# Design Analysis of Single Roller Regenerative Brake system

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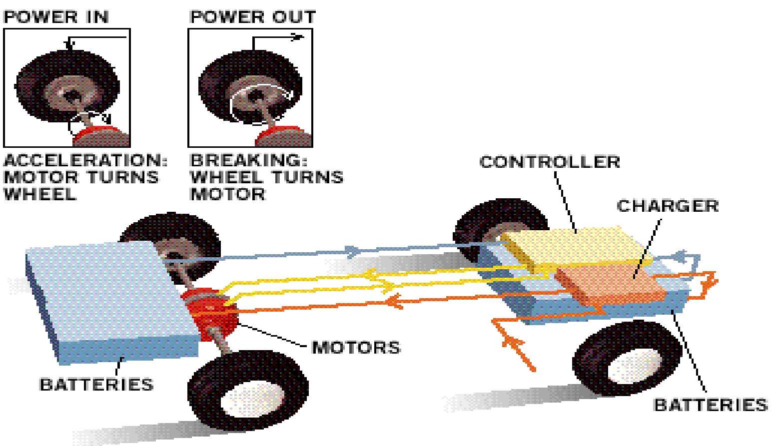
**Abstract** *:* Regenerative braking system is a system for recovering the moving vehicle's kinetic energy under braking load (ie, when brakes are applied) and to convert the this loss in kinetic energy of vehicle which usually would be wasted and dissipated as heat in the brakes into useful form of energy either mechanical or electrical. Conventional regenerative braking systems available in the market are converting the loss in kinetic energy of the vehicle into electrical energy that is stored in battery for further use. It is important to note that the kinetic energy available as mechanical energy is first converted to electrical energy and is stored in the battery ...and then this energy is again converted form electrical energy to mechanical energy by use of motor. Present day regenerative braking systems make use of motor-generator setup for this purpose. Commercial cars due to space occupied, cost, and handling of this energy and utilization is difficult as the commercial cars may encounter frequent braking at short intervals. Hence there is a need of a innovative system to tap the usually wasted loss of kinetic energy to suitable mechanical energy .The proposed mechanical to electrical regenerative braking uses a innovative planetary gear train and dedicated drum brake system to recover the loss of kinetic energy from the wheel hub of the vehicle and convert it to electric energy through a flywheel ad dynamo arrangement. This system is compact , practical and a low cost solution that converts the loss of kinetic energy of vehicle during braking and stores it as electrical energy and gives minimal loss in transmission there by leading to better efficiency and better conversion ratio as compared to any other earlier braking system using motor-generator set up. . 3-d Cad model of system for optimal energy recovery capacity, optimal factor of safety, using Unigraphix Nx-8.0 and CAE of critical component such as the input drum shaft, flywheel gear and friction roller is done meshing using Ansys Work-bench 16.0 is done in the present study.

***Keyword**: - Regenerative Braking, Momentum, Electrical energy, Storage Battery*

## I. INTRODUCTION

Kinetic energy recovery system is used on hybrid gas/electric automobiles to recoup some of the energy lost during retardation or stopping. This energy is converted in to electrical energy and saved in a storage battery for later use to power the motor whenever the car is in electric mode. Conventionally when the brake pads rub against the wheels (or a disc connected to the axle), excessive heat energy is also created. This heat energy dissipates into the air, wasting up to 28 to 30% of the car's generated power. The car's fuel efficiency is reduced over time owing to this cycle of friction and wasted heat energy. More energy from the engine is required to replace the energy lost by braking. Electric motors and electric generators (such as a car's alternator) are essentially two sides of the same technology. Both use magnetic fields and coiled wires, but in different configurations. Regenerative braking takes advantage of this dual nature and whenever the electric motor of a hybrid car begins to reverse direction, it becomes an electric generator or dynamo to generate electricity which is fed into a storage battery for later to power the car.

Regenerative braking system takes energy normally wasted during braking and turns it into usable energy. It is not, however, a perpetual motion machine. Energy is still lost through friction with the road surface and other drains on the system. The energy collected during braking does not restore all the energy lost during driving but it improve energy efficiency helps the main alternator. This is the other technology to be employed controls vehicle speed by converting a portion of its kinetic energy (energy of motion) into another useful form of energy. The energy so produced could then be stored as electric charge in the automobile battery .



## II. PROBLEM STATEMENT:

Disadvantages Of Existing Systems (Need For Project) :

1. Existing systems aim at converting basically the momentum (m x v) of the vehicle in to mechanical energy ….which is further converted into electrical energy by dynamo to be stored into batteries….this energy stored in batteries is later reused to accelerate the vehicle using DC motor….there are bound to be conversion losses at each stage due to in-efficiency of each component of system –viz, the dynamo ---battery---and the electric motor.

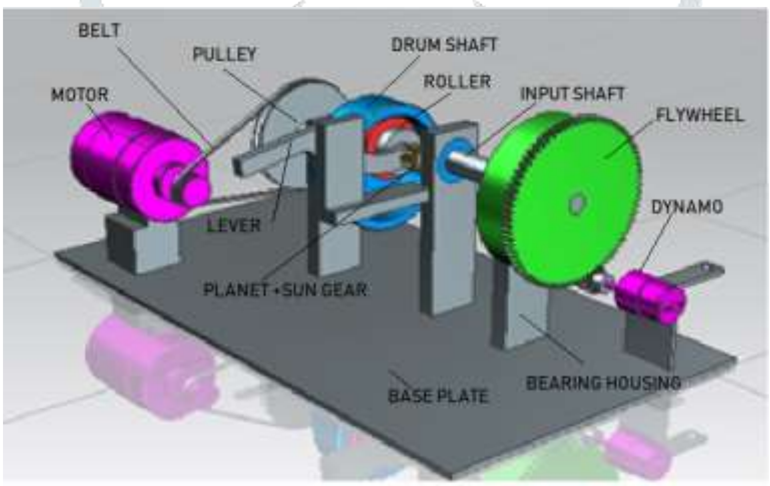
2. The system components of the above discussed system are extremely costly …thereby making implementation of technology close to impossible.

3. Computers and electronic controls are absolutely essential to run the system, hence the running cost of such system is considerably high.

Hence there is need of a simpler system that will convert and store the momentum energy (kinetic energy) into electrical energy via as simple system that by reducing the conversion losses and keep the system production, installation and running cost to minimum.

## III. SOLUTION TO PROBLEM:

The technology used in the single roller regenerative braking system –mechanical regeneration type is as follows




The system as shown above comprises of an electrical motor which is used as prime mover to the prototype. The motor is variable speed which permits to test the set up at various speeds. The motor drives the input drum shaft thus resembles the wheel drum hub of the vehicle by an open belt drive. The brake force is applied to the drum by means of the planet roller that is mounted on a floating pin with an spur pinion at its other end. The pin is mounted on lever which is hinged at its center. The brake lever when applied the friction roller comes in contact with the input drum and starts rotating, its rotary motion is transferred to the sun gear from the planet gear mounted on the planet roller pin. The sun gear is mounted on the main shaft which also carries the flywheel gear. The flywheel gear drives the pinion mounted on the generator. The motion of the flywheel is transferred to the generator and thus electricity is produced.

## 2. Literature review :

[1] As per Mr. Pulkit Gupta , the research work embodied a technology that saves energy from getting wasted by using regenerative braking systems (RBS). According to the when driving an automobile, a great amount of kinetic energy is wasted when brakes are applied, which then makes the start up fairly energy consuming thus a product that stores the energy which is normally lost during braking, and reuses it is necessary The use of regenerative braking system in automobiles provides us the means to balance the kinetic energy of the vehicle to some extent which is lost during the process of braking. The authors in their paper have presented two different methods of using the kinetic energy which generally gets wasted by converting it into either mechanical energy or into electrical energy. Flywheel is used for converting the kinetic energy to mechanical energy other method uses Electric Motor to convert Kinetic Energy into electrical energy.

[2] As per Mr. GouYanan, To improve driving ability of electrical vehicle, a braking regenerative energy recovery of electrical vehicle was designed and therefore the structure of it had been introduced, the energy recovery potency of whole system was outlined and a extremely economical management strategy was suggests, then it had beenembedded into the simulation of ADVISOR2002. The recovery efficiency of the system was up to 60%, the electrical vehicle energy recovery potency was effectively improved.

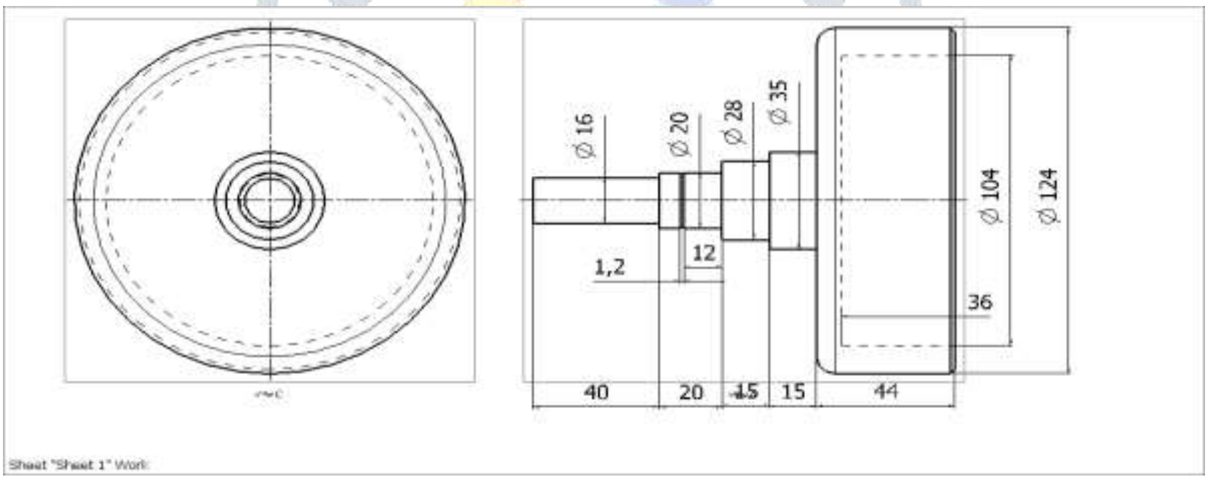
[3] As per Mr. Siddharth K. Patil , here is a need of specific technology that recovers the energy, which gets usually wasted. So, in case of automobiles one of these useful technology is the regenerative braking system. Generally in vehicles whenever the brakes square measure applied the vehicle involves a halt and therefore the K.E. gets wasted thanks to friction within the sort of K.E.. Victimization regenerative braking system in vehicles permits United States to recover the K.E. of the vehicle to some extent that's lost throughout the braking method. Enables us to recover the kinetic energy of the vehicle to some extent that is lost during the braking process. In this paper the author discusses two methods of utilising the kinetic energy that is usually wasted by converting it into either electrical energy or into mechanical energy. Regenerative braking system will convert the K.E. into voltage with facilitate of electrical motor. And it can even convert the K.E. into energy that is equipped to the vehicle whenever it's required, with the assistance of a regulator.

[4] As per Mr. Olufemi In recent years, increased concerns over the impact of the conventional car (ICE – Internal Combustion Engine) on the environment have led to renewed interest and advancement in the Electric Vehicle (EV). While the advancements in the EV technology have been able to overcome many of its initial limitations, the need to improve overall efficiency of the vehicle has led to the design of the regenerative braking system (RBS). The RBS will be used to convert the car's mechanical energy and also the heat that would have been lost during braking into electrical energy

### 2.1 Literature Gap

From careful stud of the literature pertaining to the problem of energy recovery from the momentum of the vehicle that is wasted during the braking process , many methods are proposed , few including flywheels and some with motor generator combination, There is a need to develop a system that could use minimal space and take up minimum cost. The project aims at design development and analysis of one such system using a planet friction roller system

### 2.2. DESIGN OF INPUT DRUM SHAFT




**Material Selection**: -Ref :- PSG (1.10 & 1.12) + (1.17)

| DESIGNATION | ULTIMATE TENSILE STRENGTH N/mm$^2$ | YEILD STRENGTH N/mm$^2$ |
|---|---|---|
| **EN24** | 800 | 680 |

⇒ fs allowable = 0.18 X 800=144 N/mm$^2$

⇒ T design = 0.475 Nm

This is the allowable worth of shear stress which will be iatrogenic within theshaft material for safe operation. Check for torsional shear failure of shaft

$$Te = \frac{\Pi}{16} fs\, d^3$$

⇒ $fs_{act}$ = 16 x 475

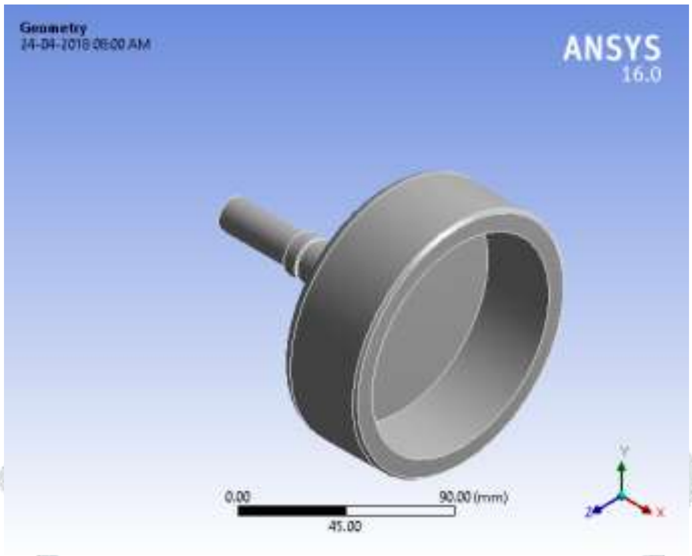
$$\overline{\qquad\qquad} \quad \Pi \times 16^3$$

$f_{act}$ = 0.55 N/mm$^2$

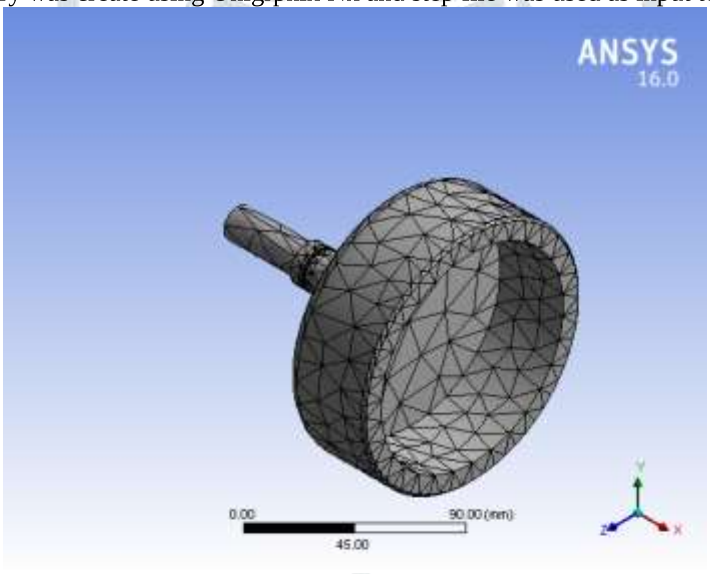
As; $fs_{act} < fs_{all}$

Input drum shaft is safe under torsional load

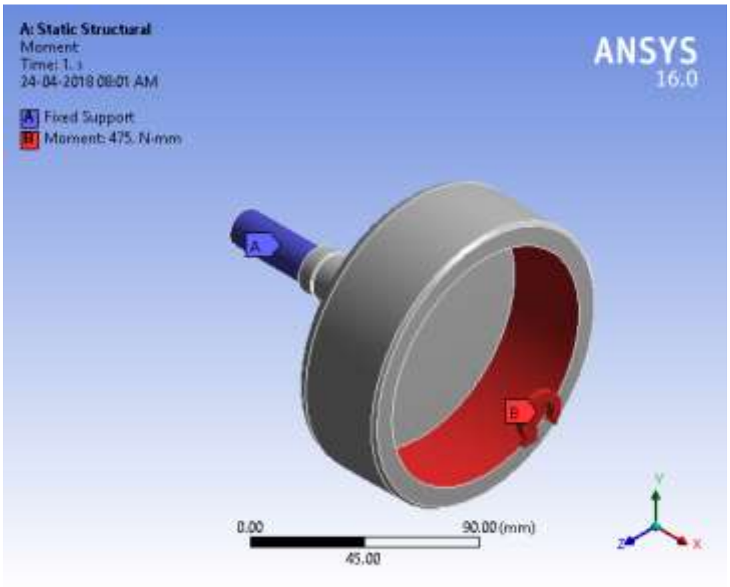
### 2.2.1ANALYSIS OF DRUM SHAFT:



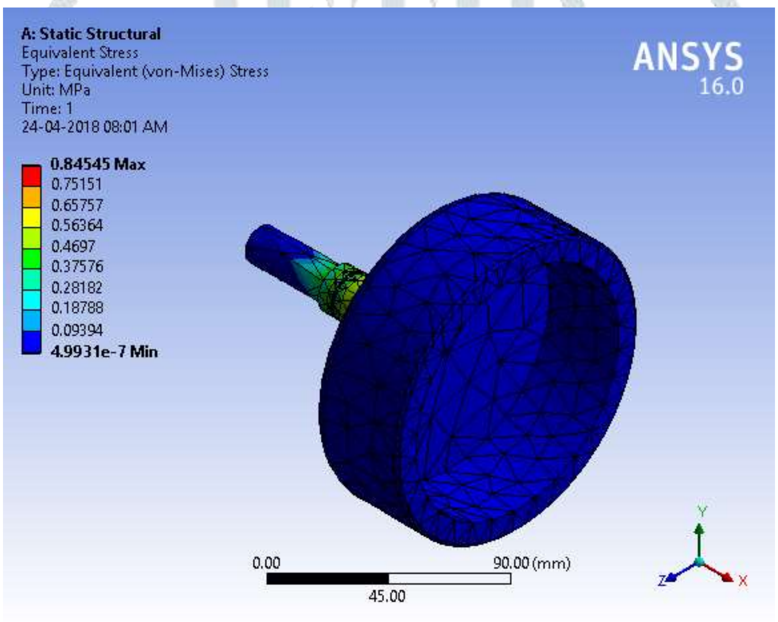

The geometry was create using Unigrphix Nx and step file was used as input to the Ansys.



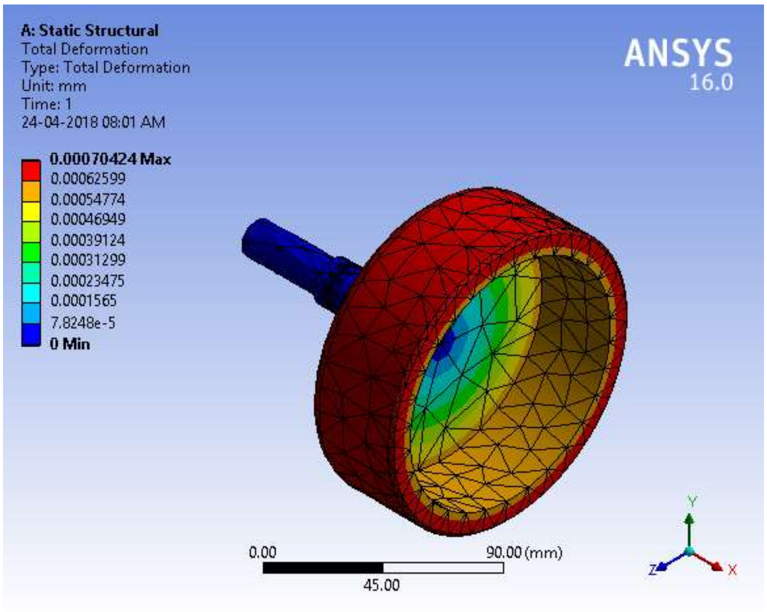

Ansys free mesher was used for meshing




The loading is doone as per diagram above .

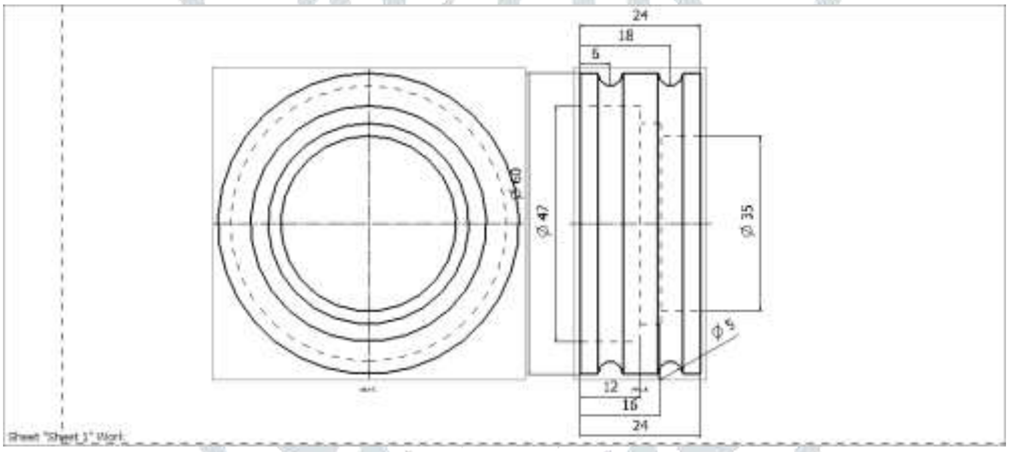



As the induced stress is well below the permissible limit the part is safe.




As the deformation is very negligible the part is safe.

**2.3. DESIGN OF ROLLER:**




MATERIAL SELECTION: -Ref :- PSG (1.10 & 1.12) + (1.17)

| DESIGNATION | ULTIMATE TENSILE STRENGTH N/$mm^2$ | YEILD STRENGTH N/$mm^2$ |
|---|---|---|
| **EN9** | 600 | 480 |

⇒ fs allowable = 0.18 X 800=144 N/$mm^2$

⇒ T design = 0.475 Nm

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

Check for torsional shear failure of shaft

$$Te = \frac{\Pi}{16} fs\, d^3$$

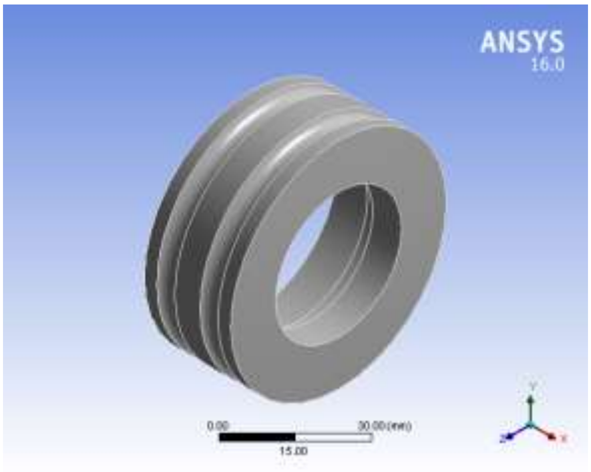
$$\Rightarrow fs_{act} = \frac{16 \times 475 \times 60}{\Pi \times *(60^4 - 47^4)}$$

$f_{act}$ = 0.006 N/$mm^2$

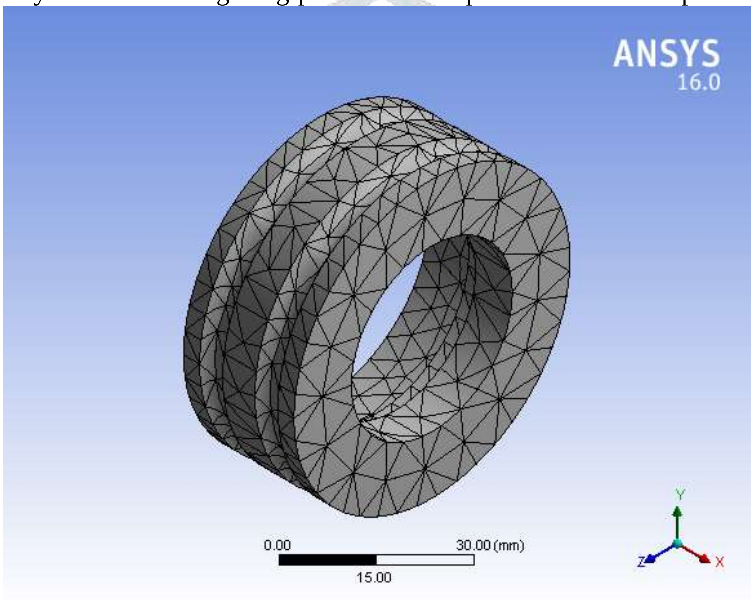
As; $fs_{act} < fs_{all}$

Roller is safe under torsional load.

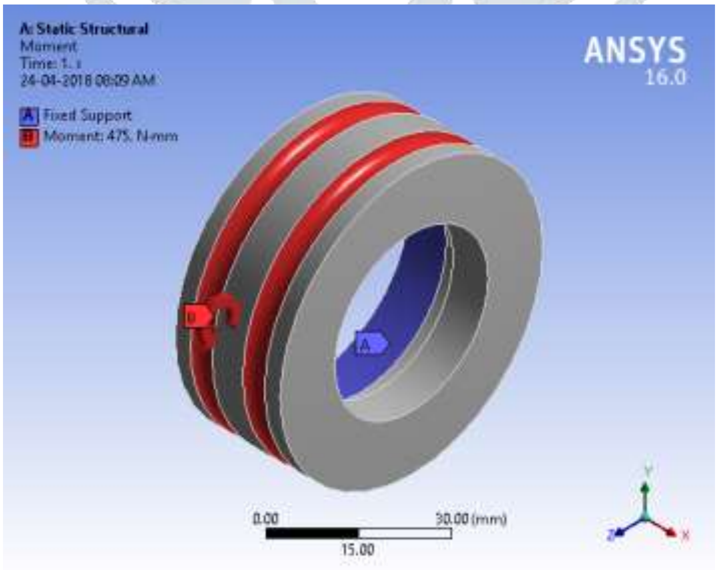
**2.3.1 ANALYSIS OF ROLLER :**

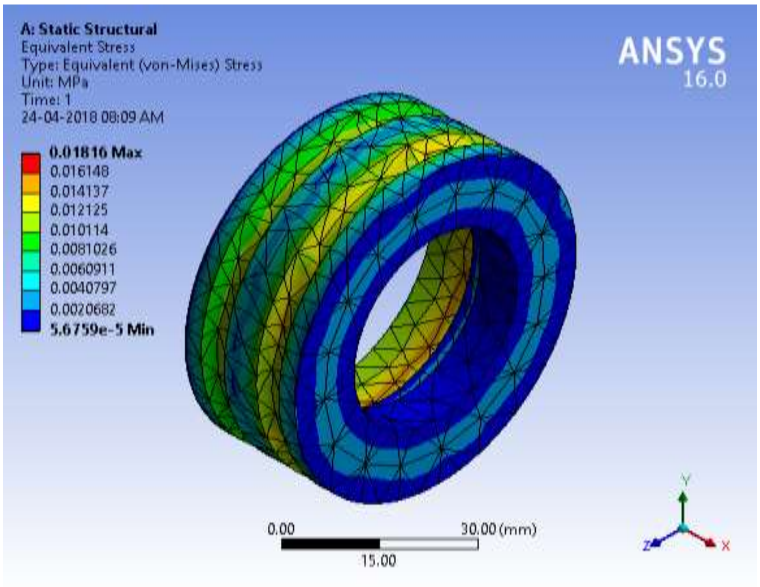



The geometry was create using Unigrphix Nx and step file was used as input to the Ansys

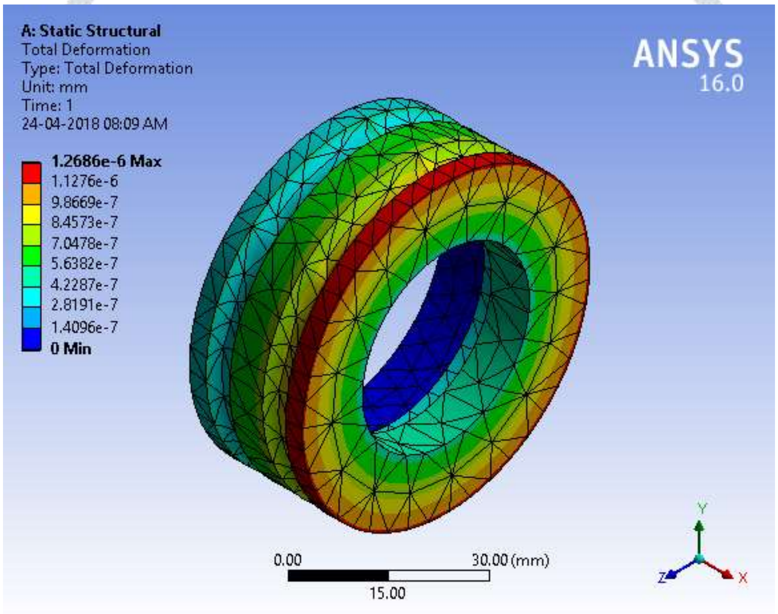



Ansys free mesher was used for meshing.



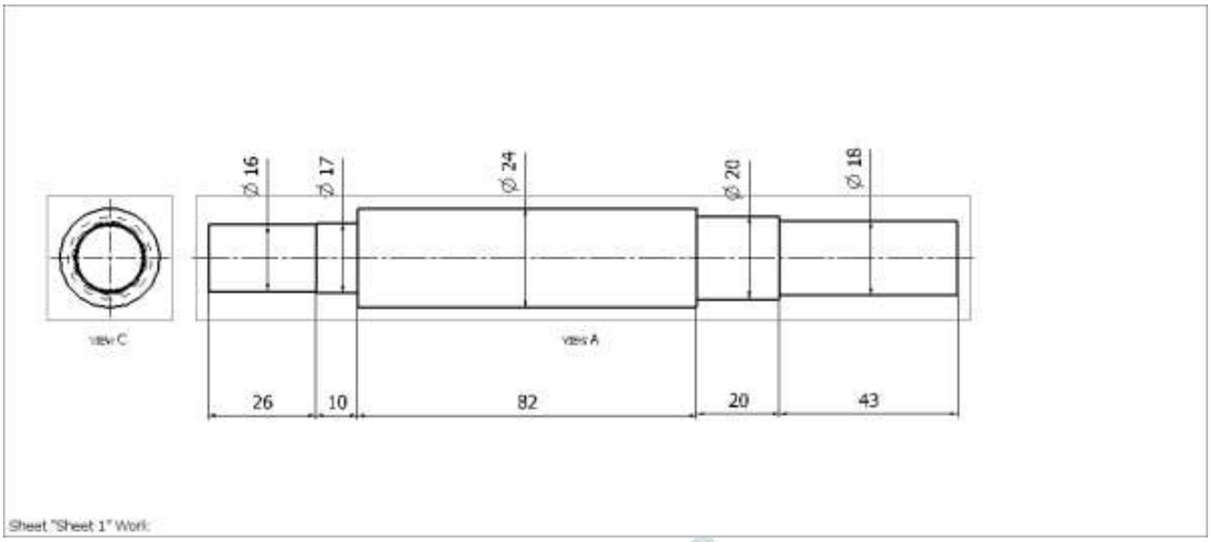



As the induced stress is well below the permissible limit the part is safe




As the deformation is very negligible the part is safe

**2.4 .DESIGN OF INPUT SHAFT:**




Material Selection: -Ref :- PSG (1.10 & 1.12) + (1.17)

| DESIGNATION | ULTIMATE TENSILE STRENGTH $N/mm^2$ | YEILD STRENGTH $N/mm^2$ |
|---|---|---|
| **EN24** | 800 | 680 |

⇒ fs allowable = 0.18 X 800=144 $N/mm^2$

⇒ T design = 0.475 Nm

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

Check for torsional shear failure of shaft

$$Te = \frac{\Pi}{16} fs\, d^3$$

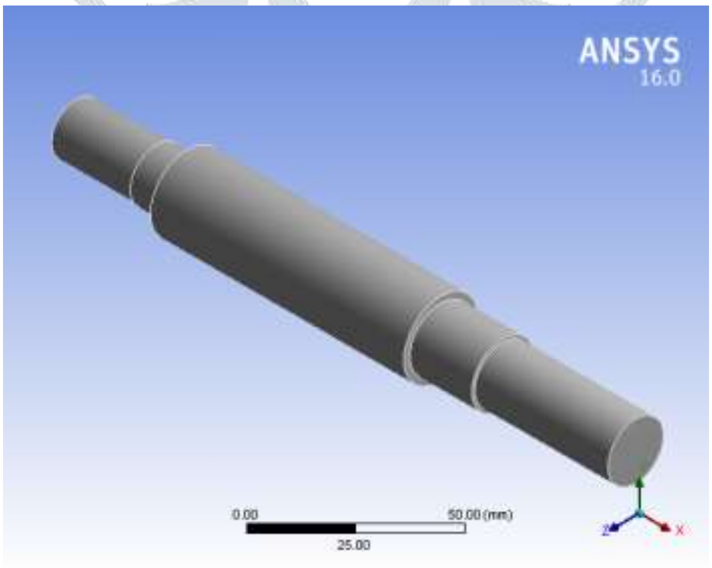
$$\Rightarrow fs_{act} = \frac{16 \times 475}{\Pi \times 16^3}$$

$f_{act}$ = 0.55 $N/mm^2$

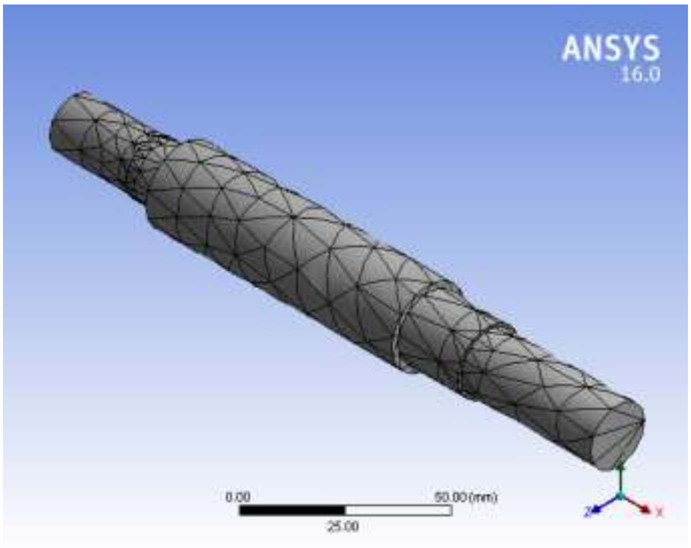
As; $fs_{act} < fs_{all}$

Input shaft is safe under torsional load.

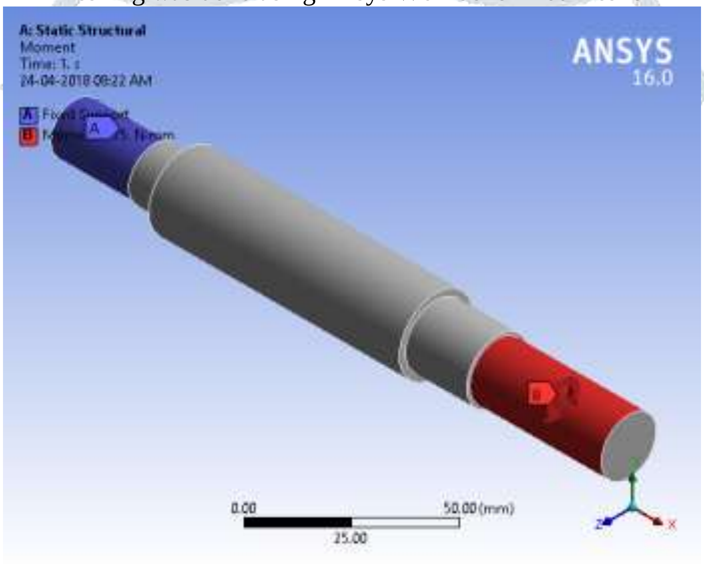
**2.4.1 Analysis of Input Shaft**

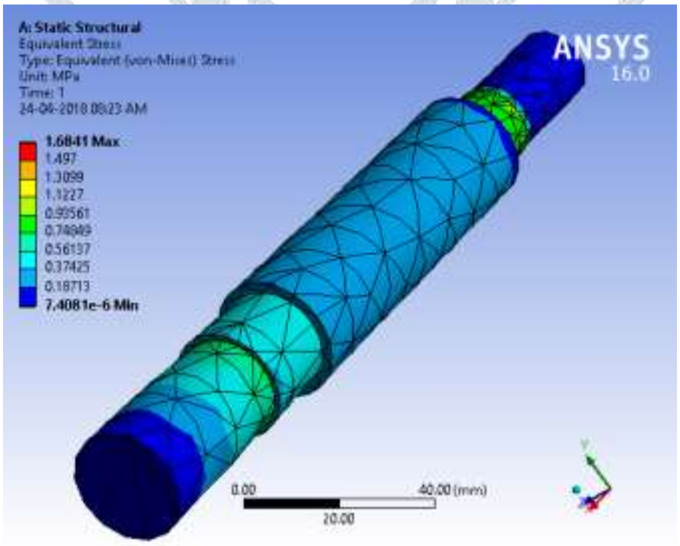



The geometry was create using Unigrphix Nx and step file was used as input to the Ansys

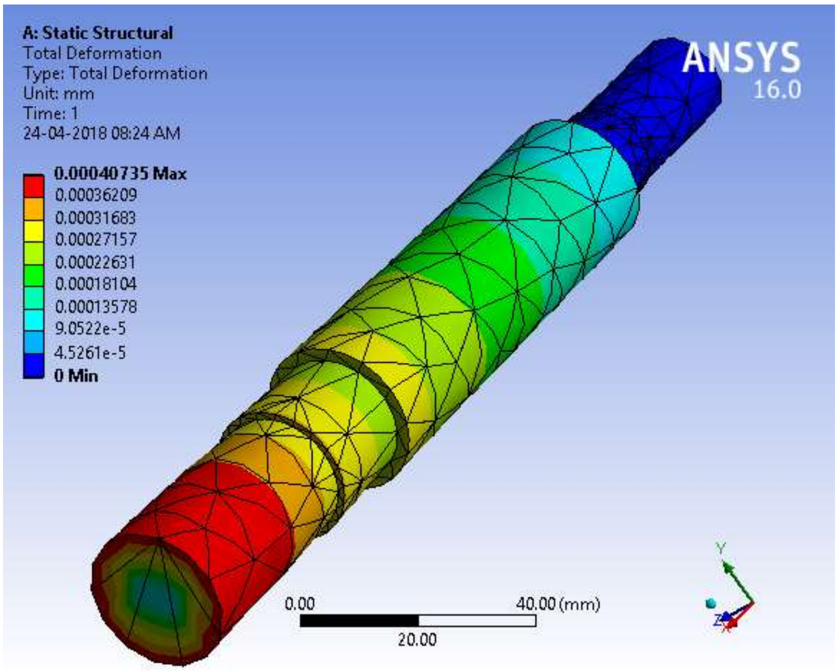



Meshing was done using Ansys Workbench free mesher



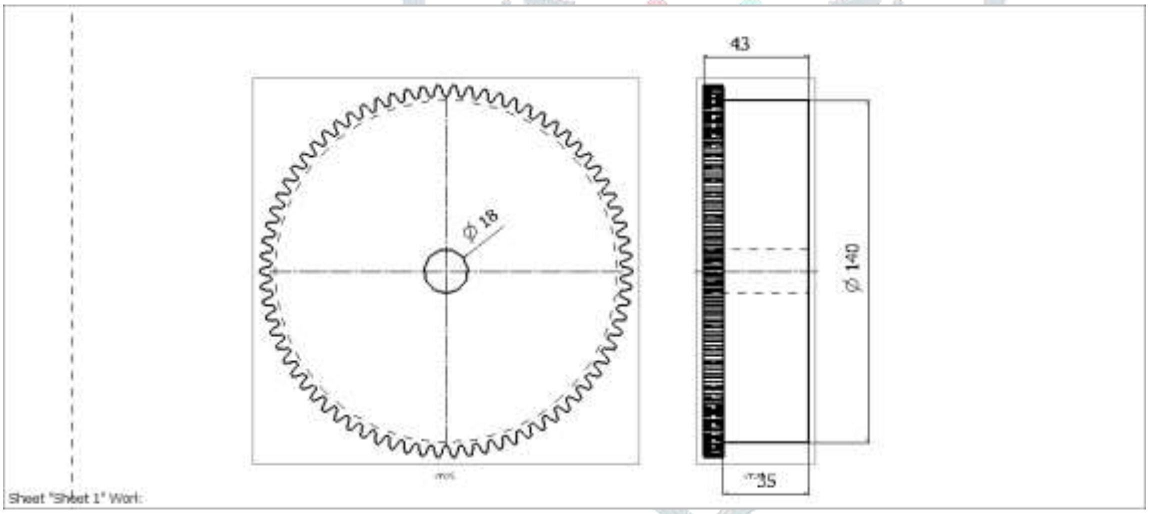




**As the induced stress is well below the permissible limit the part is safe**




**As the deformation is very negligible the part is safe**

## 2.5 .DESIGN AND ANALYSIS OF FLYWHEEL




MATERIAL SELECTION: -Ref :- PSG (1.10 & 1.12) + (1.17)

| DESIGNATION | ULTIMATE TENSILE STRENGTH N/mm$^2$ | YEILD STRENGTH N/mm$^2$ |
|---|---|---|
| **EN9** | 600 | 480 |

$\Rightarrow$ fs allowable = 0.18 X 800=144 N/mm$^2$

$\Rightarrow$ T design = 0.475 Nm

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

Check for torsional shear failure of shaft

$$Te = \frac{\Pi}{16} fs\, d^3$$

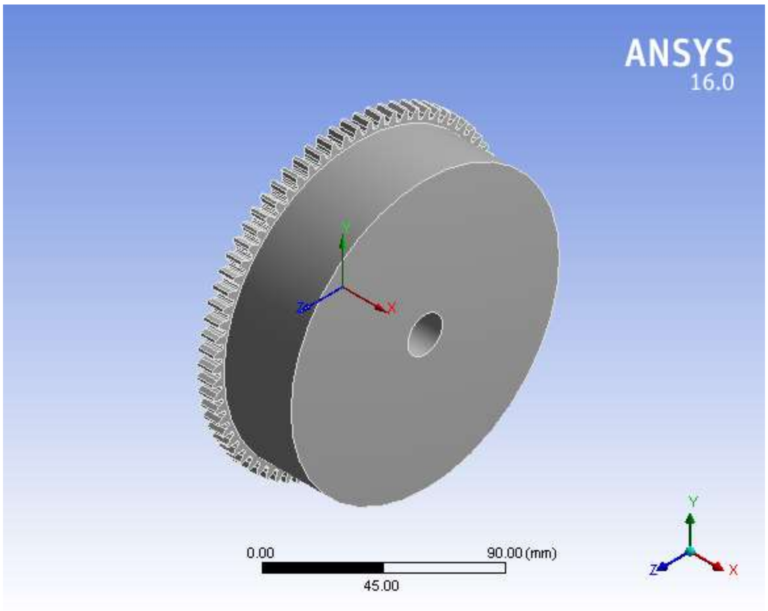
$$\Rightarrow fs_{act} = \frac{16 \times 475 \times 140}{\Pi \times *(140^4 - 18^4)}$$

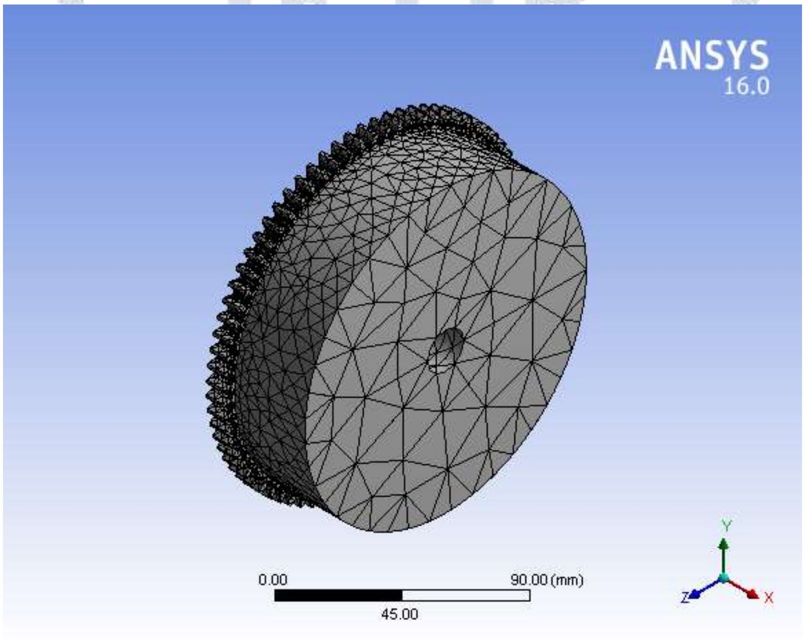
$f_{act}$ = 0.001 N/mm$^2$

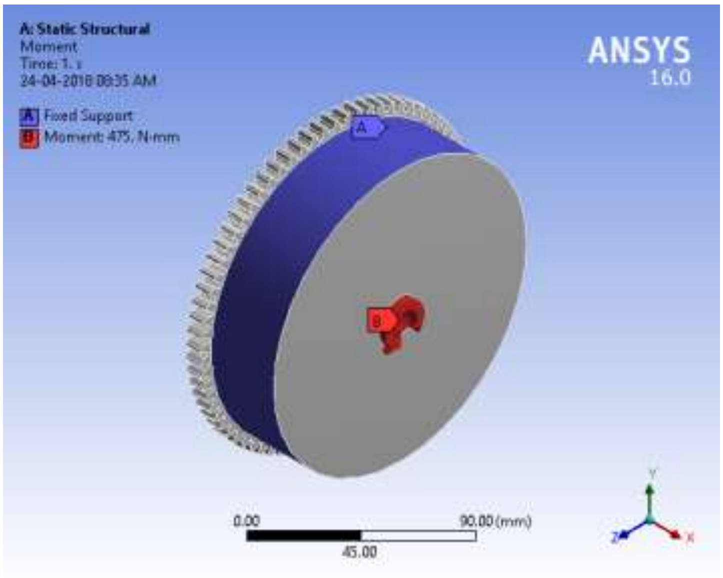
As; $fs_{act} < fs_{all}$

FLYWHEEL is safe under torsional load.

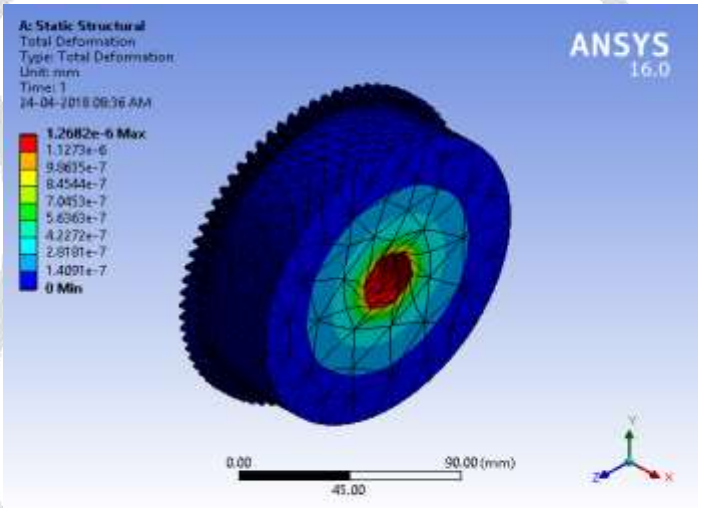
**2.5.1 Analysis of flywheel :**






**As the induced stress is well below the permissible limit the part is safe**




**As the deformation is very negligible the part is safe**

## IV. CONCLUSIONS

After careful review of literature it was found that no specific solution to problem of energy recovery from the momentum of the vehicle that is wasted during the braking process , many methods are proposed , few including flywheels and some with motor generator combination, There is a need to develop a system that could use minimal space and take up minimum cost

An innovative solution is proposed to the problem and all critical parts of the sytem have been designed and anlaysis of the same has proven the parts to be safe.

## V. ACKNOWLEDGEMENT

In the due course of project with the valuable guidance of Guide. Prof. xxxxxxxxr. the project was completed as per schedule and desirable results were achieved.

## VI. REFERENCES

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[2]. Regenerative Braking System in Automobiles Siddharth K. Patil InternatIonal Journal of research In MechanIcal engineering & technology

[3].. Regenerative Braking System (RBS) Olufemi Odutola, Isaac Donkor, Getachew Tesfamariam, Theodore Kahiya