PRESENTATION ON

Incorporated Testing, Design Engineering, Fabrication and Services are provided to conform tailor-made solutions for Gold Industry
Gold is a precious metal, as are silver and the platinum group metals (platinum, palladium, rhodium, iridium, ruthenium and the extremely rare osmium).

They are called precious metals because of their great resistance to chemical (and environmental) attack, because of their scarcity and, particularly in the case of gold and silver, because of their universal use in jewellery.

They frequently occur in nature as “native” metals, that is in the metallic state and not as compounds, though often they are in combination with other metals in mineral form, and frequently in combination with each other.

Because of their strong resistance to chemical attack, techniques for separating the individual precious metals are often complex, particularly those for the platinum group metals (pgm’s).
Why should we need to enter in the Gold Refinery process business?

- Refineries are quite lucrative businesses. It's all really about services or processes.

- Why refinery process is required? No one can do any work without profit. In this Refinery process, the profit occurs in all the ways. Actually in this refinery process profits will be for each and every material and there is no wastage.

Let's see how many ways are there getting profits while doing refinery process:

- While selling the scrap gold, it can be assay it, to find out exactly what percentages of what metals has been provided them. In such a way for finding to provide the output charges are applicable. The first profit will be for the "Serving charge"

Continued...
Then for using acids to dissolve some metals and not others to purify the valuable metals.

If Suppose for selling some gold scrap getting second profit. For example selling some 14K gold scrap. actually the sold gold scrap consists of metal alloy of 58% gold, 20-25% silver, and 12-7% copper by weight.

Proportions vary by different alloys, but the Karat of gold is always a fraction of 24. 24K is 99.9% pure and 12K is 50% pure.

Anyway, getting payment for the gold, at less than 58% what gold traded for on the day they receive the shipment because the gold sold was scrap, therefore of a lesser value because it needs to be processed (by them) to be of pure value again.

Continued...
Another way of profit for devalued rate for scrap, and in case it has been missed it, both silver and copper have a value, and are traded as commodities, but the refinery probably won't pay for the other metals in the alloy. Though it may not be as big a number as the gold, they deal in volume and the little numbers add up.

By the very process of removing the impurities they increase the value of the metal, and that is the main making profit. Used metal has less value as pure, unless it has historical or sentimental value.

If a refinery has purified an alloy into it's purest state, the metal is in a more rare state. The laws of supply and demand follow. Since refineries are the main source of pure metal, they stand to make the first, and most, profit from the refining process.

Why should we need to enter in the Gold Refinery process business?
Gold Refining

It has been seen that the various gold-containing materials available to the gold refiner, whether primary material from mines or natural sources or scrap gold products, have a high probability of containing silver and copper, and frequently may contain other base metals and platinum group metals.

For the purposes of discussing the refining techniques, it is therefore assumed that the refinable gold material also contains silver, pgm’s and base metals and their behaviour in the processes will be addressed in turn.

**Metal refining is made up of two types:**

- **Primary:** Primary refining is the refining of gold ore from the ground
- **Secondary:** Melting of scrap down to a fine gold product is considered secondary refining.

There are many techniques from which gold can be extracted, in both primary and secondary refining.
Bullion Purity

bullion Purity can be fineness of

- 995 in parts per thousand.
- 999 in parts per thousand.
- 999.9 or 999.99 in parts per thousand.
Refinable Materials

REFINABLE MATERIALS:

- Mined Gold
- Alluvial Gold
- Scrap Jewellery
- Scrap Dental Alloys
- Other Gold Materials
Assaying of Gold

- Before gold can be sent to the smelter, it must either be weighed, in the case of scrap gold, or the customer and the smelter must agree on the estimated metal to gold content before extraction.

- Assayers take a drilled sample of gold bullion from the customer and send it off to a lab to determine the precious metal content within the bullion. The assaying process is a condensed refining process that allows the content of precious metals to be discovered.

- Assay results must agree with the multiple tests that are performed and if they do not, the samples are melted again to make it homogeneous and tested again. Sweeps, which tend to be a lower quality gold, are incinerated to burn all combustibles then converted into a fine homogeneous powder.

- After this process, the powder can then be sent to an assayer to determine the precious metal content through samples.
Assaying Techniques

Types of Assaying Techniques:

- Fire Assay
- ICP Spectrometry
- X-Ray Fluorescence
- Touchstone
- Density measurement
Gold Refining Methods

Types of Refinement

Seven methods are commonly employed for purification:

- MILLER PROCESS
- FIZZER CELL
- WOHLWILL PROCESS
- AQUA REGIA
- PYROMETALLURGICAL
- CUPELLATION
- INQUARTATION AND PARTING
The Miller industrial process refines scrap metal with an unknown but measurable content of gold into gold with a purity of 98 to 99 percent.

The Miller process begins when scrap metal is melted into chunks small enough to put into crucibles, using a furnace and some form of granulator.

Granulators make the gold chips look like corn flakes, with a high surface area, so that during the chemical process all gold is thoroughly treated. The gold flakes are put into a crucible, which is heated until the metal becomes molten, and then aerated with chlorine gas.

The chlorine gas reacts with all metal that isn't gold, so that the chlorides created can be separated from the gold, creating a fine product.
Outline of Miller Refining Process

GOLD + SILVER + BASE METALS + PGMs

BUBBLE CHLORINE GAS THROUGH MOLTEN METAL

GOLD + PGMs CAST AT COMBINED PURITY OF 99.5 - 99.7%

FURTHER REFINING NECESSARY TO REMOVE PGMs AND / OR TO PRODUCE 99.99% PURE GOLD

BASE METALS AND SILVER FORM CHLORIDE SLAG OR VOLATILES
The Wohlwill process produces gold of a purity greater than 99.99 percent.

The Wohlwill process involves electrolysis, in which an ingot of more than 95 percent gold is suspended in chloroaauric acid. The ingot is called the anode; the cathodes, 24 karat gold strips, are also floating in the chamber.

Electric current is run through the chloroaauric acid, and the acid and electrolysis dissolve the anode and collect pure gold on the cathodes. These cathodes are taken out and melted down into fine gold.

Often industry locations use first the Miller process followed by the Wohlwill process, although the Wohlwill process is more expensive, requires more equipment and requires high gold inventories.
Cupellation is a refining process in metallurgy, where ores or alloyed metals are treated under high temperatures and controlled operations to separate noble metals, like gold and silver, from base metals like lead, copper, zinc, arsenic, antimony or bismuth, present in the ore.

The process is based on the principle that precious metals do not oxidize or react chemically, unlike the base metals; so when they are heated at high temperatures, the precious metals remain apart and the others react forming slags or other compounds.
Outline of Cupellation Process

Low grade scrap containing gold, silver, base metals and PGMS after incineration

Smelt with flux, iron sulphide and lead oxide

- Slag
- Matte of copper sulphide
- Lead bullion containing gold, silver and PGMS

Cupellation

- Alloy of gold, silver and PGMS
- Lead oxide

Further refining necessary to produce gold
Inquartation and Parting

- The technique mirrors part of the Fire Assay process used in the analysis (assay) of gold. Inquartation involves initially diluting the gold in the refinable material to about 25% (literally ‘quartering' the gold) by melting with the appropriate addition of copper or silver, granulating the melt so as to generate a high surface area and then treating with nitric acid.

- The acid will dissolve the silver and base metals, leaving behind the gold. The acid treatment is known as parting as it ‘parts' (separates) the gold from the silver and base metals. Dilution of the gold content is necessary to ensure that the nitric acid can readily attack and dissolve the base metals and silver, some of which may be otherwise masked by the gold. Any palladium which is alloyed in the gold will also be removed by the acid.
Outline of Inquartation & Parting Process

GOLD + SILVER + BASE METALS + PGMS

MELT, WITH ADDITION OF SILVER TO ENSURE GOLD CONTENT IS <25%, AND GRANULATE

GOLD + SILVER + BASE METALS + PGMS IN GRAIN FORM

TREAT WITH NITRIC ACID, FILTER

GOLD PLUS IRIDIUM, RUTHENIUM, RHODIUM, OSMIUM

BASE METALS, SILVER, PALLADIUM AND PLATINUM IN SOLUTION

FURTHER REFINING NECESSARY TO PRODUCE PURE GOLD IF PGMS PRESENT
The Fizzer Cell Process is an improved Wohlwill Process whose main change is the cathode design. There is a porous ceramic container that works like a membrane whose purpose is to avoid gold losses and adhesion of some impurities on cathode surface.

The electrolytic cell is drained and filtered. A very important aspect of this process is referred to the possibility of treating impure anodes, basically when the silver content is as high as 10%.
This process is not strictly a refining process but a means of converting scrap jewellery alloys into clean gold-silver-copper alloy suitable for realloying into new jewellery alloys.

The principle is to smelt scrap gold alloy under a flux and to bubble air or oxygen through the molten metal to electively oxidise impurities such as zinc, cadmium, iron, tin, lead. The oxidised metal impurities combine with the flux to form a slag on the surface of the melt. Typically the reaction time can be about one hour and the end point is best determined by estimating the copper content of the slag. Detailed analysis of the metal is necessary before subsequent use.
Outline of Pyrometallurgical Process

- Gold + Silver + Base Metals + PGMs
  - Melt with flux, bubble air, oxygen through melt
    - Gold + Silver + Copper + PGMs
      - Suitable for recycling into jewellery alloys
    - Other base metals form slag
The Aqua Regia Process is appropriate to be employed in small scale and the metallic gold to be obtained is as pure as 99.9%. The main steps of the process are to dissolve the precious metals and some impurities. Since the Aqua Regia is a mixture between nitric acid and hydrochloric acid, part of the silver will remain in solution and other part will form a silver chloride precipitate. Then, it is important to be careful with the silver content.

It must be mentioned that the silver chloride formation has a negative effect on gold dissolution. Once the dissolution is performed, the solution and the precipitate are separate by filtration operations. The solution contains gold and is treated with reducing agents such as ferrous sulphate, sulphur dioxide or sodium bi-sulphate. Gold powder of high purity is obtained and can be melted later. When gold precipitates, platinum group metals remain in solution and have to be recovered by other procedure.
Outline of Aqua Regia Process

GOLD + SILVER + BASE METALS + PGMS
(ENSURE SILVER IS <10%)

GRANULATE, HEAT IN
AQUA REGIA, FILTER

SOLUTION CONTAINS GOLD, PLATINUM,
PALLADIUM AND SOME BASE METALS

TREAT WITH REDUCING AGENT,
FILTER

PURE GOLD POWDER

WASH, DRY AND GRANULATE

PRECIPITATE OF SILVER CHLORIDE, WITH
IRIDIUM, RUTHERENIUM AND RHODIUM
AND OSMIUM

FURTHER TREATMENT TO RECOVER
SILVER AND PGMs

SOLUTION CONTAINING PLATINUM AND
PALLADIUM AND BASE METALS

FURTHER TREATMENT TO RECOVER PGMs
GOLD REFINING
PROCESSING METHOD
Gold refining is a highly complex process which requires a deep understanding of material science, pyrometallurgy, multi stage chemical separations and analytical science.

- **EVALUATION**
- **SMELTING**
- **CHEMICAL LEACHING**
- **CHEMICAL SEPARATION**
Evaluation is a critical stage in our pgm refining process.

During this step it determine the pgm content of the customer’s material to check with them what quantity or value of pgm required for them. return to them and the lead time for refining.

Material tracking is crucial, and on receipt all customer batches are uniquely barcoded to ensure full traceability during evaluation.
Once terms are agreed feeds are no longer handled on a customer by customer basis, but are combined together in much larger batches for smelting.

In this pyrometallurgical process material is melted at temperatures over 1200 C for around 12 hours in large revertory furnaces to separate the non-metallic components.

Two types of bullion feed are produced: a silver based feed containing primarily platinum and palladium, and an iron based feed which contains all five of the pgms.
The two bullion feeds then move to the chemical leaching plant, where they undergo multiple leachings to further concentrate the pgms into solution.

The silver based bullion is suspended in concentrated acid to slowly leach platinum and palladium into solution and separate out any gold.

Gold impurities are sent for further refining. Silver is removed and further treated into saleable products, some of which are used in other businesses in the group.
Chemical Separation

- Chemical separation is a highly complex multistage process in which we separate out the five pgms into their final product forms, commonly a pgm sponge, although other forms are produced depending on customer requirements.

- The chemical separation process involves a series of solvent extractions, evaporation, dissolution, precipitation and filtration steps to produce highly pure orgometallic salts for each individual pgm.

- These salts then undergo several heat treatments steps to reduce them to the final pure platinum group metal which is weighed and packed, ready for dispatch to customers.
Star Trace introduce the latest internationally adopted method of chemical refining, the Gold Refinery has incorporated further improvements to suit the refining needs of our own Biotech research and development facilities along with our indigenous manufacturing capability Star trace is able to develop and produce world class top of the line refineries.

As with our other precious metal and precious stone mining products Star Trace can provide proper training and prompt after-sales service support as well as specialized consultancy for the specific requirements of our clients.
Gold Refinery Machine - Features

- Refines gold scrap, filings, dust, sweepings, etc.
- Safer and Faster Processing.
- Latest Technology.
- Purifies Gold (Au) up to 999.9 and Silver (Ag) up to 995.0,
- Minimum handling of Equipments.
- Designed to be easily setup and quickly operational.
- Turnkey installation, user-friendly.
## Gold Refinery Machine - Specification

<table>
<thead>
<tr>
<th></th>
<th>7kg gold/8 hours</th>
<th>25kg gold/8 hours</th>
<th>50kg gold/8 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reactor Material</strong></td>
<td>Titanium</td>
<td>Titanium</td>
<td>Titanium</td>
</tr>
<tr>
<td><strong>Filtration System</strong></td>
<td>Scrubber (4 Columns)</td>
<td>Scrubber (4 Columns)</td>
<td>Scrubber (4 Columns)</td>
</tr>
<tr>
<td><strong>Transfer of Acid</strong></td>
<td>Closed circuit – Works under vacuum</td>
<td>Closed circuit – Works under vacuum</td>
<td>Closed circuit – Works under vacuum</td>
</tr>
<tr>
<td><strong>Exhausted Gas</strong></td>
<td>No smell, no smoke, pH7, no Nitrogen Oxide</td>
<td>No smell, no smoke, pH7, no Nitrogen Oxide</td>
<td>No smell, no smoke, pH7, no Nitrogen Oxide</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>Anticorrosive PP(Polypropylene)</td>
<td>Anticorrosive PP(Polypropylene)</td>
<td>Anticorrosive PP(Polypropylene)</td>
</tr>
</tbody>
</table>

### Note:
1. Technical data specification subject to change
2. Special Gold refinery machine can be made on request, Please send us Your's Technical data and application, required for our engineers to provide.
Gold Ore concentrate processing plant
Gold ore concentrate with chemical & Electrowinning processing plant
Gold ore pre-concentrate processing plant
Gold processing plant

Gold processing plant

Gold extraction from tailings

Gold Trommel Plant (200 - 300 TPH)

Gold Trommel Plant (100 TPH)

Portable Gold Trommel Plant (100 TPH)

Portable Gold Wash Plant (200 TPH)
Gold ore Processing equipments

- Jaw Crusher
- Cone Crusher
- Ball Mill
- Hydrocyclone
- Gold Concentrator
- Spiral Separator
- Concentrating Table
- Flotation
- Mineral Jig
- Trommel Screen
- Electrowinning
- Screw Classifier
- Slurry Pump
- Sluice Box & Gold Pans
- Leaching Tank
- Vibrating & Dewatering Screen
- Mercury Retorts
- Belt Conveyor
THANK YOU

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