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METAL PRODUCTION BASING ON THE E-SCRAP PROCESSING

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ABSTRACT
The paper is a brief review of an internal investigations and studies on e-scrap processing and metal production in MMI Bor. The Study bases on a business idea occurs after the MMI Bor expert team investigations of literature and practice on e-scrap processing.
The experiments and analysis results are presented in the first part where the chosen technological solution is described including the basic parameters for the economic analysis.
The final part of the paper is a résumé of the economic analysis that approves economical benefits of the e-scrap processing and profitability of metal production in MMI Bor.
Conclusion signifies the investigations and the study importance for realisation of a project generating great ecological and economical benefits for the investor, Timok region and Serbia.
Key words: e-scrap processing, metal production, investigations, technology, economy

1. INTRODUCTION
E-scrap processing and metal production in MMI Bor is a bussines idea based on serious considerations of the actual trends in associated technology and economy fields. As an R&D institution MMI Bor has experience, staff and equipment for the processing and production.

As the e-scrap is one of the growing global ecological problems its processing is in the focus of the researchers and others interested in the problem sollution. As it contains number of different metals (copper, zinc, iron, precious metals etc.) and other materials (plastics, glass organic materials) that are well marketable [1] the metal production basing on its processing apears to be profitable.

Acording to the actual reports e-scrap quantity has been gradually rising at anually rate of 3-5% which means 10-50 bilion tones every year [2]. Actual recycling rate of the worlds e-scrap is variable: while it is 86% in Japan and 50-60% in EU it is 12-13% only in Serbia [3]. To rise the e-scrap recycling rate in Serbia it is necessary to organize it better from the initial phase of getthering and sorting to the final processing and supporting activities. It is also important to organize it in acordance with the EU legislation. Aiming that, Serbian Governemnt have adopted the Law on Waste Management and the Law on Packaging and Packaging Waste [4].

Truing to keep step with the actal trends and the situation in the field, MMI Bor, with its reach R&D experiences, qualified staff and equipments capacities, undertook some investigations and framed a bussines project as a part of its med-term plan. The project is expected to be realised in the IRM special production department. The investigation results and the projects basics are briefly ressumed and presented in the papers next parts.

2. INVESTIGATIONS RESULTS

2.1.Printed circuit board characteristic content

Printed Circuit Board – PCB is the basic row for the special metall production basing on e-scrap processing. Acording to the previous experiences and the new investigations in MMI Bor the PCB has the following metals and other materials content: 20,60% Cu, 1,86% Zn, 1,34% Pb, 3,71% Sn, 0,91% Fe, 0,01% Ag, 0,0068% Au, 27,10% plastic and 44,30% Bakelite.
Seven types of PCB were considered and the following is concluded: The average metal part content is 28.6 % including the copper dominating 20,6%. Precious metals contents is of the greatest importance for their shera in the final market value of the production is 65- 80%.

2.2. Processing technology phases

Piromethalurgy

Separation of the metal and non metal parts of the PCBs planed for processing in MMI Bor results with about 16 t of metals. After preparing the metal part for processing and selection a mix of metals would be produced. The copper part of the mix would contain 95% of copper.
As the average copper content in the metal part is about 70% that is the copper content in the metal part containing copper about 11,8 t metala ($16\times0,7\times1,05 = 11,76 \approx 11,8$ t). In that part there is $11,8\times0,95 = 11,2$ t of copper.
During the pyrometalurgical phase copper containing part suffers certain metals losses (Zn and Pb mainly). These metals evaporate with the melting gases or, eventualy, go by through the slag. Rroughly the melting losses of the metals are about 2,5% which means that after the melting phase the situation is the followeing: $11,8\times0,975 = 11,5$ t copper anodes containing 11,2 t of copper and also precious metals, contaminants and impurities.
Metal recovery of the hydrometallurgical treatment of metal parts will be: for copper ≈ 99%, for gold ≈ 98%, for silver ≈ 93% and for palladium ≈ 98%. This means that electrolysis will have at disposal: 11.0 / 12 = 0.92 tons of anodes per month, while the average weight of anodes will be 958/28 = 32.86 kg. (28 anodes is the electrolysis capacity, which annually is 336 anodes) [5,6].

Elektrolysis

After melting and casting the electrolysis is provided with 11 tons of anodes, with 95% Cu-10.45 t. The content of precious metals in the anodes is: max 0.1% - 0.011 t, respectively: Au: 3.183 kg, Ag: 7.7616 kg. Impurities (Pb, Sn, Zn, Fe): 4% - 0.44 t.
The process of electrolysis will result in the loss of certain metals, roughly 9%. The metal recovery in the electrolytic process will be: for Cu: 95%, for Ag: 97% and for Au: 98%.
After the electrolytic refining the following is obtained:
• 9.9275 t - 9.9 t of copper cathodes (as the final product)
• 550 kg of anode slime containing 275 kg of Cu, 7.529 kg of Ag and 3.12 kg of Au.
• 270 kg impurities (Pb, Sn, Zn, and Fe) distributed in the anode slime and partly in the electrolyte.
After the electrolytic refining of anodes the obtained slime (550 kg) is to be set copper free to the copper content in the sludge of 2% for the further precious metals refining [3,7].

Refining

Copper free anode sludge of 275.00 kg contains the following amount of precious metals:

- 3130,00 g Au
- 8215,00 g Ag
- 900,00 g Pd

With the following adopted recovery of precious metals (based on laboratory experiments):99 % for gold, 98 % for silver and 96 % for paladium the final products quantities per year are:

- 3100,00 g Au
- 8050,00 g Ag
- 860,00 g Pd [5,8,9].
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2.3. E-scrap processing technology block cheme

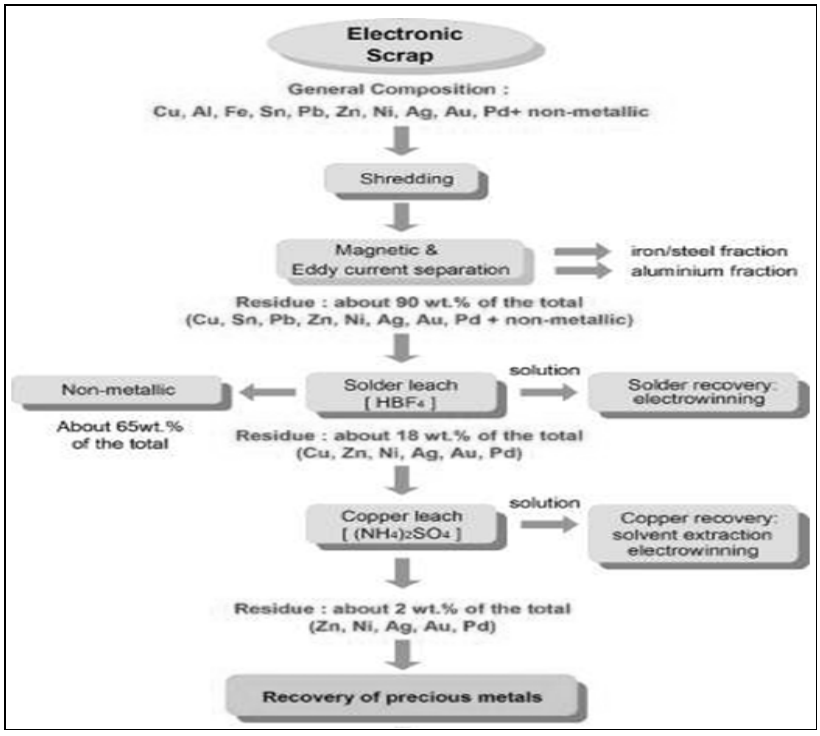

Figure 1. E-scrap processing technology block cheme [5]

3. ECONOMIC ANALYSIS AND THE PROJECT EVALUATION

3.1. Basic parameters for the economic analysis

Production capacity, structure and value

- Copper : 10,260 t /year. * 4600 EUR/ t = 47196 EUR
- Gold : 3,100 kg/god * 24000 EUR/kg = 74400 EUR
- Silver: 8,050 kg/god * 360 EUR/kg = 2898 EUR
- Palladium: 0,860 kg/god * 12000 EUR/kg = 10750 EUR

Investments

Equipment 50200 EUR , Working capital 18290 EUR i Others 10642 EUR

Funding

Own funds 31 ,49 % ili 24 920 EUR, Bank loan for new equipment: 68,51% ili 54 212 EUR

Capital costs

Depreciation 10% of the equipment value, Maintenance 5% of the equipment value, Insurance 0,5 % of the equipment value, Interest 15% on the raised bank loan.

Material and energy costs

Piro methalurgy 4044 EUR, Elektrolysis 7080 EUR and Refining 3568 EUR

Labour costs

Piro methalurgy 5520 EUR, Elektrolysis 14670 EUR and Refining 9112 EUR

Other expenses

Processing: Cu 700 EUR / t , Au 150 EUR /kg, Ag 10 EUR /kg, Pd 150 EUR /kg, Environmental costs 1 000 EUR / year., Export supporting services 8% of Au&Ag income, Chemical analysis 1 200 EUR / year., Other expenses 2 000 EUR / year. [5].

3.2. Financial projections and the project evaluation

All financial projections done for the six year period,including one year of investment and five years of production, indicate the project feasibility:

- Income statement indicates profit throughout the years of the production period
- Financial Cash Flow indicates permanent liquidity and all years positive net cash flows
- Economical Cash Flow indicates positive indicators of the project profitabiliti:

  - ✓ Internal rate of return IRR = 74.20%,
  - ✓ Net present value (discounted at 15%) $NPV_{15\%}$ = 138 755 EUR
  - ✓ Pay back period PBP = 2 years

Final evaluation of the investment in the project of e-scrap processing and metal production in MMI Bor is completely positive. Basing on the projected technology and basic parameters the project economy is out of question. Even with the more pessimistic basic parameters profitability of the project would be enviable and ecological benefits would be great. So the project of e-scrap processing and metal production in MMI Bor is fully justified. [5]

4. CONCLUSION

The paper presents the MMI Bor own investigations and studies results on e-scrap processing and metal production project. The project is expected to be realised in the MMIs special production department.

The investigations results were the base for the chosen technological solution described as one of the possible processing variants. Basing on the chosen processing technology the initial parameters for economic analysis were determined.

Economic analysis including the basic parameters and the financial projections (Income Statement, Financial Cash Flow and Economic Cash Flow) resulted with positive indicators for the project appraisal. The analysis resulting indicators (internal rate of return, net present value and payback period) approve the feasibility and profitability of the metal production based on e-scrap processing in MMI Bor.

Beside the feasibility and the profitability the project of metal production based on e-scrap processing in MMI Bor is fully justified also from the environmental protection aspect. The project is expected to generate great economic and also ecological benefits not only for the MMI Bor s the investor but also for the Timok region and Serbia.

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