

Database of Materials for the Evaluation of the Impact of Harmful Substances in Metallurgical Processes

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Abstract: The study contains a description of the use of IT material base in foundry, refining and metallurgy processes. The program is an extension of applications for the assessment of physicochemical and refining properties of metallurgical slags and process base related to the production of brass. However, the functionality of this part is related to the assessment of the harmfulness of the use of specific substances in both laboratory and industrial processes. Thanks to the simple search interface, the user can get quick information about the dangers that can be carried by substances used by him. In addition, you can also check what protection measures should be used when working with the substances in question. The program also draws attention to the utilization of waste materials after production and research processes.

Keywords: Management, Environmental Protection, Toxicity of the Substance, Program, Counteraction, Protection

1. Introduction

Continuous technological development entails continuous and progressive degradation of the natural environment. In many branches of the economy there is a tendency to increase the production process at any price without paying attention to ecological aspects. In agriculture itself, the introduction of genetically modified food was to be a panacea for the problem of hunger in the world, while research indicates its very negative impact [1, 2]. In addition to the use of fungicides, pesticides and fertilizers, which causes visually pleasing and tasty products, but are in large quantities very heavily polluted. The use of nitrates and other preservatives, as well as dyes to a greater extent, will poison products that reach our table, which has a very negative impact on human health [3]. Heavy emissions, in particular the metallurgical industry, are a particular source of pollution for the environment. It has a negative impact on the environment in many different areas and in many places, and extraction and processing may have long-term or even long-term consequences [4, 5]. Therefore, preventive and scientific-research activities should be started from this place. Conducting industrial activity that has a negative impact on

the external environment is dictated by obtaining a product with specific features [6, 7, 8]. In developed countries, the old methods are not based all the time. We are looking for new solutions to reduce production costs and reduce the negative impact on the environment, thus obtaining a product with even better parameters. Meanwhile, it is often already in laboratory research that new solutions are being sought with the use of hazardous substances, or are investigating processes that have already been described. Such activities lead not only to uneconomical management of resources, but also have no positive impact on the environment. The use of an appropriate computer program in conjunction with a database that gathers experience and the results of research by authors and other scientists collected from world literature allows to eliminate unnecessary activities. In addition, familiarization with the characteristics of hazardous and recommended substances may result in faster finding a new and cheaper method that does not adversely affect the natural environment.

2. Analysis of the Issue

The metallurgical industry is an area that significantly affects environmental pollution. During the production of

copper itself, already at the stage of its extraction, there is a very strong interference in the rock mass, which may have irreversible effects. According to the Polish Geological Institute, the mining activity itself causes a very strong disturbance of the water balance. One can also notice the drying of the well in households and municipal intakes, and the quality of surface and underground water changes significantly. [9].

Meanwhile, the process of producing finished products is a long way to go. Excavated material goes through many intermediate stages before it can extract valuable metal from it. Tailings, which is formed in large quantities, must be deposited on heaps of many hectares, and research [10] indicates that the rain it leaches out many compounds, including heavy metals. However, sulphates, solid dissolved compounds and chlorides are the most visible in the extract obtained from the tailings.

Although tailings is a big problem, also in the volumetric aspect, attention should be paid to enrichment processes that generate a very large amount of flotation waste. From year to year, ore enrichment plants produce tens of millions of tons of waste, which must be stored somewhere [11]. It is worth noting here that they contain valuable elements that could be recovered in the future and if only they manage to develop an economically viable process of their extraction from waste, then it will definitely be implemented into industry.

Finally, the concentrate from the processing plants goes to the metallurgical complex, where it passes a long route as well as pyro and electrometallurgical processes, the effect of which is obtaining pure metals (not only copper). Each of the processes generates its pollutants and harmful waste. Thanks to the rational management and pro-ecological work of KGHM, these values can be reduced from year to year, however, the main problems that pose a threat to health are dust and gases emitted directly into the atmosphere. Despite the fact that they pass through a series of machines and devices aimed at their elimination, you can't reduce their content to zero.

In this study, however, attention was drawn to another very important aspect, which in the context of the metallurgical industry is very rarely touched or not touched at all. It is, among others, about the use of refining processes both in production and in test phases as well as conducting laboratory tests in terms of the selection of new recipes, as well as determining appropriate process parameters, taking into account the harmfulness and impact on the environment and health of specific substances. This applies not only to production and processing processes related to copper metallurgy and accompanying metals. Attention is also drawn to the need to look at this problem, in every place where this type of work is carried out, that is, research or work at high temperatures using even simple and seemingly non-harmful chemical compounds.

3. Solution

The "brass -prop" computer application is a development of the concept of determining the physicochemical properties of the extraction coatings with the use of an IT database system (Figure 1). [12, 13]

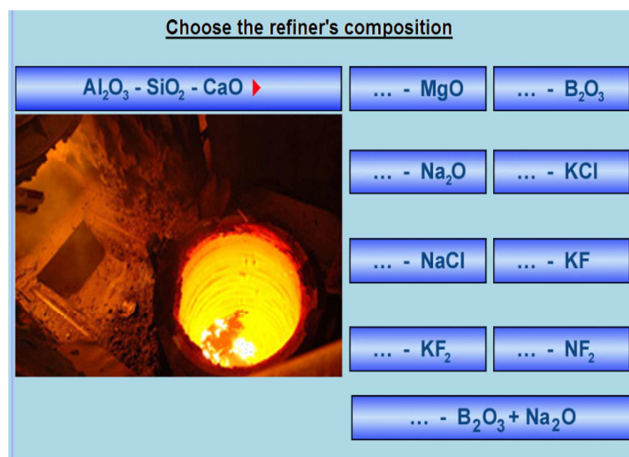


Figure 1. A fragment of the database for determining the physicochemical properties of refiners.

It allows not only to determine the composition of copper scrap on the basis of their characteristics. Composition determination is performed as a result of searching a large database of various alloys (Figure 2). [14]

Enter the brass symbol to determine its composition:

MO59

Wyznacz

Znak	Cecha	Cu [%]	Zn [%]	Mn [%]	Fe [%]	Pb [%]	As [%]	Sn [%]
CuZn39Pb2	MO59	57-60	37,5-42	-	-	1,0-2,5	-	-
CuZn39Pb2	MO59	58,5-60	37,5-40	-	-	1,5-2,5	-	-

List of brass appearing in the base:

Znak	Cecha	Cu [%]	Zn [%]	Mn [%]	Fe [%]	Pb [%]	As [%]	Sn [%]
CuZn37Pb0,5	M063	62-64	35,3-37,7	-	-	0,3-0,7	-	-

Figure 2. A fragment of the database for determining the chemical composition of scrap - copper alloys.

The application, in addition to the above advantages, has tools to help you calculate the load charge, which tool has been prepared for the method developed by the authors. The following figure shows a calculator that facilitates calculating the load of charge (Figure 3). [15]

	A	B	C	D	E	F	G	H	I
1	a1	b1							
2	-29,77	99,55		x=	2,122449	y=	36,36469		
3	a2	b2							
4	-0,37	37,15							
5									

	A	B	C	D	E	F	G	H	I	J
1	x1	y1	x2	y2						
2	0	99,55	2	40						
3						y=	-29,775	x +	99,55	

	A	B	C	D	E	F
1	x1	y1	x2	y2		
2	2,12	36,36	0	99,55		
3						

Figure 3. Fragment of the program - a calculator that facilitates the calculation of feedstock for copper alloys.

The application contains an interesting appendix describing the determination of process parameters and end properties in copper production [16, 17]. You can find here not only information on the processes of alloying, refining or the machining process of a given material. There is a fairly accurate description of the destiny of a given material with the analysis of mechanical properties such as stretching, hardness, elongation taking into account the dimensions, shapes and geometry of the material as well as a description of the morphology of the hard particles that have been tested. The following figure (Figure 4) presents a screenshot of the base showing information on physical, chemical, mechanical and process properties of copper alloys, along with the possibility of introducing their own further observations about a given metal or alloy.

Another element appearing in the computer program is the database of threats related to the substances described in the brass-prop application. It contains a list of all substances present in the database. At this point, the user can find a set of data on specific substances that have been sorted alphabetically in relation to the chemical symbol. User can also provide the symbol of a given compound in a simple search engine, so that without a manual search of the database, can familiarize yourself with the characteristics of a given compound.

The first and most important information that is obtained by the user from the database is the so-called diamond of fire. This is a standard that was introduced in the United States by the National Fire Protection Association. The diamond of fire consists of 4 basic colors indicating different types of threats. These include the blue color - indicating a health hazard, red - indicating the flammability of the substance, yellow - determining the instability of the compound, which may also determine its reactivity and white color indicating special hazards and risks associated with eg corrosive, choking substance, strong substance oxidizing, poisonous, or even radioactive. Apart from the white symbol, describing a specific risk using appropriate standardized abbreviations (eg CRY - a cryogenic substance), the remaining squares are described with numbers from 0 to 4. In this case 0, in the

context of health, means no health risk in the case of normal contact, meanwhile, 4 reports that even very short contact with the substance can cause death or serious poisoning.

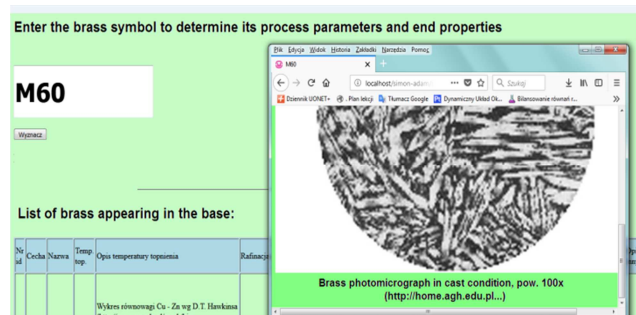


Figure 4. A fragment of the database describing the process, physical, chemical and mechanical parameters of copper alloys - in this case M60 brass.

In the case of the database described in the basic form, a table is presented below (Table 1) describing the number of compounds present in the database along with the division into their level of risk in the context of health, flammability and instability.

From the table presented (Table 1) it can be clearly seen that the compounds used in refining processes and other metallurgical operations are essentially non-flammable, as it applies to all 24 substances introduced into the base.

Most of them also show high stability of the compound, only 4 have a slightly higher degree of instability, while only 1 has a grade 3 for the metal element Ni - Nickel, and its detailed description for section 10 "Stability and reactivity" informs avoiding heat, fire and sparks in his presence. However, the threat to the substance for health deserves special attention. Only 11 of them show no danger in the case of normal contact, and 13 of them can cause harm. 3 of them may cause temporary damage to health, 7 of them may cause temporary damage to health with the risk of complications, and 3 of the described compounds may cause serious poisoning (which concerns Na₂O, NaF and CaO). At this point, one should also pay attention to another very important issue, where compounds can be classified as not posing health hazards in the case of normal contact, meanwhile, in the conditions of high metallurgical temperatures, the employee of both the steelworks and the laboratory may be exposed to inhalation of fumes and dust, which can have a very harmful effect. For example, iron "Fe", which is classified at zero level, for human health can be given, whereas exposure to chronic inhalation of dust of this element in polluted air can lead to so-called non-collagenic pneumoconiosis. On the other hand, the classification of lead in the context of health hazard is described at level "1", meanwhile it is not only a very toxic substance, where it is assumed that the toxic dose is about 0.5 gram, but in addition it is very easy to poison it, through the system respiratory, digestive and even through the skin. The lead vapors are especially dangerous when it is overheated to higher temperatures, since the melting point of the lead is less than

328 degrees C, and although its boiling point is quite high, as it is almost 1700 degrees C, intensive evaporation starts already at 600 degrees C. In the context of other hazards, we can only encounter a dangerous reaction in contact with water, which concerns two substances - Mn manganese and pure Zn zinc.

Further information that the database user can read from it concerns the so-called H-phrases and P-phrases regarding the substance. On January 20, 2009, the CLP (classification, labeling and packaging) regulation in force throughout the European Union came into force and, as the name suggests, regarding the classification, labeling and packaging of all chemical substances. H-phrases indicate the type of hazard that can be encountered in the case of contact with a given substance. Using appropriate symbols, they can indicate

physical, chemical, health and environmental hazards, as well as provide other important information. H and P phrases, replaced the previously applicable, until June 1, 2015, respectively, R-phrases (risk phrases) and S-phrases (safety phrases).

In the next section, the user can read the above-mentioned phrases P, which indicate precautions to be taken in case of contact with a given substance. They indicate not only general information about the product, but also about prevention, response, storage and finally disposal of materials in contact with the substance. Thanks to the information contained in the first three sections regarding a given compound, the user can very quickly get acquainted with information that can be exposed in the event of contact with a given material.

Table 1. List of substances present in the database in relation to the degree of hazard.

Degree of health hazard	The number of substances	The degree of flammability of the substance	The number of substances
0	11	0	24
1	3	1	-
2	7	2	-
3	3	3	-
4	-	4	-
Degree of compound instability	The number of substances	Other threats	Description of danger - Quantity of substance
0	20		
1	1		
2	2	W	Reacts vigorously with water in an unspecified and dangerous way - 2
3	1		
4	-		

The next three columns contain supplemental information. They concern first of all data on the toxicological nature of a given material. Looking closer at this information, you can find very rich information about various negative impacts on health or even life. The user can learn about the allergic reaction in the case of contact with the skin, the possibility of eye irritation, and even cancer and the appearance of tumors in the event of a substance entering the body regardless of the route. The organs with direct contact with the substance are the most exposed to negative effects. It is also significant that even substances considered harmless can lead to serious disorders, and in extreme cases also death in the event of getting into the body in too high amount. An example may be NaCl, a popular kitchen salt, where, according to toxicological data of the company "Sigma Aldrich", the deadly dose administered orally to a rat is 3.55 g per kilogram of body weight, meanwhile according to U.S. The National Library of Medicine human lethal dose is only 1 gram per kilogram body weight accepted orally. It is also worth noting that some substances or elements may have mutagenic effects on reproductive cells (egPb - lead) or harm the unborn child (B₂O₃ - boron oxide III, Pb - lead, Na₂B₄O₇ - borax).

The next column is ecological information and data on the harmfulness of the substance entering the environment. Particularly noteworthy in this case are aquatic organisms, which are extremely sensitive to any pollution of the aquatic environment. Even to a small extent, substances found in a

water reservoir can cause the death of fauna. For example, the presence of aluminum "Al" in water at a concentration of only 0.12 mg / l causes the death of rainbow trout in 96 hours, and the occurrence of zinc "Zn" at a concentration of only 450 µg / l causes the death of karasu at the same time . It should be noted that these substances are described with the symbol "0" in the fire diamond indicating health risks, which would illicitly suggest that such substances are completely harmless. The high toxicity of the substance, especially in the aquatic environment, is the result of the fact that the substances in the water, very quickly get into the bloodstream of the fish through the gills causing lethal effects there.

Enter a symbol to check its properties:				
Ni				
Wyszukaj				
Symbol	Diamant ognia	Rodzaj zagrożenia	Środki ostrożności	Informacje toksykologiczne
Ni		Może powodować reakcję alergiczną skóry. Podejrzewa się, że powoduje raka. Powoduje uszkodzenie narządów poprzez długotrwałe lub powtarzane narażenie. Działa szkodliwie na	Nie wypuszczać do środowiska. (Unikać uwalniania do środowiska.) Stosować rękawice ochronne/odzież ochronną/ochronę oczu/ochronę twarzy. W przypadku złego samopoczucia zasięgnąć porady/zgłosić się pod opiekę lekarza	Rakotwórczość: Ten produkt stanowi lub zawiera składnik opisany jako potencjalnie rakotwórczy na podstawie klasyfikacji IARC ACGIH, NTP, lub EPA. Ograniczone dowody rakotwórczości w badaniach na zwierzętach IARC: 1 - Grupa 1: Czynniki rakotwórczy dla ludzi (Nikiel, proszek, średnica cząstek < 1 µm). 2B - Grupa 2A: Czynniki przypuszczalnie rakotwórczy dla ludzi (Nikiel, proszek, średnica cząstek < 1 µm). IARC: 1 - Grupa 1: Czynniki rakotwórczy dla ludzi (Nikiel, proszek, średnica cząstek < 1 µm). 2B - Grupa 2A: Czynniki przypuszczalnie

Figure 5. A fragment of the database describing the types of hazards and precautions for the selected substance.

The last column that has been included in the database is a

link to a PDF document, which is a safety data sheet for a given substance. Here is a very accurate description of the compound, or element, consistent with current knowledge on the subject. It contains 16 sections, which describes, among others, its physicochemical properties, hazards, personal protective equipment, first aid measures, and even conduct in the event of a fire, or a description of how the product is stored. The above figure (Figure 5) presents a fragment of the database presenting hazards, precautions and toxicological information for a searched substance - in this case Ni nickel.

4. Summary

Summing up the work done, it can be concluded that the next element of the computer application, this time paying special attention to the ecological aspects of materials used in the metallurgical industry, can be invaluable help for people working in this industry. Before proceeding in your work, whether for research or other work with a given material, you should always read the information about the substance and be aware of what hazards it may have and what should be particularly used - for your health. An essential equipment of every laboratory or industrial plant is appropriate protective clothing, masks, goggles, gloves, aprons, and in special cases also oxygen masks with a closed circuit. It is also worth noting that metallurgical laboratories in which refinery research is conducted at high temperatures should be equipped with fume hoods, that is, laboratory extracts that provide for the discharge of harmful substances from enclosed spaces which, as can be seen from the study, are not missing.

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