Kinetic Energy Storage and Recovery System using Torsion Spring

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***Abstract*--Energy consumption of a nation is usually considered as an index of its development. Energy is vital for social and economic development. In fact, modern civilization is very much dependent on energy availability, and the whole infrastructure rests upon it. The fossil fuels like coal, oil and natural gas which is at present are supplying 95% of the commercial energy of the world resources and are not going to last for many more years. Our life style is changing very fast and from a simple way of life we are shifting to a luxurious life style. If we just look at the number of electric gadgets, private cars and scooters in our locality we will realize that they have multiplied many folds and all of them consume energy. To meet the increasing energy demands, efforts are being made to improve existing technologies and to develop new approaches for optimising the energy consumption. In this paper kinetic energy storage and recovery system using torsion spring is analysed, the mechanism required to transmit the energy from and to the spring is designed, then its efficiency is tested and amount of fuel saved when this system is adapted to any vehicle for every time the brake is applied is calculated.**

Keywords—KERS, Torsion spring, Energy, Planetary Gear System, Flywheel, Efficiency, Fuel consumption.

I.INTRODUCTION

The transportation sector includes all modes of transportation from personal vehicles (cars,light trucks) to public transportation (buses,trains) to airplanes, One might think that airplanes, trains and buses would consumes most of the energy used in this sector but, in fact, their percentage are relatively small about 9% for aircraft and about 3% for trains and buses. Personal vehicles, on the other hand, consume more than 60% of the energy used for transportation. Our personal vehicles consume more energy than public transportations.

Only about 15 percentage of the energy from the fuel we put in our tank gets used to move our vehicle down the road or run useful accessories, such as air conditioning. The rest of the energy is lost to engine and driveline inefficiencies and idling. Engine losses-62.4%, Idling losses-17.2%, Accessories-2.2%, Driveline losses-5.6%,Aerodynamic drag-2.6%, Rolling resistance-4.2%, Overcoming inertia and Braking losses-5.8%. Therefore, the potential to improve fuel efficiency with advanced technologies is enormous.

Regenerative brake is an energy recovery mechanism which slows down a vehicle or object by converting its kinetic energy into another form, which can be either used immediately or stored until needed. This contrasts with conventional braking systems, where the excess kinetic energy is converted to heat by friction in the brake linings and therefore wasted.

There are several types of regenerative braking systems which differs each other in several ways one of them is energy storing element. Basically there are two types of energy storing elements, electrical energy storing elements and mechanical energy storing elements. In mechanical there are two types of energy storing elements flywheels and springs.

II.SPRING

Spring is a mechanical energy storing element which stores the energy in the form of Strain energy or Elastic Potential Energy. Elastic potential energy is Potential energy stored as a result of deformation of an elastic object, such as the stretching of a spring. It is equal to the work done to stretch the spring. Since the energy which is stored in the spring as Elastic potential energy, this energy is stored only the material deforms with its elastic limits. When the material deforms the stress is induced inside the material. When this induced stress in increased above the certain value the spring's deformation doesn't regain its original position. So the deformation of the spring is limited by its maximum allowable stress. When the stress induced in the material increased higher than its yield stress then permanent deformation occurs. So the maximum energy storing capacity as strain energy of a material and also it is called as proof resilience is depend up on the yield stress (σy) and Young's Modulus (E).

$$U=(\sigma y^2/2E)\times V$$

From the above equation it is observed that the maximum energy storing capacity of the material in terms of strain is depend only up on the Yield strength ,Young's Modulus and volume of the material. When the yield strength of the material is increased the energy storing capacity of the material is increased square the times. So the good spring should be made up of the material which has higher Yield strength and lower Young's modulus. There are different types of spring available such as Compression Spring (Open Coil Helical Spring), Expansion spring (Closed Coil Helical Spring), Torsion spring, Spiral springs etc. In torsion spring and spiral spring, the opposing force is in terms of torque. The below discussed KERS system makes use of torsion spring which is easy to fabricate and commercially easily available and gives the output effort in terms of torque. The energy storing capacity of the torsion spring is differs from the material's proof resilience value due to its geometrical shape.

For Torsion spring,

$$U = (Mb^2\times\pi\times D\times N) / (2EI)$$

Where,

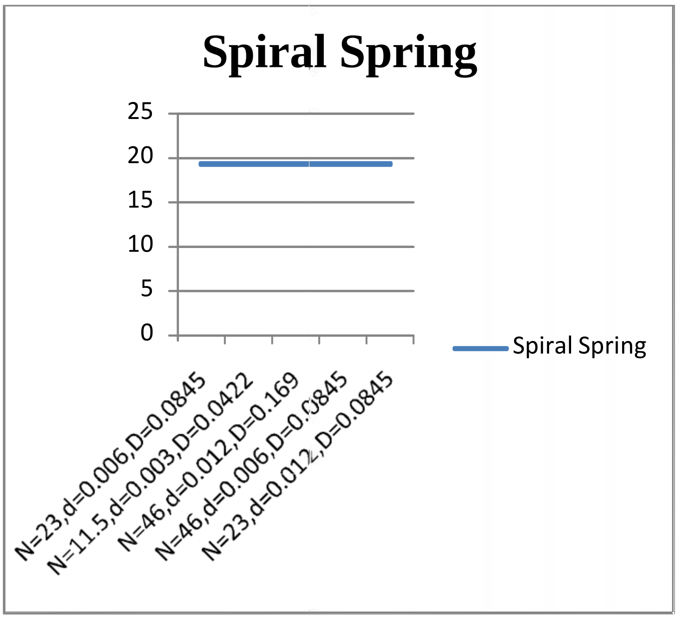
Mb = Bending Moment, D = Outer Diameter,

N= Number of turns, E= Young's Modulus,

I= Moment of Inertia

III.OPTIMIZING THE ENERGY TO WEIGHT RATIO OF TORSION SPRING

In order to do the optimization of torsion spring, the energy densities of spring with 5 different dimensions are found and graph is plotted.

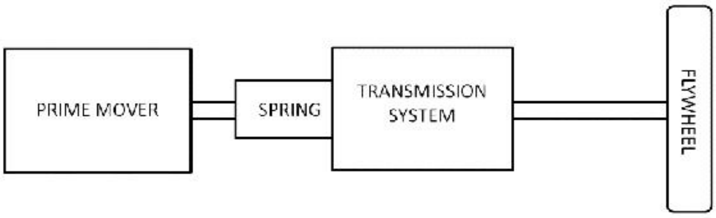


Graph 1: Comparing the energy density of the torsion springs of different geometry.

Material	N=23, d=0.006 m, D = 0.0845 m	N=11.5, d=0.003 m, D = 0.0422 m	N=46, d=0.012 m, D=0.169 m	N=46, d= 0.006 m, D = 0.0845 m	N = 23, d = 0.012 m, D = 0.0845 m	Average (J/kg)
Carbon Steel Wire	19.34 J/kg	19.34 J/kg	19.34 J/kg	19.34 J/kg	19.34 J/kg	19.34

Table 1: Comparing the energy density of the torsion springs of different geometry.

IV.CONSTRUCTIONAL DETAILS OF EXPERIMENTAL MODAL



SIRAL SPRING:

Commercially available torsion spring of below specifications,

Material = Carbon Steel

Young's Modulus (E) = $207*10^9$ N/m^2

Maximum allowable stress (σ_b) = $552*10^6$ N/m^2

Inner Diameter = 70 mm

Outer Diameter =82 mm

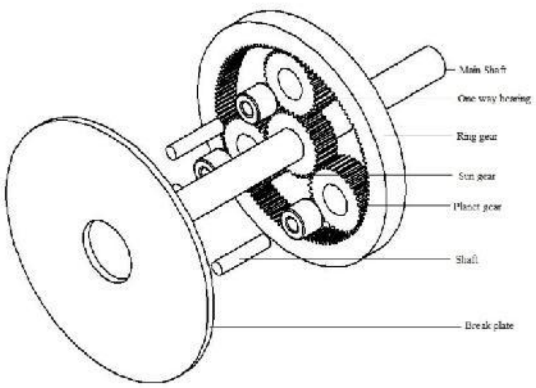
Thickness = 6 mm

Number of turns =23

PLANETARY GEAR SYSTEM:

Planetary gear system consists of,

1. Ring gear.
2. Sun gear.
3. Planet gear.
4. One way bearing (one way clutch).
5. Break disk.

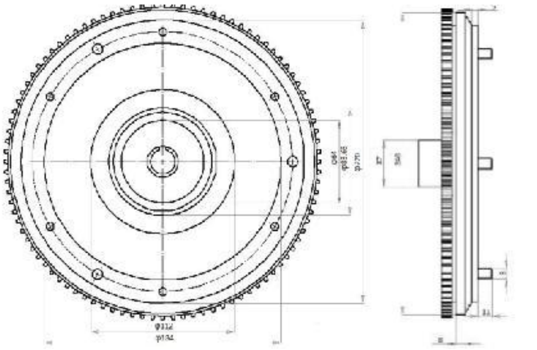


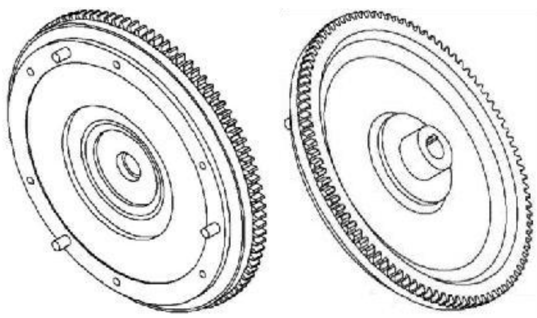
FLYWHEEL:

Flywheel is fixed at the end of the shaft to provide the inertia.

Material = Cast iron

Weight = 5.5 Kg





CONCLUSION:

It is observed that the energy density or energy storage capacity of the spring per unit mass remain same for various parameters such as number of turns (N), Nominal diameter (D) and wire diameter (d). The energy storing capacity is independent of geometrical features of the spring. So it is understood that to maximize the energy storing capacity of the spring, it is not necessary to find the optimal dimensions of the torsion spring. So, it is decided to select the standard available spring in the market for the KERS system. With that selected spring, the experiments are to be conducted to find the fuel economy of the IC engine if the KERS system is adopted.

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