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Ways to Increase Competitiveness and Efficiency of Metal Goods Production from Scrap and Nonferrous Waste

V. A. Kozhanov, V. A. Popov, E. E. Mushik

Donetsk State Research & Design Institute of Ferrous Metals
14 Lagutenko St., Donetsk 83086, Ukraine

Rational utilization of secondary metallurgical raw materials and use of all factors of product quality improvement when working out normative acts are covered in the paper.

Keywords: COMPETITIVENESS, EFFICIENCY, SCRAP, METAL PRODUCTS, NONFERROUS WASTE, ALUMINUM, CUPRUM, LEAD

Results and Discussion

Alloys on the basis of aluminum, cuprum and lead are produced from scrap and nonferrous waste in Ukraine. Production output of aluminum alloys, cuprum and copper alloys has been dropping, and production output of lead alloy has been increasing since 2000. Production of lead and its alloys decreased also in conjunction with economic crisis in 2008 (**Table 1**).

The majority of alloys produced during 2003-2008 were delivered for export.

Market of copper alloys produced from scrap and waste is in the complicated situation. A great amount of scrap and pure copper are used for bronze and yellow metal production and are eliminated from the process of metal goods production from refined copper.

Exported bronze of grades ОЦС5-6-5 and ОЦС3-13-4 does not meet the standards of foreign countries as well as secondary aluminum and is used in most cases as a charge material for refined copper production with stannum and lead extraction. The main consumers are copper-smelting plants. But the greatest loss of the state from the export of these alloys consists in that only cuprum is often evaluated in them, but stannum, zinc and other metals are not paid.

Yellow metal is delivered for export in the form of bar of grade ЛСД or pig yellow metal with increased concentration of impurities, that is why its price is much lower than the world level.

The majority of bronze exported from Ukraine in the form of ingot bars or billets has deviations in chemical composition in relation to both main components and impurities, but nevertheless corresponds to requirements of GOST 614-97 (**Table 1**), which allows producing alloys with deviations in coordination with a consumer, i.e. does not promote enhancement of metal products quality. Similarly, yellow metal produced according to GOST 1020-97 (**Table 1**) is delivered for export with deviations.

There are enterprises with developed infrastructure, high level technologies, modern process equipment and quality control system that are among 100-150 leading enterprises of Ukraine.

Cathode copper has been successfully produced from scrap and waste at joint venture "Punkom-YuN" (Odessa) in Ukraine since 1998 at “Zaporizhzhya Plant of Non-Ferrous Alloys” Ltd. and “Konstantinovsky Factory of Metallurgical Equipment» since 2005. These enterprises produce cathode copper of grades M00, M0, M1 from scrap and waste. Total capacities are approximately 18 thousand tons per year. However, one of priorities is a technology of secondary copper raw materials processing developed at JSC "Artyomovsk Non-Ferrous Metals Processing Plant" with the use of up-to-date equipment including continuous shaft furnace; fire refining technology; holding furnace; casting wheel; 9-stand continuous rolling mill.

JSC “Artyomovsk Non-Ferrous Metals Processing Plant” is a leader of nonferrous

Table 1. Alloy production in Ukraine for 2003-2008

Alloy	Years					
	2003	2004	2005	2006	2007	2008
	Production, thousand tons					
Aluminum	135.8	106.3	105.4	102.1	110.0	96.1
Copper	82.5	77.4	87.2	68.0	83.0	81.8
Lead	40.4	48.0	47.8	50.1	54.9	44.9
	Export, thousand tons					
Aluminum	97.0	73.3	69.0	56.6	65.0	45.2
Copper	45.4	45.1	54.1	32.0	57.3	27.0
Lead	15.0	16.2	12.9	10.9	15.0	8.8

metallurgy in Ukraine. Products of this plant in the form of extruded pipes and bars, wire, copper contact wire, yellow metal, copper wire rod,sheets, strips made of cuprum, yellow metal and copper-nickel alloys, the sanitary fixture and the household purpose products are known and appreciated not only in Ukraine but also in many countries of the world. Now this leading plant of nonferrous metallurgy of Ukraine produces more than 100 standard sizes of semimanufactured materials and products from 100 grades of cuprum, nickel, zinc and aluminum based alloys.

Scrap and waste of yellow metals and bronzes are reasonable to process for cast alloys. Classical processing methods are production of ingot bars and their use in foundry shops. Rarely, liquid melt prepared from scrap and waste is teemed into forms or used for bar continuous casting. Yellow metal and bronze castings are made by dead-mold casting, chill casting, pressure-die casting and other special casting methods. Center die casting for large and medium castings is widespread in Ukraine. "Zaporizhzhya Plant of Non-Ferrous Alloys" Ltd. is a modern plant producing high-quality semimanufactured materials and products from scrap and waste of copper and aluminum alloys. The range of finished products includes cathode cuprum, copper and aluminum granulated material, bearing bushing for railway transport, copper wire rod, electric-technical wire.

There is a conundrum: for Ukrainian plants it is profitable to export preparatory alloys as high concentration of impurities in them simplifies reclaimer operation and cancels rigid requirements to production processes, which at the same time increases losses from export by 10-15 % for each ton or 120-200 dollars. So, a damage is caused to the state. In our opinion, 18-20 advanced plants are enough for effective processing of copper and aluminum raw materials with modern processing lines and quality control system in the market of secondary non-ferrous metals of Ukraine.

The structure of costs when producing metal products from scrap and waste of cuprum and its alloys is presented in **Table 2**. Limited application of secondary aluminum alloys is caused by their low quality.

Table 2. Structure of costs when producing metal products from scrap and waste of cuprum and its alloys

Article, steel grade		Copper pipe M2-M3	Copper pipe CuDHP	Brass bar ЛЗ63	Brass plate and slab ЛС59-1	Brass bar ЛС59-1	Copper cathods
No.	Cost item						
1	Raw materials	72.44	64.30	66.46	47.83	77.47	84.00
2	Auxiliary materials	1.60	1.50	0.94	1.37	1.24	
3	Fuel	1.48	1.50	0.54	0.81	0.69	
4	Electric power	2.65	2.50	1.67	5.65	2.13	3.00
5	Base and extra wages	4.19	3.97	4.76	4.93	5.82	5.00
6	Equipment maintenance expenses	6.00	7.33	8.69	13.42	4.30	2.00
7	Other	11.64	18.90	16.94	25.99	8.35	6.00
9	Total cost	100	100	100	100	100	100

The present situation in the Ukrainian market does not promote the principal task in secondary nonferrous metallurgy, namely: high-quality products made from scrap and waste for, first of all, satisfaction of domestic market needs and also for export. Many plants do not have advanced equipment and cannot ensure the requirements specified for castings.

At present in the European countries, the bulk of products made from scrap and waste is produced at plants with capacity more than 20 thousand tons of alloys per year, which is explained, first of all, by efficient application of charge preparing equipment and melting units that cannot be used at small plants. For example, lines with high-power crushing machines are applied for crushing mixed aluminum scrap, which are paid back in case of processing not less than 10 thousand tons of scrap per year. As mentioned above, a consumer demands delivery by lots not less than 20, rarer 10 tons in order to receive a homogeneous lot. The latter cannot be fulfilled in melting units with bath capacity from 0.25 to 10 tons. Majority of specialized plants occupied in metallurgical processing of scrap and waste have the equipment with capacity less than 10 tons and very simple pouring equipment.

Optimum power of plants is defined also by applied means of mechanization of raw materials preparation processes, melting units charging, refining and pouring, as well as removal and purification of aggressive gases and eventually high labor productivity.

In Germany, only 23 plants are engaged in processing at annual output of secondary aluminum alloys 575 thousand tons, 12 plants of them have capacities 20 thousand tons per year. Japan produces 1 million t/year at 75 plants, including 30 - from 20 to 100 thousand t/year. USA make 1.5 million t/year at 34 plants, including 15 - from 20 to 100 thousand t/year. Situation in Ukraine is rather interesting against this background, because approximately 110 thousand tons per year of aluminum alloys are made at more than 70 plants. What product quality can we talk about at such organization of production in secondary nonferrous metallurgy in our country?

In European countries, the bulk of metal is produced in rotating drum-type furnaces with application of liquid salt fluxes. Usually, produced alloys correspond the standards and are usedfor casting manufacture for automobile, tractor and other branches of machine-building industry.

Competitiveness of secondary nonferrous Metallurgy products is known to define by standard, technical and economical parameters. As applied to secondary aluminum alloys, the basic characteristics defining their competitiveness are as follows:

1. Chemical composition conformity to one of analogues: USA - A380-1; Europe - DIN 226.
2. Minimum concentration of gaseous and nonmetallic inclusions.
3. Stability of physic-mechanical properties.
4. Homogeneity of chemical composition in the whole lot of alloys (not less than 10 tons).
5. No surface defects and oxide inclusions.
6. Stable size of micro- and macrograins.
7. Finished product packing.

Chemical composition of alloys exported from Russia and Ukraine and alloys from USA, Japan and Germany are presented in **Table 3** for comparison of characteristics.

Distinctive features of alloys applied in our countries (AK5M2, AK9M2, AK8M9) are elevated magnesium concentration (usually from 0.5 % to 0.85 %) and high concentration of impurities. Minimum concentration of magnesium in foreign alloys is ensured by not only its content in the charge materials but also, first of all, by applied technology ensuring refining from magnesium in salt rotor furnaces and out-of-furnace refining units. Applied two-stage refining of alloys ensures minimum concentration of magnesium (usually less than 0.2 %) and simultanuous removal of gaseous and nonmetallic inclusions. Majority of Ukrainian plants have no such technology. And GOST 1583-89 on chemical composition of alloys does not oblige manufacturers to ensure double refining. In this case, the minimal requirement to alloy producers is satisfied.

As for accomplishment of competitiveness criteria, it is necessary to take a minimum of technical and organizational measures in order to satisfy some of them. Stability of micro- and macrograins size is especially important. It can be achieved by alloy inoculation with alloying compositions refining the grain. But melt alloying is not used in alloy production from scrap and waste.

Applying similar technologies, foreign companies use less costly bad quality raw materials. For foreign scrap consumers, consumption of bad quality raw materials is not a big problem as melting units applied for aluminum alloy production allow reducing magnesium concentration from 3.6 to0.1%.

Magnesium is removed due to its selective reaction with salting liquids in short drum

Table 3. Chemical composition of aluminum alloys

Alloy of country	Concentration of elements							
	Cu	Si	Mg	Zn	Fe	Mn	Ni	Sn
1. ADS 12 Japan	1.5-3.5	9.6-12.0	0.3	1.0	0.9	0.9	0.5	0.3
2. DIN 226 Europe	2.0-3.5	8.0-11.0	0.3	1.2	1.2	0.1-0.5	0.3	0.1
3. A380-1 USA	3.0-4.0	7.5-9.5	0.1	2.9	1.0	0.5	0.5	0.35
4. AK5M2	1.5-3.5	4.0-6.0	0.2-0.85	1.5	1.0	0.2-0.8	0.5	-
5. AK5M4	3.0-5.0	3.5-6.0	0.25-0.55	1.5	1.0	0.2-0.6	0.5	-
6. AK9M2	0.5-2.0	7.5-10.0	0.25-0.85	1.2	0.0	0.1-0.4	0.5	-
7. AK8M3	2.0-4.5	7.5-10.0	0.25-0.50	1.2	1.3	-	0.5	-
8. AK7	1.5	6.0-8.0	0.20-0.55	0.5	1.0	0.2-0.6	0.3	-

Alloy of country	Concentration of elements			Mechanical properties			Output of cast aluminum alloys made of scrap and waste, %
	Ti	Pb	Total impurities	Strength σ_{YS2}, MPa	Elongation δ, %	Hardness HB, MPa	
1. ADS 12 Japan	-	-	-	260	1.2	1000	60
2. DIN 226 Europe	0.15	0.2	-	270	2	1000	60
3. A380-1 USA	-	-	-	280	1.5	1000	50
4. AK5M2	0.05-0.20	-	2.8	206	1	600	60
5. AK5M4	0.05-0.20	-	2.8	196	0.5	900	4
6. AK9M2	0.05-0.20	0.15	2.5	274	1.5	850	2
7. AK8M3	-	0.15	4.1	216	1.0	900	1
8. AK7	-	-	3.0	196	2.0	750	25

rotating furnaces. It is very easy to produce, for example, aluminum from scrap and waste of not doped aluminum or AK5M2 from waste of not doped aluminum strained and motor scrap. But it is much more effective to produce high-quality aluminum alloys from these charge materials for manufacture of such parts as cylinder block parts, cylinder heads, engine cylinder block for cars and agricultural machines, bodies of gas gears, etc. Advanced high-quality aluminum alloys are implemented very slowly in domestic manufacturing engineering. Alloys of domestic standards are still applied though they are inferior in operation and mechanical properties.

Off-market developments are still used in the documentation justifying manufacture of products. It is necessary to reconsider the current state in the market of alloys with the use of scrap and nonferrous waste. Many alloys under GOST 1583-89 have been developed with the unique purpose to facilitate operation of metallurgical plants. There is also other opposite tendency radically differing from the conventional ones in the countries of European union, USA and Japan. Many castings in Ukraine and Russia are made of primary metals whereas in the specified countries alloys from secondary materials are used for the same castings. This situation has occurred as a result of consumer`s demand neglect in favor of easier operation of plants producing alloys from secondary materials. Now, for example, in Germany it is not possible to find a plant that uses reverberatory hearth furnaces for recycling scrap and waste of aluminum alloys used, unfortunately, at many plants of Ukraine.

Analysis of raw-material base state and its effect on metal products quality shows that our plants use better quality raw materials than the foreign ones. But, having the best raw materials, we produce not competitive alloys with some minor exceptions.

The structure of costs for producing metal products from scrap and waste of aluminum alloys is presented in **Table 4**. Expenditures connected with fuel and power resources and salary are 6.0-7.5 % while in foreign countries these expenditures for aluminum alloy production are 25 %.

Conclusions

1. Secondary metallurgical raw materials are highly effective and should be used rationally.

Table 4. Structure of costs for producing metal products from scrap and waste of aluminum alloys, %

No	Alloy grades / Cost item	АК5М2	АД0	АД1	АД31	АК12	АК8М3	АК9М2
1	Raw materials:	86.95	89.48	89.48	89.17	88.16	86.78	87.35
	aluminum scrap	80.24	89.48	89.48	89.17	65.29	69.88	73.92
	copper scrap	2.84	0	0	0	0	5.15	2.19
	silicon	3.88	0	0	0	22.87	11.74	11.23
2	Auxiliary material	0.53	0.43	0.43	0.44	0.48	0.54	0.51
3	Fuel	3.37	2.72	2.71	2.79	3.05	3.40	3.25
4	Wages	4.05	3.26	3.26	3.35	3.66	4.09	3.91
5	Production cost	94.90	95.90	95.89	95.75	95.36	94.80	95.03
6	Other	5.10	4.10	4.11	4.25	4.64	5.20	4.97
7	Total cost	100	100	100	100	100	100	100

2. The state should not allow exporting these resources as bad quality alloys.

3. Only plants that can make the competitive alloys corresponding to the world standards should be allowed to produce secondary aluminum and copper alloys.

4. It is necessary to use all factors of product quality improvement when working out statutory acts.

5. The plants not technically re-equipped will not manage to survive under conditions of current market system.

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Пути повышения конкурентоспособности и эффективности производства металлопродукции из лома и отходов цветных металлов

Кожанов В.А., Попов В.А., Мушик Е.Е.

Рациональное использование вторичного металлургического сырья. Использование всех факторов повышения качества продукции при разработке нормативных актов.