METU EE462 Utilization of Electric Energy

Emine Bostancı

Office: C-107

Content

Load Examples

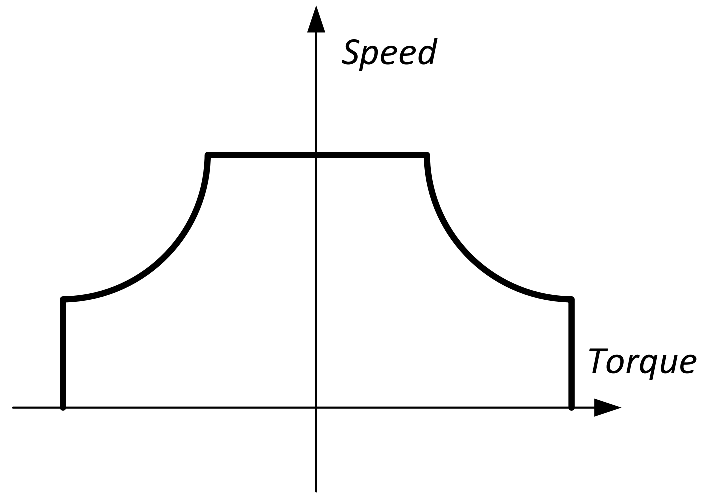
Torque-speed Loci for Change in Operating Point

Transportation Drive

A variety of transportation drives exists:

- Subway trains
- Freight train (diesel-electric locomotives)
- Road vehicles

It is not necessary for a vehicle to reverse without pause, a transportation drive can be analyzed in only quadrants 1 & 2. Reverse driving and braking are just same as positive speed operation.

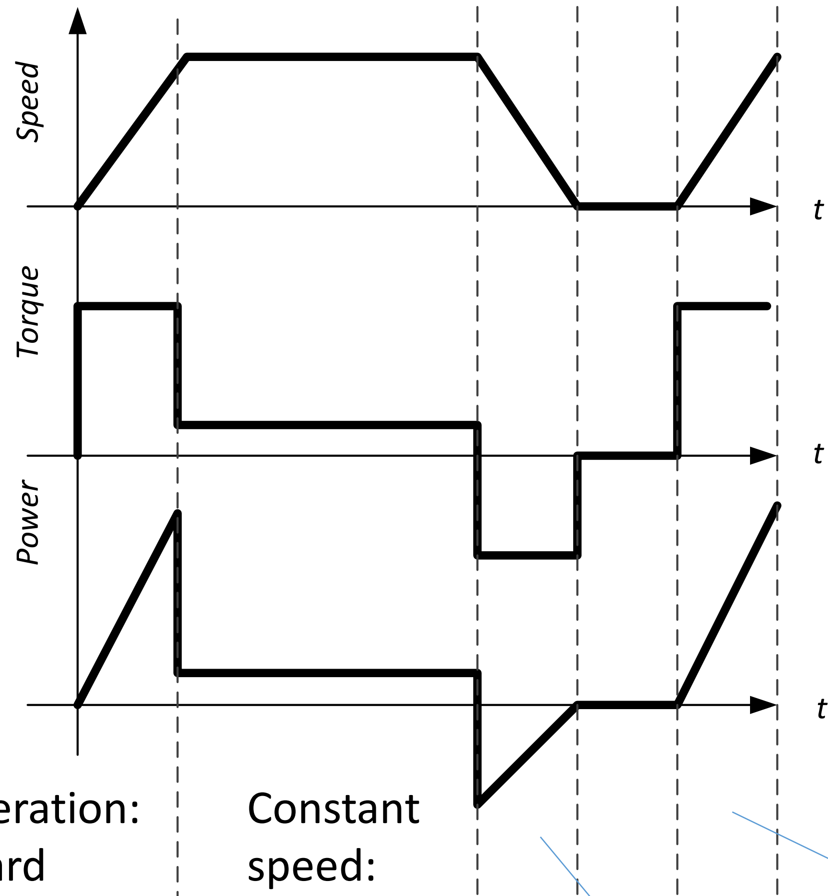


The particular feature of a transportation drive is high inertia of the mechanical system, the inertia referred to the motor shaft.

Equivalent Total Inertia:

$$J_{tot} = J_r + mr^2$$

Transportation Drive



The permissible acceleration and deceleration is dictated by passenger comfort, also rate of change of acceleration that is called jerk is important.

Acceleration: Forward motoring

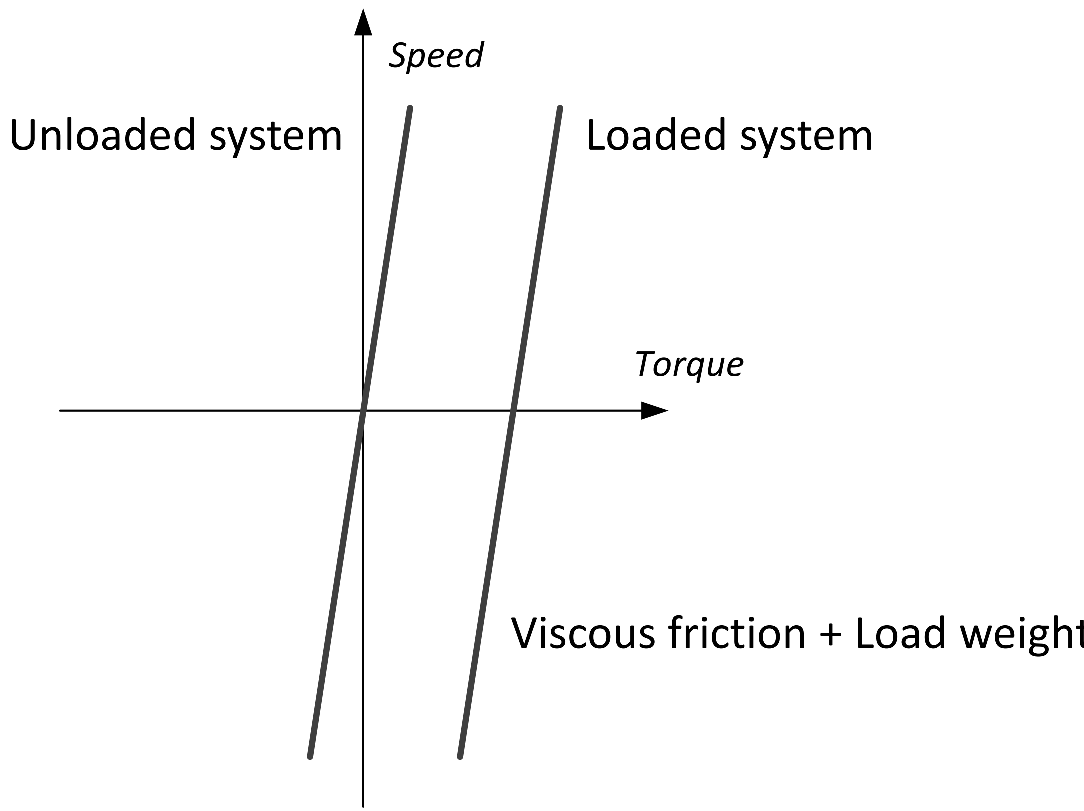
Constant speed: Forward motoring

Deceleration: Forward braking e.g. Regenerative breaking

Acceleration: Forward motoring

Hoist

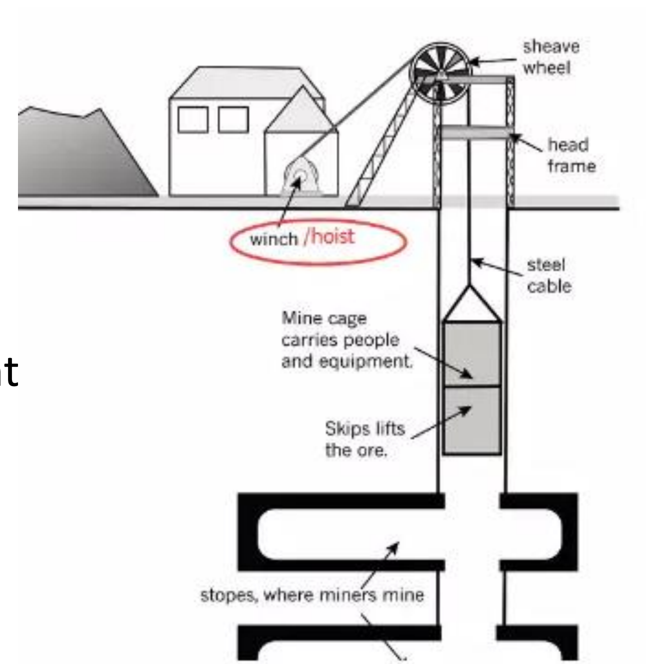
To hoist: an act of raising or lifting something.



Hoist Torque-Speed Characteristics

Examples:

- Elevator
- Crane hoist
- Mine winder



Crane Hoist

A crane hoist demands operation in 4 quadrants.

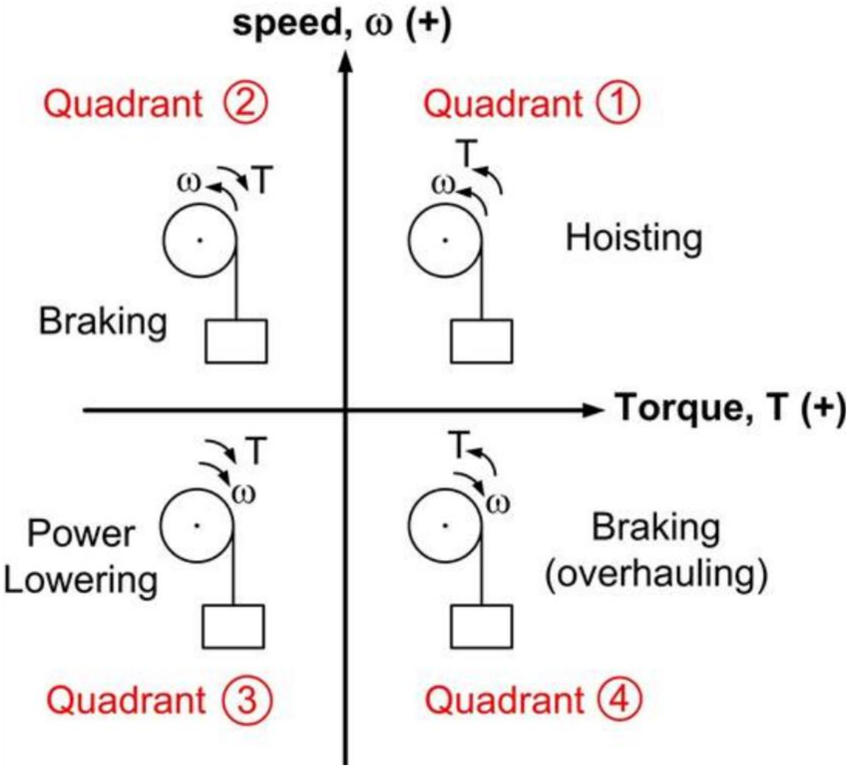
1st quadrant: Forward driving

2nd quadrant: Forward braking, system deceleration is usually low and braking is due to the suspended load, this quadrant is usually entered during transients.

3rd quadrant: High (power) speed lowering

4th quadrant: Load overhauls the machine and regenerative breaking occurs.

A fail-safe mechanical brake: A brake is released by energizing an electromagnet that compresses the springs and lifts the break shoes and in case of a power failure, this brake will be active.



Crane Hoist

1. Separately excited DC machine 4-quadrant operation
2. Load speed loci for change in operating points

Please take notes!

Braking Options

Mechanical brake: Mechanical energy of the system is dissipated as heat due to friction.

Eddy-current braking: Kinetic energy of the system is largely dissipated as eddy current losses.

Eddy current braking applications

Eddy current braking 1

Dynamic braking: Braking energy is dissipated as heat in resistors provided for the purpose.

Regenerative braking: Braking energy is supplied back to electric system or any other energy storage system.

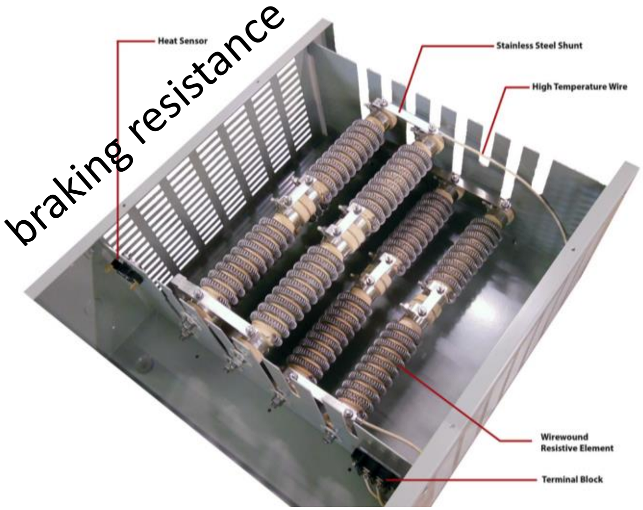
Electrical Braking

In 2nd and 4th quadrant, machine operates as a generator.

- **Dynamic Braking:** If power electronics circuit is not capable of electrical braking (bi-directional current capability is required for regenerative braking), a braking resistance will be used to dissipate the braking power.
- **Regenerative Braking:** This energy can be supplied to the electrical system to another storage system. For this we need to have the right power electronics circuit and enough space in our source. For example battery should not ne fully charged at that point of the time.

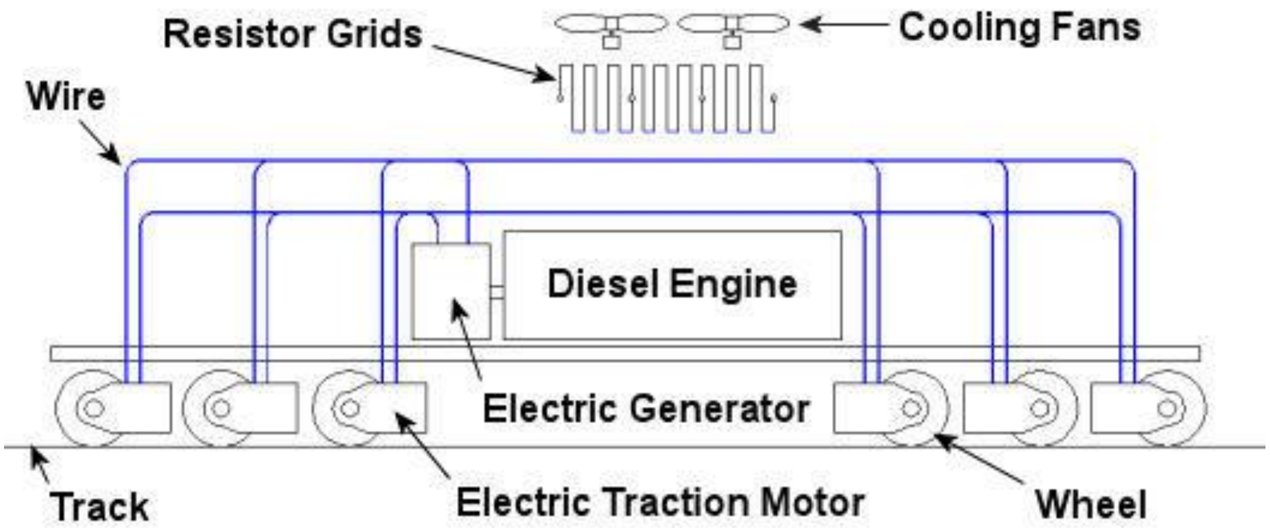
BBC KERS, Renault KERS, KERS explained

Note: Even if we can apply electrical braking, the system also has a mechanical brake. We will try to maximize the usage of the electrical braking



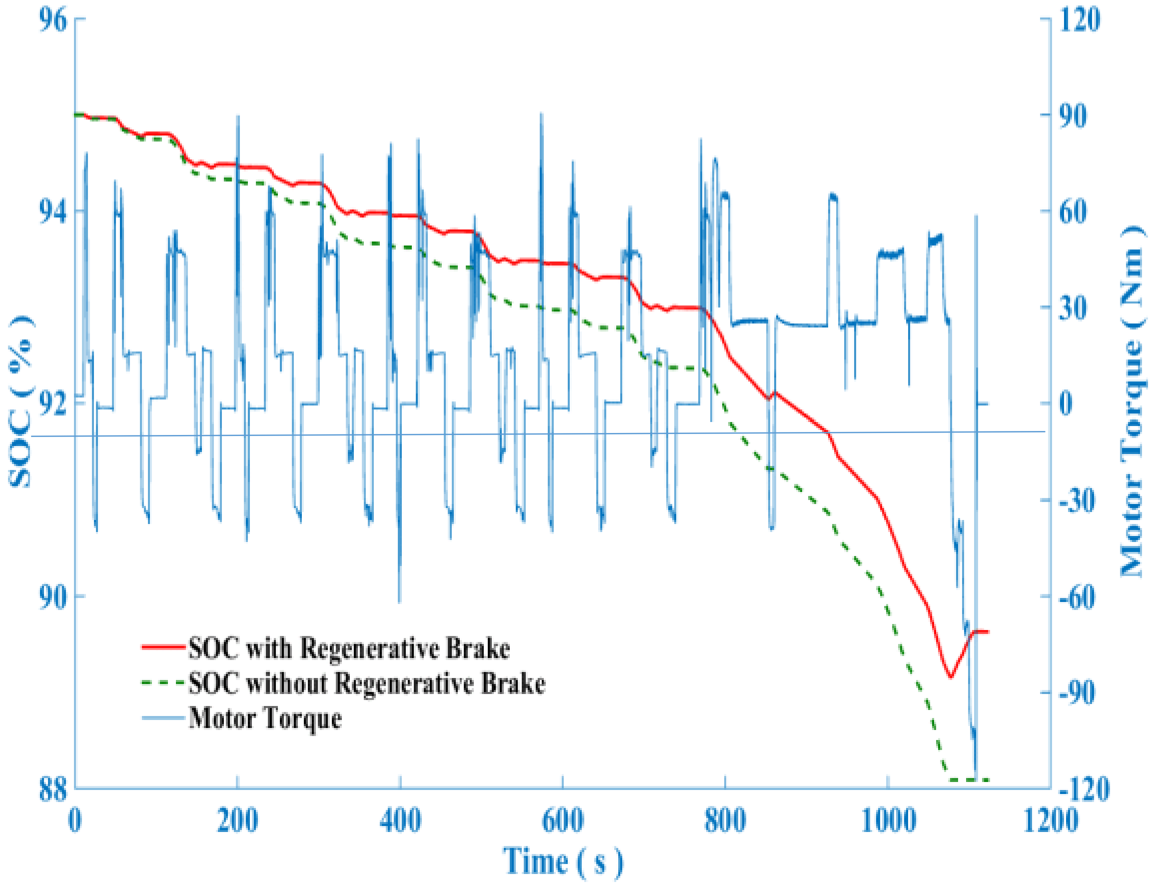
Dynamic Braking Example - Locomotives

Locomotives



[Dynamic Brake Noise](), [Dynamic Brake Fan Problem]()

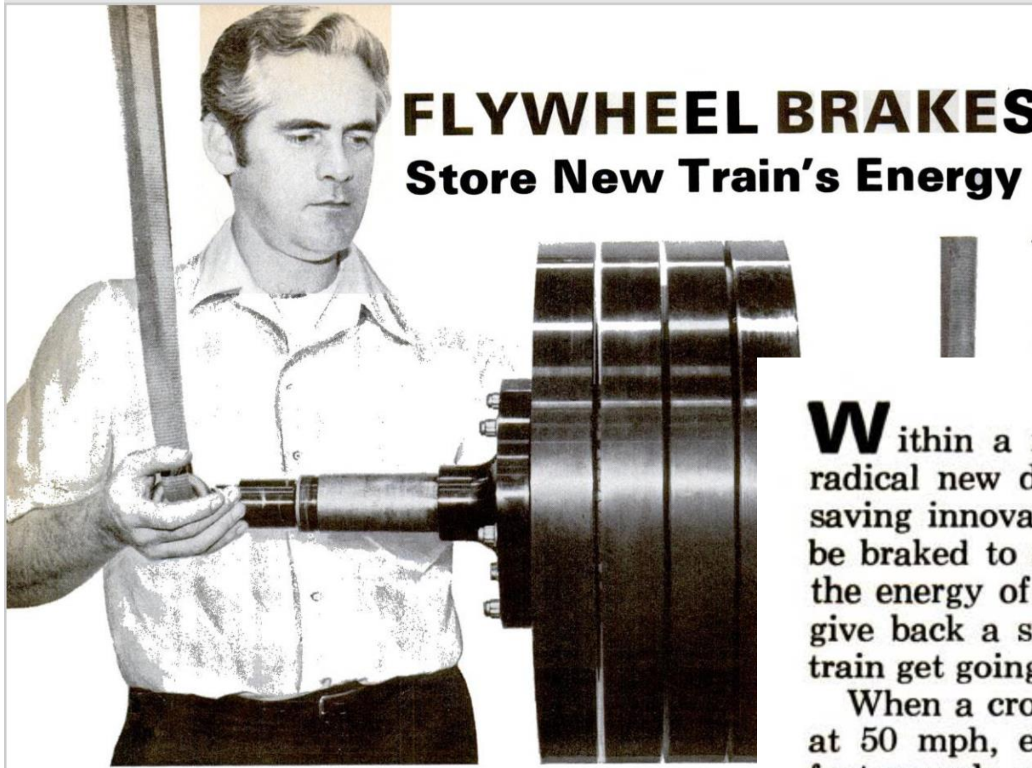
Regenerative Braking Example - Vehicle

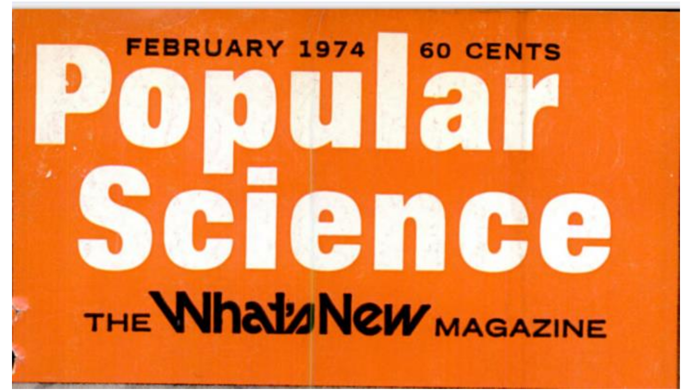


SoC: State of charge of battery – Charge level of a battery.

Thanks to regenerative braking, we can increase vehicle efficiency. In some models, starter machines are used to regenerate some part of the brake energy. Those cars have bigger batteries.

Regenerative Braking Example - Subway

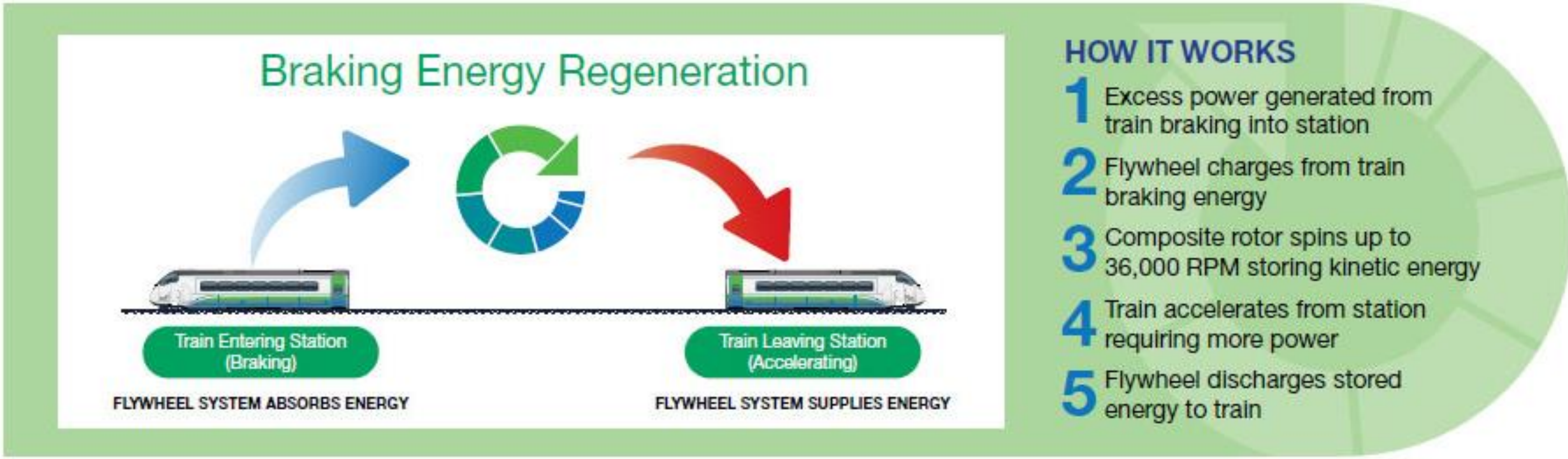




Within a month or two, a pair of subway cars of radical new design will pioneer a momentous, energy-saving innovation in rapid transit. A subway train will be braked to a stop by spinning flywheels, which store the energy of the moving cars. Then the flywheels will give back a substantial part of the energy to help the train get going again.

When a crowded subway train roars toward a station at 50 mph, each car is a projectile with 8½ million foot-pounds of kinetic energy. The only way to stop the train is to get rid of that energy. Old-fashioned brake shoes screeching against the wheels turn it into heat. So do more modern dynamic brakes, which generate electric current that flows through resistor grids. Either way, a moving train's energy goes down the drain—and has to be replaced from the third rail. The new cars will introduce New York City straphangers to a better way:

Regenerative Braking Example - Subway



Source: https://kinetictraction.com/flywheel-energy-storage-applications/

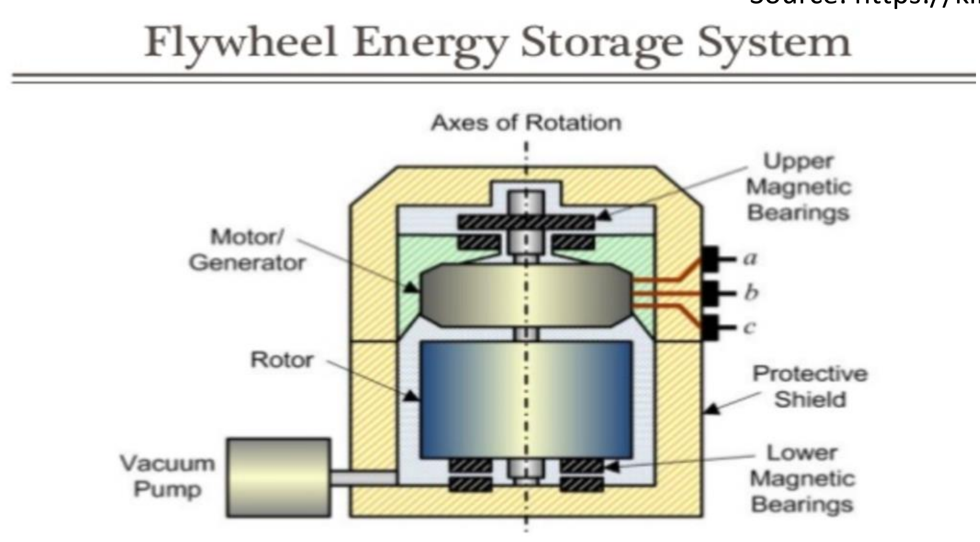


Diagram of a typical flywheel energy storage system.

A flywheel energy storage system is also an electrical drive itself.

More Drive Examples

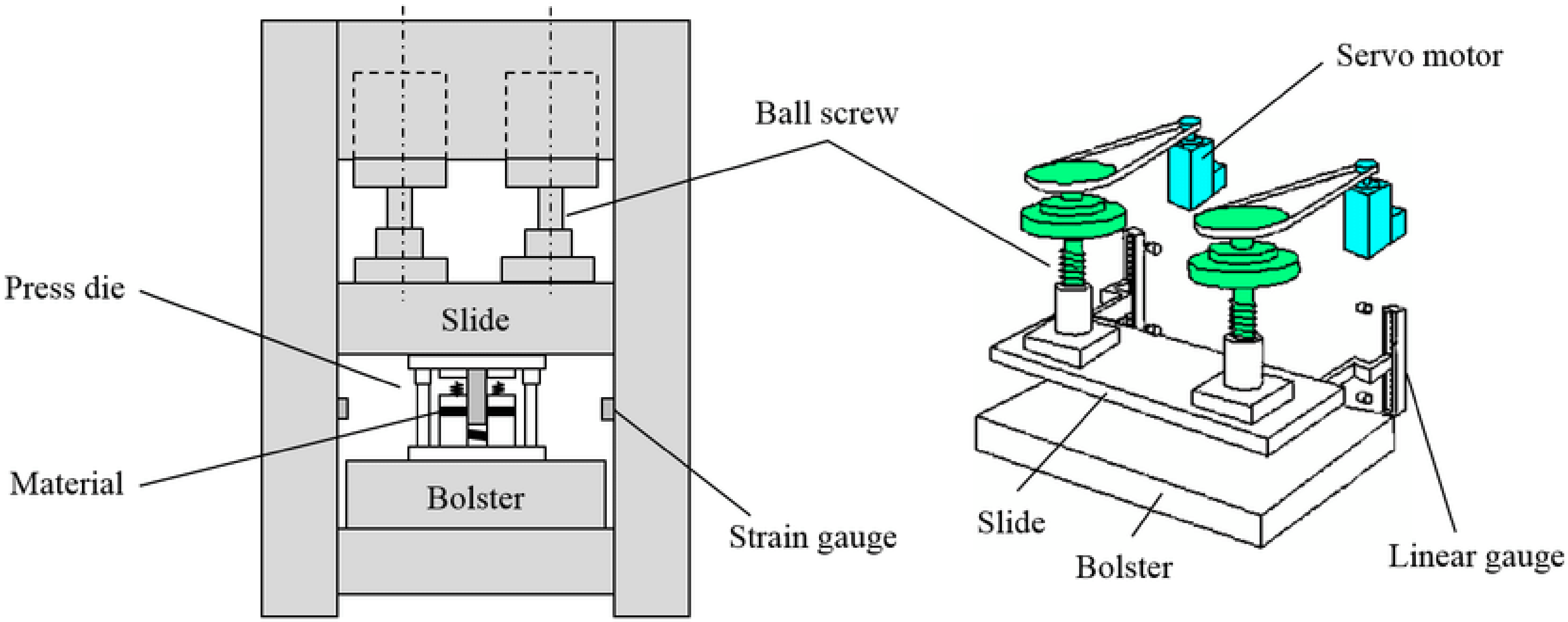
Production:

[BMW i3 Electric Motor Production]

[How a car is made: Part 2 - The press shop]

[How a car is made: Part 5 - Robots in production]

Dynamic Braking Example – Servo Press



Video: Servo Press

More information!