FORGING FURNACES – REFRACTORIES/INSULATING – CARBON FOOTPRINT REDUCTION

July, 2026

1. Introduction:

¿What is forging?

Forging is a manufacturing process that deforms metals using localized compressive forces. Unlike casting, the metal is not melted, but rather worked in its solid state to change its shape and improve its mechanical properties..

¿ What is a forge?

The term forge has three main meanings depending on the context:

• **The workshop**: The physical location or factory where the metal is worked.

• **The machinery**: The furnace or installation where the metal is heated before being deformed.

• **The act**: The actual action of forging the material.

Main Forging Types

• **Hot forming:** The metal is heated above its recrystallization temperature to make it highly malleable.

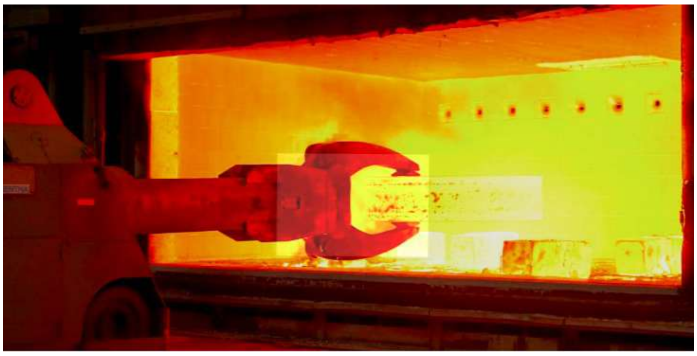
• **Cold forming:** The metal is deformed at room temperature, which increases its strength but limits the creation of complex shapes.

Key benefits of the process:

• **Increased strength**: Aligns the internal grain of the metal with the shape of the workpiece.
• **Eliminates defects**: Reduces internal porosity of the material through pressure.
• **Material savings**: Produces less waste than machining by cutting.

2. Description:

Since our field of action mainly revolves around refractory and thermal insulating materials, along with their assembly and repair, we will focus this work on **hot forging**, specifically in **forging furnaces**.



[Forging furnaces Classification]

For the development of your work, you can structure the types of ovens under these three main classifications.:

A. By Fuel Type

• **Gas Furnaces** (Propane/Natural Gas): These are the most efficient and common type of furnace today. They offer precise temperature control, rapid heating, and clean combustion that does not contaminate the metal with residue.
• **Coal Furnaces** (Traditional Forge): These use mineral coal (coke) or vegetable coal. The metal is placed directly into the embers. They require a continuous air blower and generate more waste (slag), but are valued in artisanal forging.
• **Electric Induction Furnaces**: These use electromagnetic fields to heat the metal from the inside almost instantaneously. They are extremely precise, safe, and clean, making them ideal for mass industrial production.

B. By their dimensions and structural design

• **Chamber kilns** (or box kilns): These have a fixed, enclosed structure with a front door. They are used for medium-sized or individual pieces.

• **Rotary hearth or continuous kilns**: These are giant industrial kilns where pieces enter at one end on a conveyor belt and exit at the other, ready at the ideal temperature.

• **Portable kilns**: Small, lightweight structures (common in farrier forges) that operate using portable gas cylinders.

C. By the type of thermal lining

• **Refractory bricks**: Dense blocks that absorb and retain a huge amount of heat. They take longer to heat the kiln, but maintain a very stable temperature and withstand physical impacts well.

• **Ceramic fiber blanket**: A lightweight, insulating material that resembles thermal cotton. It allows the kiln to reach its maximum temperature in a few minutes and consumes less fuel, but it is fragile and must be protected with rigid refractory cement.

3. Energy Management:

Energy efficiency in forging furnaces is critical, as heat expenditure represents one of the largest operating costs. Optimizing consumption depends directly on three key pillars: **lining materials**, **design and operation, and combustion technology**.

Below are the key points detailed for the development of this section of your work:

1. Optimization through Thermal lining

The lining is the barrier that prevents heat from escaping. The selection of materials defines energy efficiency:

• **Hybrid systems (Multi-layer insulation):** The best industrial practice is not to use a single material, but rather layers. An inner layer of **dense refractory brick** (which resists physical and chemical wear) is placed, backed by an outer **layer of low-conductivity ceramic fiber blanket**. This reduces heat loss through the outer walls (conduction losses).

• **Use of high-emissivity coatings**: Special paints or ceramic coatings are applied to the inner walls of the furnace. These materials reflect infrared radiation back toward the metal instead of absorbing it, accelerating heating by up to 15%.

• **Reduction of thermal mass** (Thermal inertia): Furnaces lined purely with ceramic fiber have a very low thermal mass. This means that the oven does not "steal" heat to warm itself, achieving massive energy savings in workshops that turn the oven on and off daily (intermittent operation).

2. Efficiency Based on Work Methods (Operation and Management)

The way daily work is managed drastically impacts fuel consumption:

• **Continuous Load Planning**: Turning the furnace on and off consumes a lot of energy to bring it up to operating temperature. Grouping pieces to work on in continuous shifts maximizes residual heat.

• **Strict Control of Door Openings**: Every time the door is opened to insert or remove a piece, a massive amount of heat is lost through convection and radiation. The use of automated dampers, air curtains, or minimal openings for piece passage prevents these losses.

• **Automated Shutdown/Standby Mode**: Implement systems that automatically reduce burner power to a minimum when the operator is forging the piece on the anvil and the furnace is empty.

3. Heat Recovery and Combustion Technologies

In gas and fossil fuel furnaces, the majority of energy is lost through the chimney as hot gases.

• **Recovery Systems (Recovery Units):** This consists of a heat exchanger installed in the chimney. The hot exhaust gases preheat the cold air entering the burner. Preheating the combustion air to 400°C can **generate net fuel savings of between 15% and 25%.**

• **High-Efficiency Burners (Modulating and Regenerative):** Older burners operate on an "on/off" basis. Modern burners modulate the flame by adjusting the precise air-to-gas ratio (stoichiometric control), preventing excess air from cooling the combustion chamber.

• **Energy advantages of induction:** If the focus is purely on saving energy, electromagnetic induction is the epitome of efficiency. It requires no preheating, has no chimney to lose heat through, and energy is transferred directly to the metal via magnetism, activating only when the workpiece is physically inside the coil.

4.-Energy Savings Calculation (Example):

A practical example of energy savings calculations arises from comparing the energy consumption of a traditional brick kiln versus a modern ceramic fiber kiln with a heat recovery system in the chimney.

Case Study Scenario

- **Material to be forged**: Carbon steel parts.
- **Operating temperature**: 1200 °C.
- **Daily production**: 1,000 kg of steel per day.
- **Fuel:** Natural Gas (Approximate calorific value: 9.3 kWh/m³).
- **Operating days per year**: 250 days.

Step 1: Theoretical energy required to heat the steel

First, we calculate how much energy the metal needs to physically absorb to reach 1200 °C.

- **Formula: Q** = m x Cp x ΔT
- **Mass (m):** 1,000 kg
- **Specific heat of steel (Cp):** 0.16 kcal/kg°C (average in that temperature range) or its equivalent of 0.000186 kWh/kg°C.
- **Temperature difference** (ΔT): 1200 °C - 20 °C = 1180 °C. Net energy in the metal = 1,000 kg / 0.000186 kWh/kg °C * 1180 °C = approximately 220 kWh/day

Step 2: Comparison of Consumption Based on Furnace Efficiency

No furnace utilizes 100% of the energy. Most of it is lost through the walls (lining) and the chimney.

Oven 1: Traditional (Overall Thermal Efficiency of 15%)

Due to losses through the heavy brick walls and the hot gases escaping freely through the chimney, this oven wastes 85% of its energy.

- **Total energy consumption**: 220 kWh / 0.15 = 1,466.6 kWh/day
- **Natural gas consumption**: 1,466.6 kWh / 9.3 kWh/m³ = **157.7 m³/day**

Oven 2: Modern Efficient (Overall Thermal Efficiency of 40%)

Thanks to the ceramic fiber lining (reduced heat loss through the walls) and the heat recovery system (which preheats the combustion air using the chimney), the efficiency increases dramatically to 40%.

- **Total energy consumption**: 220 kWh / 0.15 = 1,466.6 kWh/day
- **Natural gas consumption**: 550 kWh / 9.3 kWh/m³ = **59.1 m³/day**

Step 3: Annual Savings Balance

Now we multiply the difference by the 250 working days in a year to see the total impact.

- **Daily gas savings**: 157.7 m³ - 59.1 m³ = **98.6 m³/day**
- **Annual gas savings:** 98.6 m³/day x 250 days = **24,650 m³/year**

Economic and Environmental Impact (Estimated Example)

- **Economic savings**: Assuming an average industrial gas cost of USD 0.40 per m³, the savings are **USD 9,860 per year.**
- **Carbon Footprint Reduction**: Each m³ of gas burned emits approximately 1.9 kg of CO_2.

Emissions reduction= 24,650 m³ x 1.9 kg= **approx. 46,835 kg of CO_2 avoided per year**

Why do these savings occur?

1. **Lower Thermal Inertia:** A traditional brick kiln takes up to 3 hours to preheat in the morning (burning gas without producing any fuel). A ceramic fiber kiln reaches 1200 °C in just 20 minutes.
2. **Less heat loss through the walls (more insulating materials).**
3. **Heat Recovery Effect:** The air entering the burners of a modern kiln is already at 400 °C thanks to the heat recovered from the chimney, so much less fuel (gas) is needed to raise the temperature to 1200 °C in the kiln chamber.

4. How to redesign the furnace lining and how to select the most suitable materials to improve its efficiency:

Based on everything discussed, if our furnace is several years old and was not built with materials that provide good insulation, we should proceed to **REDESIGN** its refractory and insulating lining. This should be done according to the following principles:

1. **Friction or support areas of the steel to be heated:** Obviously, in this area, we must guarantee durability based on wear and tear. We should use bricks (45% or 60% alumina), but with a lower layer of type 23 insulating bricks, and below that, ceramic fiber boards.
2. **Wall and ceiling areas:** In these areas, we should consider using ceramic fiber modules (up to 1400°C) for the lining, in order to significantly reduce heat transfer and heat accumulation. A microporous board or ceramic paper can also be used as a layer alongside the steel sheet.

Resumen:

El The forging process requires high energy, and effectively saving energy will result in better costs and a reduced carbon footprint. Therefore**, redesigning** the refractory-insulating lining with more modern and up-to-date materials will allow us to achieve this goal.

This is where we believe that **Soluciones Refractarias SRL** are here to anticipate, solve, and install these materials.
Our company has all the resources to address these issues:

- Top-level technical advice.
- State-of-the-art materials, specifically designed for this problem.
- Cladding design and thermal calculations.
- Installation of the various materials using appropriate procedures.
- Convective hot air drying.stá presente para poder prever, solucionar e instalar esos materiales.

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Energy utilization in industrial furnaces

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All aspects concentrated in one place, our space!!!!