

Modeling and Analysis of Flat Spiral Spring Based Speed Breaker Device for Generation of Electricity

G. Vamsi Krishna, Seeram Srinivasarao, P.Sriharsha, B.V.Neerav, G.E.N.M.S.Satyasai

Abstract: *The human being in the present days without electricity is very difficult for survival. Drastic increase of population demands more electrical energy to meet their day to day requirements, but by using conventional resources to generate electricity is insufficient to meet the requirement. Hence, to conquer this problem, the authors suggested new methodology of generating electricity from non conventional resources. The present work focus on renewable sources of energy, which are popular because of pollution free and abundantly available from the nature. One such energy is generating electricity by using speed breakers; it is innovative and new concept. Most of the roads are crowded with vehicles; there is a chance of tapping the kinetic energy of moving vehicles into electrical energy through speed breaker. The developed rack and pinion mechanism is used to convert this kinetic energy into electrical energy through flat spiral torsion spring, which is the crucial part of the mechanism and used to store and release the energy. The model developed using SOLID WORKS software and spiral spring is analyzed through ANSYS software and results were found satisfactory. The generated electricity is used to illuminate traffic signals, sign boards, direction boards and street lights etc.*

Index Terms: Flat spiral torsion spring, Generator, Kinetic Energy, Pinion and Rack, Renewable Energy, Speed Breaker

I. INTRODUCTION

In the current scenario, electricity his essential power need for all the sectors of human life. The consumption of electricity per capita and availability is the index of national standard of living. The economy of any country can be estimated based on availability of energy, which is an input source to all the sectors.

The main reasons of energy crisis are two, the first reason is the rapid growth of population and the second reason is living styles of human life has been increased drastically. Highly populated cities are specially connected to each other with national and express highway on these road vehicles can run at maximum speed.

Roads are essential means of transportation and so along with the population, the number of wheels on the road is increasing. Their speed also increasing with the development of the high-speed engines. But some areas like market and school where driving at high speed can be dangerous for human life so far safety precaution government road Development Corporation install speed breaker near such areas. The present speed breakers occur rigid in construction and the abundant energy losses when any vehicles pass over it. This loss may be in the form of kinetic energy. This loss of energy can be converted from the kinetic form to other useful form of energy. So the idea to convert this energy into an electrical form is the novel of this project. The growth of the number of motor vehicles yearly increases in India had been 20 percent during the last decade. It increases traffic day by day and it leads to laying speed breakers more and more on the roads to prevent the accidents. These numbers of speed breakers are reducing the kinetic energy of moving vehicles and in order to save this loss of kinetic energy an innovative mechanism needs to develop, which can be used to convert kinetic energy into some useful work. On speed breakers lot of energy is wasted due to frictional forces which are required to slow down the speed of the vehicles. While vehicle passes over a speed breaker with slow speed its weight is sufficient to press the speed breaker and this movement of the dome is converted into generating electricity. In this paper, explaining how electricity generated from speed breaker and underneath mechanism working. The speed breaker consists of hemispherical dome and bottom of this dome one end of the rack is connected and this rack is meshed with pinion which is mounted on the generator shaft. Whenever the vehicle across the speed beaker dome, because of its weight and inertia force sufficient to press the dome against strong springs which are supported bottom of the dome and these springs are required to regain dome to its original position. The downward motion of the rack is converted into rotary motion of the pinion which in turn rotates the generator shaft through meshing gear trains. This high-speed rotational motion will be transmitted to the generator and it will convert the rotational mechanical torque into electrical energy.

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Modeling and Analysis of Flat Spiral Spring Based Speed Breaker Device for Generation of Electricity

The speed breakers lying on roads are utilized to generate renewable energy like electricity, which can be used to illuminate different lights such as the lighting of streetlights, road signals, signboards, etc. The developed mechanism consists of single sided and double-sided racks, flywheel, pulleys, pinions, flat spiral torsion spring, lock disc and main shaft etc. The conversion of reciprocating motion into rotary motion can be achieved by any one of the following mechanisms.

1. Cam and follower mechanism
2. Rack and Pinion mechanism
3. Roller mechanism
4. Crank and shaft mechanism
5. Scotch yoke mechanism
6. Spring coal mechanism etc.

Applications: The developed model having the following numerous applications.

- a) For home applications.
- b) For street lighting.
- c) For signal lighting.
- d) Sign boards on the roads
- e) Lighting of the bus stops
- f) Lighting of the check post on the highways
- g) For small industry applications.
- h) For other application on the roads like loud speaker, signal light, road indicator, direction indicator etc.

II. LITERATURE REVIEW

Several researchers have approached to develop different methodologies to use loss of kinetic energy at speed breakers to convert into mechanical energy and there by generate electric power. The different approaches adopted by the researchers are presented below.

Amol Sheshrao Fawade[1] developed mechanism to generate electric power using compressed air which is generated through piston and cylinder compressor arrangement and compressor will get input motion through rack and pinion mechanism, rack will get the reciprocating motion through speed breaker. Dave Jaymin J[2] developed power generation system through nonconventional energy source of compressed air. When vehicle passes over the speed breaker, this will move downward motion which in turn transmits this motion in to compressor then the compressed air stores in the compressor. The advantage of this setup is to convert wasted energy into useful work.

G. Ramakrishna Prabu and G.Ethiraj[3] have developed electricity generating device from speed breakers using gear arrangement and electronic gadgets. The principal of working is to convert potential energy to electrical energy.

This system is used to convert potential energy of vehicle at high altitude on a speed breaker into kinetic energy. Whenever the vehicles climb on inclined plates/roads, it gains potential energy which can be utilized to provide device underneath the speed breaker dome and when the breaker come down the downward motion is transmitted through crank type lever fitted to a ratchet wheel type mechanism. This in turn rotates shaft loaded with springs, and coupled with dynamo to convert kinetic energy into electric energy.

A. Padam Rao [5] has developed mechanisms to tap the loss of kinetic energy at speed breakers to electrical energy. He developed crank shaft mechanisms, Spring Coal mechanism, Roller mechanism and Pinion and rack mechanism. These mechanisms are used to convert kinetic energy of moving vehicles to mechanical energy of the rotating shaft which in turn rotate the dynamo shaft. Aniket Mishra, Pratik Kale and Atul Kamble [7] have developed the rack and pinion mechanism to convert kinetic energy of the moving vehicles into mechanical energy which in turn generate electricity. R.Gupta and S.Sharma[9] attempt to show the different techniques to generate electricity through speed breakers with their limitations. It is observed from the literature review that based on many of researchers converted kinetic energy into mechanical energy intermittently there by continuation generation of electricity is not possible. There is no literature reporting that using speed breaker concept to generate uninterrupted power. Therefore there is a vital need to make an attempt to address this problem and develop the mechanism to generate continuous power against intermittent supply of input power.

III. PROCEDURE

Conversion of loss of kinetic energy of moving vehicles into generation of electrical power is explained through block diagram as shown in figure 1. When automobile vehicles are moving on the Speed Breaker, the speed breaker pressing down words and the developed mechanism to energize and de-energize spiral spring and supply continues rotational motion to electric generator, then it generates electric power which is utilized to end user applications like, streetlights, traffic signals and lamps. etc.

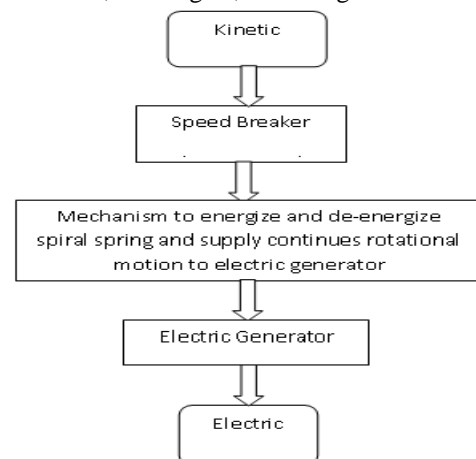


Fig 1: Block Diagram



IV. METHODOLOGY

Whenever vehicles are passing on the Speed Breaker, the speed breaker pressing down words and the lever contains teeth is attached underneath to speed breaker dome. This rack drives the main shaft through pinion gear arrangements in desired direction as shown in figure 2.

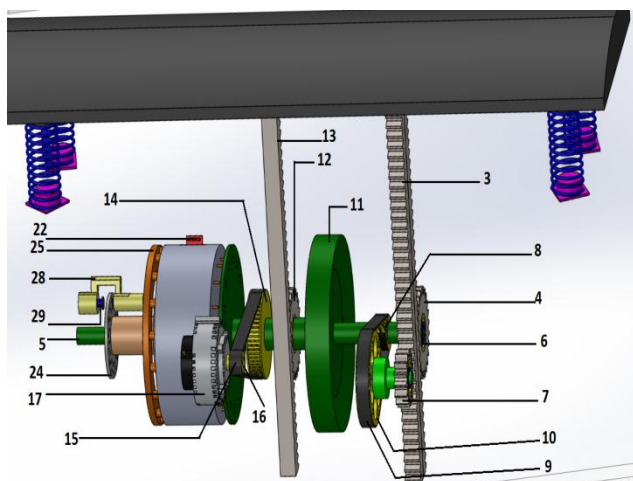


Fig. 2: Detail 3D view of working mechanism

The main components as shown in figures 2, 3 and 4 of the mechanism are 3. Double sided rack; 4,7,12. Pinion; 5. Main shaft; 6. Lock disc; 8,10. Pulley; 9. Belt; 11. Flywheel; 13. Single sided rack; 14, 16. Timing pulley; 15. Timing belt; 17. DC Dynamo; 22. Flat spiral spring; 24. Disc; 25. Outer spike disc; 28. Caliper; 29. Piston.

Whenever there is no load on the dome then the entire setup of dome will come to original position against spring forces. During in this direction the pinions which are meshing to rack are rotating in reverse direction, In order to avoid this reverse direction the pinion is mounting on sprocket wheels, which allows only in one direction and other direction the pinion will rotate freely on the shaft. It ensures that always the main shaft will rotate in one direction only. Flywheel is mounted on the main shaft which is used to regulate the speed of the main shaft in all the directions of rack movements. The main shaft coupled with generator to produce electricity.

As a result flywheel will rotate and this rotation of the flywheel will cause the DC generator to produce electricity. The generated electricity can be utilized to light the lamps/ input the grid power system. Whenever vehicle is passing on to the speed breaker then the dome of the speed breaker presses down due to weight of the vehicle and downward motion of the it is transmitted to pinion through rack. The return of the dome to its original position is achieved by compression springs which are placed at bottom of the dome as shown in figure 2. The single sided rack meshing with pinion which is rigidly mounted on the main shaft. The double sided rack is used to move the main shaft on both directions up and down motion of the rack. A flywheel is rigidly fixed on the main shaft and its function is to run the shaft uniformly against fluctuation of the energy. The dynamo is connected to main shaft through belt drive which converts mechanical energy into electrical energy. Irrespective of the traffic the power is generated

continuously with the help of flat spiral torsional spring, which energize when vehicles moves on the speed breaker and if there is no vehicles pass on the speed breaker during that period the stored energy of the spring is released and de-energized. All these mechanisms housed under the dome, which is called HUMP. The electrical output can be increased by arranging these domes in series and generated electrical power can be amplified and stored by using different electrical devices.

V. FUNCTIONS OF MAIN COMPONENTS OF PROPOSED SYSTEM

The proposed mechanism consists of the following main components which are modeled by using SOLID works software.

1. Speed Breaker
2. Rack
3. Power transmitting shaft
4. Flywheel
5. DC dynamo
6. Drum

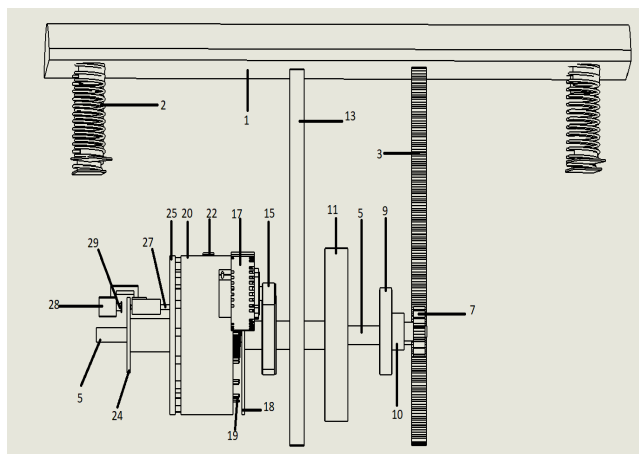


Fig. 3 shows the detail 2D front view of working mechanism

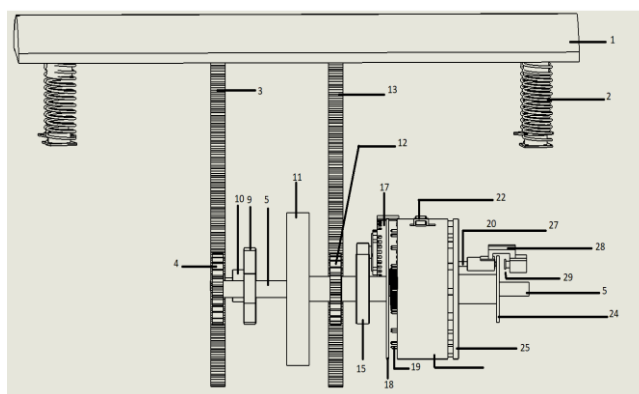


Fig. 4 shows the detail 2D rear view of working mechanism

The following sections discussed the detail function of each component.

A) Speed Breaker

The speed breaker made of cast iron, which withstand high force and capacity to absorb vibrations. The dome of speed breaker is supported on four compression springs which are required to regain its original position of dome after vehicle is pass on speed breaker. At the bottom of the speed breaker the two racks are welded which are moving up and down along with dome and these are the main links to transmit reciprocating motion of the speed breaker.

B) Rack

There is one single sided rack and one double sided rack both are welded to dome. Single sided rack is meshed with pinion which is fixed on the one direction bearing to the main shaft of drum. The double sided rack is used to get the power in both the ways as shown in figure 5. One side of double sided rack is meshed with fixed pulley which is mounted on the one direction bearing and other side of teeth is meshed with another pulley which is fixed on one direction bearing. When speed breaker is pushed down then the two racks are moving down and the two pulleys meshing with rack are rotating the main shaft. Due to spring forces the speed breakers return back to original position, during return the double sided rack is used to rotate the main shaft, therefore in both the directions the main shaft rotates.

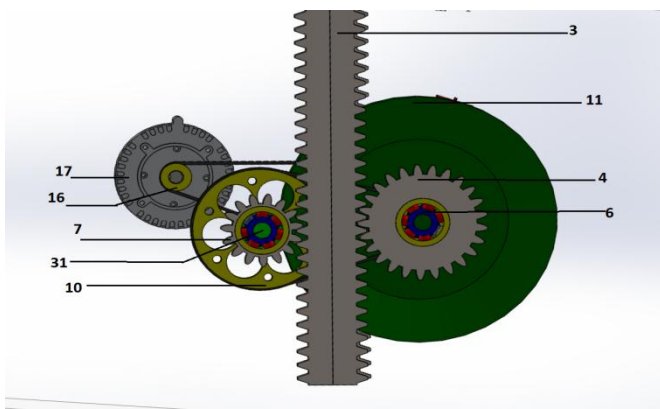


Fig. 5: Mechanism to produce power in both the directions of the rake movement

C) Power transmitting shaft.

The purpose of this shaft is to transmit the torque and rotational motion to the DC dynamo. It carries one direction bearings, pulleys, Flywheel, gear and drum. The main shaft assembly as shown in figure 2.

D) Flywheel

A flywheel is mechanical component and acting as a reservoir, it absorbs energy during the period where the supply of energy is more than requirement and releases energy where the requirement is more than the supply of energy. The main function of flywheel is to reduce torque fluctuations of the shaft due to variation of input torque on the main shaft. Flywheel is rigidly mounted on the main shaft and it will maintain uniform speed the shaft which in turn rotates the dynamo.

E) DC Dynamo

A dynamo is a device which is used to generate electricity and its working according to Faraday's laws. Whenever a current carrying conductor is moving in a varying magnetic field, an electromotive force induced in the conductor. This device consist of stator which provides magnetic stationary field and armature which is rotating windings within the stationary field. The electrons in the metal move due to magnetic field cause to push the electrons.

According to [Faraday's laws of electromagnetic induction](#), whenever a conductor is placed in a varying magnetic field (OR a conductor is moved in a magnetic field), an emf (electromotive force) gets induced in the conductor. The magnitude of induced emf can be calculated from the [emf equation of dc generator](#). If the conductor is provided with a closed path, the induced current will circulate within the path. In a DC generator, field coils produce an electromagnetic field and the armature conductors are rotated into the field. Thus, an electromagnetically induced emf is generated in the armature conductors. The direction of induced current is given by [Fleming's right hand rule](#). The motion of the wire within the magnetic field causes the field to push on the electrons in the metal, creating an electric current in the wire. On small machines the constant magnetic field may be provided by one or more permanent magnets; larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils. The electricity created by this dynamo can be stored in batteries and can be further used according to requirement.

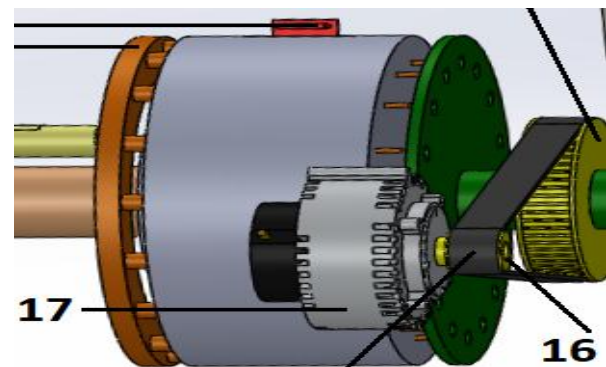


Fig. 6: Dynamo (17)

F) Drum

Drum is housing which is accommodating spiral spring and mechanism to wound and unwound the spring and inner and outer spike rings.

VI. WORKING PRINCIPLE

Working principle of speed breaker mechanism is explained through the half sectional view of complete setup as shown in figure 7. When vehicles passes over the speed breakers the rack 3 and 13 are moves downwards and pinion 4 and 12 will rotates in clockwise direction by rotating the shaft 5 in the same direction.

Pinion 7 will rotate freely on the one way bearing. Once vehicle passes over the speed breaker, the speed breakers will move upwards due to spring forces, during this upward motion the pinion 7 will rotate the main shaft via belt drive and other two pinions 4 and 12 are freely rotate on the one way bearing. This type of arrangement with both the directions the main shaft will rotate and the rotational motion is transferred to wound the flat spiral spring.

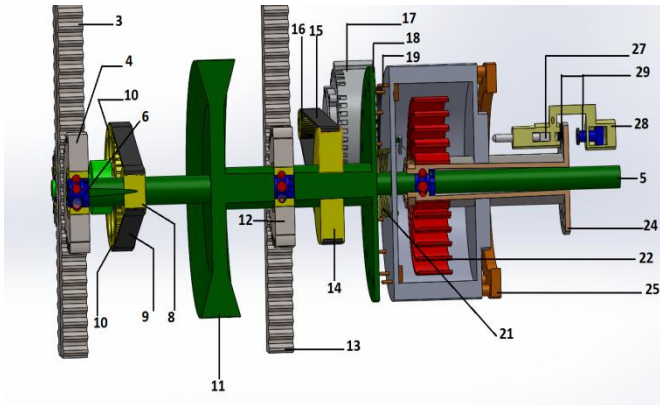


Fig 7. Sectional view of working mechanism

A) Lock Mechanism

Pinion or Pulley is fixed to outer ring and main shaft is fixed to inner ring as shown in figure 8. The pinion rotates in anti-clock wise direction and the outer ring is also rotates in the same direction and pins which are hinged to outer ring are slides over slant teeth of inner ring and inner ring remains stationary. If the pinion rotates in clock wise direction, the pins are locked to teeth of inner ring and inner ring starts rotating the main shaft.

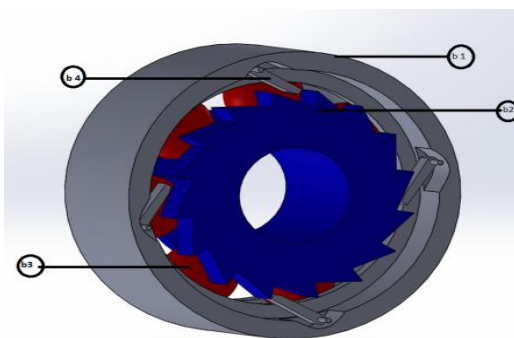


Fig. 8: Locking mechanism

B) Drum Assembly mechanism

The working mechanism of drum is illustrated with the help of half sectional view as shown in Fig. 9. When vehicle passes through the speed breaker, then the two pistons (p2) and (p3) in the caliper (22) lock the disc (23) from rotating to which the lower end of the spiral spring is connected. Simultaneously the piston (p1) moves the drum towards lock disc (18), since drum (20) is locked to the lock disc through spike disc (19) it starts rotates in anti-clockwise direction with the main shaft (5). The upper end of the spiral spring is connected with the drum, therefore the spiral spring starts winding. When hydraulic brake is released, the drum is pushed back with the help of compression spring

(21) fitted between the lock disc and the drum. Then the drum gets locked with the second spike disc. Since the brakes are released spring starts to unwind by rotating the bearing. A string 23 is connected to the one way rotating bearing at the center of the drum and the spike disc as shown in figure 9. The string winds to the one way rotating bearing simultaneously with the spiral spring. when the spring is wound completely the string also will wind completely therefore the string pulls the spike disc back, therefore the drums link with lock disc gets disconnected then spiral springs get unwound. A spring is connected between the drum and the spike disc, since the string get loosen again spike disc get locked with the lock disc. The drum again rotates in anti- clockwise direction and spiral spring starts winding.

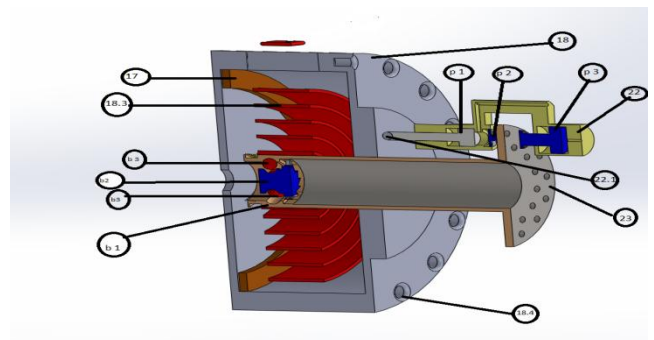


Fig. 9: Half sectional view of drum

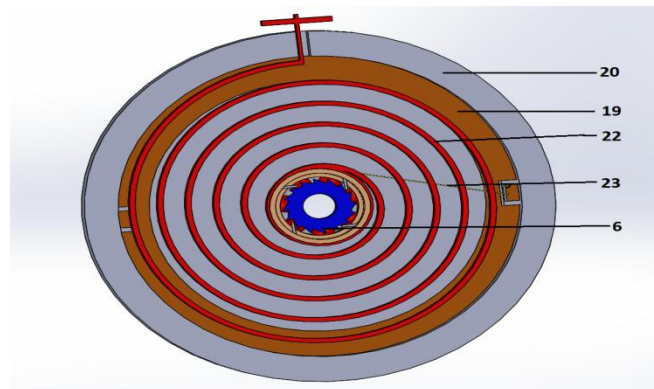


Fig. 10: Spiral spring housing

VII. RESULTS

The performance of crucial part Flat spiral spring of the power generation system has been analyzed using ANSYS software and results have found as shown in figures bellow. Static structural analysis being carried out and maximum deformation found was 0.89058 mm as shown in figure 11 and also performed deformation along individual axis as shown in figure 12, along X-axis the deformation found was 0.001568 mm and it's almost negligible. Shear elastic strain in XY plane of the spiral spring was found 1.035×10^{-5} as shown in figure 13. The total deformation under tensile load was found 2.2245 maximum and zero minimum as shown in figure 14.

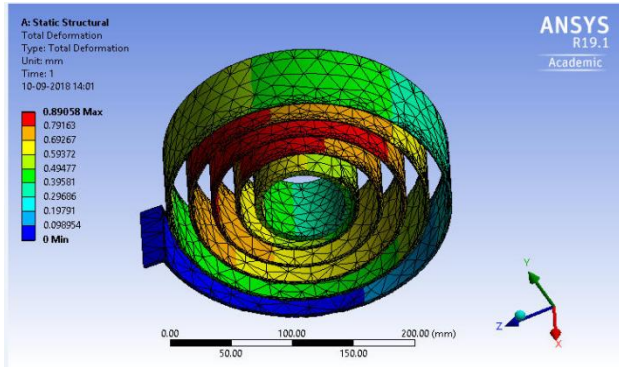


Fig 11: Total deformation of the spring material

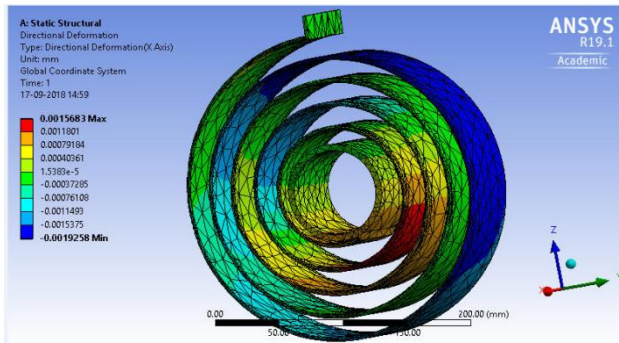


Fig 12: Deformation along X-axis

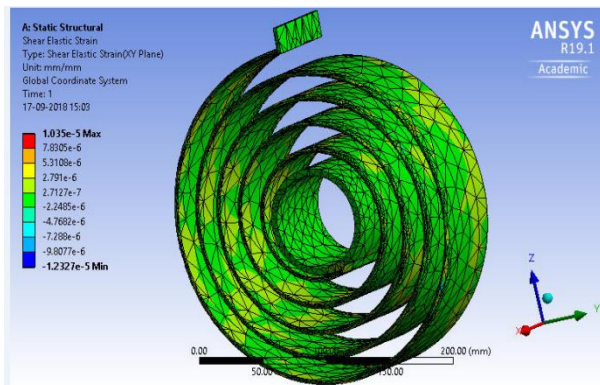


Fig 13: Shear Elastic Strain

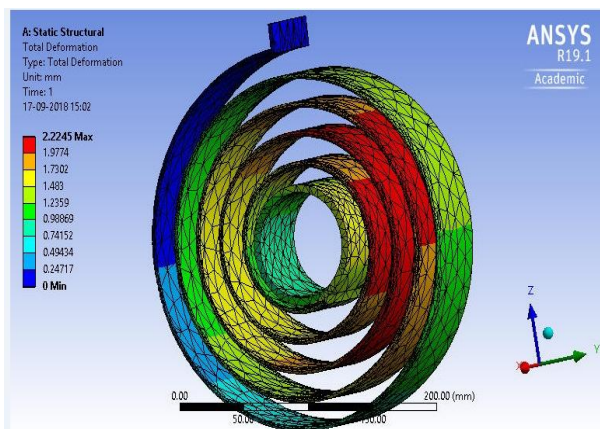


Fig 14: Deformation under tensile load

VIII. CONCLUSION

In the present scenario most of the devices operate with electricity and requires a large supply of electricity. By using conventional resources amount of generating electricity is difficult to meet the demand. Therefore a small

attempt tries to meet the demand by using renewable energy generation through speed breaker. This project makes use of that energy and used it to produce electricity to overcome power shortage in India and the rest of the world. Springs of Yamaha bike are used which are easily available and cost efficient. The inverter was designed to make this project power efficient. Efficiency is improved by using shock springs and specially designed rack pinion due to which mechanism is able to bear more heavy vehicles. The whole mechanism is placed in a dome, which can be placed anywhere. The developed mechanism is used to generate electricity from speed breakers has been successfully implemented. Operation of this mechanism does not require any fuel input, low running cost and also it is a non conventional form of energy and hence it is very useful in the present energy crisis.

FUTURE SCOPE:

The developed mechanism consists of mechanical movable parts which develop frictional forces and wear and tear is more and it requires frequent maintenance. The initial cost of this mechanism is very high, the overall efficiency, reduced due to frictional losses. The single speed breaker is used to generate the low amount of electricity and in order to increase electricity use multiple speed breakers.

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