Sigma Weld
Digital Welding Inverters for MMA, TIG, MIG

RESISTANCE HEATING VS. INDUCTION HEATING

A Running Cost Comparison

Introduction

In industries requiring precise and efficient heating solutions, the choice between resistance and induction heating methods can significantly impact operational costs and productivity. This white paper provides a detailed comparison of these two technologies, focusing on running costs and efficiency. By examining key parameters and presenting comparative data, we aim to offer valuable insights for making informed decisions about heating processes in industrial applications.

Technology/Process Overview

Resistance Heating

Resistance heating involves passing an electric current through a resistive element, generating heat that is then transferred to the workpiece. This method is widely used due to its simplicity and relatively low initial investment. However, it can be less energy-efficient and may result in uneven heating.

Induction Heating

Induction heating, on the other hand, uses electromagnetic induction to generate heat within the workpiece itself. A high-frequency alternating current is passed through a coil, creating a magnetic field that induces eddy currents in the material, resulting in rapid and localized heating. This method offers higher energy efficiency, precise temperature control, and faster heating cycles.

Cost/Efficiency Analysis

To provide a clear understanding of the cost implications, we present a comparative analysis based on a specific industrial application. The following data reflects the parameters and results observed for Pre-Heat/Post Heating on a Heavy Fabrication:

Flexible Induction Coil setup on a 2 m diameter long-seam job demonstrating minimal setup time and insulation coverage.

Job Details:

- Job Diameter: 2 Mtr
- Job Thickness: 65mm, 185mm
- Type of Heating: Long Seam
- Required Temp for Pre-Heat: 205°C
- Required Temp for Post-Heat: 350°C
- Seam Length: 3 Mtr

COMPARATIVE TABLE

Parameter	Induction Heating	Resistance Heating	Remarks
Time to reach Pre-Heat temperature	20 minutes	2.5 hours	Induction heats directly; much faster ramp-up
Mains Current (Loading time)	35–45 A	80–90 A	Induction uses significantly lower current
Mains Current (Holding/Soaking)	40–50 A	80–90 A	Lower sustained current for induction
Setup time for Post-Heat	10 minutes	2 hours	Induction coil setup is faster than element/pad setup
Time to reach Post-Heat temperature	40 minutes	3 hours	Faster post-heat reduces cycle time greatly
Temperature Range	205°C – 350°C	205°C – 350°C	Same metallurgical target for both methods

Detailed Process & Calculation Overview

To understand the comparative data more clearly, it is important to explain how the setup time and power consumption are calculated under real industrial conditions.

Setup Time Process

Setup time covers the preparatory steps before the heating cycle begins — including **coil mounting, thermocouple connection, and insulation wrapping** around the weld seam.

For the given job
(2 m diameter vessel, 65 mm – 185 mm wall thickness, 3 m long seam, preheat 205 °C / post-heat 350 °C):

- **Resistance Heating:** Typically requires **about 2 hours** of setup because multiple ceramic pad heaters must be positioned, clamped, and insulated evenly along the 3 m seam.
- **Induction Heating:** Uses a **flexible coil** that can be wrapped directly over the seam and connected within **10 minutes**, giving a **91 % reduction** in setup duration.

Power Consumption Calculation

Power consumed (kWh) = Voltage (V) × Current (A) × Time (hrs) ÷ 1000

Assuming a **440 V three-phase** power supply:

- **Resistance Heating (Pre-Heat Cycle):**
  440 × 85 A × 2.5 hrs ÷ 1000 = ≈ **93.5 kWh**
- **Induction Heating (Pre-Heat Cycle):**
  440 × 40 A × 0.33 hrs ÷ 1000 = ≈ **5.8 kWh**

Detailed Step-by-Step Energy Calculation — Resistance vs. Induction Heating

Given: line voltage V = 440 V
Formula used:
Energy (kWh) = (V × I × t) / 1000

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1) Resistance heating — pre-heat
Energy = (440 × 85 × 2.5) / 1000
= (37,400 × 2.5) / 1000
= 93,500 / 1000
= 93.5 kWh

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2) Resistance heating — post-heat (average current)
Average current = 33.3 A, time = 3.0 h
Energy = (440 × 33.3 × 3.0) / 1000
= (14,652 × 3.0) / 1000
= 44,000 / 1000
= 44.0 kWh

Resistance total (pre + post):
93.5 + 44.0 = **137.5 kWh**

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3) Induction heating — pre-heat
Energy = (440 × 40 × 0.33) / 1000
= (17,600 × 0.33) / 1000
= 5,808 / 1000
= 5.8 kWh

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4) Induction heating — post-heat (average current)
Average current = 31.4 A, time = 0.667 h
Energy = (440 × 31.4 × 0.667) / 1000
= (13,816 × 0.667) / 1000
= 9,215 / 1000
= 9.2 kWh

Induction total (pre + post):
5.8 + 9.2 = **15.0 kWh**

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5) Percentage reduction:
((137.5 – 15.0) / 137.5) × 100 = **≈ 89 % reduction**

The above calculations clearly demonstrate that **Induction Heating consumes approximately 15 kWh**, compared to **137.5 kWh with Resistance Heating** for the same heating cycle.
This represents an **energy reduction of about 89%**.

Such a drastic reduction directly translates to:

- **Lower operational energy costs**
- **Faster heating cycle times**
- **Improved process control** (accurate, uniform temperature)
- **Reduced maintenance and downtime** (no heating elements to replace)

For the complete pre-heat + post-heat sequence:

Method	Total Power Used	Energy Saved
Resistance Heating	≈ 137.5 kWh	—
Induction Heating	≈ 15 kWh	"≈ 89% reduction" for uniform phrasing.

Technical Insight — Why Induction Is More Efficient

Parameter	Resistance Heating	Induction Heating	Key Difference
Heat Transfer Method	Conductive (element → part surface)	Direct electromagnetic heating of metal	Induction heats the workpiece itself, minimizing losses
Energy Utilization	~30–40% efficient	85–95% efficient	Less heat wasted to surroundings
Temperature Uniformity	Often uneven, slow heat transfer	Uniform and quick	Better metallurgical control
Maintenance	High (elements wear/burn out)	Low (solid-state electronics)	Lower downtime and spares
Cycle Time	Long due to slower ramp-up	3–5× faster	Higher productivity

Operational Impact

The substantial reduction in energy usage and setup time results in **lower electricity cost**, **less operator involvement**, and **faster job turnaround**.
For heavy-fabrication workpieces like this 2-m-diameter long-seam joint, induction heating not only enhances productivity but also contributes to **sustainable and energy-efficient operations**

Summary

The data clearly demonstrates the advantages of induction heating over resistance heating in terms of setup time, heating time, and power consumption. Key highlights include:

- **Setup Time Reduced by 91%** (10 mins vs 120 mins)
- **Time to Pre-heat Reduced by 86%** (20 mins vs 150 mins)
- **Power Consumed Reduced by 89%** (15 units vs 137.5 units)

Conclusion

In conclusion, while resistance heating may offer a lower initial investment, induction heating provides significant long-term cost savings and efficiency improvements. The reduced setup times, faster heating cycles, and lower power consumption make induction heating a more sustainable and productive solution for industrial heating applications. This analysis provides a strong foundation for businesses looking to optimize their heating processes and reduce operational costs.