

## THE IMPORTANCE OF RECYCLING METAL

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**ABSTRACT.** Recycling is a part of an integrated system of Waste Management and it also represents a separation of materials from waste and their reuse. This includes: collection, separation, processing and production of new products from used parts or materials. Secondary raw materials of metal, beside successful replacement of primary raw materials, during the processing require much fewer investment funds to build the manufacturing facilities, less energy consumption and preservation of nonrenewable natural resources is very distinctive and there is also less pollution of environment with waste products as a result of their processing. The basic objective of waste material processing is to get secondary raw materials whose structure is similar to the structure of the material that it comes from. In that way all the advantages of getting secondary raw materials from the waste become clear in contrast to getting the primary metals from mines. Recycling has ecological, economic and social importance.

### **ЗНАЧЕНИЕТО НА РЕЦИКЛИРАНЕ НА МЕТАЛИ**

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**РЕЗЮМЕ.** Рециклирането е част от една интегрирана система за управление на отпадъци, включваща сепарация на материали от отпадъците и тяхната повторна употреба. Тя включва: събиране, сепарация, обогатяване и производство на нови продукти от вече използвани части или материали. Вторичните суровини от метали, освен успешно заместване на първичните суровини в процеса на обогатяване изискват много по-малко инвестиции за изграждане на производствени мощности, както и по-малко енергийни ресурси. Съхраняването на невъзобновяемите природни ресурси е много важно и оттук значението на рециклирането. При обработката на отпадъци се получават вторични суровини със структура близка до тази, от която произхождат. Това дава предимство за получаване на вторични суровини в противовес на разработването на мините, при които се получават т.н. първични метали. От тази гледна точка рециклирането им има голямо екологично, икономическо и социално значение.

### **Introduction**

Recycling has a long tradition, and as an essential component of environment protection it has also become very important in a relatively short time. Primary purpose of recycling is to obtain useful materials from the production waste, intermediate product, old metal waste and old materials.

It is well-known that metals come from primary and secondary raw materials. Metal production from the primary raw materials – ores and concentrates, represents the basic production. A long-term exploitation has resulted in the depletion of ores and so it is more expensive to obtain metals and concentrates. With the increasing use of metal, there is a growing amount of waste materials – so called secondary raw materials that, in regard to ores, contain a considerable larger share of metal. Because of this the methods for their processing and obtaining metals have been developed in modern metallurgy, whose amount, in relation to their current production from primary raw materials, is considerably larger.

There are two types of waste material: production and amortization waste. Metal scrap appears as a result of the manufacturing process and it is the waste of the process itself. When the finished product, which contains metal, has expired shelf life than the amortization waste will arise (Branković, 2002). Both types of waste should be returned into the circle, from the point of utilization of metal as well as from the point of

ecology. The exhaustion of the rich ores due to the extremely large volume of long-term exploitation and not very promising opportunities to find new sites, indicate the growing need to preserve the environment and start processing of the secondary raw materials.

At the same time, the processing of the large quantities of ores in the mine-metallurgy companies manufacture a considerable amount of waste such as slag, dust, sludge from furnaces etc. There is also a large amount of metal scrap. These solid scraps cause great concern because of their safe disposal and pollution control. If you throw these scraps directly in the environment, they will, except for taking the space, pollute the soil and rivers. So the use of metal that is obtained from metal scrap will not only solve the problem of pollution but it will also preserve the ores for future.

It is important to distinguish that while processing the secondary raw materials a huge saving of energy can be obtained compared to the processing the primary raw materials. In the processing of ores you can achieve a maximum economy if the by-products and production waste are completely reused. Since some of the metal is lost in each stage of the process, the total utilization represents an economy of the process.

As the consumption of metal is constantly growing, ore reserves are smaller and smaller. This situation requires that

manufacturing secondary metals preserves the primary raw materials. Because of this fact, obtaining metal from these metal scraps aroused interests for the research all over the world. Large quantities of aluminum, steel, copper, lead, zinc, silver, gold and other metals have been produced so far out of the secondary raw materials. These metals are particularly valuable types of waste because they belong to the non-renewable natural resources. It is possible to process through recycling most of the metal. For example, cans are mostly made of aluminum. Manufacturing the new one from the old aluminum you use 95% less energy. When recycling cans you can manufacture metal parts for a washing machine or parts for cars, while manufactured recycled steel is used to make car bodies, steel girders or parts of engines.

## Definition of recycling and its importance

Recycling is a separation of waste materials and their reuse. Gathering waste, its separation, processing and manufacturing a new product are links in the chain of recycling. It is not only enough to reduce and avoid the waste, but it is also necessary to separate it at the source according to the type of waste, because only separated gathering waste enables implementation of recycling. Recycling is based on three basic principles:

- R – reduce
- R – reuse
- R – recycle.

You can achieve the following strategic objectives using the process of recycling:

- saving the raw materials (all materials come from nature and they come in a limited amount);
- saving energy (there is no use of energy during the primary processing, as well as during the transport that follows the processes, and you can get the additional energy by burning materials you don't recycle);
- protection of the environment (waste materials degrade living environment, so using the recycling process we protect it);
- creating new jobs opportunities (processes of recycling materials mean investment of knowledge and work, which creates the need for the new positions).  
Regarding the possibilities of reuse, materials can be:
  - recyclable – they can be reused returning them into the manufacturing process
  - non-recyclable – they can't be returned into the process and are used to get energy – by burning them or they are stored in an ecologically safe way;
  - hazardous – hazardous materials that are harmful for a man and his environment;
  - harmless – materials that are not harmful for a man and his environment.

The most interesting fact about recycling is certainly that it enables that one product, after it has been used, can be returned in the manufacturing process. The best indicators of the recycling importance are the countries that invest a lot in this process. On the list of European countries with the highest percentage of recycling you can find Belgium, Germany,

Austria, Luxemburg and Holland. The level of development of these countries unequivocally indicates the importance and possibilities that recycling has in modern manufacturing processes.

## Processing the secondary raw materials

It is well-known that because of corrosion relatively small part of metal is transformed into non-ferrous form, and since less energy is used for processing the secondary raw materials than it is used to manufacture the primary metals from ores, secondary metals actually are not the energy consumers, but they are a kind of the energy accumulators if they are constantly recycled and economically processed. There are three or four types of the secondary raw materials sources. It is important that each of them is used as rationally as possible, i.e. to get all the useful components. This is why the golden rule of processing the secondary raw materials is that in the smelting process we have to get usable alloy of the same or similar composition as the initial raw material. This is the only way to get the basic metal and all the other alloy elements. Because of this the secondary raw materials have to be gathered separately and classified according to certain alloys. If we don't know or if we are careless the secondary raw materials can be mixed with other metals, for example tinned copper wires, which requires their careful unrolling so that they can be successfully used further on. The problem begins when two alloys of similar appearances mix up but their components are incompatible.

Nowadays 30-45% of non-ferrous metals can be manufactured in the world from the secondary raw materials. There is no such statistical review in Serbia. Table 1 show the data connected to recycling of non-ferrous metals, and on this basis you can see that the share of the secondary raw materials in non-ferrous metals consumption is rising in the western countries.

Table 1  
*Share of the secondary metals in consumption of aluminum, copper, zinc, lead and tin in western countries in %*

METAL	1974	1978	1985	1987	1990	1995	2000
Aluminum	20.8	22.7	25.8	30.1	33	35	40
Copper	39.2	35.2	37.7	45.2	57	50	55
Zinc	18.4	17.6	23.3	22.6	25	27	29
Lead	37	41.4	47.4	51	55	58	61
Tin	18	19.4	21.1	40	45	44	46

It is also well-known that energy consumption in the process of getting the secondary metals is considerably less than the primary metals. The quoted fact is important if we analyze the trend of metal and energy price. The price of metal in the last three decades has increased on the average from 45-80% and of energy 4 times.

Table 2  
*Increase in prices of the main non-ferrous metals and energy and share of the energy price in the metal price in %.*

METAL	Price increase in 1957/1987	Share of the energy price in metal price
Aluminum	1.81	29.0
Copper	1.41	8.0
Zinc	1.49	1.5
Lead	0.91	15.0
Tin	1.56	6.5

Energy aspect of getting metals is shown in the picture 1.

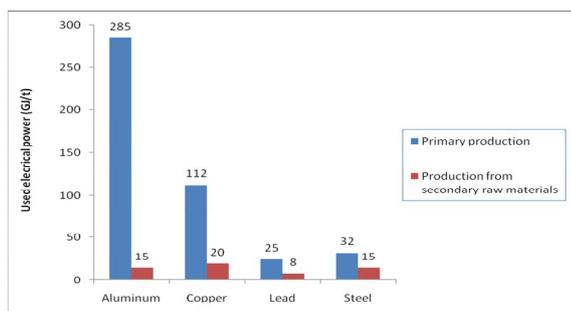


Fig. 1 Energy aspect of getting metals

Processing the metal materials mutually connected influences are formed between the raw materials, need and ecology. It is necessary to attain an optimal relationship between these parameters, in order to realize maximum demands in terms of utilization of raw materials, energy consumption and protection of the environment (Ilić, Gulišija, Kamberović, 2006).

### Iron scrap and secondary raw materials based on non-ferrous metals

Forge products can be used as primary raw materials or they can be processed in other products. After we use them a great part of these products is thrown away. Iron scraps appear because of discarded machines, industrial and agricultural machinery, household appliances, railway tracks, cars, old ships and communal waste (Ilić i sar., 1998). From all of the devices, old cars are particularly important. The number of vehicles in the world is constantly growing, and one third of them are in the United States of America. Most of the cars have an average life of about 12 years. Over 30 million of vehicles are processed every year, and one third of them in America. Most of these vehicles consist of iron and steel (on average about 70%). The next metal by quantity is aluminum, which is 20%. There is also an insignificant quantity of lead, copper and zinc. Nonmetal components are plastic, glass and rubber. The vehicles produced since 1990 have got less steel and iron, and more plastic and glass. The level of recycling is high and is about 90%.

Manufacturing of non-ferrous metals, including their use for manufacturing alloyed steel, is only 7% of the world steel manufacture, but their unit price is considerably higher. The number of non-ferrous metals is very large. Because the price of the unit is high, there are efforts to decrease their consumption, trying to improve alloys, using composite materials, plastic, graphite, ceramics, and so on. Although these aims are sensible, they make recycling more difficult. The level of recycling of old lead is 55%. The recycling level of aluminum and copper is considerably lower and is 25%, and of zinc even lower. The recycling level is low, because there is no efficient collection net. Companies for waste preparation, which sort it, separate, increase and clean waste of non-ferrous metals don't use the equipment of the large unit capacities, as they do with steel scrap. This is why we need not only excellent companies for sorting and devices for identification but also much more complex devices and technology lines for separation and preparation of all forms of secondary non-ferrous metals. The value of scraps which are sent to the

blending depends on attention of the sorting companies, in other words technological preparation of waste material. The materials prepared in this way have considerably larger usability for further metallurgy processing. The basic rule in the processing of secondary metal raw materials is to get metal or alloy of the same or similar composition as the initial raw material.

### Aluminum

In the past 100 years, aluminum has been representing a metal which is being used in industry more and more. Aluminum offers, with the capacity of low specific density, an alternative to steel and it can potentially increase the efficiency of vehicles, and because of this its use in the car industry continues to grow. The main obstacle for the widespread use of aluminum for the car bodies is its price. Energy requirements for aluminum smelting represent only 5% of energy used for the primary manufacture.

In developed countries, using aluminum imported from other countries is the same as if they buy electrical power. When aluminum is recycled you reuse the energy once more. For example, each kilogram of aluminum which is recycled from the cans saves almost about 46kWh electrical power.

One of the basic problems with the secondary aluminum is recycling old cans. In addition to improving organization for gathering cans, technical development demanded also improving recycling technology. The second problem in the processing is that cans' lids are made of different alloy. This level of recycling has not been such a big problem so far. If the level of recycling exceeded 70%, then it would be a serious problem.

### Copper

A large amount of this metal is obtained from secondary raw materials. The resources of secondary copper are slag, cables, wires, radiators, brass and bronze. The procedure of manufacturing copper depends on the quality of the scraps. Scraps rich in copper with more than 40% Cu are smelted and refined into reverberatory furnaces and rotary kilns. Waste of low value which contains about 5% of copper is smelt in shaft furnaces plus coke and this is how we manufacture black copper. Further on, black copper is processed and refined as the primary (Vračar, Jovanović, Cerović, Stopić, Kamberović, 1997; Vračar, Jovanović, Cerović, Stopić, Kamberović, 1997).

Copper has a high level of recycling in relation to many other non-ferrous metals. About two thirds of used copper can be reused as a secondary raw material after some time. In contrast to ore reserves, secondary copper is a renewable resource for manufacturing copper. Copper scraps are more and more important as a resource for obtaining finished copper products primarily because there has been used a great effort and work to obtain them and it is much better for ecology contrasted to processing copper ores.

The main sources of secondary copper are countries of developed world, which makes sense, if you take into consideration concentration of the world's capacity for processing copper and real potential for recycling of old copper. Over 80% of the total secondary raw materials are also used in those countries. The system of collecting, sorting and preparation for the processing of all raw materials is very developed so that all the useful components could be used and the most favorable economic effects could be achieved.

For copper and its alloys production waste is 65% and amortization waste is 35%.

Recirculation copper waste (its own waste) appears during the metallurgy manufacture of alloys, rolling, casting, extracting, minting and cable production. The amount of recirculation waste is not the same in all countries, because it depends on technical level of the country, applied technology, production discipline etc (Todorović, Urošević, Slavković, 2007).

### Zinc

The sources of secondary zinc include brass, waste powder of zinc and zinc oxide and slag from the foundry. A great amount of zinc is recycled as a refined zinc oxide or Zn powder or a compound such as zinc sulfate and zinc chloride. Only about 10% of zinc scrap is recycled as a refined metal because of many problems that appear during the refinery process of these raw materials. One quarter of total amount of manufactured zinc is used as a coating that we get metal from in very limited quantities. Zinc scrap such as hard zinc is got in reaction between molten zinc and steel strip in galvanizing. Zinc from these compounds may be produced by distillation or in a treatment with aluminum.

### Lead

Lead acid batteries are the most important source of secondary lead (Nikolić, 2000). There are numerous processes of separation in the world nowadays where you can get as a product metal lead, paste, separators and plastic. Underdeveloped countries are processing secondary lead raw materials insufficiently. This problem is not taken seriously in Serbia, although this activity where you don't have to invest a lot and where the organization is good can make a significant financial effects.

### Tin

It is well-known that the most of tin is used to coat other metals. The sources of secondary tin are boxes of cans and smelter slag. To get it from tinplate scraps and cans is very limited because of the collecting problems. Tin from tinplate is obtained by hydrometallurgical process which is dissolution of tin with the solution of hot caustic soda that has sodium nitrate or methyl-nitro benzene acid (Ilić, Stopić, 2000). After the solution is obtained, the next step is electrolysis.

### Magnesium

Rapidly increasing use of magnesium in the past twenty years has caused the increasing consumption of this metal (Hornobogen et al., 1993). The increasing use of magnesium is the reason why this growth will have a long-term impact on industry of reduced magnesium. To process the obtained Mg scrap and manufacture metal, besides collecting and classifying, an adequate preparation should be carried out, so that it can be efficiently assimilated into refined metal. This is why today in developed countries intensive researches are being conducted in this area.

### Precious metals

Because the price of precious metals is high, a lot of effort is made to get these metals in the furnaces of non-ferrous metals. The main sources of secondary precious metals are alkaline solutions, electrolytes, slag, printed circuit, electronic waste, alloy plating, medicines, jewelry, waste in dentistry, and platinum catalysts. The method of obtaining depends on scraps. For example solid waste is treated in a pyrometallurgical method and liquid in hydrometallurgical. In both methods metal is finally obtained by electrolysis.

### Conclusion

Recycling is a very complex process from the point of environmental protection and intensive consumption. Production and consumption of new products are enormously increasing. After their use people gradually throw them away and there is a huge amount of waste materials. If reduction of the waste is not attainable at the source, then the next strategy that is to be used is recycling, i.e. reuse. Products that we obtain from the primary raw materials, ores, are followed by energy consumption and pollution of water, air and soil. To obtain materials from secondary raw materials takes less energy than to obtain metals from ores so there is a strong demand to recycle them as much as possible. In this way secondary raw materials represent a new form of accumulated energy. Because of all this, the maximum of our attention should be paid to the recycling processes in the future, so that waste materials would be successfully recycled to get metals and to protect our environment.

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