Operation of the Plasma Arc Furnace

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How To Operate a Plasma Arc Furnace

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Today's Focus

I. Definitions & Descriptions of the Technology

II. The Unique Characteristics of a Plasma Arc Furnace

III. Process of Smelting Catalyst with a Plasma Arc Furnace

I. Definitions & Descriptions of the Technology

What is a Plasma Arc Furnace?

Think Smaller Footprint

More Like This

Think Smaller Size

More Like This

Think Smaller Volume

More Like This

Think More Efficient

More
Like
This

Think of a More Controlled ENVIRONMENT

More
Like
This

Think More Precise

More
Like
This

Definition of Plasma

Plasma is often called “the fourth state of matter,” along with solid, liquid and gas. Just as a liquid will boil, changing into a gas when energy is added, super heating a gas will form a plasma. Keep in mind that plasma does have mass.

Definition of Plasma Arc Furnace

A Plasma arc furnace is a water cooled refractory lined vessel heated by an electric “PLASMA” arc torch which penetrates the roof of the furnace. The electric arc creates a molten bath of slag/alloy heating the bath to approximately 1500 dg. C. and actually stirring the melt pool to efficiently and effectively “SMELT” the material.

Definition of Smelting

Smelting is a pyrometallurgical method of combining ore or metal containing substrates with fluxes and reducing elements, usually quicklime and carbon to facilitate the reclamation of the contained valuable metal.

ANCIENT SMELTING

Smelting in the Context of PGM Industry

During smelting the ceramic-like supports of the catalysts form a slag material which has a lower density than the metallic components which are then able to move through and settle beneath the slag and be separated.

*Metals smelting-collection method for recycling of platinum group metals from waste catalysts: A mini review- Chuan Liu https://orcid.org/0000-0001-6367-3737, Shuchen Sun sunsc@smm.neu.edu.cn, and Ganfeng Tu - Waste Management & Research: The Journal for a Sustainable Circular Economy

Smelting in the Context of PGM Industry

The addition of a collector metal is often required due to the small particle size of the metallic particles which inhibits their settling rate through the slag. The collector metal forms larger particles which settle through the slag at a faster rate and absorb the target metals forming an alloy.

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Smelting in the Context of PGM Industry

This alloy is rich in the target metals and is then sent for subsequent refining, usually via hydrometallurgical routes. *

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Definition of Refining

In metallurgy, Refining refers to the purification or concentration of a desired metal or metals within an alloy.

It is to be distinguished from other processes such as smelting in that smelting involves a chemical change to the raw material, whereas in refining, the final material is usually identical - chemically to the original one, only purer.

II. The Unique Characteristics of a Plasma Arc Furnace

What is the Best Application of the Plasma Arc Furnace?

The Major Parts of the Furnace

- Water-cooled Furnace Shell
- Water Cooling System
- Refractory Lined Interior with Graphite Crucible
- Feed System
- Plasma Torch
- Robot to Articulate Torch
- DC Power Source
- Exhaust System
- Overflow Slag Tap Hole
- Alloy Tap Hole

Types of Furnace

Furnaces used in precious metal recovery from spent catalyst can be classified as either:

1. The conventional DC arc or AC arc furnaces, or

2. Plasma Arc Furnace

Key Differences of a Plasma Arc Furnace

- An Electric Arc furnace uses either a single graphite electrode (DC current) touching the melt and establishing an arc between the graphite electrode and the melt pool or three graphite electrodes (AC current) with the arc formed between the tips of the electrodes.

- A plasma arc furnace uses a fabricated water cooled tungsten tipped torch that penetrates a sealed roof and twizzles the arc above the melt pool.

Key Benefits of a Plasma Arc Furnace

It runs continuously with intermittent alloy taps whereas the electric arc furnace operates in a batch process.

This results in continuous slag to over-flow and provides consistent retention time and temperature control.

Key Benefits of a Plasma Arc Furnace

The plasma arc furnace is smaller than the electric arc furnace requiring less of a foot print and less energy consumption.

Key Benefits of a Plasma Arc Furnace

The plasma furnace can be operated in more tightly sealed environment and with less off gas velocity minimizing PGM reporting to the baghouse fly ash.

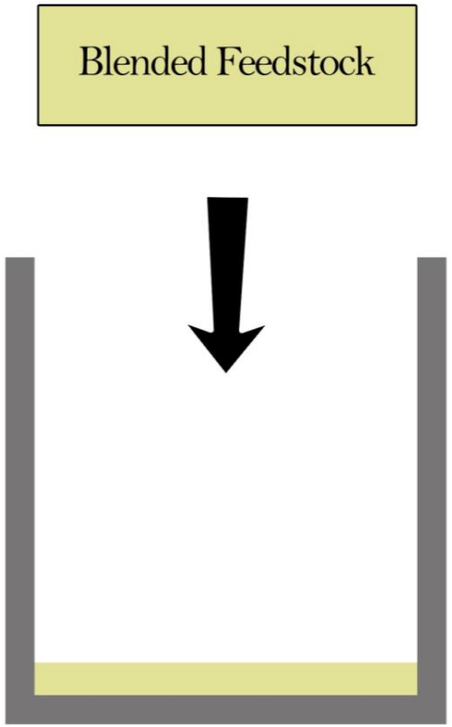
Key Benefits of a Plasma Arc Furnace

The plasma arc has mass so it provides a gentle stirring action facilitating the interaction of reduced alloy within the bath which in turn improves the recovery percentage of PGMs.

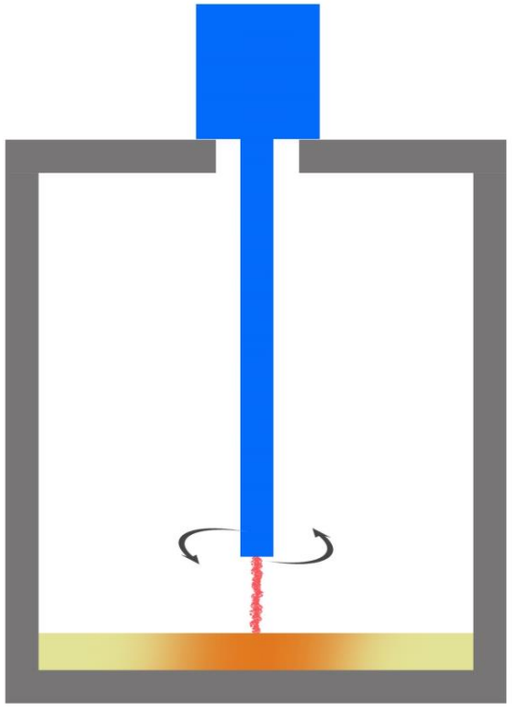
III. Process of Smelting Auto Catalyst with a Plasma Arc Furnace

At the Completion of the Smelting Process You End Up With 3 Output Products

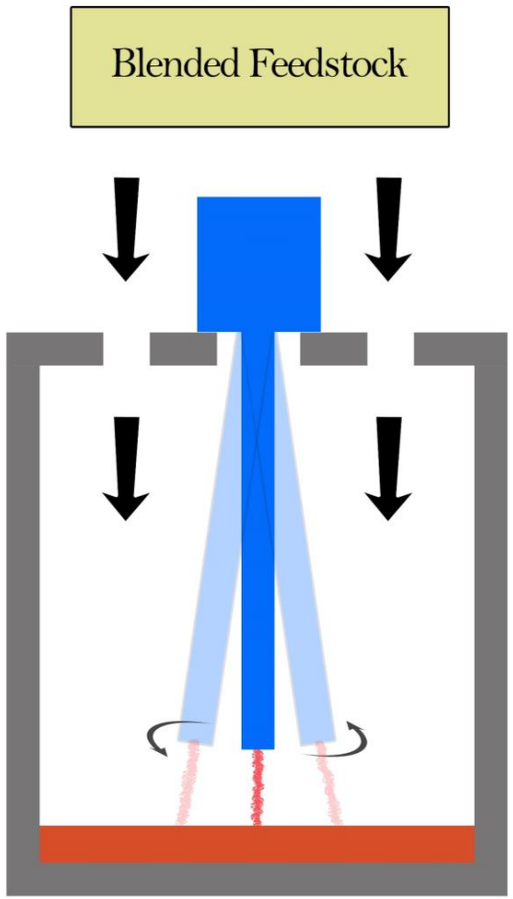
- Slag – A mineral substrate that is composed of two or more elements that forms a low melting point eutectic and facilitate smelting by forming a liquidous bath.
- Fly Ash – The flue dust or bag house dust captured through the exhaust system.
- PGM Alloy – The collector metal of iron or copper in which platinum, palladium and rhodium is dissolved.



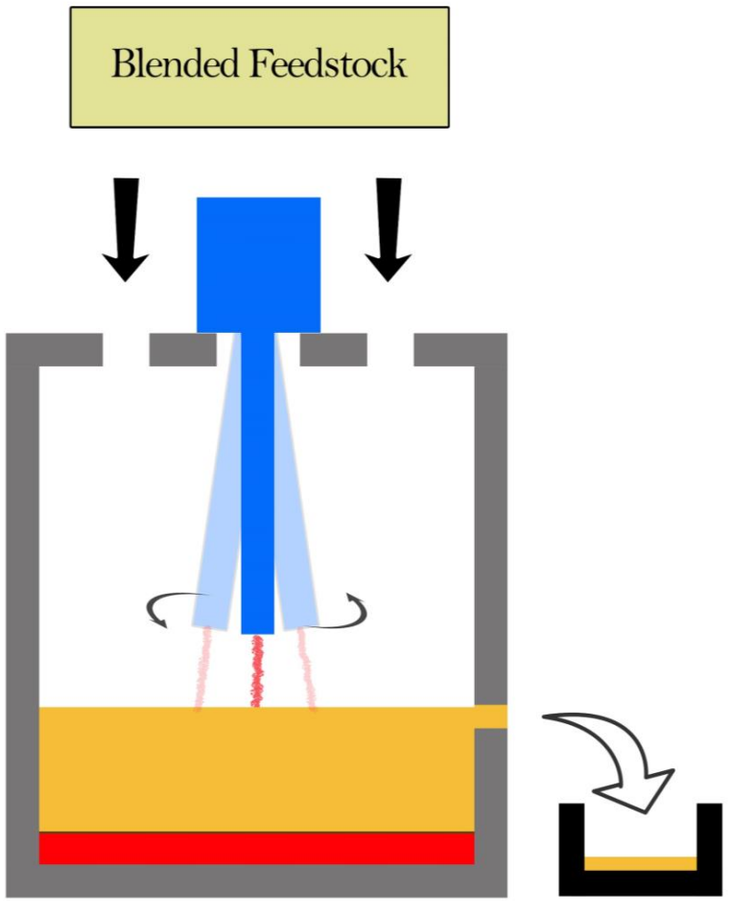
- Cleaned, milled, and sampled catalyst material is blended with other materials before being fed to the furnace.



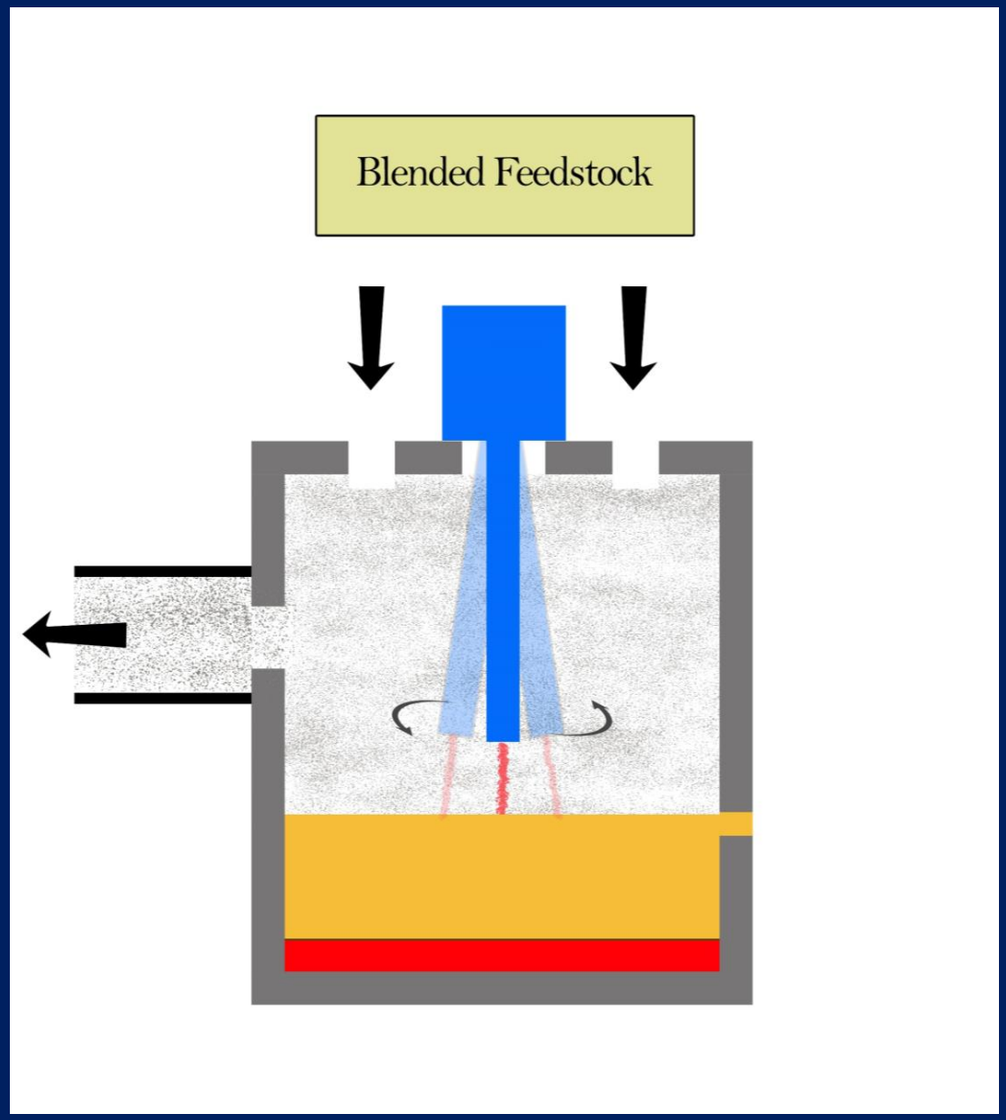
- The Plasma Arc Torch is positioned appropriately, and “Firing Plasma” strikes an arc.
- The plasma arc begins to melt the material and starts to create a “melt pool”.



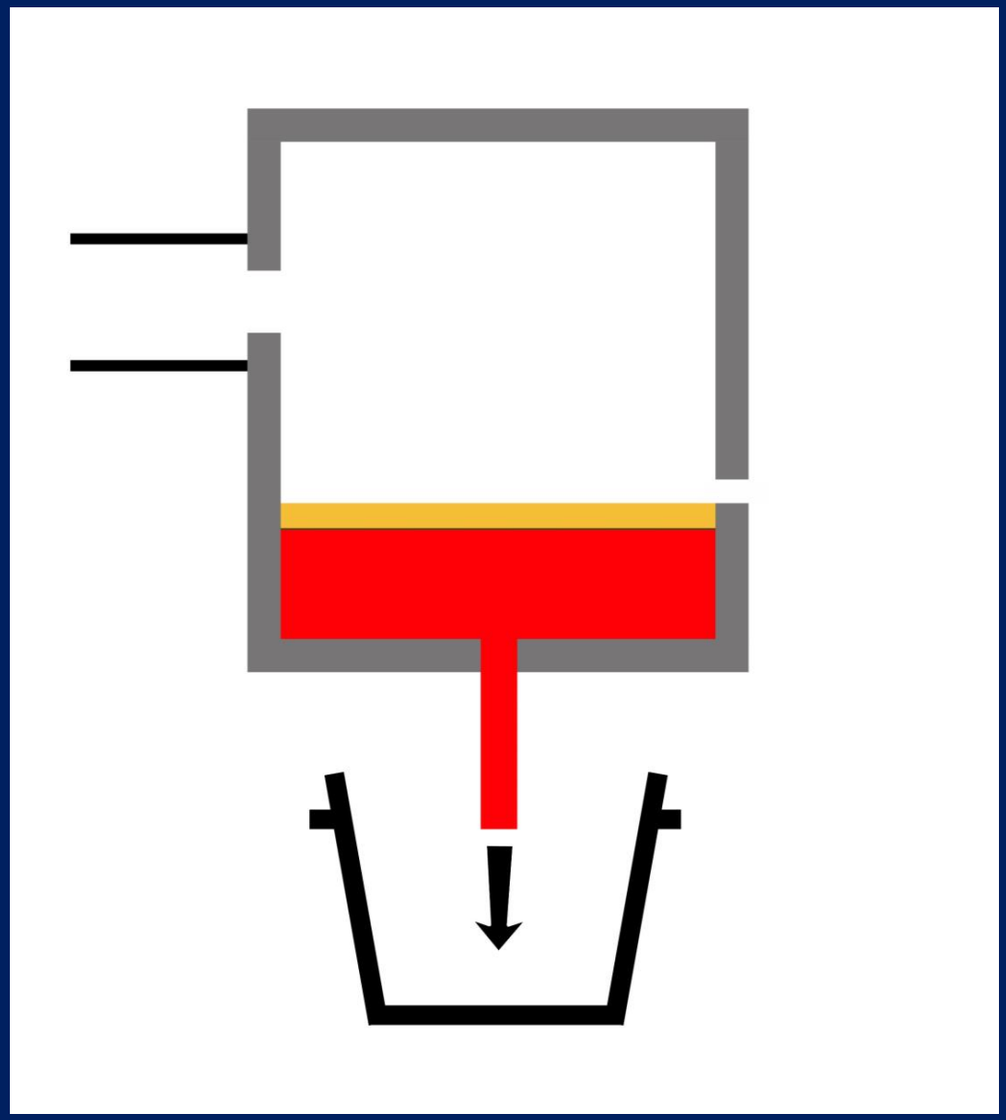
- Once a small “melt pool” has been established, the torch begins to rotate, or ‘twizzle’, slowly increasing in radius to create a larger and larger molten bath
- Blended feedstock is added in continuous feed to increase volume in the furnace
- As volume increases in the furnace, the melt begins to separate



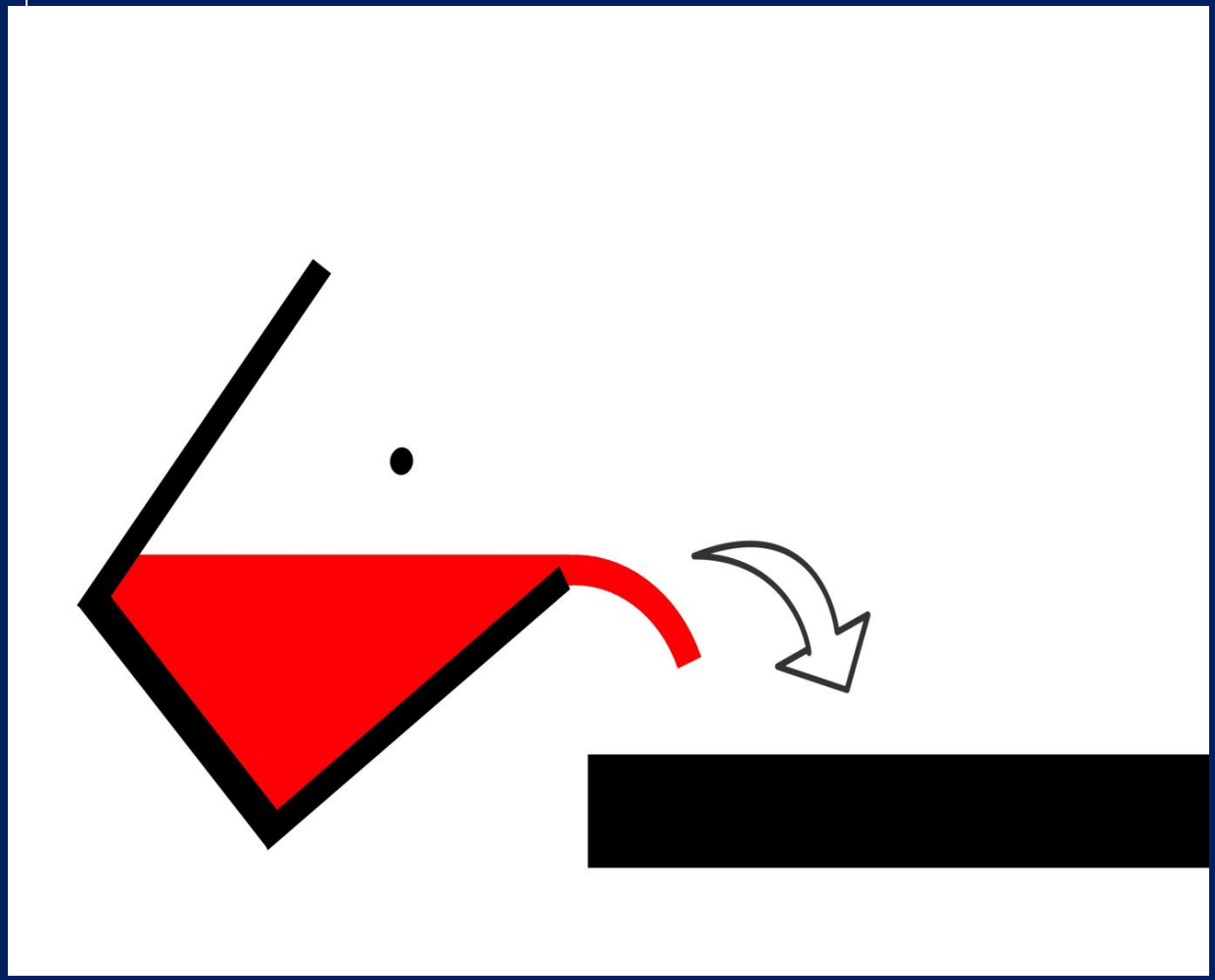
- Heavy collector metal binds to PGM’s and falls to the bottom
- Once the overflow level is established a continuous overflow of waste slag exits from the side of the furnace.
- Waste slag is captured and tested for PGM content. If ppm are low, slag is considered disposable and discarded. If remaining ppm are economically viable, material is crushed and fed back to furnace.



- As the furnace smelts the catalyst, a certain amount of dust/soot/fly ash is generated.
- The Fly Ash has the potential to contain significant levels of PGM's so it is collected and tested.
- As with the waste slag, if the ppm's are low, it is considered disposable. If higher levels are detected the Fly Ash is further processed to capture the PGM's.



- After sufficient smelting, the alloy in the bottom of the furnace accumulates.
- At intervals the plasma torch is withdrawn, and the furnace is tapped to capture the PGM rich alloy

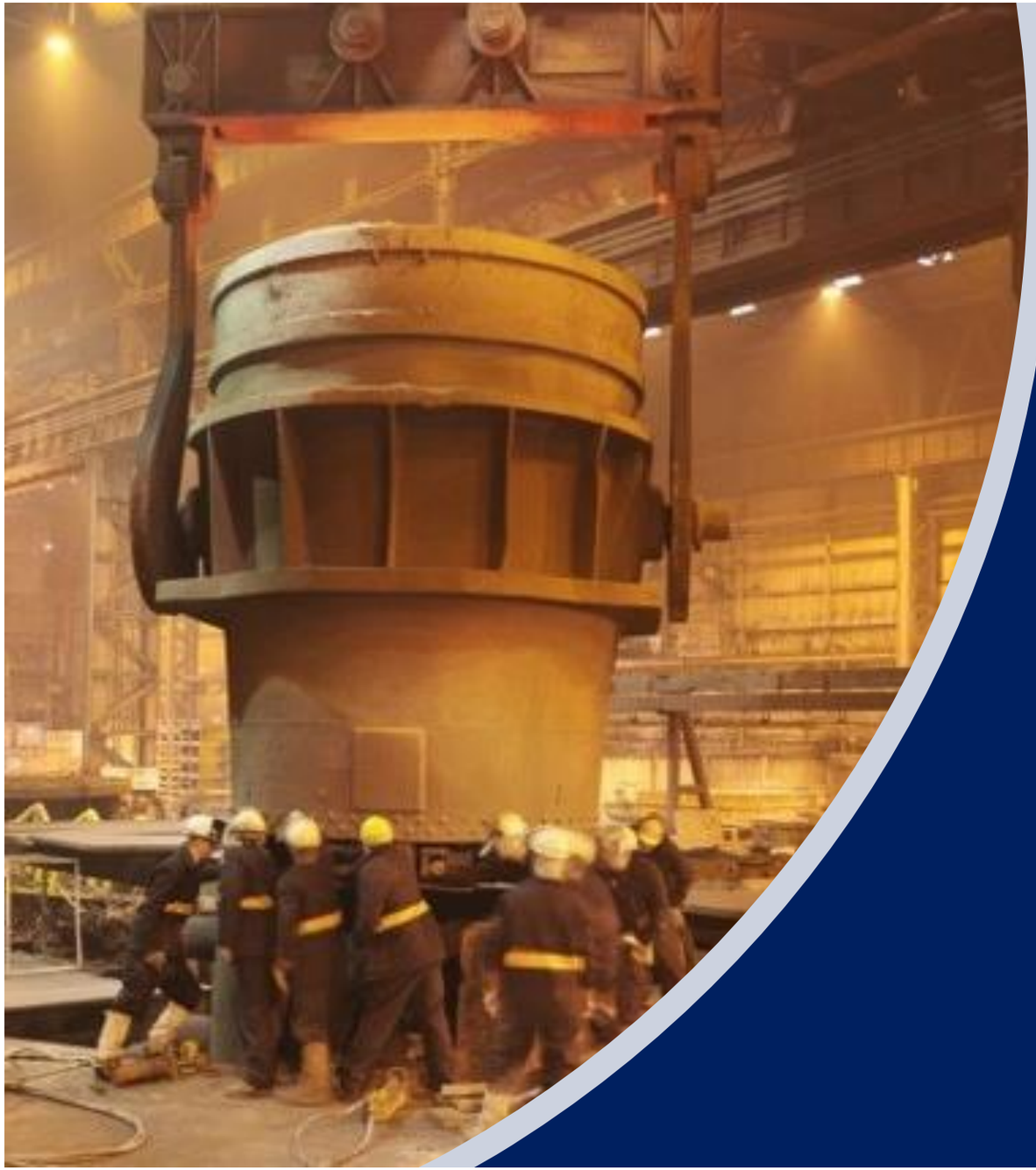


- The alloy containing the rich PGM’s is captured in a ladle and then quickly poured out on a flat surface to spread and cool
- As the alloy cools it separates between a layer of alloy and a layer of residual slag

- Slag from a tap is richer in PGM's than overflow slag so it is processed, milled and returned to the furnace for additional smelting

- The Alloy is cleaned, milled, sampled and sent on for enhancement and refining

So How Do You Tap A Plasma Arc Furnace?



Again
Think
More
Precise

More
Like
This

Conclusion

While Plasma Arc Furnaces are not capable of handling as large a volume as other traditional furnaces, they are extremely efficient and as such they are particularly well suited in size, function, and ability to play an important role in the recovery of PGM’s.