CLAIMS

1. A pneumatic regenerative system for a railway vehicle, the railway vehicle including a locomotive with a main drive mechanism, and the railway vehicle including plurality of axles that rotate when the railway vehicle is propelled along a railway, the system comprising:

   a plurality of pneumatic drive mechanisms, each pneumatic drive mechanism mechanically coupled to one of the plurality of axles of the railway vehicle, one of the plurality of pneumatic drive mechanisms being coupled to a one of the plurality of axles of the railway vehicle which is not mechanically driven by the main drive mechanism of the locomotive, each pneumatic drive mechanism comprising:

      an accumulator that is operable to receive and store pressurized air; and

      a pneumatic device operably coupled to one of the plurality of axles and the accumulator, the device operable in a first configuration, where the device is driven by rotation of the one of the plurality of axles during a braking operation of the railway vehicle to generate and store pressurized air in the accumulator, and a second configuration, where the pneumatic device receives pressurized air from the accumulator to drive rotation of the one of the plurality of axles during an acceleration operation of the railway vehicle.

2. The system of claim 1, wherein each pneumatic drive mechanism further comprises:

   a controller that selectively configures the pneumatic device to operate in the first configuration during the braking operation of the railway vehicle and the second configuration during the acceleration operation of the railway vehicle.

3. The system of claim 2, wherein the controller is configured to deactivate the pneumatic device during the braking operation when a measured pressure within the accumulator reaches or exceeds a maximum value.

4. The system of claim 1, wherein each pneumatic drive mechanism further comprises:

   a heat exchanger disposed between the pneumatic device and the accumulator, where the heat exchanger is in fluid communication with the pneumatic device and the accumulator.

5. The system of claim 4, wherein each pneumatic drive mechanism further comprises:

a heat storage apparatus coupled to the heat exchanger, where the heat storage apparatus is in thermal communication with the heat exchanger.

6. The system of claim 5, wherein the heat storage apparatus includes a tank filled with a liquid.

7. The system of claim 5, wherein, when the pneumatic device operates in the first configuration, the heat exchanger extracts heat from the pressurized air prior to the pneumatic device storing the pressurized air in the accumulator, the heat exchanger storing the extracted heat in the heat storage apparatus.

8. The system of claim 5, wherein, when the pneumatic device operates in the second configuration, the heat exchanger introduces heat from the heat storage apparatus to the pressurized air prior to the pneumatic device utilizing the pressurized air from the accumulator to drive rotation of one of the plurality of axles.

9. The system of claim 1, wherein air is input into the pneumatic device from an environment in which the railway vehicle operates when operated in the first configuration, and air expanded within the pneumatic device is exhausted to the environment when operated in the second configuration.

10. The system of claim 1, wherein the locomotive includes a plurality of axles, each of the pneumatic drive mechanisms disposed on the locomotive being mechanically coupled to one of the plurality of axles of the locomotive.

11. The system of claim 10, wherein the pneumatic drive mechanisms and the main drive mechanism, when operating in the second configuration, separately and independently provide energy to the each of the plurality of axles of the locomotive during the acceleration operation.

12. The system of claim 1, wherein

the accumulator is an air storage apparatus configured to store compressed air, and

the pneumatic device is a reversible pneumatic device in fluid communication with the air storage apparatus, the reversible pneumatic device operable as an air compressor during the braking operation of the railway vehicle, where the reversible pneumatic device stores air within the air storage apparatus, and the reversible pneumatic device operable as an air motor

during the acceleration operation of the railway vehicle, where the reversible pneumatic device draws and expands pressurized air from the air storage apparatus.

13. The system of claim 12, wherein rotation of the plurality of axles during the braking operation of the railway vehicle causes the reversible pneumatic device of each pneumatic drive mechanism to store compressed air within the air storage apparatus.

14. The system of claim 12, wherein the reversible pneumatic device of each pneumatic drive mechanism utilizes the compressed air within the air storage apparatus to drive the reversible pneumatic device and drive rotation of the plurality of axles during the acceleration operation of the railway vehicle.

15. The system of claim 12, wherein each pneumatic drive mechanism further comprises:

    a transfer case coupling the reversible pneumatic device to the one of the plurality of axles.

16. The system of claim 15, wherein the transfer case includes a continuously variable transmission.

17. The system of claim 16, wherein each pneumatic drive mechanism further comprises:

    a controller coupled to the transfer case and the reversible pneumatic device, the controller controlling the continuously variable transmission to optimize operation of the reversible pneumatic device during the braking operation of the railway vehicle and optimize rotation of the one of the plurality of axles during the acceleration operation of the railway vehicle.

18. The system of claim 1, wherein the pneumatic device further comprises:

    an air compressor that is operably coupled to one of the plurality of axles so as to activate the air compressor and generate pressurized air during the braking operation of the railway vehicle, wherein the

    accumulator receives and stores the pressurized air from the air compressor during the braking operation of the railway vehicle; and

    a pneumatic motor that receives the pressurized air from the accumulator to activate the pneumatic motor such that, during activation, the pneumatic motor provides energy to the one of the plurality of axles during the acceleration operation of the railway vehicle.

19. The system of claim 18, wherein each pneumatic drive mechanism further comprises:

    a controller that selectively couples the air compressor with the one of the plurality of the axles during the braking operation of the railway vehicle and selectively activates the pneumatic motor during the acceleration operation of the railway vehicle.

20. The system of claim 18, wherein air is input into the air compressor from an environment in which the railway vehicle operates, and air expanded within the pneumatic motor is exhausted to the environment.