8(b). Explain the principle of energy storage by a flywheel in utilities. on what factors does energy storage depend?

The principle of energy storage by a flywheel involves converting electrical energy into kinetic energy by accelerating a rotating mass (the flywheel) and then converting it back to electrical energy when needed. Flywheel energy storage systems are used in utilities to store and release electricity rapidly to help manage fluctuations in power demand and supply. Here's an overview of the principle and factors influencing energy storage by a flywheel:

1. Principle of Energy Storage: Flywheel energy storage systems operate based on the principle of rotational inertia. When excess electricity is available in the grid, it is used to accelerate the flywheel, increasing its rotational speed and storing the energy as kinetic energy. This kinetic energy can be retrieved later by slowing down the flywheel, and it is converted back into electrical energy.

2. Flywheel Components: A flywheel energy storage system consists of several components, including the flywheel itself, a rotor assembly, bearings, a motor/generator, and a control system. The flywheel is typically made of a lightweight material with a high tensile strength, such as carbon fiber composites or steel alloys, to ensure efficient energy storage and release.

3. Factors Affecting Energy Storage:

a. Rotational Speed: The energy stored in a flywheel is directly proportional to its rotational speed. The higher the speed, the greater the kinetic energy stored. However, there are limits to the maximum speed due to material and structural considerations.

b. Mass and Moment of Inertia: The mass and distribution of mass in the flywheel affect its moment of inertia, which determines the amount of energy stored for a given rotational speed. Increasing the mass or distributing the mass further from the axis of rotation increases the energy storage capacity.

c. Efficiency: Energy storage systems inevitably incur losses during the storage and retrieval process. The efficiency of the flywheel system, including mechanical losses due to friction and electrical losses during energy conversion, impacts the overall energy storage and retrieval efficiency.

d. Control and Power Electronics: The control system and power electronics play a crucial role in managing the charging and discharging of the flywheel, optimizing the energy storage and release processes, and maintaining system stability and safety.

e. Environmental Considerations: Flywheel systems are generally considered environmentally friendly since they do not involve hazardous chemicals or emissions. However, the manufacturing process and materials used should be assessed for their environmental impact.

f. Safety Considerations: Flywheel energy storage systems require safety

measures to prevent catastrophic failures due to excessive speeds, mechanical stresses, or component failures. Containment systems and robust structural design are implemented to ensure safe operation.

g. Cost: The cost of implementing a flywheel energy storage system depends on various factors such as the materials used, manufacturing processes, control system complexity, and maintenance requirements. Cost considerations are essential in evaluating the economic viability of such systems.

Flywheel energy storage offers benefits such as rapid response times, high power density, long service life, and minimal maintenance requirements. However, it may have limitations in terms of energy capacity and duration compared to other energy storage technologies like batteries or pumped hydro storage.

Overall, the design and performance of a flywheel energy storage system depend on the rotational speed, mass, moment of inertia, efficiency, control systems, environmental factors, safety considerations, and cost considerations. These factors must be carefully evaluated to determine the suitability and effectiveness of flywheel energy storage in utility applications.