ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Materials Engineering

Mechanical Regenerative Braking System for Higer Bus

A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Automotive Engineering

By

Dabi Beyen

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Mechanical Systems and Vehicle engineering program

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in the thesis entitled "**Mechanical Regenerative Braking System for Higer Bus**" in partial fulfillment of the requirements for the award of the degree of Master of Science in Automotive Engineering is an authentic record of my own work carried out from February 2017 to September 2017 under the supervision of N.Ramesh Babu Department of Mechanical and Vehicle Engineering, Adama Science and Technology University, Ethiopia.

The matter embodied in this thesis has not been submitted by me for the award of any other degree or diploma. All relevant resources of information used in this thesis have been duly acknowledged.

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Student

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief. This thesis has been submitted for examination with my approval.

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Advisor

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Approved by board of Examiners

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ACRONYMS

KERS	*Kinetic Energy Recovery System*
RBS	*Regenerative Braking System*
MRBS	*Mechanical Regenerative Brake System*
ICE	*Internal Combustion Engine*
EV	*Electric Vehicle*
CAD	*Computer Aided Drafting*
ESS	*Energy Storage System*
AC	*Alternate Current*
KE	*Kinetic Energy*
KE1	*Kinetic Energy of the Vehicle without passengers*
KE2	*Kinetic Energy of the Vehicle with passengers*
$\Delta t1$	*Temperature Change with the Old Brake drum*
$\Delta t2$.	*Temperature Change with both Old Brake drum and Regenerative disc*

ABSTRACT

There were many efforts have been made in finding alternative energy sources rather than based on petroleum fuels due to its intermittency and increase in price. The other approach is to use the available energy effectively by minimizing the energy wastage and recycling the energy by using regenerating devices. During utilization the energy need to be converted from one form to the other form. This conversion causes energy wastage/loss/ due to inefficiency of the device used to convert the energy. In braking the vehicle kinetic energy converted into heat energy and wasted to the environment. This braking energy can be stored in regenerating devices such as fly wheel, high voltage battery, flat spiral spring, etc before it converted into heat. This energy reused to restart the vehicle or for acceleration. Higer bus is one of the transportation means in Addis Ababa that used for short, medium and long distances. The bus brake operates repeatedly due in loading and delivering the passengers. The aim of this thesis work is to design and analysis MRBS for Higer bus using flat spiral spring as energy storage device. MRBS stores braking energy in a flat spiral torsion spring in the form of strain energy and the energy stored permanently in the spring until needed. This MRBS is designed for Ankai Higer bus operated in Addis Ababa that delivers about 55 passengers per trip beyond the manufacturer limit 40 passengers. According to the result, the energy stored in the flat spiral spring is inversely proportional to both spring length and the vehicle speed. The spring efficiency for the spring length of 2000mm or 2m moving at 40km/h is greater than 45 percent. If the length of the spring and vehicle speed is further increased the efficiency of the spring lowered. The CAD Model of the planetary gear assembly made using CATIA VR5 and Solid work software and the model imported into Ansys 16.0 for structural analysis in Ansys workbench. From analysis the result for stress, strain and deformation distribution had drawn. The AAK compact alternator is also connected to one end of the MRBS to get an output of around 1.7kWatt (1680Watt). The electric energy regenerated can be used to recharge the battery or to fulfill electric need of the vehicle. It is to recommend the automotive industries, automotive manufacturers and the universities to motivate and fund the researchers to investigate to develop environmentally friendly and technologically advanced regenerative brake system

Key words: *Regenerative Braking, Brake disc, wasted energy, planetary gear, sun gear, spiral flat spring*