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Modern Technologies of Gold Production

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Abstract: *Gold production in the world by 2029 will grow to 133 million ounces (4136 tons) from 106 million ounces projected at the end of 2020, according to the forecast of Fitch Solutions. According to the report, the annual production growth in this period will be about 2.5%, against 1.2% in 2016-2019. The main growth will come from Russia. Gold production will grow to 15.5 mln ounce (482.1 tonnes) in 2029 from 11.3 mln ounce (351.5 tonnes) in 2020. This translates into an average annual growth rate of 3.7% during 2020-2029. As a result, Russia will overtake China as the largest gold producer, accounting for 11.6% of global production by 2029, up from 10.6% in 2020. On the other hand, China's gold production is expected to remain roughly flat over the next 10 years with a CAGR of 0.2%, a marked slowdown from the 3.1% CAGR over the previous decade. Fitch's review says this is the result of stricter environmental regulations. At the same time, large Chinese firms will increase investment in foreign gold projects, as the growth in demand for gold in the country far exceeds the growth in production. Australia will see moderate production growth in the coming years, supported by a strong portfolio of projects, rising gold prices and competitive operating costs. Continental production is projected to grow from 11.7 mln ounce in 2020 to 14.2 mln ounce by 2029, averaging 2.2% annual growth.*

Keywords*— Gold, boiling, mechanical mixing, hydrometallurgy, extraction, sorption, disorption*

Gold is a soft yellow metal. Chemical sign - Au. The density of gold is 19.32 g / cm^3. The melting point is 1064 ° C and the boiling point is 2856 ° C.

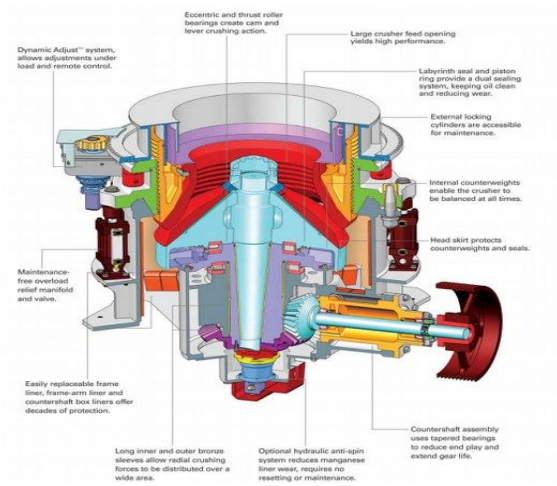
1. In the ore, gold occurs in the native state (yomba). It is found in some refractory ores by mechanical mixing with sulfide minerals.

Deposits: Muruntau (Navoi), Amantaytau (Navoi), Oltin topgan (Tashkent), Chodak (Namangan), the average gold grade in the ore is 5 g / t.

Nugget of gold

2. Preparation of gold ore for processing,

Grinding: Gold-bearing quartz ores are ground in 2 stages (3 stages if necessary) as they are not very hard. Ore is mined to sizes of 10-15 mm and less. Jaw and cone crushers are used.



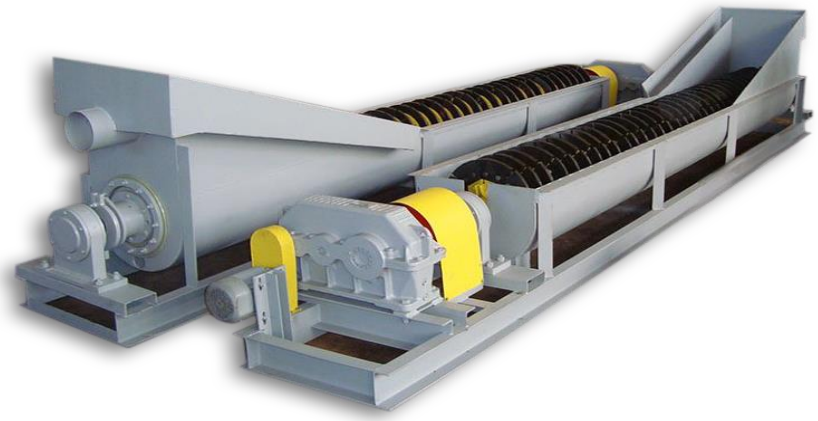
Cone crusher

Grinding: In ball or rod mills, the size of the ore is ground to 0.074 mm (74 μm) in an aqueous medium. The 74 micron ore should be over 80%.

The purpose of crushing and grinding is to expose the surface of the desired mineral.

Ball mill (MSHTs brand)

Classification: classified by spiral classifiers, producing sand and drainage.



Spiral classifier

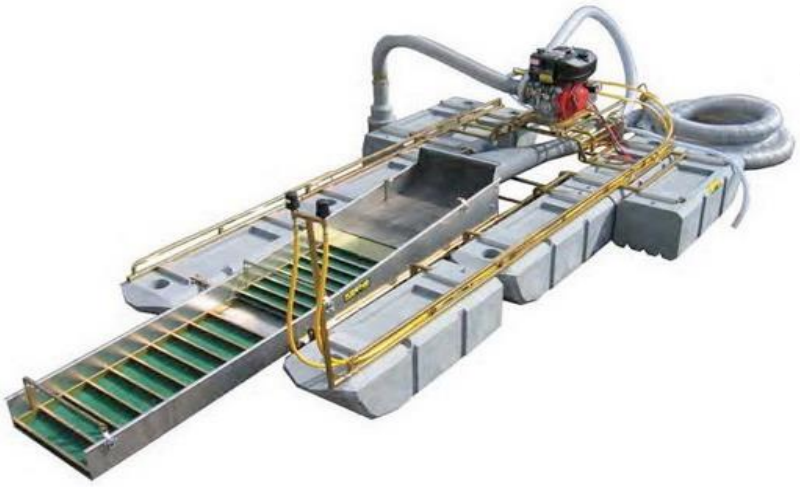
Thickening: the resulting plum is thickened in a classifier. It is divided into pulp and liquid parts.

Thickener

3. Beneficiation: Quartz gold ores are gravity beneficiated. For example,
- enrichment on concentration tables (basic);

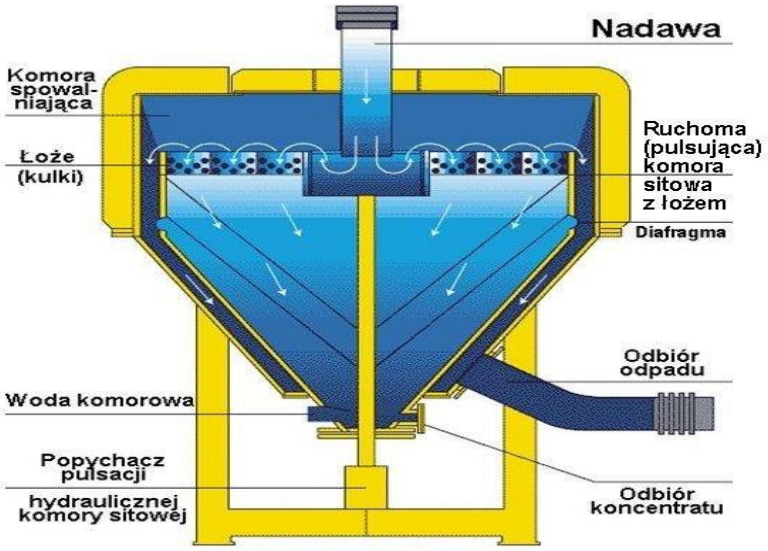
Concentration table

- enrichment at sluices;



Overview of gateways and accessories

- enrichment in jigging machines;



Sinking machuine

- enrichment in heavy media (in suspensions).

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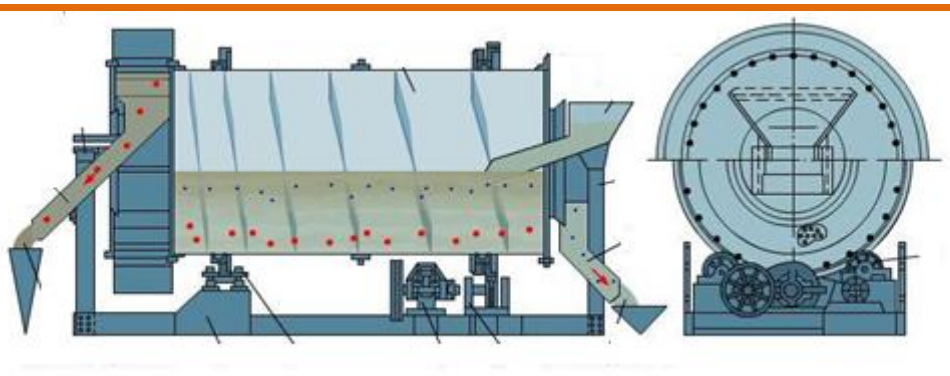


Equipment for gold beneficiation in heavy environments

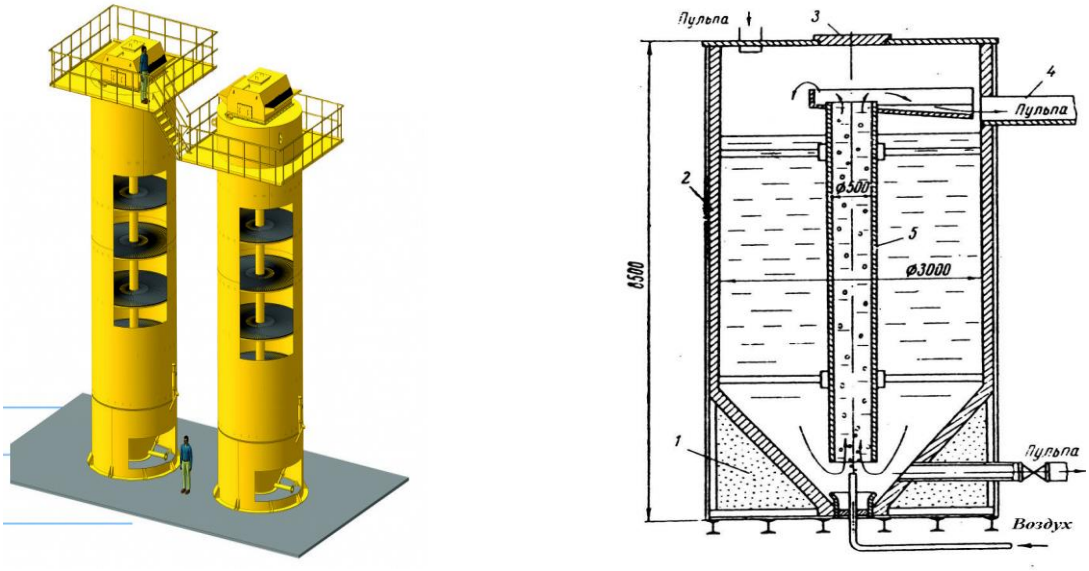
In these gravity methods, if there are too many large particles in the concentrated concentrate, they can be separated mechanically or washed with water (physical method). Chemical methods are also used to separate very fine and dispersed gold that remains after mechanical separation of large grains of gold. Hydrometallurgical processes are used.

4. Leaching of gold-bearing ores:

The cyanide method is used in gold mining on an industrial scale. Gold pulp is exposed to 5-10% solutions of NaCN, KCN or Ca $(CN)_2$, and atmospheric oxygen (oxidizing agent) is fed into the solution. As a result, Au undergoes a chemical reaction that dissolves and passes from the solid phase to the solution phase. The solution medium must be highly alkaline (pH = 11-12). For this, lime is added to the solution during thickening before cyanidation, which is also called "protective alkali". This is because toxic cyanic acid can form and evaporate in neutral and acidic environments. The equation for the chemical reaction of the process:

$4Au + 8NaCN + O_2 + 2H_2O = 4Na[Au(CN)_2] + 4NaOH$

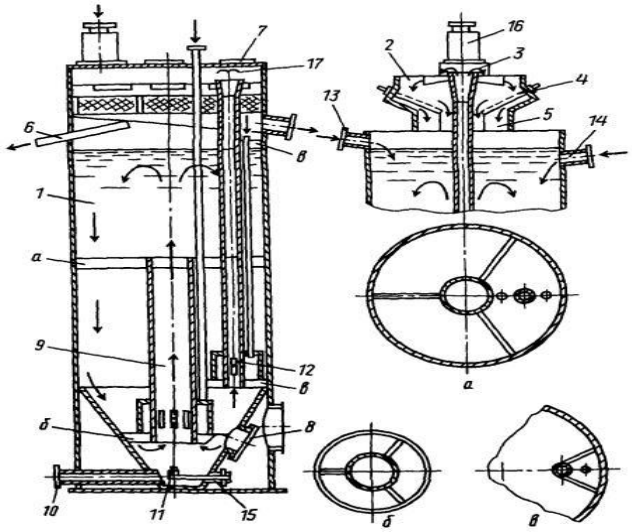
After selective leaching, the concentration of gold in the solution is 0.2-0.4 mg / l. The cyanide process is carried out in reactors. An example of a cyanide reactor is an apparatus called a Pachuc.



Gold Leaching Pachuc

5. Sorption:

Gold-bearing complexes formed from solution after selective leaching of Au are recovered from solution using ion exchange resins. In this case, gold in solution is chemically absorbed (chemisorbed) in the volume of the resin. Since the solution is in the form of an anionic complex, anion exchange resins or anionites are added to the solution. The selective leaching sorption process is carried out in special packs.



Pachuca design

One of the resin grades: AM-2B

A - anion exchanger;

M - macroporous;

2 - doubling the swelling;

B - bifunctional.

Reaction of the sorption process:

$$Na[Au(CN)_2] + R\text{-}OH = R\text{-}Au(CN)_2 + NaOH$$

Information about resins: Resins are organic, solid polymeric materials with which ionic groups are exchanged in chemical reactions.

They are also called other ion exchangers (or sorbents). Depending on the exchangeable ion, there are 3 types of ion exchangers:

Anionite - anion exchange resin (AM-2B);

Cation exchanger - cation exchange resin (KU-2);

Ampholyte is a resin that exchanges cations and anions.

Anion exchange resins are used to adsorb gold. The chemical structure of one of the anion exchange resins used in the sorption of Au:

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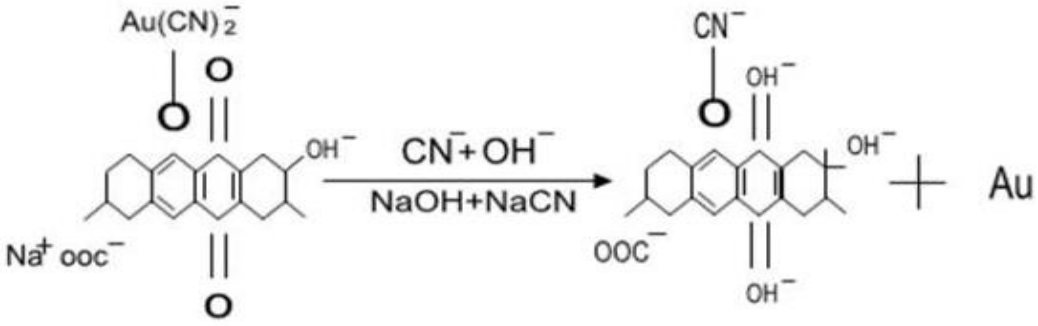
Anionite (AM-2B)

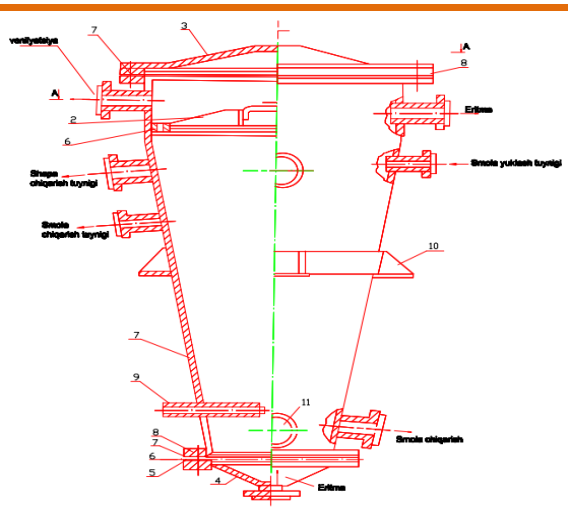
6. Desorption process. Saturated resins for gold are desorbed.



The desorption process is the opposite of sorption, in which Au is reintroduced into solution from the resin. For this, a solution of thiourea in sulfuric acid (CS $(NH_2)_2$) is applied to a resin saturated with Au. Process mechanism:

$2R\text{-}Au(CN)_2 + 2CS(NH_2)_2 + H_2SO_4 = [AuCS(NH_2)_2]_2SO_4 + R_2\text{-}SO_4 + 4HCN$

After desorption, the amount of gold in the solution is 2-4 g / l. This shows that the amount of gold is 10,000 times richer than before. This means that the sorption-desorption process can enrich solutions, even at a low Au content. The solution obtained after desorption is called a regenerate and is sent to electrolysis. The desorption process is carried out in special desorption columns.



Schematic structure of a desorption column

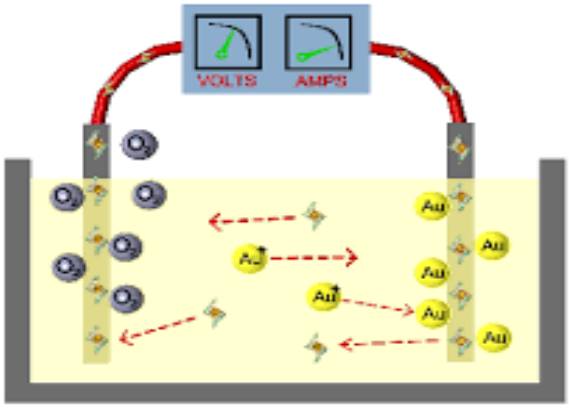
7. Electrolysis:

The Au solution is electrolyzed with a current of +1.5 and +1.6 V. At the same time, it reduces gold at the cathode and O_2 (oxygen) is oxidized at the anode. The processes that take place on the electrodes are as follows:

At the cathode: $Au^+ + 1\bar{e} = Au^o$ (Au is reduced);

At the anode: $4OH - 4\bar{e} = 2H_2O + O_2$ (oxygen is oxidized).

Electrode materials: the cathode is made of graphite and the anode is made of Ti. There is a membrane between the electrodes, which prevents contamination of the cathode gold with harmful elements.



Gold recovery by electrolysis in an electrolytic bath

8. The resulting cathode gold is melted in induction furnaces and poured into various molds to obtain various castings.

Gold bars

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