International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-8, August 2014

Regenerative Braking System

Vijeta Handa, Rishabh Tanwar

***Abstract*— In today's world where energy and resource management have become important issues it's necessary to utilize the energy in every form. One such form of energy which is being wasted every day in abundance is through dynamic braking system. While applying dynamic braking kinetic energy is converted to electrical energy. The energy from rotor is removed and from that of stator remains same. The rotor is connected to resistors so that the dissipated energy is send to resistor along with blowers and hence wasted. Regenerative braking is an energy saving mechanism which utilizes the energy by giving it back to the system or can be stored for other purposes. In electric motor regenerative system is applied. For rail systems, regenerative system is the key for efficient energy consumption and hence should be used widely.**

***Index Terms*— Regenerative braking, electric vehicle, rail system, hotel load, air brakes, dynamic braking system, HP regen-horsepower regenerative.**

I. INTRODUCTION

Regenerative braking system system is one in which motor acts as generator. Due to reverse action it produces electricity which is used to charge the batteries or send back to the system.

The areas which require constant power for pantry operations or air conditioning, this load requirement can be acquired by the recovered energy. This energy is released and stored by AC traction systems. This eliminates the need for any external power system. The first regenerative system was used in the car Amitron in 1967. This invention of American motors was first to recapture the energy and charge its nickel-fluoride batteries. It gave a range of 150 miles at 50mph. This method is currently being used in electric locomotives, electric and hybrid cars and metro systems. Self generation and End of Generation system is being replaced by Head On Generation. *In HEG, hotel load facilities can be easily facilitated by the energy from regenerative braking.* Using HEG has inspired new electric locomotive designs like ALP-46 and WAG-9 which have substituted the need of dynamic brake resistor grids and have adopted self powered vehicles to employ regenerative system.

II. WORKING

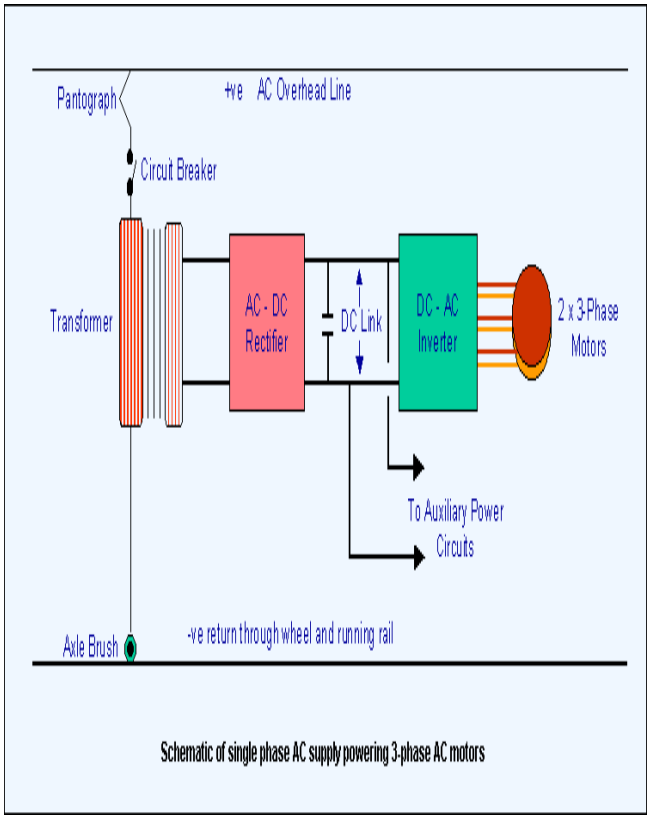
Motors work on the principle that in forward direction they convert kinetic energy into mechanical energy which moves the vehicle and in reverse direction, it produces electricity or heat. In conventional ways, this heat was wasted but now methods have been discovered where this energy is recaptured. Thus, motor starts operating like a generator. This electricity is usually fed back to batteries. It is highly efficient especially in hybrid vehicles like Toyota Prius and in fully electric cars like Tesla Roadster.

Manuscript received July 26, 2014.

Vijeta Handa, Electronics and Communication, GTBIT, GGSIPU, New Delhi, India, 9810819594

Rishabh Tanwar, Electrical & Electronics, MAIT, GGSIPU, New Delhi, India, 9716445453.

III. CIRCUIT DIAGRAM

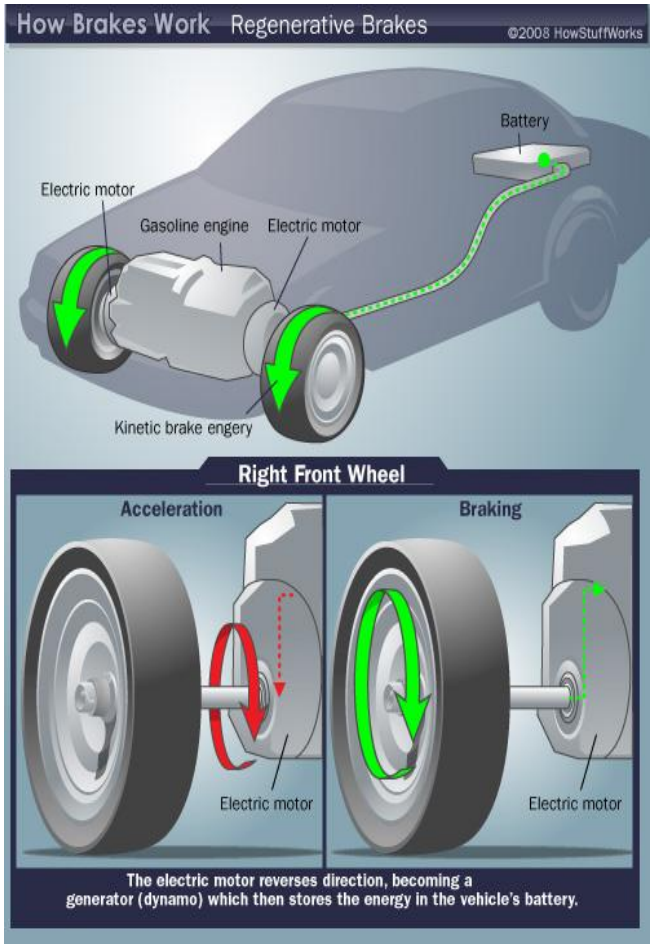


The above diagram represents the regenerative braking system in an electric locomotive. The overhead line receives 25kV from battery. This voltage is sent to pantograph. As the circuit completes, all functions of heating, lightning, air conditioning starts. When brakes are applied, the speed decreases and the energy is sent back to the overhead main line. In this way, the energy consumption is done judiciously.

IV. APPLICATIONS

A. Electric Car

In an electric vehicle, regenerative brakes convert vehicle's kinetic energy into chemical energy and are stored in the battery for further use. When the car decelerates, the motor turns into a dynamo feeding back the energy to battery. This reduces the need for external plugging.



B. Rapid Metro

Rapid metro, also known as third rail system gets 750 V DC and do not contain overhead lines. They receive power from battery through third rail and uses regenerative braking system. These are the first brakes which provide almost 100 percent efficiencies and reduce the speed up-to 5km/hr. They have eliminated the use of air brakes and hence proved to be the best rail system. All the energy is used there and then. It is send back to the tracks and used for air conditioning. This energy can also be transferred to the simultaneous track and used by the other metro. Rapid metro is the greatest achievement and paves the way for regenerative braking.

V. HANDLING OF REGENERATIVE BRAKING

If regenerative energy is produced in excess, certain equipments are required to handle it. For this, regenerative energy is to be calculated in horsepower and then compared by driver's horsepower rating. If (HP regen/HP drive) <=0.1, then measures are not required to handle this energy.
If calculations show the need for external measures, then certain calculations for wattage and amps are done.

A. Determination of speed cycle

N1 = Minimum Speed
N2 = Maximum Speed
t1 = Total Cycle Time
t2 = Deceleration Time

B. Calculation of system inertia data

System inertia =
WK2s = WK2m + (WK2L / GR2)
where WK2s = Total system inertia
WK2m = Motor rotor inertia
WK2L = Driven load inertia
GR = Gear ratio as defined as Motor Revolutions/ Driven Load Revolution

C. Calculation of regenerative torque required to decelerate the load:

TR = Tdecel - Tf = WK2s * (N2-N1) - Tf/308*t2
where Tdecel = time required by deceleration
TR = braking torque in ft-lbs.
Tf = friction torque

D. Caculation of HP required at top speed:

HPregen = (TR * N2)/5250

E. The value of HP regen is compared to the drive's rating to determine that whether external braking equipment is needed or not.

If (HPregen/ HPdrive)*100 >10%, then external braking equipment is recommended and average power generation, peak power and peak regeneration current are determined.

A. Average Power Generation is calculated by:

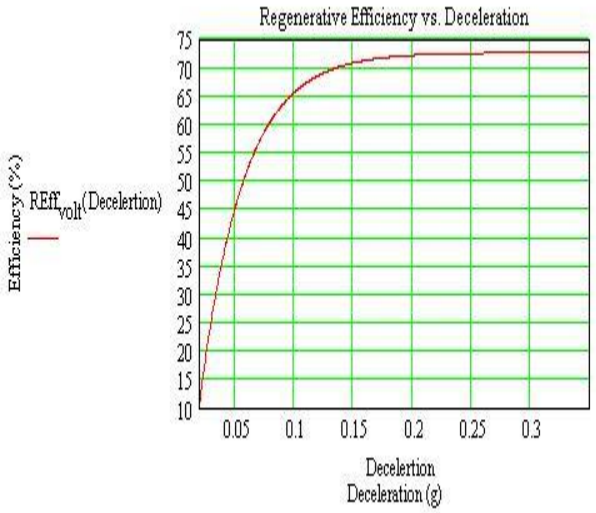
HPregen = (TR * (N2+N1)/2) *t1(decel time)/250 * t2 (total cycle time)
and Watts(regen) = HP(regen) * 746

B. Peak power should be less than the peak rating of regenerative unit.

C. For peak generation, regenerative current is calculated to compare with the current rating of regen unit. This current should not exceed the rated ampere capacity of the desired braking system.
For 460 VAC Drives, Iregen = 1.2 * Hpregen
For 230 VAC Drives, Iregen = 2.4 * Hpregen
For other voltages, the numeric constant can be determined through the ratios.

VI. EFFICIENCY

In conventional vehicles, efficiency is only 20 percent rest is discarded through friction. Regenerative braking increases this up-to 45 percent and rapidly reduces the fuel consumption. Hydraulic regenerative braking steeply ascends the potential of a vehicle. These methods not only consume the wasted energy but also help in conserving the fossil fuels. Apart from the high efficiency, drivers can appreciate the extended range of electric vehicles.



VII. CHALLENGES

Regenerative braking is usually accompanied with conventional braking system because the former can slow down the speed but cannot achieve zero acceleration. Dynamic or friction brakes are used to achieve emergency brakes and to bring the vehicle to a complete halt. These brakes also act as backup at times of ineffectiveness of regenerative brakes. Also at rough terrains or wet surface, dynamic brakes are necessary as regenerative brakes may not be present on all wheels example two-wheel drive car. Sometimes the amount of energy released is more than the energy required for charging so in these cases friction brakes help in dissipation of extra heat.

For these reasons, effective regenerative braking is required for high efficiency. GM EV-1, created by Abraham Farag and Loren Majersik, was the first car to produce desired braking effect.

VIII. CONCLUSION

Regenerative braking is the path breaking invention. If the disadvantages are overcome this system will be create a new era where fuel consumption will decrease rapidly. In regenerative braking the energy finds a new home rather than being lost as heat and friction. It will mark a new journey of eradicating the usage of coal and hence decreasing the cost. Chemically, electrically in all ways energy can be stored and used accordingly. Moreover, CO2 emissions are also reduced. There is still scope for improvement and with proper system we can achieve the full potential,

REFERENCES

[1] http://www.teslamotors.com/blog/magic-tesla-roadster-regenerative-braking
[2] http://auto.howstuffworks.com/auto-parts/brakes/brake-types/regenerative-braking.htm
[3] http://alternativefuels.about.com/od/hybridvehicles/a/regenbraking.htm
[4] http://history-of-inventions.blogspot.in/2012/03/first-smart-car-with-regenerative.html
[5] http://www.carsdirect.com/green-cars/how-does-regenerative-braking-work
[6] Vijeta Handa, final year student of ECE. Completed 12th from CBSE boards with 87 percent.
[7] Rishabh Tanwar, final year student of EEE. Completed 12th from CBSE boards with 89 percent.