Lab Experiment 16

Open Ended Lab

Name :____	**Roll No :** ______________
Score :____________ **Signature of Lab Tutor :**_____________________	**Date :** ___________

WARD-LEONARD SYSTEM FOR DC MOTOR

PERFORMANCE OBJECTIVE:

1. Smooth and stepless speed control.
2. High efficiency.
3. High starting torque.
4. Load adaptability.
5. Quick response to changes.
6. Integration with control systems.

COMPONENTS WHICH WE USED:

- 3 DC machines
- Induction Motor
- Voltmeter
- Rheostat
- DC power supply
- Connecting Leads

INTRODUCTION:

The Ward-Leonard System has been instrumental in the evolution of motor control systems. Invented in the early 20th century, it was one of the first solutions that enabled precise control over DC motor speed and direction, something critical in industrial environments. Before the Ward-Leonard System, controlling motor speed was challenging, with few options to vary it smoothly and reliably. The Ward-Leonard System achieved variable speed control by adjusting the DC voltage supplied to the motor's armature, with the use of a motor-generator set.

The primary components include an AC motor (prime mover), a DC generator, and the DC motor itself. The AC motor drives the DC generator, which in turn produces the adjustable DC voltage needed to control the motor. This system's flexibility in speed control, combined with its smooth reversibility and high starting torque, made it a staple in heavy-duty applications, particularly in sectors that require load-lifting capabilities, such as cranes, elevators, and steel rolling mills.

CONSTRUCTION OF THE WARD-LEONARD SYSTEM:

The Ward-Leonard System consists of a carefully designed assembly of mechanical and electrical components. Each part is aligned and interconnected to ensure smooth transmission of power from the prime mover to the generator and, subsequently, to the load motor.

1. **Prime Mover (AC Motor)**:

The prime mover is typically a three-phase AC motor, though some systems may use a gas or diesel engine, especially in portable or isolated applications.

It provides the mechanical energy needed to drive the DC generator. It is often mounted on a sturdy base along with the generator to reduce vibration and mechanical misalignment.

2. **DC Generator**:

The DC generator is coupled directly to the prime mover's shaft. Its role is to convert the mechanical energy from the prime mover into DC electrical energy, which is then supplied to the DC motor.

The output voltage of the generator is controlled by adjusting its field winding excitation. This adjustability is key to controlling the speed of the DC motor.

3. **DC Motor**:

The DC motor acts as the load motor, connected to the output of the DC generator. It utilizes the variable voltage supplied by the generator for speed control.

The motor itself is built to handle a wide range of input voltages and high torque outputs, making it suitable for demanding applications like lifting and hauling.

4. **Field Regulator**:

The field regulator is a control device used to adjust the current in the generator's field winding. By controlling the field current, it adjusts the magnetic field strength within the generator, which in turn changes the voltage output.

This field regulation enables a smooth transition from low to high speeds and vice versa, without causing abrupt changes in the motor's operation.

5. **Control Panel**:

The control panel houses various switches, meters, relays, and other controls needed for operating the system. It allows operators to monitor voltage, current, and other key parameters and includes switches for reversing the direction of the motor.

The control panel also provides safety features, protecting the system against issues like overloads and short circuits.

The entire assembly is mounted on a common frame to ensure alignment and minimize vibration. This construction setup is essential for stable, efficient operation, as even slight misalignments could lead to reduced performance or mechanical wear over time.

WORKING OF WARD-LEONARD SYSTEM:

The Ward-Leonard System operates in a sequential process that involves starting, speed control, reversing, and braking.

Starting Process:

The AC prime mover begins operation, driving the DC generator. As the generator rotates, it produces an initial DC voltage, supplied to the armature of the DC motor.

By carefully increasing the generator's field excitation, the operator can raise the armature voltage gradually, allowing the motor to start smoothly without a surge in current.

1. **Speed Control:**

Speed control is achieved by adjusting the generator's field excitation using the field regulator. Increasing the field excitation raises the generator's output voltage, resulting in higher motor speed. Conversely, reducing excitation lowers the voltage and decreases the motor's speed.

This continuous and smooth adjustment capability is a core benefit of the Ward-Leonard System.

2. **Reversing the Direction:**

To reverse the motor's direction, the polarity of the generator's output voltage is changed. This is typically done through a reversing switch in the circuit or by altering the field winding connections of the generator.

This feature is especially useful in applications requiring bidirectional movement, such as cranes and lift systems.

Braking:

The system allows for braking by dissipating the motor's kinetic energy. This is achieved through dynamic braking, where the motor's energy is routed through a resistive load, or through regenerative braking, where energy is fed back to the generator.

SCHEMATIC DIAGRAM:

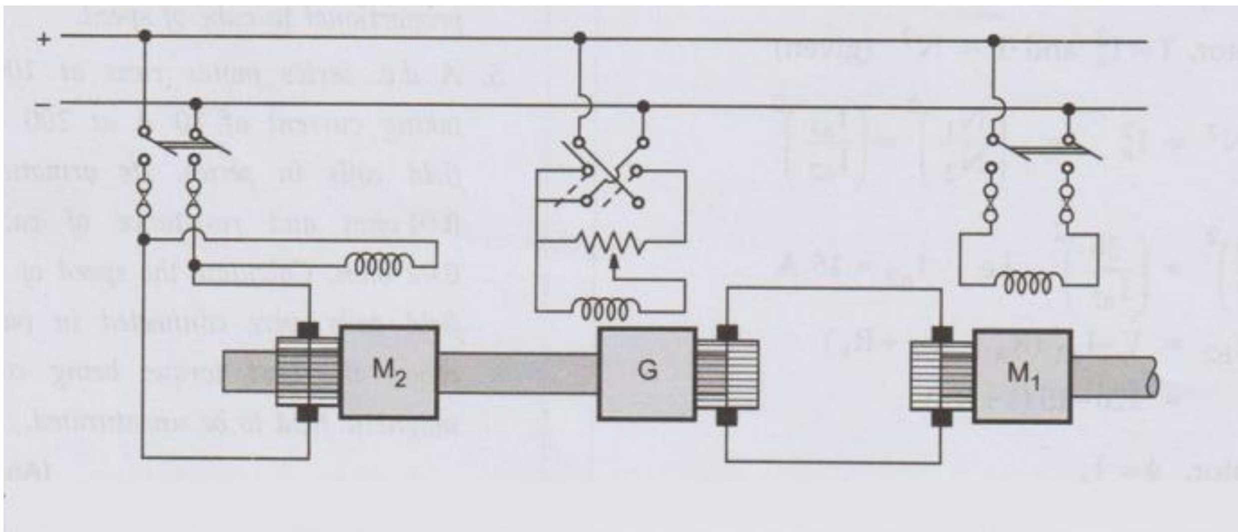

Fig. 4.22.1 Ward-Leonard speed control method

THEORY AND METHODOLOGY:

The Ward-Leonard System operates on the principle of controlling the voltage applied to the armature of a DC motor to control its speed. In a DC motor, speed (N) is directly proportional to the armature voltage (V) and inversely proportional to the field flux (Φ). In this system, speed control is achieved by varying the output voltage of the DC generator connected to the motor's armature.

1. Speed Control through Voltage Variation:

- By adjusting the field current of the DC generator, the output voltage is varied, which directly affects the DC motor’s speed. Higher generator field current produces a stronger magnetic field, leading to a higher output voltage and increased motor speed.
- This control is continuous and allows for fine adjustments, providing smooth speed transitions without the stepwise changes associated with gear systems or mechanical drives.

2. Reversibility:

- Reversing the direction of rotation in the DC motor is essential in applications like elevators and cranes. The Ward-Leonard System achieves this by reversing the polarity of the generator's output voltage. By switching the connections in the generator’s field windings, the current direction is altered, causing the motor to run in the opposite direction.

3. Braking:

- The Ward-Leonard System enables braking by using the motor’s kinetic energy and dissipating it through resistive elements or feeding it back to the generator. This process, known as dynamic braking, is crucial for applications that require frequent stops, such as hoists and elevators, where controlled deceleration is necessary.

OPERATIONS:

- **Starting**: The prime mover initiates operation by driving the generator, supplying initial voltage to the motor.
- **Speed Variation**: Adjusting the field excitation changes the generator's voltage output, thereby increasing or decreasing the motor speed.
- **Reversing**: The system can reverse the polarity of the generator voltage, allowing the motor to change direction.
- **Braking**: Dynamic braking is possible by controlling the generator and motor configurations, which helps in stopping the motor effectively.

APPLICATIONS:

- **Elevator and Crane Control**: Precise control over speed and direction is essential.
- **Steel Mills and Rolling Machines**: High torque and flexible speed control are required for heavy-duty applications.
- **Electric Locomotives**: Reliable speed control over long periods is needed.
- **Printing Presses and Textile Mills**: Where accurate speed synchronization is important.
- **Elevators and Hoists**: Smooth acceleration and deceleration ensure passenger safety and load stability.
- **Cranes**: High starting torque and accurate speed control are critical for lifting heavy loads.
- **Steel Mills**: Rolling and cutting machinery benefit from the flexible speed control provided by this system.
- **Printing Presses**: Synchronized speed control is vital for high-speed, high-precision printing.
- **Electric Locomotives**: Early electric trains used this system for reliable control over acceleration and deceleration.

CONCLUSION:

The Ward-Leonard System is an effective and reliable method for controlling the speed and direction of DC motors. Despite its high maintenance requirements and energy losses due to the use of a motor-generator set, it remains useful in industries that require precise control. Although it has been largely replaced by modern power electronic drives, understanding its principles and operation provides a foundation in motor control systems and continues to be relevant for specific applications where reliability and control precision are paramount.