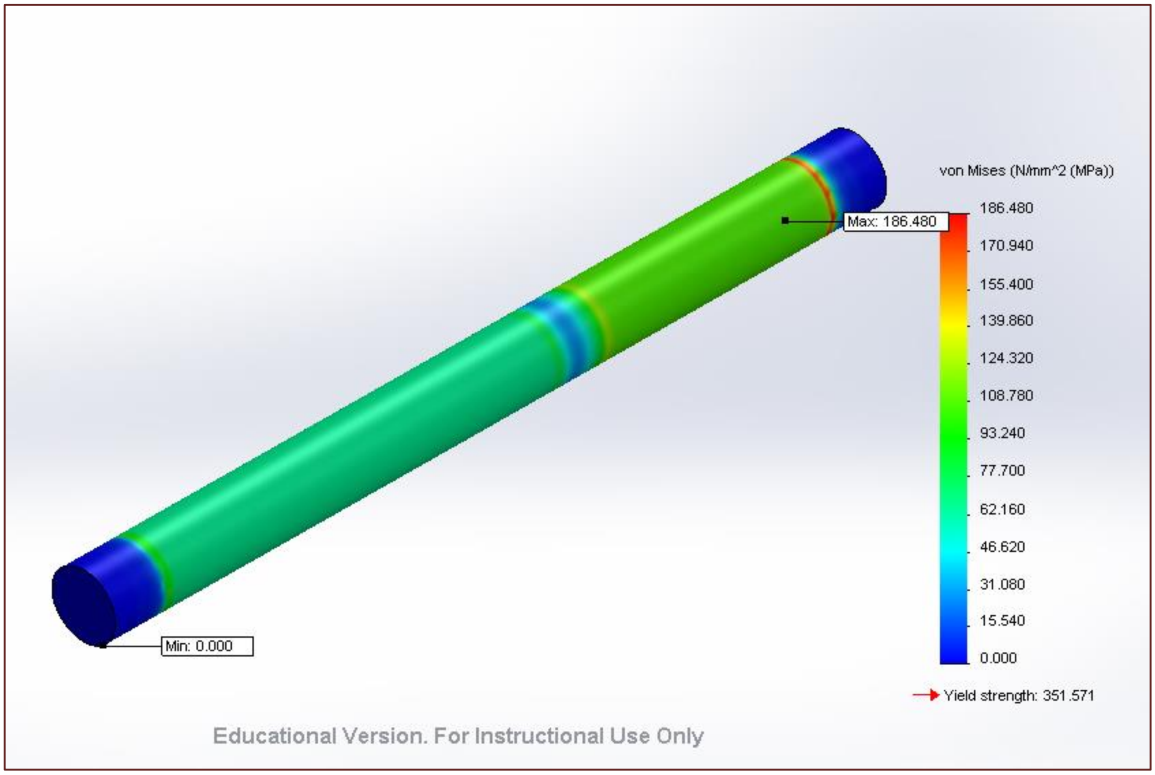
Flywheel

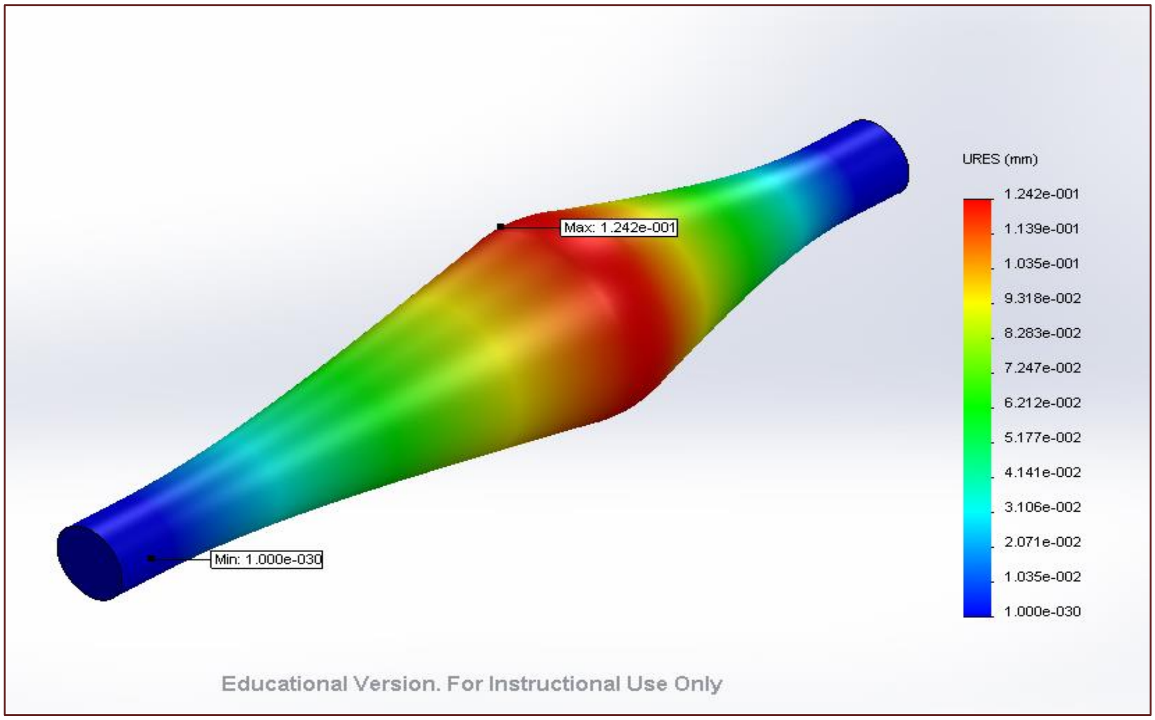




Quantity	Minimum value	Maximum value
Von Mises Stress	0.00417752 N/mm^2 (MPa)	10.7842 N/mm^2 (MPa)
Displacement	0 mm	0.0549164 mm
Factor of Safety	32.6006	N/A

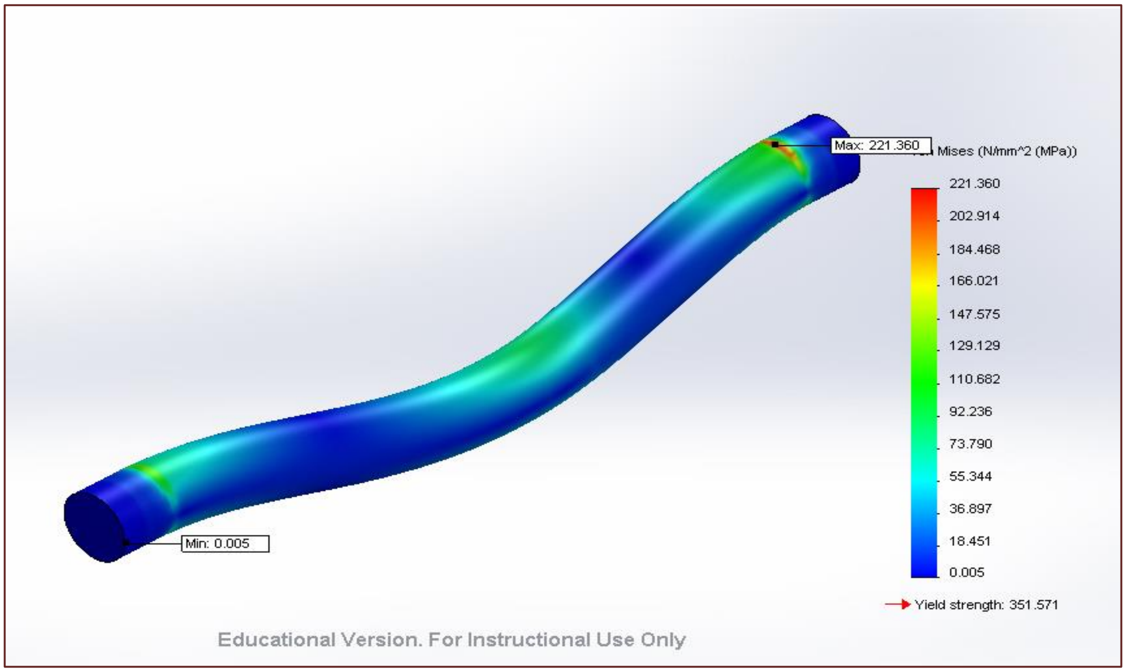
Shaft (Torsion)

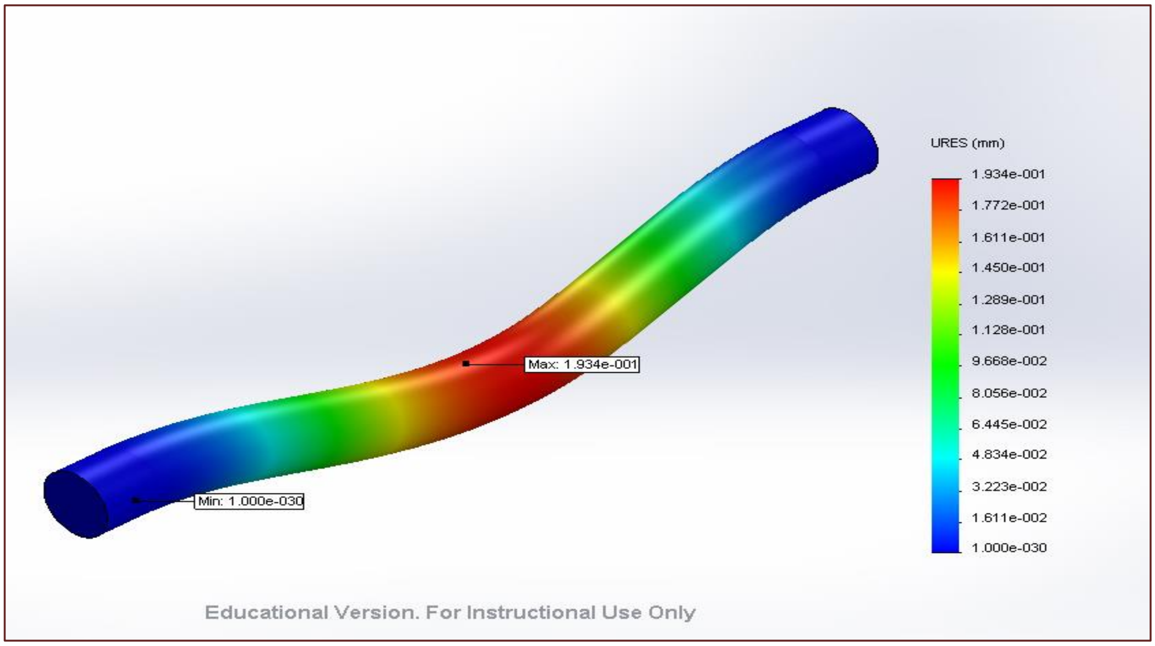




Quantity	Minimum value	Maximum value
Von Mises Stress	0.000408699 N/mm^2	186.48 N/mm^2 (MPa)
Displacement	0 mm	0.12424 mm
Factor of Safety	1.8853	N/A

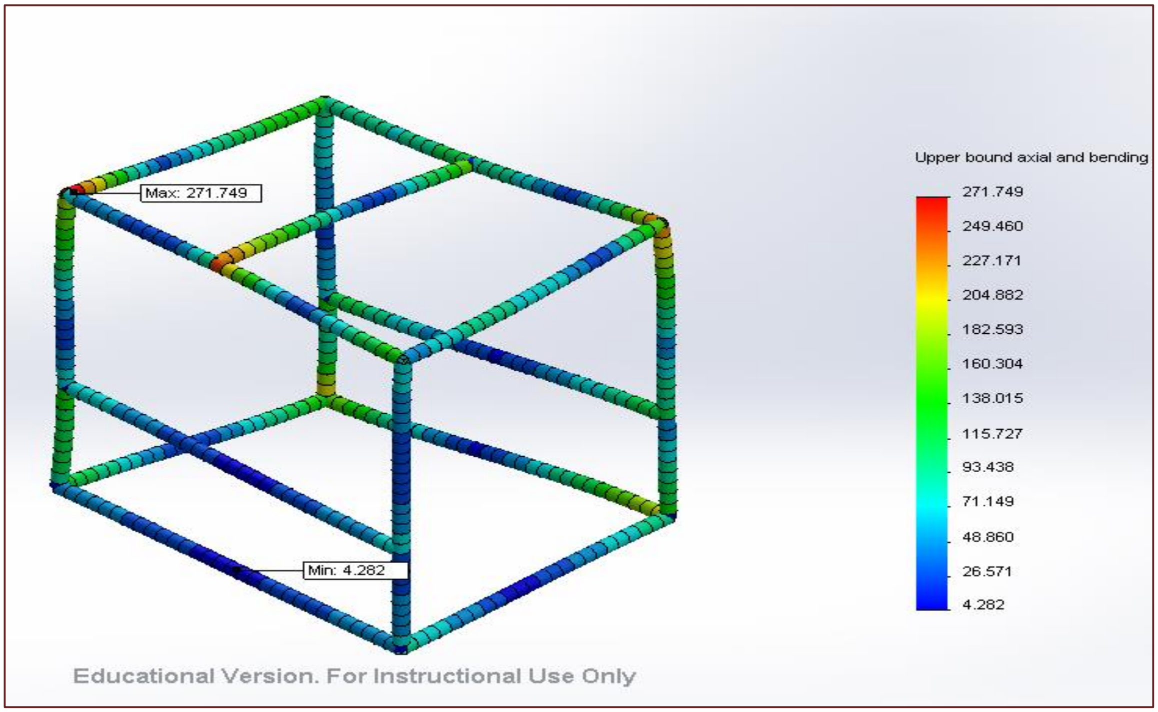
Shaft (Bending)



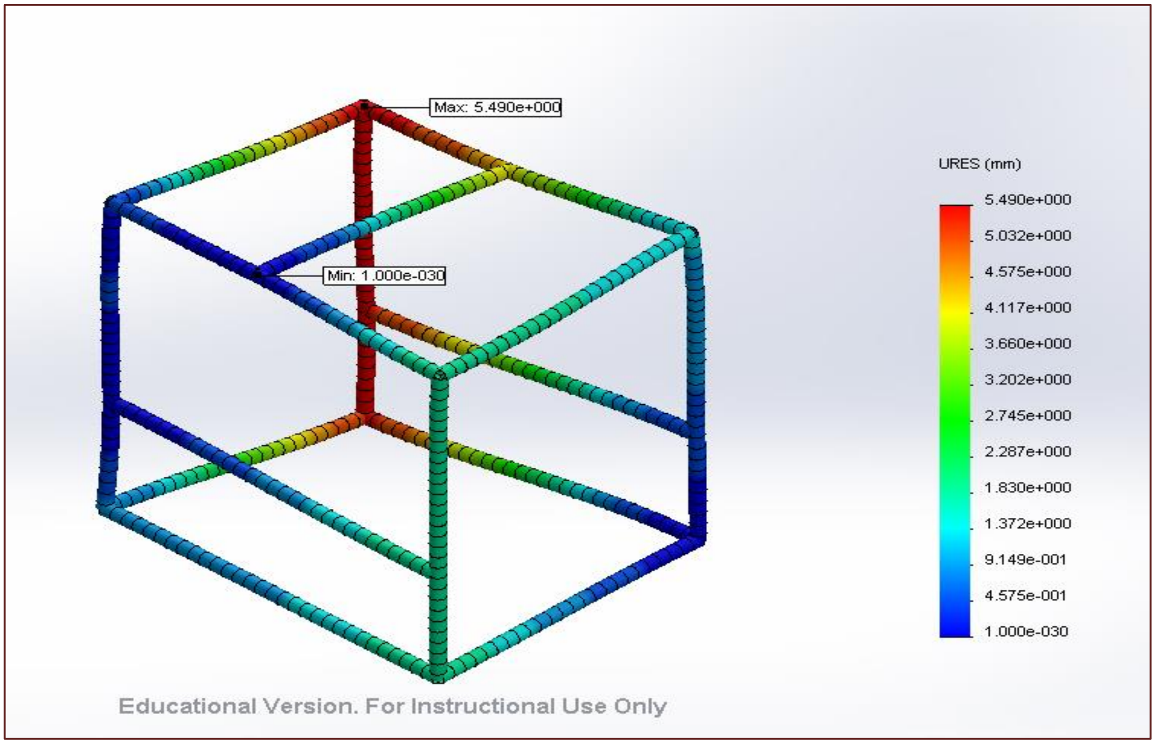


Quantity	Minimum value	Maximum value
Von Mises Stress	0.00459293 N/mm^2 (MPa)	221.36 N/mm^2 (MPa)
Displacement	0 mm	0.193354 mm
Factor of Safety	1.58823	N/A

Frame

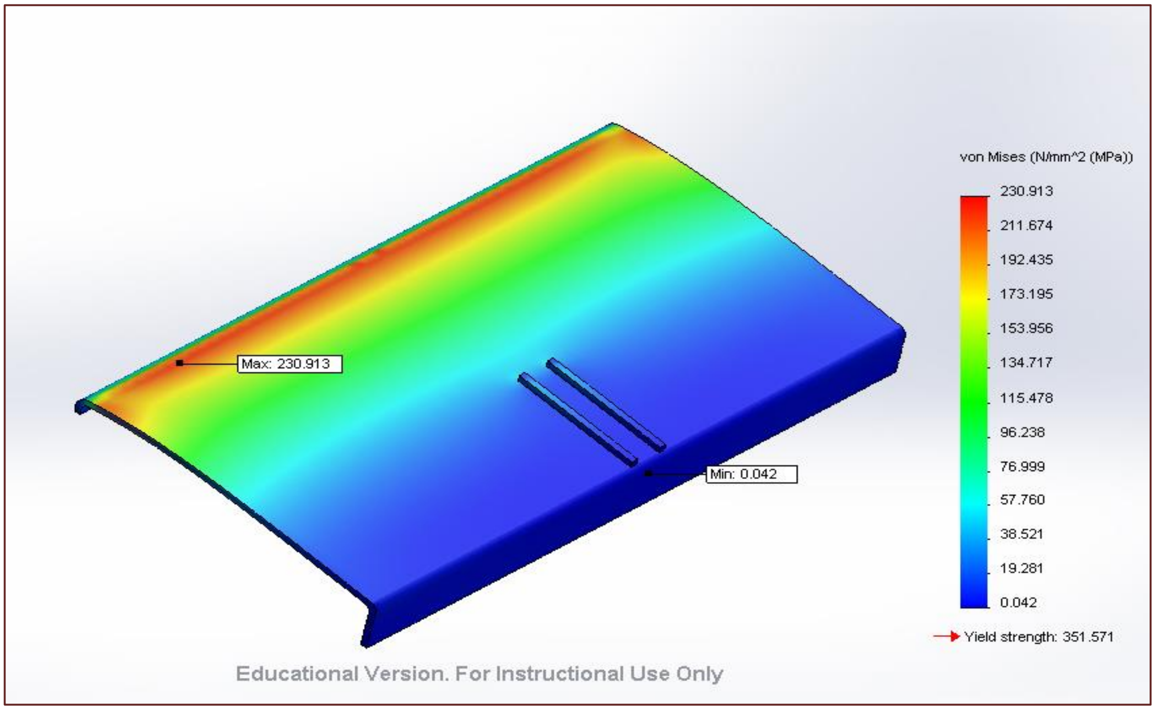


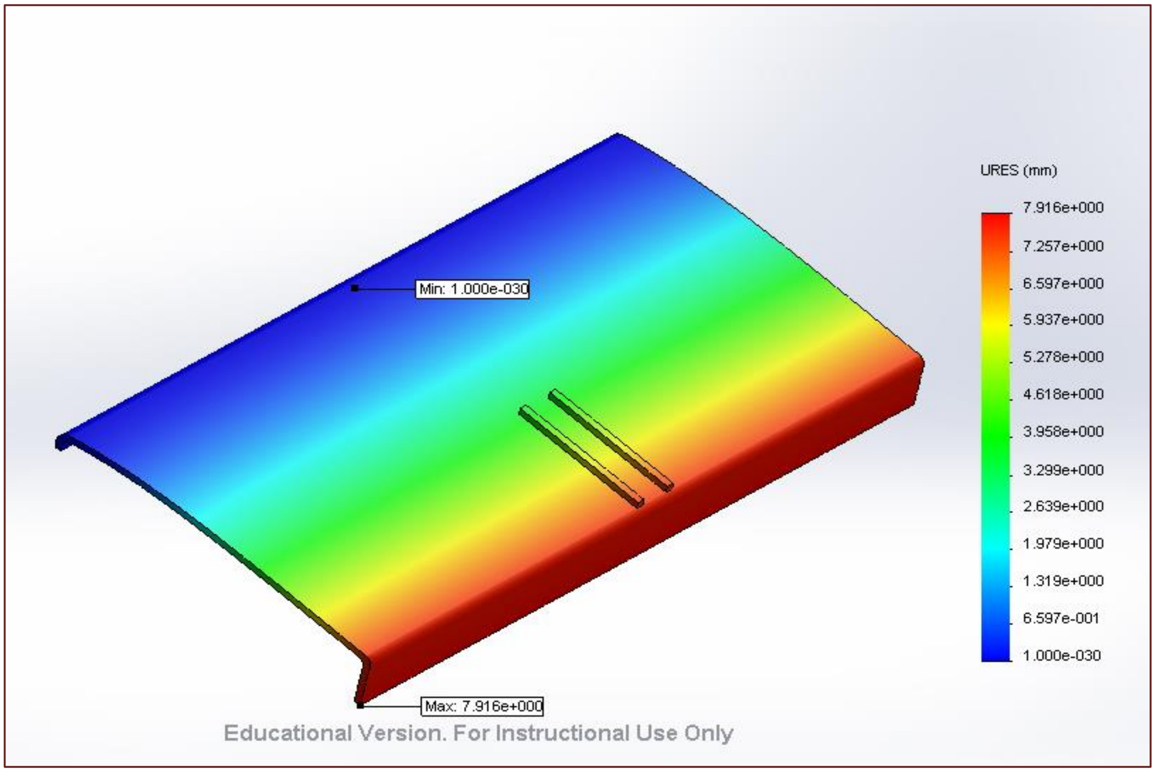
Max: 271.749
Min: 4.282
Upper bound axial and bending
271.749
249.460
227.171
204.882
182.593
160.304
138.015
115.727
93.438
71.149
48.860
26.571
4.282
Educational Version. For Instructional Use Only



Quantity	Minimum value	Maximum value
Von Mises Stress	0 N/mm^2 (MPa)	271.749 N/mm^2 (MPa)
Displacement	0 mm	5.48967 mm
Factor of Safety	1.29374	N/A

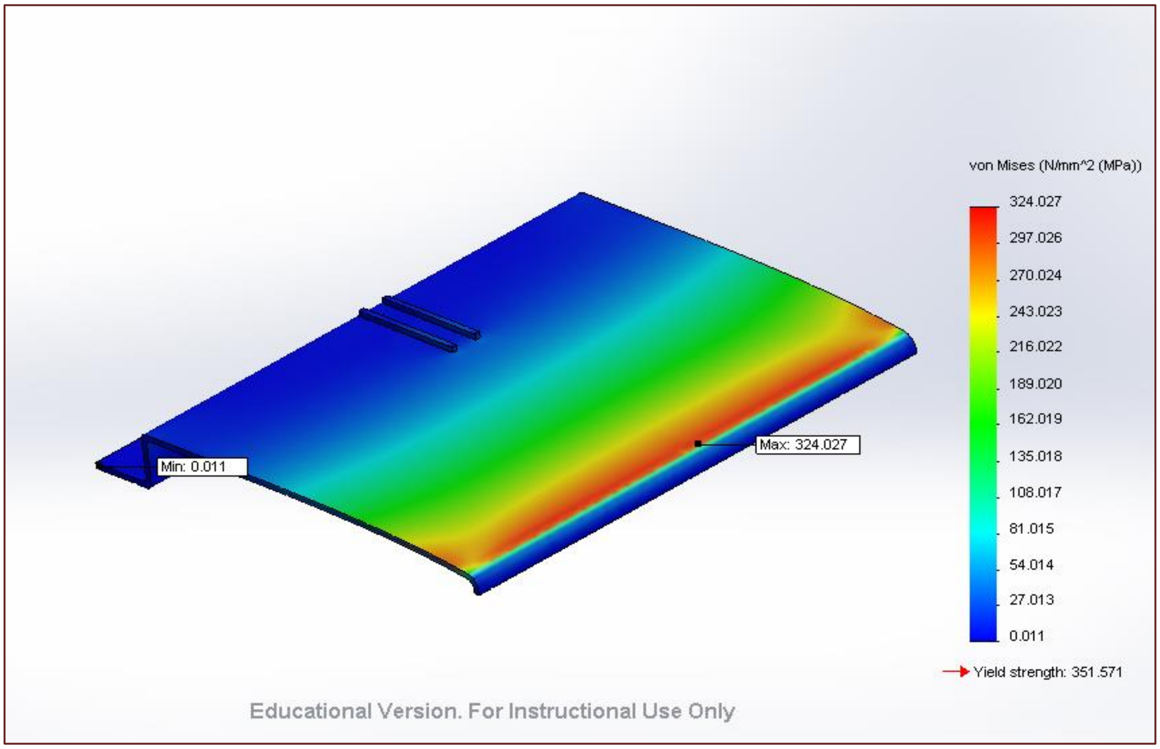
Flap Plate 1

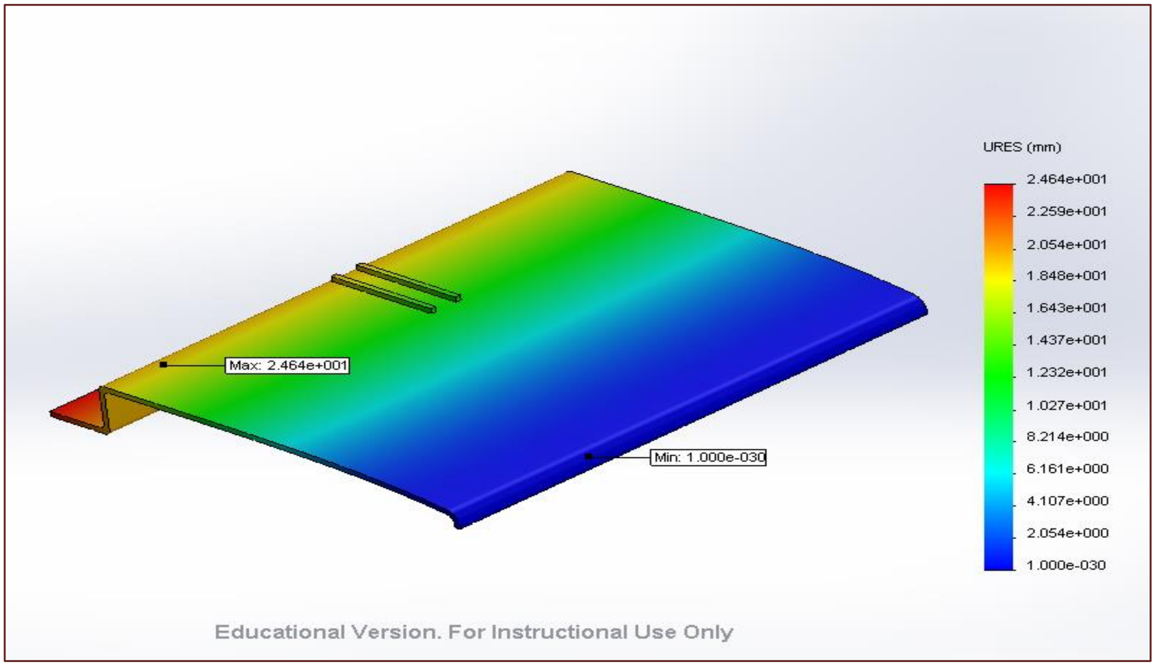

von Mises (N/mm^2 (MPa))
230.913
211.674
192.435
173.195
153.956
134.717
115.478
96.238
76.999
57.760
38.521
19.281
0.042
Yield strength: 351.571
Max: 230.913
Min: 0.042
Educational Version. For Instructional Use Only



Quantity	Minimum value	Maximum value
Von Mises Stress	0.042012 N/mm^2 (MPa)	230.913 N/mm^2 (MPa)
Displacement	0 mm	7.91644 mm
Factor of Safety	1.52253	N/A

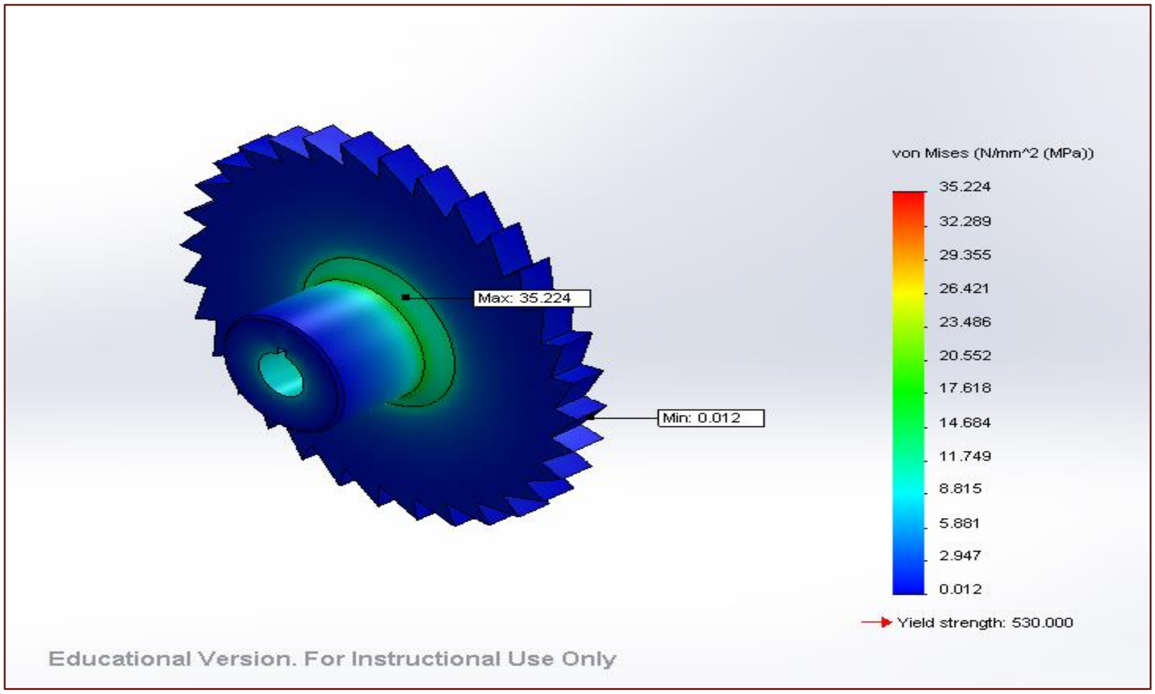
Flap Plate 2


von Mises (N/mm^2 (MPa))
324.027
297.026
270.024
243.023
216.022
189.020
162.019
135.018
108.017
81.015
54.014
27.013
0.011
Yield strength: 351.571
Max: 324.027
Min: 0.011
Educational Version. For Instructional Use Only

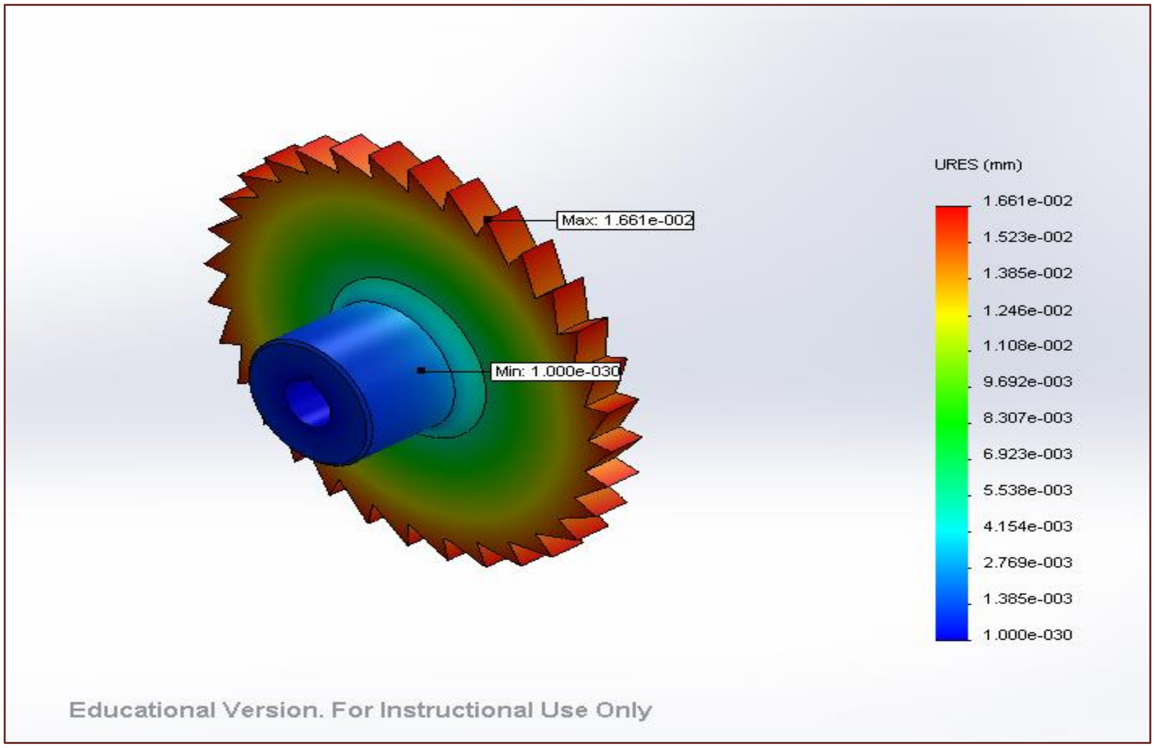


Quantity	Minimum value	Maximum value
Von Mises Stress	0.0112215 N/mm^2 (MPa)	324.027 N/mm^2 (MPa)
Displacement	0 mm	24.642 mm
Factor of Safety	1.08501	N/A

Ratchet



Max: 35.224
Min: 0.012
von Mises (N/mm^2 (MPa))
35.224
32.289
29.355
26.421
23.486
20.552
17.618
14.684
11.749
8.815
5.881
2.947
0.012
Yield strength: 530.000
Educational Version. For Instructional Use Only



Quantity	Minimum value	Maximum value
Von Mises Stress	0.0123005 N/mm^2 (MPa)	35.2236 N/mm^2 (MPa)
Displacement	0 mm	0.0166146 mm
Factor of Safety	15.0467	N/A

CONCLUSION

The existing energy crisis calls for innovative solutions that are cheap and easy to set up. We aimed to create a prototype that can generate electricity from the vast reserves of untapped kinetic energy dissipated by vehicles on busy roads. A system of this type has the following advantages:

- It is a source of renewable energy and it will lessen the dependence on conventional fossil fuels.
- From an environmental point of view, it is both clean and sustainable.
- It is easy to maintain and does not require any labor for its operation.
- It occupies a small amount of space and it does not cause any obstruction to traffic.
- I will provide electricity all-round the year.
- It can be used in a variety of places ranging from streets to schools or hospitals etc.

The system can have the following applications:

- The electricity generated from this system can be used to run street lights, traffic signals and can even partially fulfill the energy requirements of commercial and residential areas in the adjoining areas.
- It can be used on motorways, provide electricity to toll houses, bus stops, sign boards on the roads and also security check posts.
- The Metro Bus projects in Lahore and Rawalpindi- Islamabad have a huge potential of using this system for the generation of electricity.

RECOMMENDATIONS

- Light Emitting Diodes (LEDs) should be used for street lights, traffic signals and lights used in public places instead of incandescent lamps. LEDs are brighter and they consume much less electricity compared to the traditional incandescent lamps. Batteries must be used to store the electricity generated.
- We recommend the use of low-rpm generators, designed for use in wind turbines for this system. These generators produce a greater amount of electricity for a lesser number of rotations of the shaft.
  Reference: http://www.alibaba.com/product-detail/DX-5KW-permanent-magnet-generator-low_1856992949/showimage.html

- For street lights placed adjacent to a particular unit, solar panels can be installed on them to supplement the generation of electricity.
- We had no prior experience of getting something manufactured from the local market. Our inexperienced showed in that there are some discrepancies from the proposed design in the final product. Somebody used to the trade would have managed to get a more accurate fabrication with lesser costs.