

Ch 27 HW A DC Motor A Shunt-wound DC Motor With The Field Coils And Rotor Connected In Parallel (Figure

Ch 27 HW A DC Motor A Shunt-wound DC Motor With The Field Coils And Rotor Connected In Parallel (Figure is a fundamental topic in electrical engineering, especially within the study of DC motors. Understanding the construction, operation, and characteristics of shunt-wound DC motors is essential for engineers and technicians working with motor control, automation, and power systems. This article provides an in-depth exploration of shunt-wound DC motors, explaining their design, working principles, advantages, disadvantages, and practical applications, supported by relevant diagrams and figures.

Introduction to Shunt-wound DC Motors

Definition and Basic Concept

A shunt-wound DC motor is a type of direct current motor where the field winding (also called shunt winding) is connected in parallel with the armature circuit. This configuration ensures that both the field winding and armature receive the same voltage, which is typically the supply voltage. The primary characteristic of a shunt-wound motor is its relatively constant speed under varying load conditions, making it suitable for applications requiring stable rotational speeds.

Construction and Components

The main components of a shunt-wound DC motor include:

- **Stator (Field Winding):** Consists of field coils connected in parallel with the armature.
- **Rotor (Armature):** The rotating part that carries the armature winding, which interacts with the magnetic field to produce torque.
- **Commutator and Brushes:** Facilitate the flow of current between the stationary external circuit and the rotating armature.
- **Frame and Bearings:** Support the rotor and facilitate its smooth rotation.

The typical schematic (Figure) shows the field coils and rotor connected in

parallel, highlighting the key electrical connections.

Working Principle of Shunt-wound DC Motor

Magnetic Field Generation

When the supply voltage is applied, current flows through the field winding, producing a magnetic flux (Φ). Because the field winding is connected in parallel with the armature, the flux remains nearly constant as long as the supply voltage remains steady.

Armature Reaction and Torque Production

Simultaneously, current flows through the armature winding, generating its own magnetic field that interacts with the stator flux, producing a torque. The torque (T) in a shunt-wound motor is proportional to the flux (Φ) and the armature current (I_a):

$$T \propto \Phi \times I_a$$

Since the flux is relatively constant, the motor's speed depends mainly on the back emf and armature resistance.

Speed Regulation

The speed of a shunt-wound motor is given approximately by:

$$N = \frac{V - I_a R_a}{k \Phi}$$

where:

- V is the applied voltage,
- I_a is the armature current,
- R_a is the armature resistance,
- k is a constant.

Because Φ remains nearly constant, the motor maintains a steady speed over a range of loads, with slight variations depending on armature reaction and armature resistance.

Characteristics of Shunt-wound DC Motors

Advantages

- **Constant Speed:** Maintains nearly constant speed under varying load conditions.
- **Good Speed Regulation:** Suitable for applications requiring precise speed control.
- **Simple Construction:** Easier to manufacture and maintain compared to other types.
- **Ease of Control:** Can be controlled effectively through field excitation adjustments.

Disadvantages

- **Limited Starting Torque:** The starting torque is moderate, which may not be sufficient for heavy loads.
- **Susceptibility to Voltage Fluctuations:** Speed can vary if supply voltage fluctuates significantly.
- **Field Winding Power Consumption:** Constant power is used to energize the field winding, leading to inefficiencies.

Operational Analysis of the Parallel Connection (Figure)

Electrical Connections

In the configuration where the field coils and rotor are connected in parallel:

- Both the field winding and armature are directly connected across the supply voltage.
- The circuit ensures that the same voltage V is applied across both components.
- The field winding's resistance is designed to create an appropriate flux without excessive power loss.

Effect of Load Variations

When the load increases:

- The armature current (I_a) increases, resulting in a higher torque.
- The back emf (E_b) drops slightly, causing a small increase in armature current.
- The flux remains relatively constant because the field winding is supplied with a constant voltage, stabilizing the speed.

Conversely, when the load decreases:

- The armature current decreases.
- The back emf increases, stabilizing the motor speed.

Mathematical Analysis of the Shunt-wound DC Motor

Key Equations

- Back emf (E_b):

$$E_b = k \Phi N$$

- Armature circuit equation:

$$V = E_b + I_a R_a$$

- Torque:

$$T = k_t \Phi I_a$$

where:

- V = applied voltage,
- E_b = back emf,
- I_a = armature current,
- R_a = armature resistance,
- N = speed in rpm,
- Φ = flux per pole,
- k , k_t = constants based on motor construction.

Speed Control Methods

- Adjusting Field Excitation: Varying the field current to change flux.
- Resistive Control: Adding resistance in series with the field winding.
- Voltage Control: Modifying the supply voltage directly.

Applications of Shunt-wound DC Motors

Industrial Uses

- Lathes and Drilling Machines: Require constant speed for precision work.
- Printing Presses: Need stable speed to ensure quality.
- Elevators and Hoists: Where reliable and steady operation is critical.

Other Practical Applications

- Conveyor Systems: For uniform speed.
- Blowers and Fans: Where constant airflow is desired.
- Robotic Actuators: For precise movement control.

Maintenance and Troubleshooting

Common Issues

- Field Winding Damage: Due to overheating or mechanical failure.
- Brush and Commutator Wear: Causing sparking or poor contact.
- Armature Short Circuits: Leading to reduced efficiency or failure.
- Incorrect Field Excitation: Resulting in speed fluctuations.

Preventive Measures

- Regular inspection and cleaning of brushes and commutator.
- Ensuring proper lubrication of bearings.
- Monitoring field coil resistance and insulation integrity.
- Maintaining proper voltage supply and load conditions.

Conclusion

The shunt-wound DC motor with field coils and rotor

connected in parallel is a versatile and widely used motor type, valued for its stable speed characteristics and ease of control. Its simple construction and predictable behavior make it a preferred choice in various industrial and commercial applications. Understanding its operation, advantages, limitations, and maintenance requirements is essential for effective implementation and troubleshooting in real-world systems. Whether used in precision machinery or general-purpose drives, the shunt-wound DC motor remains a cornerstone in the field of electrical engineering.

References:

- Fitzgerald, A. E., Kingsley, C., & Umans, S. D. (2013). Electric Machinery. McGraw-Hill Education.
- Hughes, A. (2013). Electric Motors and Drives: Fundamentals, Types and Applications. Elsevier.
- Sudhakar, M., Shyam Mohan, S., & Rajashekara, R. (2009). Electrical Machines. Tata McGraw-Hill Education.

Frequently Asked Questions

What is the primary advantage of a shunt-wound DC motor with the field coils and rotor connected in parallel?

The primary advantage is that it allows the motor to maintain a nearly constant speed under varying load conditions, as the field flux remains relatively

stable due to the parallel connection.

How does the field winding connection in a shunt-wound DC motor affect its speed control?

Connecting the field winding in parallel (shunt configuration) enables easier speed regulation by varying the field current, allowing for precise control of the motor's speed.

What is the typical application of a shunt-wound DC motor with parallel-connected field and rotor coils?

Shunt-wound DC motors are commonly used in applications requiring constant speed operation, such as lathes, printing presses, and conveyor systems.

In the circuit diagram of a shunt-wound DC motor, what is the role of the field coils connected in parallel with the rotor?

The field coils generate the magnetic flux necessary for torque production; connecting them in parallel with the rotor ensures the flux remains relatively constant regardless of load variations.

What effect does increasing the field current have on the speed and torque of a shunt-wound DC motor?

Increasing the field current strengthens the magnetic field, which can decrease the motor's speed but increase the torque capability, allowing for better load handling.

Additional Resources

DC Motor

Understanding the Shunt-Wound DC Motor: An Expert Overview

The world of electric motors is vast, encompassing various designs tailored to specific applications. Among these, the Shunt-Wound DC Motor stands out for its versatility, reliability, and efficiency. This detailed exploration aims to provide an in-depth understanding of the Shunt-Wound DC Motor, focusing on its construction, working principles, advantages, limitations, and practical applications. By the end of this article, readers will have a comprehensive grasp of how this motor operates and why it remains a vital component in many electrical systems.

Introduction to the Shunt-Wound DC Motor

A shunt-wound DC motor is a type of direct current

motor where the field winding (also known as the field coil or field winding) is connected in parallel—or "shunt"—with the armature (rotor). This configuration distinguishes it from other DC motor types like series-wound or compound-wound motors.

Key Features:

- **Parallel Connection:** Both the field winding and armature are connected across the same voltage source.
- **Constant Speed Operation:** Due to the nature of its magnetic field, it generally maintains a nearly constant speed under varying load conditions.
- **Ease of Control:** Speed regulation can be achieved effectively by varying the field current.

Construction of the Shunt-Wound DC Motor

Core Components:

1. Stator (Field Winding):

- Composed of field coils made of insulated copper wire wound around the stator core.
- Connected in parallel to the armature circuit, hence the term "shunt."
- Produces a magnetic field when energized by the supply voltage.

2. Rotor (Armature):

- Consists of a laminated iron core with conductors (armature winding) embedded into slots.
- Carries the armature winding, which interacts with

the magnetic field to produce torque.

- Connected to a commutator and brushes, facilitating current transfer while rotating.

3. Commutator and Brushes:

- The commutator reverses the direction of current in the armature windings, ensuring unidirectional torque.

- Brushes maintain electrical contact between stationary and rotating parts.

4. Frame and Bearings:

- Provides mechanical support, housing the rotor and stator components.

- Ensures smooth rotation and alignment.

Schematic Overview:

In the typical diagram (referenced as "Figure"), the field coils and rotor are connected in parallel across the same voltage source. This configuration simplifies analysis and impacts the motor's operational characteristics.

Working Principles of the Shunt-Wound DC Motor

Magnetic Field Creation:

When the supply voltage is applied, current flows through the shunt field winding, creating a steady magnetic field. Simultaneously, current flows through the armature winding, producing a magnetic field that interacts with the stator's magnetic flux.

Torque Production:

The interaction between the magnetic flux from the field winding and the armature current generates a force on the armature conductors, producing torque. The commutator ensures that the direction of current in the armature conductors reverses with each half-turn, maintaining unidirectional torque.

Speed Regulation:

- Near-Constant Speed: Since the field flux is relatively independent of armature current (due to the parallel connection), the motor maintains a stable speed under varying loads.
- Effect of Load Changes: When load increases, the armature current increases, which tends to decrease the speed slightly. However, the increase in armature flux tends to counteract this, stabilizing the speed.

Voltage and Flux Relationship:

The magnetic flux ϕ produced by the shunt field is proportional to the field current I_f . Since the field winding is connected in parallel:

$$I_f = \frac{V}{R_f}$$

where V is the supply voltage and R_f is the field winding resistance.

The back emf E_b generated by the armature is related to the motor's speed (N) and flux:

$$E_b = k \phi N$$

with k being a machine constant.

Advantages of the Shunt-Wound DC Motor

1. Stable and Constant Speed:

One of the primary benefits is its ability to sustain a nearly constant speed over a wide range of load conditions, making it suitable for applications requiring precise speed control.

2. Good Speed Regulation:

Because the flux remains relatively steady, the motor's speed can be finely adjusted by varying the field current, facilitating accurate control in industrial processes.

3. Simple Construction and Maintenance:

The design simplicity and accessibility of components make maintenance straightforward and cost-effective.

4. Ease of Speed Control:

Adjustments to the field circuit (via rheostats or electronic controllers) allow for smooth and variable speed operation.

5. Wide Range of Applications:

The motor's characteristics make it ideal for machine tools, conveyors, blowers, and other machinery requiring consistent speed.

Limitations and Challenges

Despite its advantages, the shunt-wound DC motor has certain limitations:

1. Starting Torque:

The starting torque is relatively low compared to series motors, limiting its use in applications requiring high initial torque.

2. Speed Drops with Increased Load:

While better than series motors, some variation in speed can occur under heavy loads, necessitating control systems for precision.

3. Field Flux Dependency:

Any fluctuation in field winding resistance or supply voltage can affect flux and, consequently, speed.

4. Cost and Complexity:

While simple, the need for a consistent power supply and control circuitry can add to operational costs.

Practical Applications of the Shunt-Wound DC Motor

The unique combination of stability, controllability, and reliability makes the shunt-wound DC motor suitable for various applications:

- Machine Tools: Precise speed control is essential for machining processes.

- **Elevators and Hoists:** Consistent speed and smooth operation are critical.
- **Printing Presses:** Uniform speed ensures high-quality output.
- **Conveyor Systems:** Maintains constant throughput despite load variations.
- **Pumps and Fans:** Provides steady operation under variable loads.
- **Laboratory Equipment:** Used where precise and steady speeds are necessary.

Control Methods and Enhancements

Effective operation of shunt-wound DC motors involves various control strategies:

1. Field Rheostat Control:

Adjusting the resistance in the field circuit allows for fine-tuning the flux and, hence, the speed.

2. Armature Voltage Control:

Varying the supply voltage to the armature can modulate the speed but may introduce complexity.

3. Field Excitation Control:

Using variable power supplies or electronic controllers to regulate the field current provides precise control.

4. Feedback and Automation:

In modern systems, electronic controllers with feedback loops maintain set speeds under changing

loads.

Conclusion: The Relevance of the Shunt-Wound DC Motor

The shunt-wound DC motor remains a cornerstone in electrical engineering, especially for applications demanding stable and controllable speeds. Its simple yet effective design, combined with its ability to operate smoothly under varying loads, ensures it continues to find relevance despite the advent of electronic drives and AC motor technology.

While newer motor types and control methods have emerged, the fundamental principles and advantages of the shunt-wound DC motor make it an enduring solution in industry, manufacturing, and research. Understanding its construction, operation, strengths, and limitations equips engineers and technicians to select, operate, and maintain these motors effectively, ensuring optimal performance in diverse applications.

In sum, the shunt-wound DC motor exemplifies engineering elegance—balancing simplicity with precise control, and reliability with adaptability—making it a vital component in the realm of electric motors.

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