STUDYING OF PRELIMINARY ROAST AND SMELTING GOLD-CONTAINING ELECTRONIC SCRAP WITH COPPER COLLECTOR.

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Abstract: Electronic scrap is valuable type of complex recyclable metallurgical raw. Efficient technology requires complex recovering electronic scrap with extraction ferrous, non-ferrous and precious metals. Requirement of preliminary roast to remove and recycle gases from organic combusting are shown. Optimal parameters of roast has been determined.

Keywords: Gold, precious metals, copper, electronic scrap, collector smelting, recycle, roast

1. Introduction.

One of mass valuable type of complex recyclable metallurgical raw is electronic scrap. Total value of obtained electronic scrap in Russia is millions tons per year now. During conversion to market economy thousands of unprofitable plants has been stopped and liquidated in recent years, huge amounts equipment and hardware has been formed, that should be recycled. On the one hand this scrap is damage to environment, and on the other hand it’s very valuable recourse, that exceed raw mineral in precious components’ content. Usage of complex-composition hard-processing electronic scrap in metal recycling is increased now.

2. Problem discussion

Economical estimate of possible electronic scrap’s processing ways with only precious metals extraction shows low efficiency due to low content of precious components, in spite of it’s high price. Only complex recovering electronic scrap with extraction ferrous, non-ferrous and precious metals can make this technological process reasonable and efficient. Implementation of complex and full process of electronic scrap is topical, but very hard technical problem, because metals in electronic scrap have different physicochemical properties and occurs in different structural state in connections with different nonmetallic components.

3. Objective and research methodologies.

Organic materials (polystyrene, hardened paper, polyvinylchloride etc.) make 5-27 % of electronic scrap, according to scrap’s type. Organic materials have to be removed from electronic scrap preliminarily (before melt) due to high speed of organic materials’ combusting significant amount of obtained gases as well as problem with recovery and cleaning.

In connection with the above electronic scrap with precious metals is preliminarily treated by roast.

Degree of organic removal from electronic scrap in dependence of temperature, duration has been studied when research was performed, gases’ composition was determined. Degree of organic removal from electronic scrap grows with increasing of roast’s temperature and duration, according with experimental data. Full combustion (removal degree ~100%) of organic is obtained at 700 °C roast during 2 hours.

The main reactions of electronic scrap roast are polyethylene, polystyrene and polyvinyl chloride burning:

\[(C_2H_4)_n + 3nO_2 = 2nCO_2 + 2nH_2O\]
\[(C_8H_8)_n + 10nO_2 = 8nCO_2 + 4nH_2O\]
\[(C_2H_3Cl)_n + 4,5nO_2 = 2nCO_2 + nH_2O + nHCl\]

After electronic scrap roast powder-gas phase contains tin, tin and carbon oxide, lead, lead oxides, zinc, probably gallium and indium, zinc oxide, gold, silver, benzene, aldehydes, ketones, dioane, isoprene, phenol, cyclohexanol, chloric, aliphatic, heterocyclic and aromatic hydrocarbons. List of the most toxic agents is represented in table.

<table>
<thead>
<tr>
<th>Agent</th>
<th>Content, %</th>
<th>Maximum permissible concentration, mg/m³</th>
<th>Class of danger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4 dioane</td>
<td>15,00</td>
<td>0,100</td>
<td>1</td>
</tr>
<tr>
<td>acetonitrile</td>
<td>9,00</td>
<td>10,000</td>
<td>2</td>
</tr>
<tr>
<td>ethylbenzene</td>
<td>8,70</td>
<td>1,000</td>
<td>—</td>
</tr>
<tr>
<td>styrene</td>
<td>9,30</td>
<td>5,000</td>
<td>—</td>
</tr>
<tr>
<td>chlorine</td>
<td>9,86</td>
<td>0,100</td>
<td>2</td>
</tr>
<tr>
<td>phosgene</td>
<td>8,00</td>
<td>&lt;0,010</td>
<td>1</td>
</tr>
<tr>
<td>inorganic dust with SiO₂</td>
<td>6,10</td>
<td>0,500</td>
<td>3</td>
</tr>
<tr>
<td>carbon oxide</td>
<td>34,00</td>
<td>5,000</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1 – toxic agents
Gases after roast process are cleaned of noxious and toxic agents up to maximum permissible concentration by special technology.

Smelting of electronic scrap after it’s roast with copper collector allows to consolidate precious and non-ferrous metals in metal phase. Manufacturability and efficiency of copper collector smelting essentially depends on slag’s composition and physicochemical properties, particularly on viscosity. Slag’s viscosity in dependence of temperature and composition has been studied (based on system SiO$_2$-FeO-Na$_2$O-CaO-B$_2$O$_3$).

Based on this study it was concluded, that sodium silicate slags are preferable for electronic scrap smelting, due to lower viscosity and aggressivity.

According with obtained data about slag’s composition and properties, influence of collector’s amount on gold extraction during smelting has been studied. It was found, that increasing of gold extraction degree from 55 % to 98,5 % occurs with collector’s amount growth from 1 % up to 25 %. Gold distribution coefficient in copper is constant, but more copper can dissolve in significant amount of collector. In this case it should not increase the amount of copper, because of increased losses of copper with slag. Optimal ratio between scrap and collector is in range 100:(14-20).

Gold content in electronic scrap is quite low and is about 100 g per ton, after single melt gold concentration in copper can make ~0,08%. It’s unreasonable to process alloy with such gold concentration. As already noted, it is efficiently to use copper collector iteratively. As a result, gold content in copper increases up to several percent. After fourfold turn of copper collector gold content grows to 1,3 %, silver – 7,1 %, platinum – 0,9 %, palladium – 0,3 %. Gold extraction degree in four stages was 96 %, silver – 92 %, platinum and palladium – 93 %.

When melting conditions of different types of electronic scrap with copper collector was being studied, it had been found that presence of carbon in charge has significant influence on character of melt process. It was shown, that in the one hand carbon concentration shouldn’t be high, because oxidizing ambient is necessary for contained iron oxidation. In the other hand carbon concentration shouldn’t be too low, to prevent copper oxidation. According to this, in the beginning of melt oxidizing ambient is kept, and in the end of process atmosphere is turned to slightly reducing state.

Impact of air blowing has been studied for more complete removal of impurities from obtained allow. Smelting was carried out at 1320-1350 °C. Duration of air blow was 15, 30, 45 and 60 minutes. It was found, that increasing of blow duration from 15 to 60 minutes with constant rate brings to increasing gold content in copper up to 2 %. Further growth of duration over 60 minutes don’t have influence on copper content in alloy, but brings to growth of total copper losses with slags.

4. Conclusion.

Requirement of preliminary roast to remove and recycle gases from organic combusting are shown. Roast provides reduce of melting material’s volume up to 30 % and allows significant increasing of smelt equipment’s productivity. Due to preliminary roast some technical difficulties with material’s effervescence and ejection has been obviated.

Physicochemical theory and technology of smelting has been developed. Optimal slag composition allows raising precious metals’ degree of extraction up to 89-99 %, decreasing losses of copper with slags up to 0,4 % and preventing losses of platinum metals by concentrating it in copper collector.

It was found, that optimal duration of smelting is 2 hours and temperature is 1250 °C. Raw and flux ratio should be in range from 1:1 to 1:4.

The proposed technology has been passed pilot testing at Shchelkovo Factory of Secondary Precious Metals.