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DESIGN AND ANALYSIS OF REGENERATIVE BREAKING SYSTEM ON ELECTRIC VEHICLES

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Abstract

Nowadays energy crisis is the most important issue faced by many countries. To tackle it efficient machine design and electric vehicles are best fit practical solutions. In advanced countries regenerative braking system is the area where most of the work is going on. In this project we are using this regenerative breaking concept to apply brakes to vehicle and creating electrical energy simultaneously by using alternator. Regenerative braking is an energy recovery mechanism that slows a vehicle or object by converting its kinetic energy into a form that can be either used immediately or stored until needed. In the project we are applying this concept to one wheel which is rotating. Its mechanical rotary energy is converted into the electrical energy. This electrical energy can be stored and utilized in critical situations or to run the internal components present in the car. To develop and design this project we are using solid works software. Then final manufacturing and testing will be done, and results will be plotted out.

Index Terms: *Regenerative system, Finite Element Analysis, Solid works*

1. INTRODUCTION

Moving vehicles have a lot of kinetic energy, and when brakes are applied to slow a vehicle, all that kinetic energy has to go somewhere. Back in the Neanderthal days of internal combustion engine cars, brakes were solely friction based and converted the kinetic energy of the vehicle into wasted heat in order to decelerate a car. All of that energy was simply lost to the environment. Fortunately, we have evolved as a species and developed a better way. It is important to realize that on its own, regenerative braking isn’t a magical range booster for electric vehicles. It doesn’t make electric vehicles more efficient per se, it just makes them less inefficient. Basically, the most efficient way to drive any vehicle would be to accelerate to a constant speed and then never touch the brake pedal. Since braking is going to remove energy and require you to input extra energy to get back up to speed, you’d get your best range by simply never slowing down in the first place.

But that obviously isn’t practical. Since we need to brake often, regenerative braking is the next best thing. It takes the inefficiency of braking and simply makes the process less wasteful. To evaluate regenerative braking, we really need to look at two different parameters, efficiency, and effectiveness. Despite sounding similar, the two are quite different. Efficiency refers to how well regenerative braking captures ‘lost’ energy from braking. Does it waste a lot of energy as heat, or does it turn all of that kinetic energy back into stored energy? Effectiveness, on the other hand, refers to how large of an impact regenerative braking really makes. Does it measurably increase your range, or will you not notice much of a difference? No machine can be 100% efficient (without breaking the laws of physics), as any transfer of energy will inevitably incur some loss as heat, light, noise, etc. Efficiency of the regenerative braking process varies across many vehicles, motors, batteries and controllers, but is often somewhere in the neighborhood of 60-70% efficient. Regen usually loses around 10-20% of the energy being captured, and then the car loses another 10-20% or so when converting that energy back into acceleration, according to Tesla. This is fairly standard across most electric vehicles including cars, trucks, electric bicycles, electric scooters, etc. This system is called regenerative braking. At present, these kinds of brakes are primarily found in hybrid vehicles like the Toyota Prius, and in fully electric cars, like the Tesla Roadster. In vehicles like these, keeping the battery charged is of considerable importance.

2. DESIGN OF SYSTEM

Solid work is the use of computers to aid in the creation, modification, analysis, or optimization of a design.

software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. output is often in the form of electronic files for print, machining, or other manufacturing operations

Solid work is used as follows:

1. To produce detailed engineering designs through 3-D and 2-D drawings of the physical components of manufactured products.
2. To create conceptual design, product layout, strength and dynamic analysis of assembly and the manufacturing processes themselves.
3. To prepare environmental impact reports, in which computer-aided designs are used in photographs to produce a rendering of the appearance when the new structures are built.

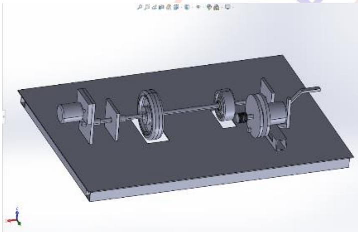


Fig.1: SOLIDWORKS Model of Regenerative Breaking System

2.1. Parts for Design and Analysis

Fig.2: Brake plate

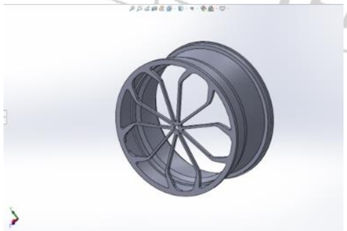


Fig.3: Wheel Rim

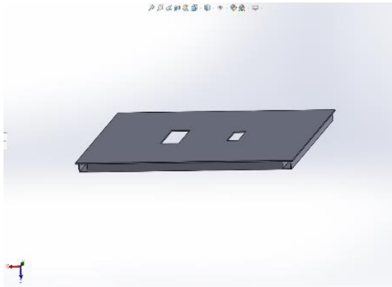


Fig.4: Base plate

Fig.5: Shaft

3. MATERIAL SELECTION FOR COMPONENTS

In this analysis four different types of materials and their properties also considered for each type of design of disc were added to the engineering data sources and the design of brake discs were imported to ANSYS 16.0 during analysis and the corresponding temperature distribution around the discs surface, total deformation, equivalent (von mises) stress and equivalent (von mises) strain were found. The materials considered are Aluminum Al 606, and Structural Steel SS 360. The reason to choose stainless steel was to find a better alternative material in the place of regular steel providing longer life of the disc and the reason for using. Aluminum was due to its high value of thermal conductivity, the disc will rapidly dissipate heat and thus cool the disc thus providing higher efficiency and better performance. Since, disc brakes are everywhere; they are also available in different shapes and sizes. The structural and temperature analysis was carried out in order to find the better performing disc type and material used in the three type of disc considered. Mechanical Properties of four chosen material are summarized in Table I and Table II

Table-1: Material Properties for Aluminum Alloy

Particulars	Al 6061
Density	2.7 g/cc
Young’s modulus	7.1E+10 Pa
Tensile yield stress	2.8E+08 Pa
Specific heat	897 J/kg-k
Poisson Ratio	0.33
Bulk modulus	6.7549E+10 Pa
Shear modulus	2.5902E+10 Pa

Table-2: Material Properties for Structural Steel

Particulars	SS 420
Density	7850 kg/m^3
Young’s modulus	2E+11 Pa
Tensile yield stress	2.5+08 Pa
Specific heat	450 J/kg-k
Poisson Ratio	0.33
Bulk modulus	1.6667E+11 Pa
Shear modulus	7.6923E+10 Pa

4. RESULTS

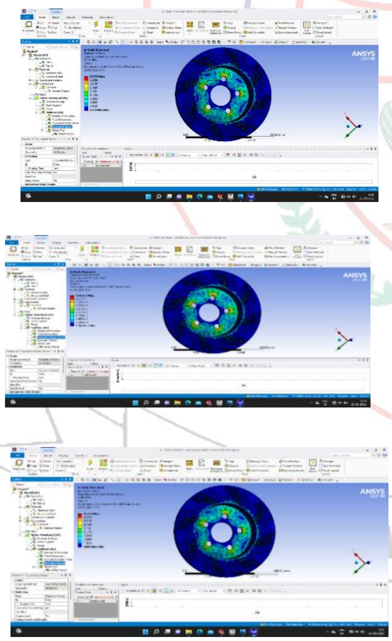
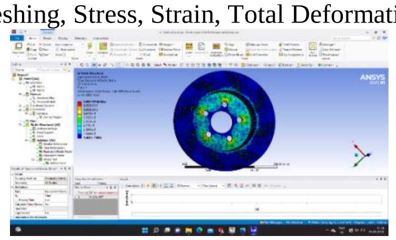


Fig. 6(a): Brake Plate Structural Steel Analysis: (Meshing, Stress, Strain, Total Deformation)



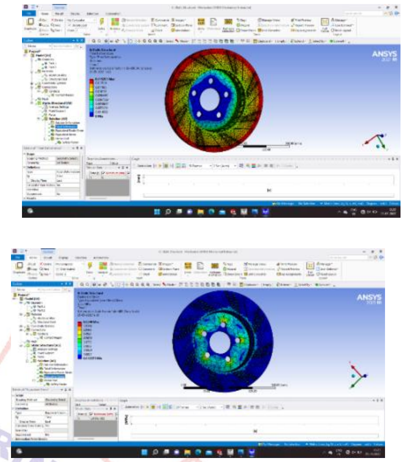


Fig. 6(b): Brake Plate Aluminum Alloy Analysis: (Meshing, Stress, Strain, Total Deformation)

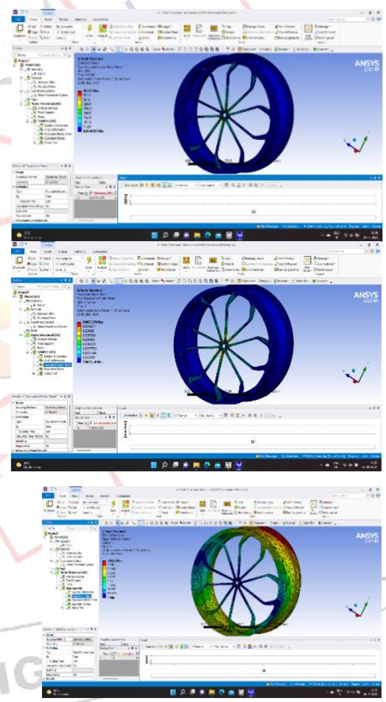
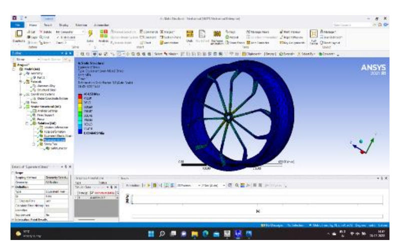


Fig. 7(a): Wheel Rim Structural Steel Analysis: (Meshing, Stress, Strain, Total Deformation)



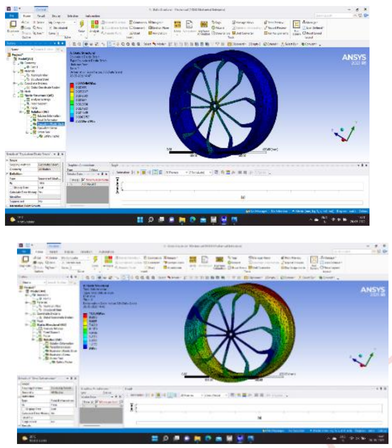


Fig. 7(b): Wheel Rim Aluminum Alloy Analysis: (Meshing, Stress, Strain, Total Deformation)

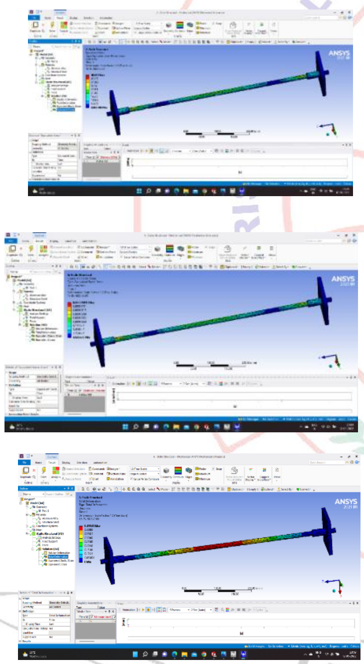
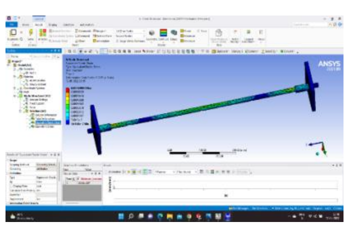


Fig. 8(a): Shaft Wheel Structural Steel Analysis: (Meshing, Stress, Strain, Total Deformation)



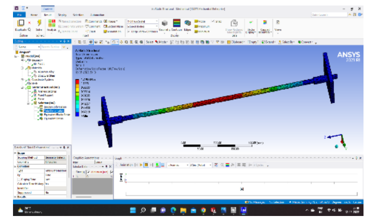


Fig. 8(b): Shaft Wheel Aluminum Alloy Analysis: (Meshing, Stress, Strain, Total Deformation)

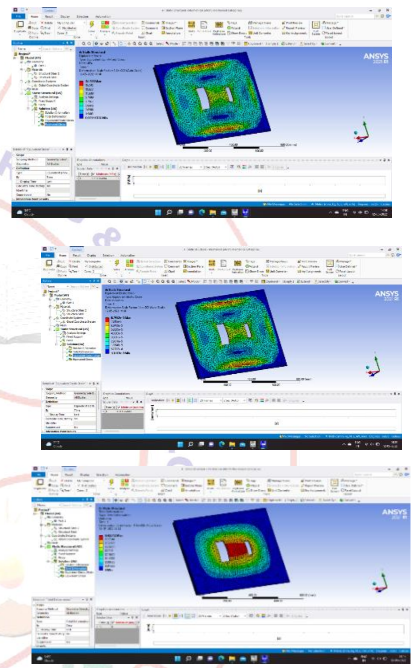


Fig. 9(a): Base Plate Structural Steel Analysis: (Meshing, Stress, Strain, Total Deformation)

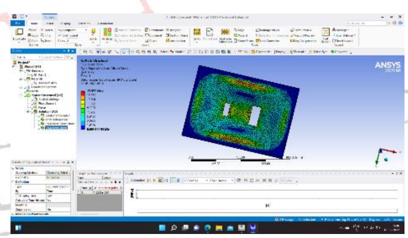


Fig. 9(b): Base Plate Aluminum Alloy Analysis: (Meshing, Stress, Strain, Total Deformation)

Table 3: Brake plate result

PARTS	NAME OF PROPERTY	STRUCTURAL STEEL	ALUMINUM ALLOY
BRAKE PLATE	TOTAL DEFORMATION	0.0055019	0.015203
	MAX.PRINCIPLE ELASTIC STRAIN	4.763	0.0001206
	MAX.PRINCIPLE STRESS	9.2793	8.9249

Table 4: Wheel rim result

PARTS	NAME OF PROPERTY	STRUCTU-RAL STEEL	Al-ALLOY
WHEEL RIM	TOTAL DEFORM ATION	3.9533	11.134
	MAX.PRINCIPLE ELASTIC STRAIN	0.0023258	0.0065464
	MAX.PRINCIPLE STRESS	46.491	464.53

4.1. Advantages

- Increase of all overall energy efficiency of vehicle.
- Improved performance.
- Emission reduction.
- Reduction in engine wear.
- Cut down on pollution related to electric generation.
- Increase the lifespan of friction braking system.
- Smaller accessories

5. CONCLUSION

While using regenerative braking system, we still need friction brakes because regenerative braking system cannot stop the vehicle effectively in case of emergency thus there is further scope of new innovations in this field. But the use of present model can also be useful. Study has showed that regenerative braking system can increase the efficiency of engine by reducing the fuel consumption thus improving fuel economy and we are able to capture the energy which was going to waste by the use of our model. So we can say that result of this project is satisfactory. Regenerative braking can save up to 30% of lost energy as well as can sustain life than conventional braking system. Besides it has a wide scope of development in future that could lead to a huge savings of energy for the world.

6. FUTURE SCOPE

Regenerative braking is more efficient than conventional braking, it is still not popular as electric vehicles and hybrid electric vehicles are still in developing phase. Energy stored in battery can be used to operate air conditioning, lights, mobile charging etc. Besides increasing efficiency of vehicle, it increases its weight too that problem can be overcome by using light materials for regenerative circuit components. As our future vehicles will be having electric and hybrid vehicles, regenerative braking system is going to be next revolution in braking system.

- Regenerative braking makes city driving more economical than on the highway.
- Fuel efficiency is greatly increased (twice).
- Emissions are greatly decreased.
- Dependency of fossils fuel can be decreased.
- Hybrids can be run on alternative fuel as well. Concern for environment is increased

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