Impact of low melting alloys at printed circuits from waste cars on strength of such remelted steel

Zoran Karastojković, Dragan Pavlović, Aleksandar Bugarinović, Željka Tomić, Milovan Janićijević

***Abstract*—In nowdays the pressing of used cars and farther their remelting is widespread out in many countries as an *clever* way of recycling & reusing the waste materials. From the point of speed of pressing and melting it is realy fast processing. It is well known that in manufacturing of the any product, a lot of itention is paid on the choosing the right materials, which to be used in fabrication. But, in contrary at the periode of recycling, here the attention is just on waste cars, no attention is paid for diversification of used materials. It is resulted that printed circuits from waste cars are also remelted in making a kind of steel. In metallurgy is well known that many steels are producing from waste steels, but those steels must be strictly controlled. Modern waste cars contain printed circuits (PC), which in their nature were built from a number of printed circuits, and those circuits must posses a low melting alloys. The role of low melting alloys in printed circuits is pretty well known and explained at appropriate literature in PC fabrication.**

***Key words*—low melting alloys, printed circuits, steels remelting, decreasing strength.**

I. Introduction

Steels are an dominant alloy in designing of cars and similar vehicles. From almost of all steels is needed the high strength, either they will be used for sheets, axles and gears. Those components are a good raw material for remelting and further for reusing of such materials. The modern vehicles every day contain an increasing number of printed circuits, without them the driving will became less secure. In every PC was built up a kind of low melting alloy (LMA). The main role in using of LMA is in achieving the low electrical resistivity, good soldering properties and obviously the low temperature of melting. Many boards on PC are not made from a metal, rather from an organic material. LMA farther are used in the manufacturing of semiconductors, batteries, even to some optical and decorative products. Other mechanical properties, as strength of LMA, are however not of the primary interest for PC as electrical conductivity does.

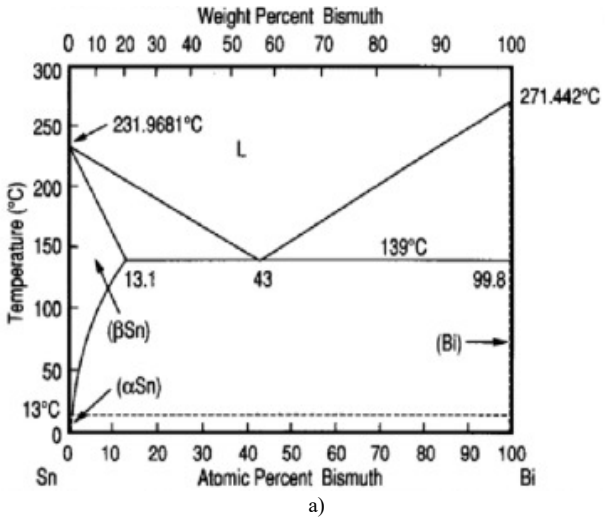
Remelting of such alloys in producing of a steel makes some new problems: steels definitely show much higher melting temperatures and mechanical properties. It becomes clear that the reusing of LMA must be strictly controled in many situations. One of the critical point in reusing of LMA represent the using pressed waste cars as an bulk material for melting.

II. What are low melting alloys

One of the main demand of alloys used for soldering of PC components is in relatively low melting temperature of such alloys. The basic components for making these alloys belong to low melting metals as: Pb, Sn, Sb, Cd, Bi, In, Ge, Te, and others [1], with the main characteristics that they are melted below 450 °C. One of the most known solder, however, is based on lead, but toxicity of lead is resulted in rejected the lead, so is wide accepted the production of solders free of lead.

Some binary phase diagrams may be simple, as shown in Fig. 1a), while the presence of third element makes the more complex diagram, see Fig. 1b).

Melting temperatures from those systems clearly are visible from those diagrams. The alloys used for soldering in producing of PC usually are melted below 300 °C, when their composition is not obviously at eutectic temperature. A few of those alloys may contain little amounts of Ag, Cu, As, and others. The chemical composition of aloys used for fabrication of PC-s should be carrefuly examined. For comparison for shown temperatures of LMA, the steels are melted in range 1500-1700 °C depending from their composition, first of all from the presence of heavy melted metals.



a)

Zoran Karastojković - Society for ethics and evaluation in culture and science, Strahinjića bana 27, 11000 Belgrade, Serbia (e-mail: zoran.karastojkovic@gmail.com).

Dragan Pavlović – LOLA Institute, Kneza Višeslava 70a, 11000 Belgrade, Serbia (e-mail: dragan.pavlovic@li.rs).

Aleksandar Bugarinović – KBV DATACOM, Vladimira Popovića 6, Belgrade, 11070 New Belgrade, Serbia (e-mail: bugar@teol.net), ORCID ID (https://orcid.org/0009-0009-3124-1636).

Željka Tomić – Academy of Technical Vocational Studies Belgrade (ATSS), Katarine Amrozić 3, 11000 Belgrade, Serbia (e-mail: ztomic@tehnikum.edu.rs).

Milovan Janićijević – Metalac a.d. Gornji Milanovac, Gornji Milanovac, Serbia (e-mail: milovjani@gmail.com).

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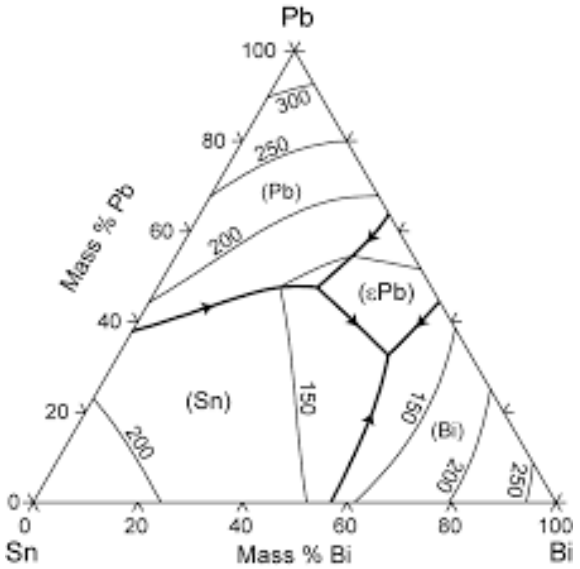


b)

Fig. 1. Phase diagrams for: a) binary Sn-Bi diagram and b) ternary Sn-Bi-Pb diagram.

One of the main property of all LMA is their electrical conductivity, as shown in Fig. 2. for pure metals, while in alloys their properties are changed.

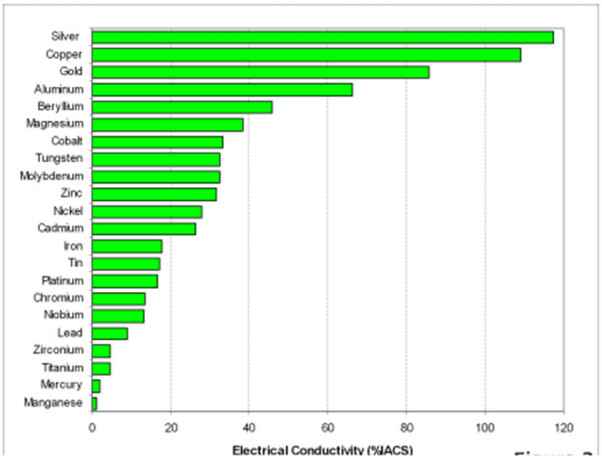


Fig. 2. Electrical conductivity of main metals used in industry.

Fluidity of an alloy markably depends from a chemical composition, Fig. 3.

III. LIQUATION AS RESULT OF SHRINKAGE DURING SOLIDIFICATION

After melting and during cooling, the shrinkage is normally occured, Fig. 2a). This effect could be appeared in welding process, when such remelted steel is used as one structural steel, when welding is frequently used, Fig. 4b).

One of the well known property in casting is a shrinkage of melted metal during the periode of solidification. It is usually resulted in appearance of last solidified layer just in the center of the wall [2], when steel is melting the LMA will be appeared also in the center. As the LMA always posses the low mechanical property, it means that both strength and reliability of such steel design and/or construction will be minimized.

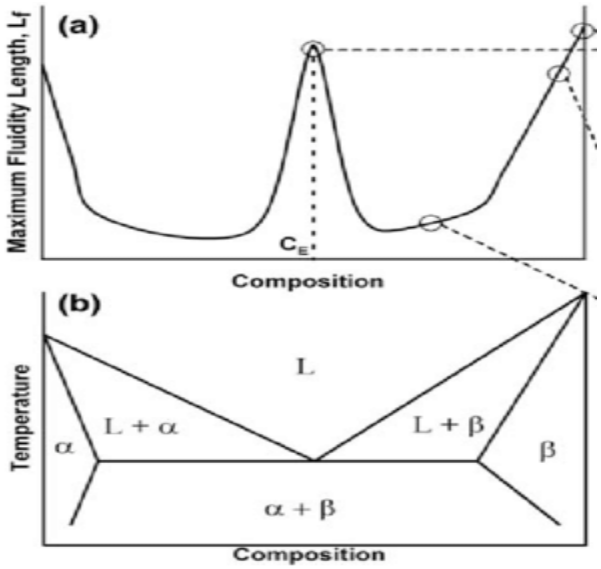
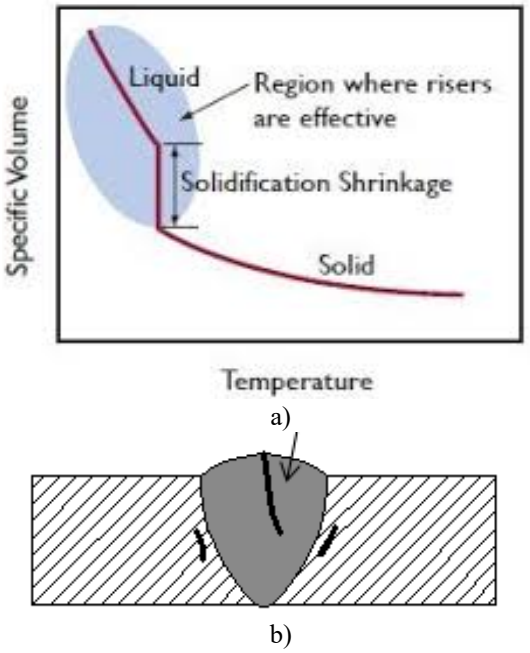


Fig. 3. Fluidity of alloys in a phase diagram.



b)

Fig. 4. Changing of volume during cooling a) and some effects when LMA are present in steel b).

Liquation is supported by presence of LMA. Liquation cracking can occur in welding, Fig. 4b), or in the heat affected zone. Liquation is resulted in localized melting at grain or other boundaries, also visible in Fig. 4b).

All of above mention metals, also their alloys, posses pretty low strength. So, low melting temperature and pretty low strength of LMA make them as an undesired material in steel production when waste cars are used for remelting. For preventing the failures of structures is needed the presence of contest of Pb, Sb and Bi at remelted steel in level obout 0.03ppm or less [22].

IV. CONCLUSION

Either used cars represents a good scrap material for recyclcing a steel, it must be kept in mind that the remelting of used cars need temperatures about 1500 ºC, while LMA are melted at 250 ºC or below. LMA from PC also posses markably lower mechanical properties in comparison to any

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steel. So, the PC should be carefully removed from a used car before the melting is started.

For preventing the failures of structures is needed the strict control of LMA when they are present into PC, and their classification, it means the contest of Pb, Sb and Bi in amounts at remelted steel even below from 0.03ppm.

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APSTRAKT

U današnje vreme, presovanje polovnih automobila i njihovo dalje pretapanje rasprostranjeno je u mnogim zemljama kao pametan način reciklaže i ponovne upotrebe otpadnih materijala. Sa stanovišta brzine presovanja i topljenja, to je zaista brza obrada. Poznato je da se u proizvodnji bilo kog proizvoda velika pažnja poklanja odabiru pravih materijala koji će se koristiti u izradi. Ali, nasuprot tome, u periodu reciklaže, ovde je pažnja usmerena samo na otpadne automobile, ne obraćajući pažnju na diversifikaciju korišćenih materijala. Rezultat je da se štampana kola iz otpadnih automobila takođe pretapaju pri izradi određenog čelika. U metalurgiji je poznato da se mnogi čelici proizvode od otpadnih čelika, ali ti čelici moraju biti strogo kontrolisani. Savremeni otpadni automobili sadrže štampana kola (PC), koja su po svojoj prirodi izgrađena od većeg broja štampanih kola, a ta kola moraju posedovati legure niskog topljenja. Uloga legura niskog topljenja u štampanim kolima je prilično dobro poznata i objašnjena u odgovarajućoj literaturi u proizvodnji PC.

Uticaj niskotopljivih legura na štampanim kolima iz otpadnih automobila na čvrstoću tako pretopljenog čelika

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