Optimization of the Brass Melting

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Abstract

The article describes the optimization of the melting brass. Brasses, as one of the most popular alloys of copper, deserve special attention in the context of the processes of melting, which in turn would provide not only products of better quality, but also reduce the cost of their production or refining. For this purpose, several studies carried out deriatographic (DTA) and thermogravimetric (TG) using derivatograph. The results were confronted with the program SLAG - PROP used to evaluate the physicochemical properties of the coatings extraction. Based on the survey and analysis of the program can identify the most favorable physico-chemical properties, which should be carried out treatments. This allows for slag mixtures referred configurations oxide matrix containing specific stimulators of the reaction. Conducted empirical studies indicate a convergence of the areas proposed by the application. It should also be noted that the program also indicates additional areas in which to carry out these processes would get even better, to optimize the melting process, the results.

Keywords: Computer aided foundry, Optimization, Brass, Melting, Program, SLAG-PROP

1. Introduction

All products made of copper and its alloys, also including brasses [1-7], are widely used in the modern world. Because of its use of the copper part recycled to the total consumption of the metal over the years is a growth. It is largely dictated by economic conditions of obtaining the metal from primary sources relative to the source of the waste. An important element of the whole process is adequate segregation of copper from its other alloys. Particularly significant impact here are such alloys as brass or bronze, which, due to its properties and the extensive use should be subject to a separate melting and refining processes [6-8].

2. Optimization of refining brasses

2.1. The concept of optimization

In order to optimize the melting process brasses, including the best conditions refineries - reducing agents, can be used very widely used method of thermogravimetric analysis (DTA) and differential thermal analysis (TG) as proposed by A.W. Bydałek [7,8]. Using the method described above can be carried out studies aimed at reducing factor EW appointment with an indication of the mass. Comparing the values reported in the table can be used to determine the properties of reducing refiner as weak, strong, or an average of reducing or even oxidation [9-11].
The following table shows the results obtained.

Table 1.
Arrangements for the description of the refineries [7]

| No. | Value of EW [kJ/mol] | Value of r [%] | Interpretation                        |
|-----|----------------------|----------------|---------------------------------------|
| 1   | << 0                | << -10         | Strong impact of reducing             |
| 2   | << 0                | -10 < r < -1   | Weak impact of reducing               |
| 3   | ≤ 0                 | -1 ≤ r ≤ 0     | No impact of reducing                 |
| 4   | > 0                 | Of no account  | The impact of oxidative               |

2.2. Results

Based on the findings presented in Chapter 2.1, made a series of studies analyzing the impact of various chemical reagents on the ability to refine the extraction coating on the base of the oxide under conditions of optimal melting process brasses. First, the circuit arrangement has a base consisting of a mixture of oxides: Al₂O₃ (9%), SiO₂ (57%), CaO (22%), Na₂O (8%) and MgO (4%). For the system as a non-metallic inclusions introduced 30% oxides SnO, ZnO and PbO on the relative composition of 1:3:2.

Table 2.
Selected results for the refining process modeling brass MO59 - inclusions SnO, ZnO and PbO

| No. | Al₂O₃ [%] | CaO [%] | SiO₂ [%] | Na₂O [%] | MgO [%] | Other                  |
|-----|-----------|---------|----------|----------|---------|------------------------|
| 1   | 9         | 22      | 57       | 8        | 4       | 40%Al₂C₃, 10%C         |
| 2   | 9         | 22      | 57       | 8        | 4       | 40%Al₂C₃, 5%NaCl + NaF₂ as 1:1 |
| 3   | 9         | 22      | 57       | 8        | 4       | 40%Al₂C₃, 5%Na₂CO₃ + NaCl as 3:1 |
| 4   | 9         | 22      | 57       | 8        | 4       | 40%Al₂C₃, 10%C         |

Table 3.
Selected results of tests for the refining process modeling brass MO59 - inclusion of CuO

| No. | Al₂O₃ [%] | CaO [%] | SiO₂ [%] | B₂O₃ [%] | MgO [%] | Other                  |
|-----|-----------|---------|----------|----------|---------|------------------------|
| 1   | 13        | 52      | 23       | 8        | 4       | 20%Al, 10%Ca          |
| 2   | 13        | 52      | 23       | 8        | 4       | 20%Al, 2%CaF₂ + NaF₂ as 1:1 |
| 3   | 13        | 52      | 23       | 8        | 4       | 20%Mn, 10%Ca          |
| 4   | 13        | 52      | 23       | 8        | 4       | 40%CaC₂, 20%Al        |
| 5   | 13        | 52      | 23       | 8        | 4       | 40%CaC₂, 20%Mn        |

Also in this case, very good results were obtained to optimize the melting brass. The best value obtained mixture of slag in 5 cases where the calculated energy index EW was at the level of -370 kJ/mol, while the mass index r until -50%. The temperature of the process was carried out as the lowest of the analyzed for this case and amounted to 1200 K.

In the final stage of the study it was decided to examine several different configurations mix Al₂O₃ - SiO₂ - Na₂B₂O₄ in conjunction stimulators with different configurations in the form of NaCl and NaF. First, the system was tested on the composition of Al₂O₃ (50%), SiO₂ (10%) and Na₂B₂O₄ (40%), adding said stimulators in various combinations. In addition, non-metallic inclusions were used as oxides CuO and ZnO, with a total weight of 30% of the sample, while maintaining a ratio of 1:2. The results are shown in the following table.
Table 4.
Selected results of tests for the refining process modeling brass MO59 - inclusions of Cu 2 O and ZnO

| No. | Composition of basic slag [%] | Additional factors - stimulators [%] |
|-----|-----------------------------|-----------------------------------|
|     | Al₂O₃ | SiO₂ | Na₂B₂O₇ | NaCl | NaF |     |
| 2   | 50    | 10   | 40      | 15   | -   | 10  |
| 3   | 50    | 10   | 40      | -    | 10  | -   |
| 4   | 50    | 10   | 40      | 15   | 10  | -   |

As can be seen, the best refining capacity shows a mixture of the composition of the third. This is achieved here energy index -130 kJ/mol, and the component to 30% by mass. The blend obtained using the above values of the two stimulators in an amount of 25% by weight of the sample while maintaining a 3:2 aspect ratio. It should be noted here that the temperature of the process was now 1300 K, which from an economic point of view is highly desirable.

In the second case the sample was examined merely consisting from Na₂B₂O₇ (60%) and SiO₂ (40%) using a similar amount of non-metallic inclusions and a combination of the stimulators. In the conducted study, the results obtained in the following table.

Table 5.
Selected results of tests for the refining process modeling brass MO59 - inclusions of Cu₂O and ZnO

| No. | Composition of basic slag [%] | Additional factors - stimulators [%] | Other [%] |
|-----|-----------------------------|-----------------------------------|-----------|
|     | Al₂O₃ | Na₂B₂O₇ | SiO₂ | NaCl | NaF |     |
| 1   | -    | 60      | 40   | 15   | -   | 40  |
| 2   | -    | 60      | 40   | -    | 10  | 40  |
| 3   | -    | 60      | 40   | 15   | 10  | 40  |

It turns out that the same composition as the promoters in the previous study has allowed to obtain the best results. Energy index EW was -45 kJ/mol, while the mass index r = -20%. Here too, the process temperature was the lowest, and it amounted to 1350 K.

Conducting these studies indicated that the most favorable conditions for melting brass overlapped with the best refining abilities slag mixtures. Is this allows, however, draw the thesis of the close and the associated correlation of these two values. A recent study carried out for the composition of Al₂O₃ (50%) and SiO₂ (50%) answers this question by giving a negative answer. The results of a recent study are presented in the following table.

Table 6.
Selected results of tests for the refining process modeling brass MO59 - inclusions of Cu₂O and ZnO

| No. | Composition of basic slag [%] | Additional factors - stimulators [%] | Other [%] |
|-----|-----------------------------|-----------------------------------|-----------|
|     | Al₂O₃ | SiO₂ | Na₂B₂O₇ | NaCl | NaF |     |
| 1   | 50    | 50   | -      | 15   | -   | 40  |
| 2   | 50    | 50   | -      | -    | 10  | 40  |
| 3   | 50    | 50   | -      | 15   | 10  | 40  |

As can be seen, the best refining capacity shows a mixture of the composition of the third. This is achieved here energy index -130 kJ/mol, and the component to 30% by mass. The blend obtained using the above values of the two stimulators in an amount of 25% by weight of the sample while maintaining a 3:2 aspect ratio. It should be noted here that the temperature of the process was now 1300 K, which from an economic point of view is highly desirable.

In the second case the sample was examined merely consisting from Na₂B₂O₇ (60%) and SiO₂ (40%) using a similar amount of non-metallic inclusions and a combination of the stimulators. In the conducted study, the results obtained in the following table.

Table 5.
Selected results of tests for the refining process modeling brass MO59 - inclusions of Cu₂O and ZnO

| No. | Composition of basic slag [%] | Additional factors - stimulators [%] | Other [%] |
|-----|-----------------------------|-----------------------------------|-----------|
|     | Cu₂O/ZnO as 1:2 | EW [kJ/mol] | r [%] | T [K] |
| 1   | 30      | -25      | -10   | 1410  |
| 2   | 30      | -35      | -20   | 1380  |
| 3   | 30      | -45      | -20   | 1350  |

Also in this case turned out to be the most preferred composition of the pacemaker using the same amount as in the previous examples. The energy index, in this case, was -65 kJ/mol, while the mass index -10. It should be noted that the process temperature in this case was 1480 K, and it was the highest presented during the research. Should therefore apply for the selection of components of slag-forming mixtures, which will minimize the melting temperature, and hence the cost of performed processes.

2.3. Summary of laboratory tests

To summarize the above experiments it can be concluded that the best blend of slag composition to optimize the processes of melting brass sample was determined by the number 5 in the second study. Only this sample received the lowest temperature process at 1200 K and the best properties refiners: energy index EW -370 kJ/mol and the mass index r -50%.

Conducting these studies raises the question. Is obtaining empirical research confirms brass melting process optimization...
with application SLAG - PROP to assess extraction of physicochemical properties of coatings [11-14].

3. Analysis of program optimization using SLAG - PROP

After the program had to choose a user interesting boundary conditions associated with the exploration areas. Then select the base point stop for refining, melting atmosphere and the search criterion with respect to temperature. Because of the above considerations limit temperature was 1480 K value, this temperature was taken as the maximum, while maintaining the appropriate value changes 1207°C. As the minimum temperature was also adopted minimum temperature taken from empirical research which is 1200 K, and therefore approximately 927°C. After the filtration of a database provided the following results.

![Areas that meet your criteria:](image)

**Fig. 1.** Screenshot for the selection of areas that meet the criteria – I
The program offered 11 areas that meet the criteria specified by the user. The optimal temperature for melting brass by application area is marked with an index of 180. Meanwhile, the designated area during the experimental program was on the second place. If the user will look at the area indicated by the description of the program will recognize that the melting temperature of the area, depending on the composition of an additional in the range from 977°C to 1700°C, wherein it appears that at a temperature of 977°C can be obtained energy index EW -140 KJ/mol and a mass index r = -15%, with the exact composition of Al₂O₃ (9%), SiO₂ (57%), CaO (22%), Na₂O (8%), MgO (4%). As can be appreciated, the database program is so broad that it is easy areas with even better conditions, in the context of process optimization melting brass.

Going therefore further illustrated course of the proceedings, changed the search criteria, the program asking if you can get an even better line-ups slag mixtures for optimization of melting brass. As the minimum temperature limit value is entered 419°C, while the maximum value specified at a level that previously described as the maximum, or 927°C. In response, obtained a list of the 4 areas shown in the figure below.

In this case, it is worth noting the area marked number 368. After getting acquainted with his accurate description can receive information that a sample can be melted already at a temperature of 970 K, which is about 697°C, to give the average reduction effects. Energy index EW reaches a value of 12.5 KJ/mol, and the mass index r = -10%, with the exact composition: with the following composition: Al₂O₃ (18%), B₂O₃ (6%), CaO (12%), Na₂O (22%), SiO₂ (42%).

4. Summary

Summing conducted research and analysis on how to optimize the melting process brasses can be seen excellent coincidence with the results presented by the application SLAG - PROP with the results derived from empirical research. It should also be noted that the program can also indicate additional areas worth attention, which optimize these processes meet the criteria posed. Using therefore proposed compositions of blends of slag produced by the program, as well as confirmed experimentally can be largely melting process optimization, and hence significant economic savings.

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