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## PLATINUM RECOVERY FROM USED AUTO CATALYTIC CONVERTERS IN ELECTROREFINING PROCESS

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Preliminary Note – Prethodno priopćenje

This paper presents possibility of removing platinum from the used catalytic converters applying copper as a metal collector in pyrometallurgical methods. The catalytic converter carrier was grinded and melted with copper. During the research obtained Cu-Pt alloy was casted as an anode. Such anode was electrically refined in order to recover platinum. Obtained results were discussed.

*Key words:* Precious Group Metals (PGM), metal recovery, used auto catalytic converters, electrorefining.

### INTRODUCTION

Auto catalytic converter is a part and parcel of every car exhaust system, the main aim of which is to decrease the exhaust gases emission to the atmosphere. Like any other catalytic converter, it is used to increase the process. Catalytic material is not changing that means it is not active in the reactions or processes. Currently catalytic converters are practically applied in all kinds of produced vehicles. The auto catalytic converter (see Figure 1) consists of steel or ceramic shell containing the carrier of honeycomb structure covered by the PGM, especially platinum, palladium and rhodium. Such construction increases the active surface, namely the contact zone of catalytic substances (Pt, Pd, Rh) with exhaust gases, which flow through the channels. TWC (Three-Way Catalyst) is a modern catalytic converter in which three reactions take place simultaneously: two oxidation reactions of CO to CO<sub>2</sub>, HC to H<sub>2</sub>O, and reduction of NO<sub>x</sub> to N<sub>2</sub>. Consequently, substances inert to the environment are obtained in the outlet of auto catalytic converter.



**Figure 1** Scheme of auto catalytic converter

Rapid development of motorization and the huge amount of used cars are the reasons why there is a necessity to lead rational management of waste coming from such sector. Possibility of reusing material, that is

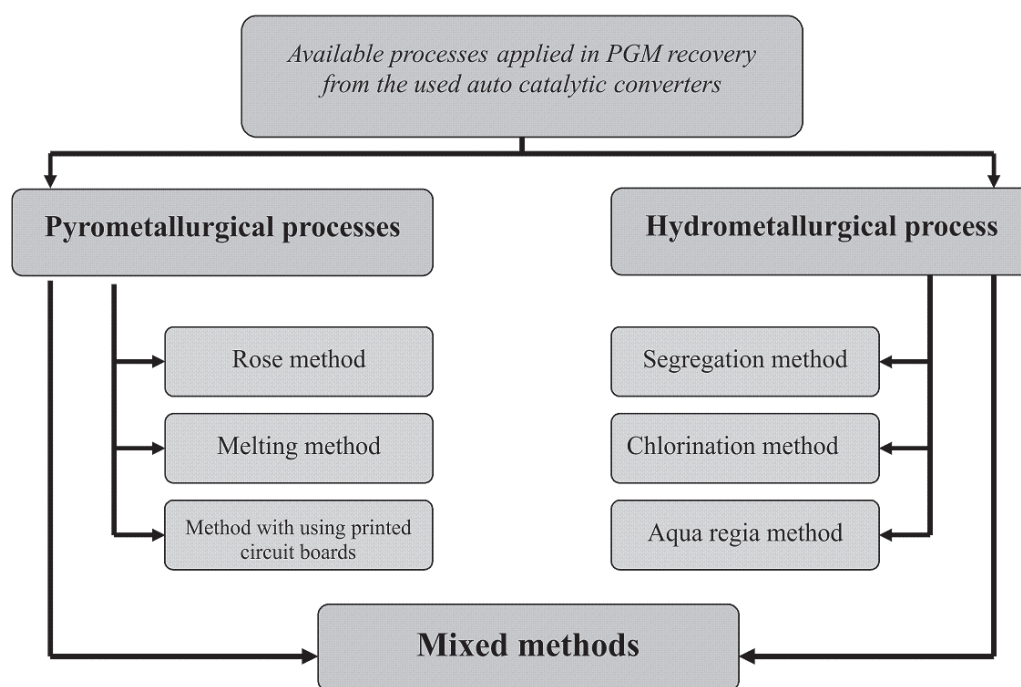
PGM metals recovery from used auto catalytic converters, becomes very important, taking into consideration the economical management of natural resources and energy. Additionally, there is less waste deposited in the storage area. The content of PGM metals in auto catalytic converter depends on the construction of catalytic converter, its use and the manufacturer (average about 2 grams of PGM metals).

### METHODS OF PLATINUM RECOVERY

Taking into account scarceness of the natural resource occurrence and energy consumption during their output, PGM metals recovery seems to become necessary both from economic and ecological point of view. So, recycling process makes a contribution to the natural resources protection and also the stabilization of PGM metals prices (limits the metal price increase caused by the growing demand of a car industry). Reuse of PGM metals recovered in such a way does not require high costs. Whereas, the considerable amount of used auto catalytic converters, that are scrapped every year makes the PGM metals recovery very profitable.

The first step to recover PGM metals and especially platinum from used auto catalytic converters is to collect and then dismantle them. After these operations catalytic converter carriers are milled and also homogenized. Then chemical analysis must be performed in order to check the level of platinum and other precious metals. If the platinum level is lower than 30 %, the thickening operation is applied. This stage includes incineration, hydrometallurgical and pyrometallurgical processes [1-7]. The last two methods can be combined. As a result, the high level of PGM metals recovery can be obtained. In such technologies many indirect operations are used to obtain pure metal. Figure 2 presents the hydrometallurgical and pyrometallurgical methods used for the treatment of catalytic converter carriers.

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**Figure 2** Available processes applied in PGM recovery from used auto catalytic converters

The next stage of PGM metals recovery is to solve and separate precious metals and purify them. Purification allows to obtain metals of very high purity. This stage, however, requires a lot of energy and also generates many chemical compounds dangerous to the environment. Processes that can be used in PGM metals purification are: calcinations, ion exchange, solvent extraction, hydrolysis, reduction and oxidation processes, as well as precipitation [8-11].

None of pyro- and hydrometallurgical methods is an universal method that can be used to recover PGM metals from all type of used auto catalytic converters. Both methods have some disadvantages:

- pyrometallurgical methods require special equipment, to reach the desired temperature, and they are not only expensive but also highly energy consuming;
- hydrometallurgical methods requires to solve the problem of harmful waste solutions generated during the process.

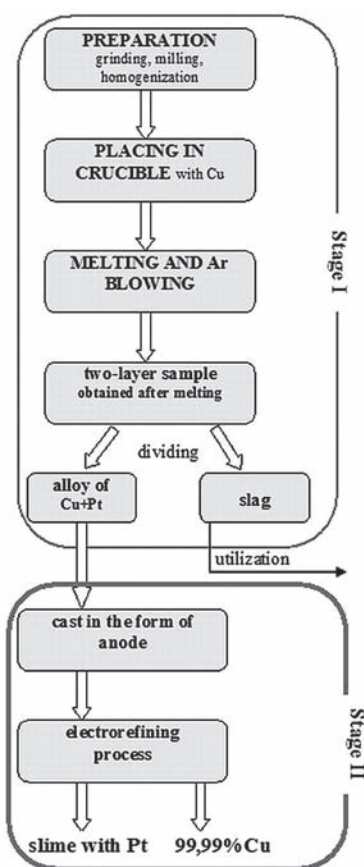
Melting method belongs to one of the simplest pyrometallurgical methods. It uses a metal collector to gather platinum and other PGM metals. Different metals such as calcium, zinc, magnesium, cadmium, lead and copper can be used as a metal collector. These metals are selected taking into account the solubility of platinum.

## EXPERIMENTAL PROCEDURE

The paper presents the research concerning the possibility of platinum recovery from used auto catalytic converters applying copper as a metal-collector. The research was carried out in the laboratory of the Metallurgy

Department at the Silesian University of Technology. The research was divided into two stages (see Figure 3).

Material for the research (carriers of used auto catalytic converters) came from different cars. The analysis



**Figure 3** Procedure taking place during platinum recovery from used auto catalytic converters in electrorefining process.

Table 1 Parameters of the test in stage I of research

Parameters of the tests	
Furnace	inductive furnace (ELKON)
Temperature	1 550 °C
Time of process	5 400 s
Argon blow	50 dm <sup>3</sup> ·h <sup>-1</sup>
Cooling	sample was cooled with the furnace
Mass of carrier	600 g
Mass of copper	1 270 g

of platinum contents in catalytic converter carrier and in the samples was conducted in the Institute of Nonferrous Metals in Gliwice. Spectrometer and ICP method were used. The analysis of ceramic carriers used in the tests indicated the difference in their platinum contents. The average content was between 0,16 and 0,32 %. As a metal-collector, copper M0B with the purity 99,99 % was used.

**Stage I.** The main aim of this stage was to melt the grinded catalytic converter carrier with copper. It was done in Elkon inductive furnace. During the melting process platinum went to copper (because its melting temperature is higher than that of the metal-collector) and the ceramic carrier created the slag. In the furnace, neutral atmosphere was kept by blown argon. Table 1 presents parameters of the test carried out in stage I of the research.

**Stage II.** The obtained copper with platinum separated from slag was melted and casted in the form of anode (see Figure 4). It was placed in electrolytic cell and then electrorefined. Table 2 presents the main processing parameters, whereas Figure 5 shows the test stand.



Figure 4 Obtained copper sample with platinum

Table 2 Processing parameters of stage II of research

Processing parameters					
No	CCurrent density/ A·m <sup>-2</sup>	Time/ h	Mass of anode/ g	Electrolyte/ g·dm <sup>-3</sup>	
				Cu	H <sub>2</sub> SO <sub>4</sub>
1	100 70		1 284	45	200
2	100	40	1 061	45	200

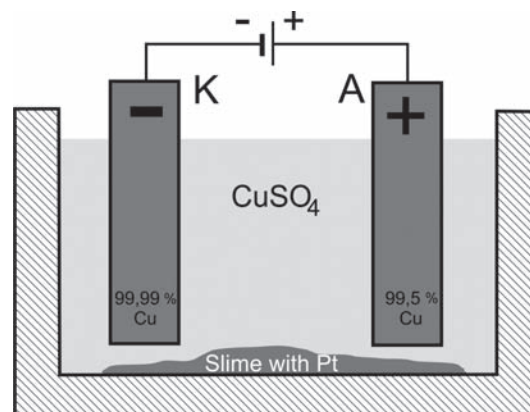


Figure 5 Scheme of test stand used for the research

## RESULTS OF THE RESEARCH

As a result of the electrorefining process the slime (see Figure 6) with platinum and other PGM metals was obtained. Table 3 presents the analysis of that slime. Pure copper was captured on the cathode, so it can be used again in the process.

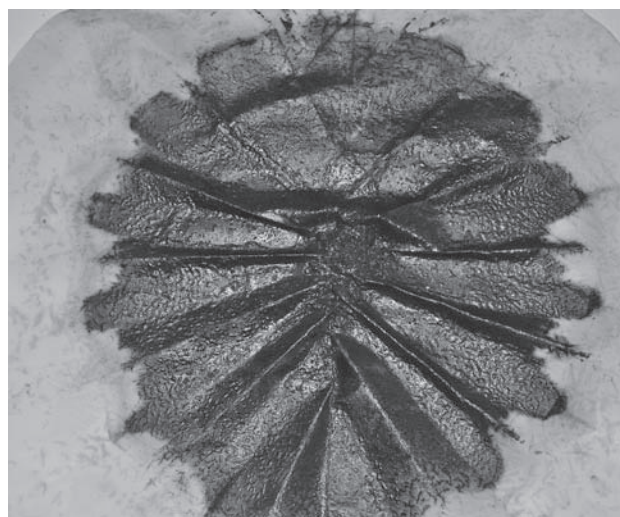


Figure 6 View of the obtained slime

Table 3 Results of electrolytic refining process

Chemical analysis and efficiency of the process				
No	Pt content			Efficiency
	in carrier	in anode	in slime	
1	0,26%	0,001%	0,15%	84 %
2	0,26%	0,001%	0,13%	80 %

## CONCLUSIONS

Nowadays the regulations concerning emission of fumes are very strict. These regulations are the consequence of constantly growing road transport and the increase of air pollution. To prevent pollution, every new car has to be equipped with the catalytic converter. The lifetime of auto catalytic converters is limited. Their duration in which the effectiveness is no smaller than 75 % is estimated for 160 000 km.

That is why, used auto catalytic converters have become the valuable source of platinum and PGM metals. At present the most important is to find simple method to recover these metals. The melting method using especially copper as a metal collector seems to fulfil such demand. The efficiency of recovered platinum is very promising, so the research will be continued. However, there are still many hydrometallurgical processes to go through in order to obtain pure platinum and other precious metals.

### Acknowledgements

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**Note:** M. Kingsford-Golinowska is responsible person for English language.