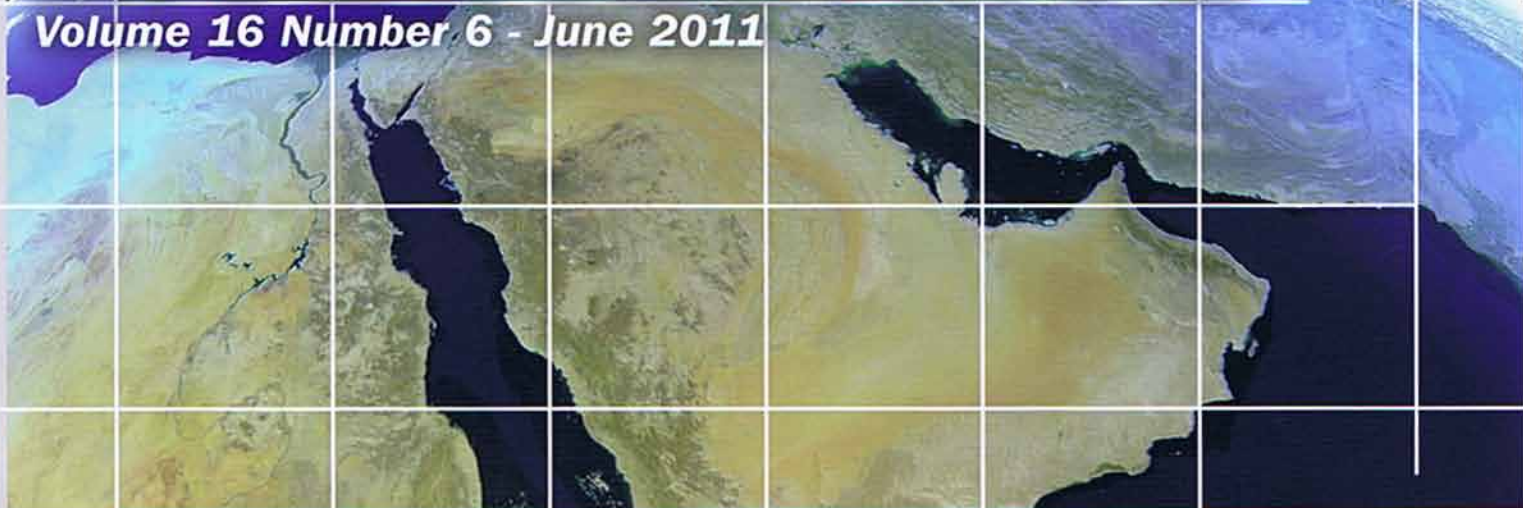
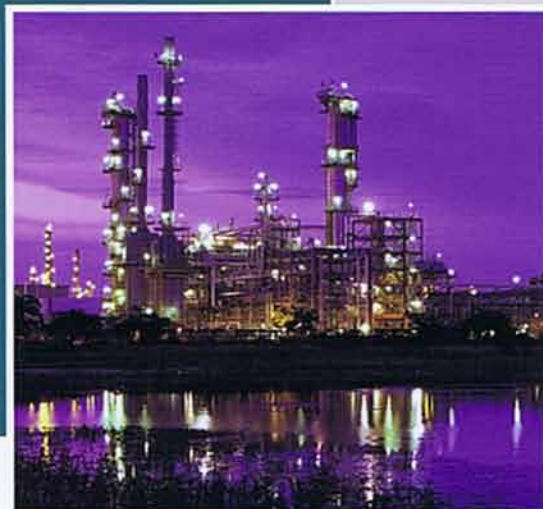


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ASSESSES THE IMPACT OF PLATINUM GROUP METAL VALUES ON THE PROFIT MARGINS OF PRECIOUS METAL CATALYST USERS.

The global economic crisis of the past few years has been rough on virtually all sectors, although there are notable exceptions. One such anomaly is the precious metals commodities market, within which prices are booming. The current high cost of precious metals (specifically platinum group metals (PGMs) including platinum, palladium, rhodium and ruthenium) is having a direct affect on refining profit margins, as these materials are widely used in hydrocarbon and petrochemical processing applications.

Due to high PGM values, users of PGMs (or other precious metals such as rhenium, gold and silver) are paying significantly more for their fresh catalysts than in the recent

past. For example, current platinum and palladium prices are at near all time highs of US\$ 1800 /oz and US\$ 750 /oz respectively at the time of writing. Hydrocarbon/petrochem processors use fixed bed reaction catalysts to facilitate hydrogenation of various intermediates. These catalysts may also be used to control and/or abate harmful or unlawful exhaust emissions for 'end of pipe' applications. Regardless of how catalysts are applied (or whether they take the form of monolithic structures, pellets, beads, or extrudates, Figure 1), eventually catalyst users must work with a precious metals refiner to recover the valuable metals from substrates and carriers such as soluble or insoluble alumina, silica/alumina and zeolites.

The rising costs of PGMs

As costs for PGMs and other precious metals rise, catalyst users will face a classic profit squeeze if recovery/refining processing turnaround time



Figure 1. Precious metal bearing catalysts are commonly used for facilitating or accelerating hydrocarbon/petroleum production processes. They are typically formulated as pellets, beads or monolithic structures.



Figure 2. A continuous catalyst sampling system produces consistent, reproducible, statistically valid samples: the most important step in the recovery and refining process.

increases along with lease rates for precious metals (as they are likely to do). While any one of these factors will decrease profits, the combination of all three could potentially trigger a 'perfect storm' with obvious negative effects. Precious metal lease rates, for example, are generally directly influenced by precious metal values. With extraordinarily high PGM prices, users are thus forced to seek relief in a number of different ways. Given that PGM users cannot control commodities prices, the next best place to turn is to a precious metals refiner. This is because the refiner has a measure of control over precious metals management, particularly with regard to recovery and refining returns.

To this end, it is prudent for precious metal catalyst users to learn as much as possible about the processes, procedures, history, customer relationships and environmental policies of the relevant refiner, either directly or from outside sources. Armed with this information, it is easier to reach an informed decision regarding the selection of a precious metals refiner that meets the particular idiosyncratic needs of a given operation.

Precious metals refiners

Many organisations recover and refine PGMs and other precious metals from spent catalysts. While they all essentially perform the same function, it is important to be aware of some considerable differences between them, as these can have a significant impact on returns and, critically, affect the risk of litigation through exposure to local or foreign environmental and regulatory governing authorities. Therefore, it is in the user's best interest to learn as much as possible about the precious metals refiner under consideration. For example, information regarding how the refiner processes spent catalysts and what equipment and procedures it uses should be on hand. Particular areas of interest include the refiner's process contamination removal methods, material sampling and assaying methods, environmental protection policies and procedures; compliance with international trade and logistics policies; and (perhaps most important) the refiner's reputation with its long term customers. All of these issues and more will have an impact on the relationship established with the precious metal refiner.

Risk of litigation

There are significant legal implications that must be considered when working with a precious metals refiner. These primarily concern environmental issues such as possible effluent or atmospheric discharges at the refiner's facility. This is because violations are taken incredibly seriously by controlling organisations, and any oversights may result in both the refiner and the refiner's customer being held liable for any violations. Based on these concerns, choosing the wrong refiner could result in a costly mistake.

Recovery and refining

The process of reclaiming precious metals from spent catalysts is referred to as 'recovery and refining' This umbrella term covers many specialised procedures, including materials documentation, contamination removal, sampling, assaying, recovery, refining, environmental considerations and total turnaround time. Each of these functions is independent; however, together they will have a dramatic affect on how much of remaining PGMs are recovered, the speed at which they are recovered and the value returned to the user. Consequently, these procedures impact the overall costs associated with an organisation's precious metals management program. While each of these functions is important, sampling procedures are perhaps the most critical elements with regard to determining the amount, and thus the value, of the precious metals in spent catalyst lots. It is in the user's best interest to understand how sampling is used to determine the precious metals content of spent catalysts.

Precious metals sampling

Most precious metal refiners use three common sampling techniques: dry

sampling, melt sampling and solution sampling. Each of these techniques offers specific advantages, but the most appropriate sampling method depends upon the type of material being processed as well as its estimated precious metals content.

Some precious metal bearing materials can be sampled only by one of these three methods, but others may be processed by more than one method. The method chosen will depend on variables including the estimated value of the precious metals content; the cost effectiveness of using one method over another for the most accurate results; practicality (a function of refining costs, materials value and other factors). As precious metal bearing catalysts are made with various substrates (and in many sizes and configurations), determining the best sampling technique is crucial to ultimately recovering the most value from the spent catalyst.

The principle of sampling involves 'reducing' large quantities of precious metal bearing material (often multiple tons) into small quantities (as little as a few grams). Samples are then extracted for analysis from different fractions and/or different stages of the resultant subplot. The sampling



Figure 3. An in house rotary kiln eliminates up to 25% of the sulfur content and 3% of the carbon from spent catalysts. It also eliminates the need for a separate, off site pre-burn step.



Figure 4. An electric arc furnace represents the latest technology for refining spent PGM catalysts.

procedure begins by converting precious metal bearing scrap into a uniform, consistent, free flowing mass so that molecules of precious metals and other constituents are evenly distributed. The results of sampling the uniform mass thus represent an accurate ratio of the precious metals content in the overall matrix.

Dry sampling

Dry sampling is used whenever materials cannot be dissolved in solution or are inappropriate to melt. Materials are considered inappropriate to melt because of their structure or because of the cost associated with melting versus the possible return. Due to the inherent difficulty of achieving uniformity, dry sampling is more complex and potentially less precise than melt or solution sampling. In fact, this method requires more judgmental skills than any of the others. Dry sampling spent catalyst materials is essentially accomplished by grinding large pieces into smaller and ever finer particles, which are allowed to free fall in a stream into a crosscut, timed automatic sampler. Representative samples are also taken periodically and sampling accuracy is typically $\pm 2\%$. There are many more steps involved in the dry sampling process, of course; but this is the fundamental idea behind the technique. Precious metal bearing catalysts are generally sampled with this technique (Figure 2).

While there are many minute details associated with precious metals recovery and refining, essentially the user's refiner selection criteria must detail the refiner's sampling, assaying and processing procedures (including turnaround time, logistics, and environmental compliance issues). All of this information should be accessible. For example, at the end of their life cycle, hydrocarbon processing catalysts are typically contaminated by sulfur, carbon, moisture and other unwanted elements, depending upon how they are employed. Given that most spent hydrocarbon/petrochem catalysts are subject to dry sampling procedures, in order to maximise sampling accuracy, the organic materials and moisture in the spent catalysts must first be removed to assure accurate evaluation of the remaining precious metals. This process is accomplished with an indirectly fired rotary kiln, which significantly enhances sampling accuracy and thus helps assure accurate determination of remaining precious metals. Furthermore, it helps reduce overall refining costs when it is carried out directly at the refiner's facility. This is a key issue with regard to the total cost of recovery and refining and, by inference, the overall profitability of a precious metals management program. The typical rotary kiln will remove up to 25% of the materials' sulfur content and up to 40% carbon content, usually at a rate of 300 - 1000 lb/hr (Figure 3).

On site contaminant removal

Contaminants in spent catalysts may also be removed by a multiple hearth furnace or fluidised bed furnace. In any case, this first step, often called 'preburning', is critical to the sampling process. Equally important (at least from a financial perspective) is how and where the contaminants are removed. Many catalyst users must first ship their large lots of spent catalysts (perhaps as much as 35 000 — 500 000 lb) to an independent facility where strip burning removes their hydrocarbon content (e.g. benzene), while coke burning removes carbon. Another additional furnace may be required for drying of fine particulates and other materials to eliminate moisture content.

There is another, equally important advantage of having the refiner handle the preburning or contamination removal procedures in house: namely, the accountability the refiner has over a specific catalyst lot. This eliminates all possibility that materials could be mixed in with unrelated materials from another organisation. In that case, there is clearly no way an accurate determination of its actual value could be calculated.

With regard to the contaminants associated with spent precious metal bearing catalysts, most typically exhibit high loss on ignition (LOI) characteristics (caused by high moisture content) and high sulfur and/

or high carbon content. Removal of these contaminants is critical to the downstream sampling process. This is because the materials must initially be free flowing (with low LOI) to arrive at a final evaluation sample that is at least accurate to $\pm 1\%$. Here, preburning can make a key difference: if the high moisture content and other contaminants are not removed, a suitably accurate sample cannot be obtained by the refiner, thus eliminating the possibility of providing a fair and true return value to the customer.

Off site contaminant removal

Longer turnaround time and additional costs are the two main considerations associated with off site strip and coke burning of spent catalyst materials. In other words, unless these capabilities are available at the refiner's facility, catalyst users must pay substantial transportation charges for shipping to an independent, off site facility. It would not be uncommon for the material to remain up to a month for processing before it would again have to be shipped to the refiner to start the actual sampling, analysing, recovery and refining process. During this time, the PGMs are unavailable to the catalyst user: therefore new metal must be acquired at current market prices and lease rates.

Prices in action

At today's* current palladium price of approximately US\$ 750/oz, a 10 000 lb lot of 1.0% palladium, at a lease/financing rate of 3% would cost over US\$ 2730/month to lease the metal contained in that material. If the user is applying platinum based catalysts, a 10 000 lb shipment of 0.3% platinum catalyst (with platinum at US\$ 1800 /oz and a lease rate of 4%) would cost over US\$ 2620 /month to lease the metal contained in this material. Using this platinum based catalyst example, a six week recovery/ refining turnaround versus a 12 week turnaround would save the user more than US\$ 3650 in lease charges. While these savings are not dramatically large, it should be noted that platinum lease rates have been as high as 200% and palladium lease rates have been as high as 100%.

The worldwide production of primary (mine production) sources, the immediate local availability of physical metal and the demand for the metals govern variations in lease rates. For the catalyst user, PGM lease rates usually represent a significant cost, since 'new' precious metals are often financed while spent catalysts are being recovered and refined. By providing faster spent catalyst reclamation turnaround times, substantial cost savings into the hundreds of thousands of dollars may be realised every year. Consequently, there is a clear trend towards establishing independent asset recovery programs (or departments) functioning as profit centres for the recovery of precious metals within an organisation.

The role of assaying

On the other hand, accurate and repeatable assaying procedures require sophisticated instrumentation for measuring the precious metals content of materials being reclaimed. A well equipped analytical laboratory utilises advanced x-ray fluorescence equipment, atomic absorption (AA) and inductively coupled plasma (ICP) emission spectroscopy, while also incorporating classic volumetric, gravimetric and fire assay techniques. When all methods are used together they provide the most thorough and precise approach for determining precious metals content in spent catalyst materials, thus assuring highest proper determination of value. Generally, the types of materials being processed determine specific assaying techniques.

Environmental concerns

As previously mentioned, the user must also consider the legal implications associated with processing procedures at the precious metals refiner.

Choosing a refiner with disregard to possible unlawful effluent or atmospheric discharges could become significantly problematic.

When selecting a refiner, the customer should be aware of how materials (both the user's own and the refiner's other customers') will be processed. For example, it is the user's responsibility to determine how any solid, liquid, or gaseous byproduct is handled at the processing facility.

For instance, exhaust air quality should be managed with state of the art pollution control systems, resulting in minimal pollutants being emitted before, during, or after refining. In addition, the process water treatment procedure should minimise all causes of pollution. While each of these functions is fundamental, there are many hidden pitfalls surrounding them with regard to environmental compliance.

Requesting detailed documentation on environmental law compliance may help determine that the chosen refiner does not violate any applicable law or regulation. In the US, the Superfund Act (CERCLA) addresses the direct responsibility of customer and refiner. This law mandates that both the company that is the source of the materials for precious metals recovery and the precious metals refiner share in the 'cradle to grave' responsibility, as well as future liability for the proper treatment and/or disposal of any materials. Therefore, when choosing a precious metals refiner, it is important to select an organisation that does not violate any applicable environmental laws or regulations. The refiner should provide copies of all detailed documentation relative to regulatory compliance. Essentially, the environment must be protected to avoid serious financial and legal consequences: the refiner's violation of environmental laws or regulations could result in heavy fines and legal costs passed onto the customer.

One way to determine if a refiner meets these criteria is to check its use of appropriate pollution abatement technology such as afterburners, bag houses, wet scrubbers and liquid effluent neutralising equipment. Furthermore, it is necessary to evaluate the refiner's approval status with all applicable agencies at local, state and federal levels. The majority of precious metals refiners will be pleased to provide copies of all required documentation, which could include permits under the Clean Air and Water Acts and prove that the company qualifies as a bona fide precious metals refiner as specified in Subpart F of the Resource Conservation Recovery Act (RCRA) regulations and the preamble to the Boiler and Industrial Furnace (BIF) Rule and its amendments. There also exists another, more recent series of laws under the overall umbrella of the US PATRIOT Act that also could have significant negative impact on precious metals users and refiners. The scope of this law is so broad, that it would make good sense to review it thoroughly before engaging any precious metals refiner for spent catalyst materials.

Conclusion

The information here is designed to provide a general approach to seeking and successfully working with a precious metals refiner for spent hydrocarbon/petrochem catalyst materials. While each of these areas discussed is important, the issue of a refiner's compliance with applicable international environmental and legal regulations is paramount. With all else being equal, a refiner's violations could create problems. Crucially, the customer's relationship with a particular refiner must be viewed as a 'partnership' and should be based upon mutual trust and fair treatment.

Notes

*Figures updated on 11th May 2011.