

TECHNOLOGY OF SPARK PLUGS

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Annotation: *The article discusses the structure, operating principles, and technological development of spark plugs used in internal combustion engines. It describes the key components of spark plugs, including the ceramic insulator, electrodes, and metal shell, while highlighting the importance of materials such as nickel alloys, platinum, and iridium in improving durability and ignition efficiency. Special attention is given to various types of spark plugs, their thermal characteristics, and modern manufacturing technologies such as laser welding and fine-wire electrode design. The paper emphasizes how advancements in spark plug technology contribute to improved engine performance, fuel economy, and reduced emissions.*

Keywords: *Spark plug; ignition system; electrodes; iridium; platinum; combustion engine; heat range; ceramic insulator; laser welding; engine performance; automotive technology.*

Spark plugs are essential components of internal combustion engines, responsible for igniting the air–fuel mixture within the combustion chamber. Their design, materials, and construction have evolved significantly as automotive technology has advanced. Modern spark plugs are engineered to provide efficient ignition, fuel economy, and reduced emissions while operating under extreme conditions such as high temperatures, high pressures, and chemical exposure.

Spark plugs generate an electric spark that ignites the compressed air–fuel mixture in gasoline engines. The ignition system supplies high voltage—typically between 12,000 and 40,000 volts—to the spark plug. When the voltage exceeds the dielectric strength of the air gap between the electrodes, a spark occurs.

Key processes:

- Voltage buildup from ignition coil
- Ionization of air–fuel mixture in the electrode gap
- Spark discharge causing combustion
- Flame propagation through the cylinder

This ignition is precisely timed to ensure maximum engine efficiency.

A standard spark plug consists of several important components:

Made of high-purity alumina ceramic, providing:

- Electrical insulation

- High thermal resistance

- Mechanical strength

Conducts high voltage to the spark gap; materials include:

- Nickel alloys (traditional)
- Platinum (long life)
- Iridium (high performance)

Forms the spark gap with the center electrode. Often made of nickel-steel alloys.

Secures the plug into the cylinder head and provides grounding.

Ensures gas-tight sealing to prevent combustion leakage.

Advancements in materials have greatly improved plug durability and performance.

Nickel Alloy Spark Plugs

- Standard, inexpensive
- Lifespan: 20,000–30,000 km

Platinum Spark Plugs

- Higher melting point
- Thin wire electrodes for better ignition
- Lifespan: 80,000–100,000 km

Iridium Spark Plugs

- Exceptional durability
- Small tip enables powerful spark
- Lifespan: 120,000–150,000 km
- Used in modern and high-performance engines

Copper is used inside the electrode for better heat conductivity.

Spark plugs vary based on design and application.

Single ground electrode; used in most engines.

Two, three, or four ground electrodes:

- Longer life
- Better spark exposure

Used in sports cars, turbocharged engines, and fuel-efficient vehicles.

Electrodeless design used in racing engines where very high RPM is required.

A spark plug must operate at the correct temperature (500°C–850°C).

- Hot plugs retain more heat (for low-speed engines).
- Cold plugs dissipate heat quickly (for high-performance engines).

Selecting the correct heat range is essential to prevent:

- Fouling (too cold)
- Pre-ignition (too hot)

Spark plug production involves advanced manufacturing processes:

Ceramic Insulator Production

- High-purity aluminum oxide is molded and sintered at >1500°C

- Precision machining ensures dielectric strength

Electrode Fabrication

- Welding of platinum/iridium tips using laser welding
- Precision forming of electrode shape

Assembly and Sealing

- Metal shell is crimped around ceramic
- Electrodes are inserted and electrically isolated

Quality Control

Includes:

- Pressure testing
- Leakage tests
- Electrical resistance measurement
- Visual inspection

Increase lifespan and spark efficiency.

Provide stronger spark at lower voltage.

Nickel plating and special heat-resistant layers prevent wear.

Modern cars require plug designs optimized for:

- Turbo engines
- Direct injection
- High compression ratios

Spark plug technology has undergone significant evolution, from simple nickel-electrode plugs to advanced iridium and platinum models with laser-welded tips. Modern spark plugs play a crucial role in engine performance, emissions reduction, and fuel economy. Their design, materials, and thermal characteristics are engineered with precision to withstand harsh conditions and ensure reliable ignition throughout their service life.

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