

OPTIMIZATION OF RECYCLING PROCESS OF WHITE BRONZE CHIPS

Ludmila Skálová, Jaroslav Luka, Bohuslav Mašek
Research Center Fortech, University of West Bohemia in Pilsen
Univerzitni 22, Pilsen, 30614
Czech Republic

ABSTRACT

This work focuses on optimization of recycling process of white bronze chips which come from the manufacturing of slide elements. Present recycling technology was applied on the chips with unsatisfactory results. The aim of this work is to increase the efficiency of recycling process and to obtain maximal amount of recycled metal with optimized recycling method which would use forming of the chips and their remelting with suitable anti-oxidation addition. Their first part of experimental program will be evaluated and a new direction of work will be proposed for further experiments.

Keywords: recycling, white bronze, forming

1. INTRODUCTION

Recycling has become an important issue in our society in last decades and the importance of recycling processes in material science has also been increasing. The reason of this recent interest in recycling is that recycling process has two important effects on our environment. First of all, it saves raw materials, natural resources and energy. Second, it also decreases ecological damage made by insurants. Recycling originally meant that the garbage was returned into the same production processes in which they were produced and recycled materials were used for the same purpose as in their first usage. However the meaning of the word has been broadened and as recycling is considered any repeatable use of production, manufacturing and consumer's wastes, energies and materials [1]. The place or time of origin of the waste and the way of its new usage are not important any more.

Recycling of metals is done with the use of recycling technologies. They consist of a set of production processes, methods and operations which gradually change the waste into secondary raw materials. The recycling of metals is preceded by the gathering and adjustment of metal waste. According to the origin of the waste it can be divided into three main groups: a) Waste from the manufacturing of machine parts. In this case the materials always have defined chemical composition and properties and therefore they can be recycled without adjustment by direct re-heating. b) Waste from the manufacturing of finished parts (for instance spoiled work). Chemical or mechanical adjustment of this waste is necessary before remelting. c) Used goods from all economic sectors which have to be adjusted as well [2].

The fraction of recycled metals in the world metal production has been therefore increasing in recent years. To keep this growth also in the future, more efficient methods of metal recycling has to be developed. It is apparent that these methods will be not only more cost effective but also environmental friendlier. One way of achieving this goal might be to incorporate suitable forming techniques in recycling processes.

As the waste to be recycled in this work were chosen the chips of so called white bronze produced by the manufacturing of slide elements. It is the form of this waste that causes problems with recycling of the chips by remelting. The chips are oxidized during remelting to a large degree and as a result most

of the metal is burned and does not melt. The reason of this behavior is that the chips have relatively small volume but large surface area. The aim of this work is to modify to-days recycling process and to increase its efficiency and also the profitability.

Recycling process of white bronze chips consisted of gathering of chips, separation of cutting liquid, and chips remelting. However recently has appeared the tendency to incorporate forming operation into this process. Gathered chips are now pressed into the packets and subsequently remelted. The advantage of packetizing is a decrease of metal loss, higher selling price of the waste in this form, decrease of manipulation costs and the possibility to obtain back most of the cutting liquids. The charge is usually protected against oxidation by the layer of charcoal.

2. EXPERIMENTAL PROGRAM

Recycled material is a ternary alloy of non-ferrous metals ZnAl35Cu5 which is called ALZEN or also white bronze. Zn-Al-Cu based alloys have been used since the Second World War for their good sliding properties as an cheaper alternative to expensive side bronzes. [1] In comparison with red brass and slide bronzes ALZEN has lower specific weight, which is a big advantage from the construction point of view. ALZEN also have higher strength and yield strength than the above mentioned metals that are usually used for slide bearings.

In the first part of experimental program the chips of white bronze were freely poured into melting cup and scattered by charcoal, according to the traditional way of processing. The efficiency of this process was close to 0% because most of the metal burned out. New recycling process was therefore designed which would lead to higher efficiency of chip recycling (Tab.1). The main difference is that the chips will be compacted into packets to decrease the surface of chips. The oxidation will than occur only on the free surface of the packet while the centre should be relatively free of oxidation. Two kinds of compacting were chosen. In the first variant white bronze chips alone were compacted while in the second case the chips were pressed together with the addition of charcoal (Fig.1) in different weight ratios. Charcoal was used as a cheapest possibility to restrict oxidation process. Several experiments with different weights and weight ratios of the packets were carried out (Fig.2) and the best results were obtained with 400g or 500g packets with the maximal possible ratio of charcoal to the chips being 1:6 (Fig.3). Higher ratios of charcoal which were originally intended to suppress oxidization caused the packets to be too brittle and cohesionless and to fall into pieces.

Table 1. The conditions of recycling processing methods.

Method of processing	Pre-heating [°C/min]	Remelting temperature / time [°C/ min]	Charcoal addition	Remelting bath	Efficiency [weight %]
A	-	780 / 180	Y	Packets	0
B	-	780 / 240	N	Packets	41
C	130/20	780 / 130	N	Packets	31
D	130/20	780 / 130	Y	Packets	26
E	320/60	780 / 240	Y	Lump waste	-2
F	320/60	780 / 240	N	Lump waste	-8

The packets with charcoal were produced in one forming operation while the packets of pure white bronze chips were prepared in several forming steps to improve their consistency. The compacting was done using the maquette of hydraulic press CKW 6000 and the pressing force of 41,25 ton. Experimental casts were done in electrical resistive oven KRG6/5. The packets were pre-heated and than also remelted in this oven. Remelting temperature of 780°C was chosen and it remained the same for all the variants of processing [3].

3. RESULTS

When the remelting bath of the first processing was prepared only from pure white bronze chips, intensive oxidation was not restricted. The result of this melt was inconvenient, because the charge was burned and the efficiency of this method was close to 0%.

The charge of method A which was compacted with the addition of charcoal did not even start to melt. The coal burned off and the porosity of the packets increased. This resulted in higher oxidation of chips and the charge burned completely (Fig.4).

The most efficient method turned out to be method B where the efficiency reached 41% (Fig.5,6). Two packets of 400g each were added into the melt during remelting process. The similar method C was carried out with pre-heated packets and the addition of heavier packets (500g each) during remelting. These small changes in processing resulted in a decrease of efficiency to 31% probably due to longer heating time necessary to melt larger volume of material, and subsequently higher oxidization of the charge (Fig.7).



Figure 1. Chips of white bronze with charcoal



Figure 2. Compacting of packets on hydraulic press



Figure 3. Packet of chips compacted with charcoal 1:6



Figure 4. Result of Method A



Figure 5. Casting of charge B



Figure 6. Result of Method B



Figure 7. Result of Method C



Figure 8. Lump waste for charge E, F



Figure 9. Result of Method E

Preheating temperature of the packets of 500°C was tried for method D. It was however impossible to manipulate the packets at this temperature because they became too brittle and had a tendency to fall in pieces. They were therefore cooled to room temperature and used as the base for melting bath of

method D. Oxidation of these packets during original pre-heating at 500°C probably caused lower overall efficiency of method D.

Melting bath of the last two methods E and F was prepared from lump waste (Fig.8). The quality of the bath was therefore higher than in previous four cases. The addition of packets compacted from chips and charcoal decreased the oxidation of the bath, but even though burning off occurred (Fig.9). In the case of method F packets of pure white bronze chips were added to the bath which resulted in even higher material loss by burning.

4. CONCLUSIONS

The addition of compacting stage to the recycling process of ZnAl35Cu5 chips increased the efficiency of recycling process from 0% to 41%. This result confirmed the suitability of forming operation as a part of recycling process of chips. Since the best result was achieved for method B, where only the packets compacted without charcoals were applied, it also implies that the addition of charcoal was not beneficial for oxidization restriction and efficiency increase.

On the base of these results several possible ways of further improvement of recycling process efficiency were proposed:

- a) Higher degree of compacting of chips can be obtained by application of isostatic forming in oil. Another solution might be to apply higher forming force on CKW press. The packets can also be compacted in two steps – first in a cold state and then heated to a forming temperature of white bronze.
- b) Charcoal which was chosen as a cheapest material for oxidation prevention can be replaced by some salts for Zn alloys, as ZINCREX D or ZINCREX D87. The salts will be more expensive, but higher efficiency of recycling process can compensate the costs.
- c) Recycling method B can be optimized. Melting time can be shortened by addition of preheated packets. The melt can be kept just under the casting temperature in not fully liquid state and it can be heated to casting temperature only before the cast.
- d) Adjustment of manufacturing parameters of slide bearings. Removal of larger white bronze chips would result in more convenient surface to volume ratio.

5. ACKNOWLEDGEMENTS

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