Water Quenching Copper Slag

1. Distribution and application conditions of copper smelting water quenching slag:

At present, the copper output in China lists the third in the world, the copper ore resources developed and utilized have been found to occupy 67.1% out of the national proven reserves, and lots of mines closes greatly, the grade of exploitation has been decreased into 0.3%—0.4%,and the structural contradictions of resource and environment has become increasingly prominent.

The copper slag in our country is produced by pyrogenic process smelting, with the property decided by the copper concentrate quality when charging in the furnace, smelting operation conditions and furnace slag cooling speed.

More than 25,000,000 tons was calculated between 1949-1992, while now only about 1,500,000 tons output each year.

Use the smelting copper furnace slag as construction materials to realize the “Zero Emission” of furnace slag, which causes serious resources waste.

General copper slag contains copper 0.3%, zinc 3%; from the SiO2, CaO and Al2O3 in copper slag, they are all mineral components of portland cement clinker, portland cement clinker is 3CaO•SiO22CaO•SiO22CaO•Al2O3•4CaO•AP2O3•Fe2O3, beside
this, it also contains the precious resources like Au, Ag.

### Analysis result of slag chemical components

<table>
<thead>
<tr>
<th>Sample</th>
<th>Component</th>
<th>Analysis</th>
<th>(%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cu</td>
<td>0.89</td>
<td>36.6</td>
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<tr>
<td></td>
<td>Fe</td>
<td>2.97</td>
<td>0.31</td>
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<tr>
<td></td>
<td>Ca</td>
<td>39.64</td>
<td>5.62</td>
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<tr>
<td></td>
<td>Mg</td>
<td>1.22</td>
<td>1.12</td>
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<td></td>
<td>SiO₂</td>
<td>1.32</td>
<td>1.45</td>
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<tr>
<td>Vietnam Copper Slag</td>
<td>Zn</td>
<td>0.89</td>
<td>36.6</td>
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<td></td>
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<td>2.97</td>
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<td></td>
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<td>1.32</td>
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<tr>
<td>Vietnam Copper Plant</td>
<td>Cu</td>
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<tr>
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<td>Fe</td>
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2. The features of copper smelting water quenching slag:

The copper smelting furnace slag is in black brown appearance and in granular or strips, there is certain metallic luster in its surface; hard quality which is easy to break but difficult to grind with the
density 3.3～4. 3kg/m3. The mineral components and inlaying relations of furnace slag are complicated, most minerals with copper content exists in cooper sulphide form, some metallic copper and a little copper oxide exists. The copper sulphide is embedded in granular, generally between 0.005～0.03mm; the granularity of metallic copper is uniform generally between 0.005～0.01 mm, while the particle size can arrive 3.0mm at most, among which has some amorphous vitreous composed by some gangue. From the analysis of furnace slag, the iron mainly existed in magnetic iron oxide and fayalite form, besides, some amorphous vitreous composed by gangue exists.

The main components in copper slag divided into: iron oxides, SiO2, Al2O3, CaO, MgO, Cu, S, etc. Some research shows that the existing main phase components in water-quenching copper slag is: fayalite (2FeO•SiO2 or Fe2SiO4), magnetite (Fe3O4), grossularite (Ca3Al2(SiO4)3) and so on. Therefore, copper slag in pyrogenic process smelting is one kind of complex silicate. The fayalite is silicate mineral, which is one kind of ferro-forsterite series. The brown colour is easy to changed into black in the air. The density is 3.91-4.34t/m3, hardness is 6-7. The grossularite is one kind of calcium aluminum silicate and garnet, which is the garnet with calcium and aluminum content. The density is
3.654t/m³ and hardness is 7.25. Therefore, the furnace slag for copper smelting is in black, compact, hard and wear-resisting glass phase after water quenching.

A lot of iron contained in the copper slag and also some valuable metallic elements like copper, cobalt, etc, therefore the copper slag can also be taken as the secondary resources for some valuable metals.

There are two valuable elements—copper and iron in the water-quenching copper slag, the copper is around 1%, which has high recovery value; while the iron TFe is around 40%, while the iron exists in two phases—fayalite and magnetite, which is difficult to separate.

3. Traditional utilization of copper smelting slag

1) Used as raw materials for cement;
2) Used in construction instead of sand;
3) Produce glass ceramics;
4) Produce cast stone;
5) Produce shaped brick;
6) Produce rock wool;
7) Pave the road and fill up the path;
8) Used as abrasive or rust remover;

At present, some plants start gradually to refine valuable elements
such as Cu, while the recovery of iron has still not seen good
technology.

Traditional iron removing method mainly has two kinds:
1) Oxidation roasting-crushing magnetic separation technology:
That is to say: utilize air or oxygen-enriched air under
high-temperature to oxidize copper slag, transforming the iron
mainly existed in olivine form in the copper slag into the iron mainly
existed into magnetite form, through cooling, to proceed crushing
and magnetic separation to the copper slag after oxidation, making
the magnetite get enrichment so that to meet the aim of iron
enrichment in the copper slag, the technology has the
shortcomings of low iron recovery rate and complex following
processings and the recovery rate is around 85% at most, the
product is iron oxide.

2) Direct reduction for copper slag to remove iron;
Use reducer to direct smelting reduction for the iron which mainly
existed in 2FeO•SiO2 (fayalite) and Fe3O4 (magnetite) form in
copper slag to reduce into metallic iron, realizing recovery iron from
copper slag being slag-iron separation under smelting state, the
iron recovery rate is around 90%, while the economic benefit is bad.
Due to the speciality of physicochemical indexes of water-quenching copper slag, the iron mainly exists in fayalite form, then adopting regular direct reduction method is very difficult to achieve expected aim.

4. Brilliant Company has two sets of technologies for the comprehensive utilization of copper smelting slag:

BLT-slag-iron separation and reduction technology is aimed at the difficulty to separate of the refractory ores like copper smelting residue、sulfuric acid slag、complex ore and ferrous tailings. The adopted “low-temperature direct smelting reduction technology” and “first smelting second separate iron technology” make the fayalite in the copper slag not only being reduced, but also make iron element form into gravel iron with granularity 3-30mm,density6.0-7.0t.m3 and iron recovery rate≥95% and get better economic benefit, which makes the copper slag and other scrap recycling and achieves comprehensive utilization effect,finally makes contribution to the national environment and social economy.

4.1 Adopt “BLT-short process slag-iron separation and reduction smelting technology” to separate metallic iron and gangue ore high titanium slag and get metallic iron products with high grade、high recovery rate.
The technology is suitable to deal with those projects with large size which the single production line scale is around 200,000 tons/year ore powder with high mechanical and automatic degree.

4.2 Adopt “BLT-reduction kiln slag-iron separation and reduction smelting technology” to separate metallic iron and gangue ore high titanium slag and get metallic iron products with high grade, high recovery rate.

The technology is suitable to deal with those projects with small size which the single production line scale is between 10,000--100,000 tons/year ore powder with general mechanical and automatic degree.
5. Product pictures:

gravel iron products
Metallic iron powder

Metallic cold-compacting pellet (MBI) products