Research on Energy Recovery System

Ziheng Huang

Nanhai Middle school, Foshan, Guangdong, 528000, China
Email: 1637489101@qq.com

Abstract:

As the number of electric vehicles continues to grow globally, more and more advanced technologies are being applied to electric vehicles. Energy recovery technology is a crucial part of them. The basic principle of how electric vehicles work is to convert chemical energy into electrical energy, and then convert electronic energy into kinetic energy. Actually, the ability of deceleration is necessary for electric vehicle. However, large amount of energy may lose due to this period. So, people developed energy in order to recover this energy.This study contain the introduction of two different types of energy recovery system, electronic energy recovery system and mechanical energy recovery system. Including two major advancements in this field in recent decades which contribute a lot in electronic recovery system. In addition, I introduced some latest research on mechanical energy recovery system which utilized hydro-mechanical technology. Most of my analysis are based on ECE (European standard operating conditions) . Worth noticing that more areas for expansion of this technology are also mentioned in my essay such as rotorcrafts and motor-driven tanks which are the latest products.

Keywords: reversibility, regenerative braking system, recovery system, energy transmission, mechanical energy recovery system, coasting and braking

1. Introduction

According to the data released by the EV-Volume, [1] global sales of new energy vehicles reached 9400 thousand in the first three quarters. As the growing of auto industry, the energy recovery system is an indispensable system for contemporary new energy vehicles. It utilizes the reversibility of energy transmission by electric motors, and during coasting or braking, electromagnetic induction is used to convert a portion of kinetic energy back into electrical energy, which is stored in a battery. This move can enhance the range of electric vehicles by about 30% and greatly promote the environmental protection industry of energy conservation and emission reduction, which is an advantage system that traditional cars cannot achieve. In today's world where environmental protection is crucial, energy recovery systems undoubtedly need to be taken seriously.

2. History and Principle Of Energy Recovery System

2.1 Early development of energy recovery system

As early as 1978, Kasama R, Naito S, and others developed electric vehicle A C. The F regenerative braking system achieves the energy recovery function of the motor under low speed braking by dispersing the current[1], but in situations where the motor rotates at high speed, such as on downhill roads, it cannot efficiently recover energy. However, this study was once considered too avant-garde at the time, as fossil fuel powered cars were still dominant. The huge oil supply at that time partly hindered the development of electric vehicles.

Until 2012, Tesla launched their first mass-produced electric vehicle - the Tesla Model S. The Model S is a luxury electric sedan with excellent range and innovative technological features, which has received widespread praise and market success. This model has caused a sensation in the field of electric vehicles and established Tesla as a global leader.

In 2016, South Korea's Sungkyunkwan University designed a reasonable allocation strategy for electric vehicles using linear friction coefficient between the front and rear axles[2], which is energy recovery technology based on distributed wire controlled braking systems.This technology utilizes mechanical and motor coordinated braking to maximize energy recovery without locking the front or rear wheels connected to the motor. From then on, a modern and efficient energy recovery system has been basically formed.The recently popular CTB (Cell to Body) technology combines the upper cover of the battery pack with the body floor, allowing the power battery system to act as both an energy source and a structural component of the vehicle to participate in the transmission and stress of the vehicle, simplifying the structure and achieving a higher degree of integration.

2.2 Electric Energy Recovery System

The most commonly used system nowadays is also the electronic energy recovery system. Under the European standard ECE operating conditions, there are two types of vehicle deceleration: coasting and braking.Most electric vehicles only recover energy while coasting, which wastes the energy lost during braking. If the deceleration effect of mechanical braking and energy recovery on electric vehicles can be balanced, it will further improve the energy recovery efficiency of electric vehicles. Taking the Feifan R7 pure electric vehicle as an example, it adopts an intelligent energy recovery system, which controls the switch of the energy recovery system through a program, so that even in braking situations, it can determine whether to adopt energy recovery depend on the strength of the driver's braking signal. That is to say, in non emergency braking situations, such as when the vehicle brakes and decelerates before an intersection, the car can also recover a portion of its energy.

Overall, this method is only based on the conversion of mechanical energy and electrical energy, but the mechanical energy recovery system mentioned below only involves the conversion between different types of mechanical energy.

2.3 Mechanical Energy Recovery System

Mechanical energy recovery system: Compared with electric energy storage, hydraulic energy storage has a higher power density, and its principle is similar to that of spring powered toy cars. It is suitable for urban road conditions with frequent load changes. According to Xu Yaoting's summary [3]on the hydraulic regenerative braking system of pure electric vehicles, the hydraulic auxiliary system utilizes gas compression to provide greater auxiliary power to the vehicle and make it more efficient in energy utilization. The speed of energy storage and release is much faster than that of batteries, and the amount of energy recovered is also greater, which relatively increases the driving range of the vehicle. When a hydraulic regenerative braking system is adopted, the load applied to the battery tends to flatten, resulting in a corresponding extension of the battery's service life. Of course, this system also has obvious drawbacks, that is, once the aging or damaged hydraulic device is in a high-pressure overload state, it is easy to create a safety hazard of explosion. The relationship between gas pressure and time in the accumulator is shown in the figure. When the accumulator reaches its peak pressure, it cannot recover energy anymore, which means that when the car is on a long downhill road section.

2.4 Advantages of this two energy recovery systems

Improving energy efficiency: Energy recovery technology can convert the kinetic energy generated during braking into electrical energy, which is stored in batteries, thereby reducing energy waste. This helps to increase the range of new energy vehicles and reduce driving costs.

Reducing brake wear: A strong kinetic energy recovery logic can effectively reduce brake wear and reduce maintenance costs. In addition, the single pedal operation mode of new energy vehicles can also reduce the fatigue caused by frequent braking.

Environmentally friendly: Energy recovery technology helps to reduce the energy consumption of new energy vehicles, reduce dependence on fossil fuels, thereby reducing emissions and pollution, and protecting the environment.

2.5 Several limitations

Generally, these two types of energy recovery technology also has other limitations.

For electric energy recovery system: When the capacity of the battery is greater than 90% or less than 10%, the working voltage provided by the battery is not stable. In order to protect the chemical stability of the battery, energy recovery should not be carried out at this time. In addition, due to the uncontrollable size of energy recovery, excessive recovery current in special circumstances may burn out electronic components or cause vehicle power outages, and its safety needs to be considered.

For mechanical recovery system: Due to the fact that this energy recovery method involves the storage of compressed gas, the maintenance cost of aging parts will be high and there will be certain risks involved. When a vehicle is hit, high-pressure gas will spray out from the damaged area, and the mechanical energy recovery system is likely to explode. This type of vehicle requires much more maintenance frequency than other vehicles and is not suitable for widespread use.

2.6 trend of development in the future

It has been proven that in the future, energy recovery systems can not only be used in automobiles, but also in the aviation industry.

Autorotation rotorcraft is a type of rotorcraft that uses the autorotation rotor as the lift surface and the propeller as the forward power. It mainly relies on the autorotation rotor to provide power, but the autorotation rotor does not carry power.

The aircraft uses the forward thrust from the propeller to drive the rotorcraft to take off. Autorotation rotorcraft has the characteristics of low cost, short takeoff distance, and high safety, making it a key direction for the popularization of civil aviation. Based on its forward thrust, its self-rotating rotor will rotate due to air flow, generating lift. If the propeller is replaced with an electric motor drive and an energy recovery system is installed on the self-rotating rotor, this means that the endurance of this type of aircraft will be greatly improved.

At the 2022 Annual Defense Show in the United States, the latest version of the 'Abrams X' tank was unveiled, which uses SAPA's hybrid system and has the ability to drive purely electric[5]. This greatly saves fuel, reduces the noise of tank driving, and also means that electronic power is beginning to move towards the off-road field. In off-road conditions, the vibration caused by rough roads can bring enormous energy to the vehicle. It is of great significance to recover the energy lost by the vibration by passing the current through a rectifier.

3. Summary

In conclusion, the booming development of new energy vehicles is the future trend. Newly launched new energy vehicles will be equipped with energy recovery systems. Due to limitations in the development of materials science, electronic energy recovery systems are still the main method used in new energy vehicles.

Energy recovery system are indispensable and the competition between mechanical energy recovery system and electronic energy recovery system is inevitable. Both parties have their own advantages and disadvantages. The advantages of electronic energy recovery systems mainly lie in reliability and practicality, while the advantages of mechanical energy recovery systems mainly lie in high recovery efficiency. With the development of future technology, perhaps mechanical energy recovery systems will become mainstream.

These systems would be wildly used in automotive industry, aviation industry ,even in military industry, showing unparalleled superiority. The special structure of rotary wing aircraft allows it to be equipped with energy recovery systems, and the release of pure electric military tanks also means that energy recovery systems may enter the field of heavy equipment.

Undeniably, there are still many shortcomings in this paper. As there are no vehicle models equipped with mechanical energy recovery systems on the market today, it is difficult to find practical examples to support my viewpoint. I can only analyze the advantages, disadvantages, and possibilities of this mechanical energy recovery system based on my judgment of materials science. When discussing pure electric military tanks, it is not difficult to find that this is the latest military technology, involving military secrets, so there is no publicly available information to prove whether electric tanks are truly advanced. It is also difficult to say that electric tanks will also be equipped with energy recovery systems in the future, and it is possible that they have already been equipped with energy recovery systems.

REFERENCES

[1] www.ev-volumes.com, 2023

[2] Kasama R, Naito S, Katada H, et al. The Efficiency Improvement of Electric Vehicles
by Regenerative Braking[J]. SAE Transactions, 1978: 1335-1344.

[3] Gao Y, Chen L, Ehsani M. Investigation of the effectiveness of regenerative braking for
EV and HEV[J]. SAE transactions, 1999: 3184-3190.

[4] Xu YAO-ting, NING Xiao-bing, WANG Qiu-cheng, Simulation analysis of hydraulic regenerative braking system for pure electric vehicle based on AMESim, 2012, 146-147

[5] AUSA General Dynamics :Abrams-X ,2022, Phoenix Net, https://baike.baidu.com/reference/62062941/4e33RHMDuOn4a9djnoWN0vTdb24NahXsuuZI5TGoXQwDcOJXFNL4B-1kRYSR6b56PITNniq5Ny2y9X4flijvlwk