THE POSSIBILITY OF USING WASTE MOLD SAND FOR ADSORPTION OF ACETIC ACID

Assoc. Prof. Štrkalj A. PhD.[1], Assoc. Prof. Glavaš Z. PhD. [1], Prof. Hršak D. PhD. [1]
Faculty of Metallurgy – Sisak, University of Zagreb, Croatia[1]

strkalj@simet.hr

Abstract: Possibility of using waste mold sand for removal of acetic acid from the aqueous solution was studied in this article. Green sand can be used several times in mold making. When the properties of green sand are not suitable for further use, it becomes waste. Waste mold sand was used in this article as an adsorbent for the removal of acetic acid from the aqueous solution. During the adsorption process, the influence of the amount of the adsorbent and contact time adsorbent/adsorbate (waste mold sand/acetic acid) on the capacity of the adsorption process was monitored. Amount of waste mold sand was varied from 25 to 125 g. Contact times were as follows: 15, 30 and 60 minutes. The obtained results indicate that the adsorption of acetic acid on the waste mold sand occurred at all used combinations of these parameters. However, for all used contact times, the greatest adsorption capacity is achieved when the ratio of waste mold sand/acetic acid was 25 g/100 mL. For all the used amount of adsorbent, the highest adsorption capacity, i.e. dynamic equilibrium was achieved very quickly, after 15 minutes. The obtained results are in accordance with the chemical composition of the waste mold sand.

Keywords: WASTE MOLD SAND, ADSORPTION, ACETIC ACID, EFFICIENCY OF ADSORPTION

1. Introduction

Today, there are various methods for the production of castings, such as sand casting, die-casting, centrifugal casting, shell casting, etc. Sand casting is used for production of around 80 % of castings. This process is suitable for ferrous and non-ferrous castings.

Between the sand casting processes, green sand is the most widely used [1 – 3]. This is actually a mixture which consists of silica sand (> 90 %), a binder (bentonite clay) and various additives which improve the properties of the mixture.

Green sand can be several times used for mold making. The properties of the green sand deteriorate with the increase in the number of cycles of use. It becomes waste when its properties are not suitable for further use.

Figure 1 schematically shows the status of the green sand (waste/non-waste).

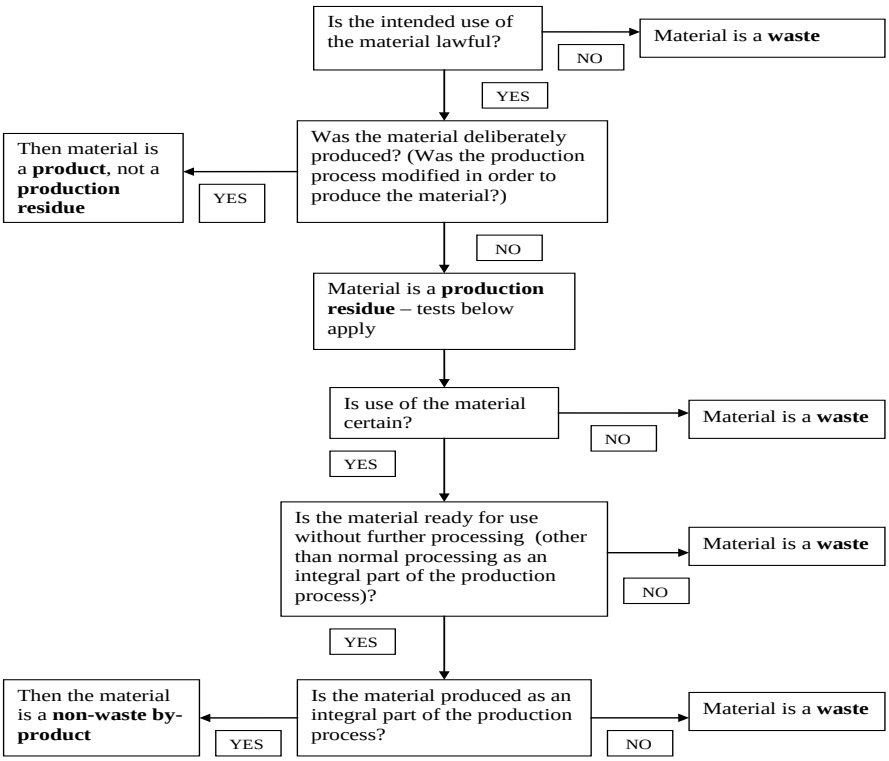

Fig. 1 *Schematic diagram of determination of the status of the green sand (waste/non-waste) [4]*

Foundry sand which is not suitable for further use in the production process of casting is recycled or disposed at an appropriate landfill. [5]. The annual amount of spent sand that was created in foundries ranges from 6 to 10 million tons [5, 6].

Of this amount, only less than 15% can be recycled in a cost-effective and safe manner [5, 6].

Recent research has focused on the possibility of using green sand as a potential agent for the removal of heavy metals and organic pollutants from wastewater [7]. Both types of pollutants do not negatively affect the growth and reproduction of living beings. However, increased concentrations can be very harmful, carcinogenic and even deadly. For this reason, they should be removed from wastewater. Adsorption is the most economical method for their removal. Influence of the amount of the adsorbent and contact time adsorbent/adsorbate (waste mold sand/acetic acid) on the capacity of the adsorption process was monitored in this article.

2. Materials and Methods

Waste mold sand that was used in this study originates from one cast iron foundry in Croatia. Standard elemental analysis was used to determine the chemical composition of the waste mold sand. The obtained results are shown in Table 1.

Table 1: *Chemical composition of waste mold sand*

Composition	*w*, %
SiO_2	90,0
Al_2O_3	1,6
Fe	6,8
Ca	0,55
Mg	0,08
Mn	0,04
Ni	0,004

Mineralogical composition of waste mold sand is shown in Figure 2.

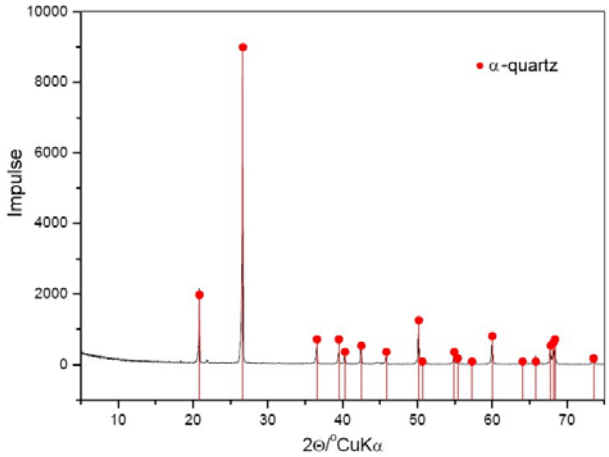

Fig. 2 *XRD analysis of waste moud sand*

The adsorption experiment was monitored a batch method. In plastic vessels was placed 25, 50, 75 and 125 g of waste mold sand. After that, the waste sand was placed in contact with 100 mL of acetic acid solution whose concentration was 0.1145 mol/L. Thus prepared adsorption systems were in contact 15, 30 and 60 minutes. Filtration was carried out after the expiration of the aforementioned contact time. The concentration of acetic acid was determined by titration with 0.1 mol/L NaOH. Adsorption capacity was calculated from the obtained data (equation 1):

$$q_t = \frac{c_0 - c_t}{m} \cdot V \qquad (1)$$

where V is volume of acetic acid (L), m is mass of waste mold sand (g), c_i and c_e are the initial and final concentration of acetic acid (mol/L).

3. Results and Discussion

Influence of the contact time and amount of the adsorbent on the adsorption capacity is shown in Figure 3.

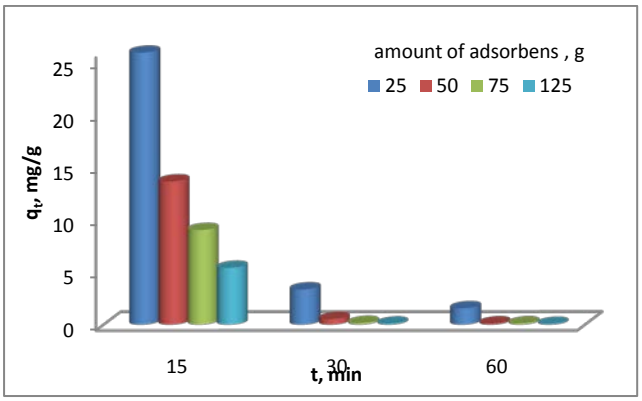

Fig. 3 Influence of the contact time (t) and amount of the adsorbent on the adsorption capacity (q_t)

Figure 3 shows that the best adsorption capacity was achieved when the ratio of adsorbent/adsorbate was 25 g/100 mL. Increasing the amount of adsorbent resulted in a decrease the adsorption capacity for all three of contact time. The initial concentration of acetic acid that was used in this study was relatively low (0.1145 mol/L), and it is possible that it is not sufficient for the binding to the larger quantity of adsorbent.

Comparison of the adsorption capacities and the contact time adsorbent/adsorbate shows that the maximum adsorption capacity is achieved within 15 minutes for all tested amounts of adsorbent. Since the adsorption capacity decreases after 15 minutes, it can be concluded that the dynamic equilibrium was achieved relatively quickly, within 15 minutes. Adsorption capacity decreases after 15 minutes, which may indicate the occurrence of desorption. Desorption occurs when the adsorbate by means of physical forces binds to the adsorbent. Physical forces are not strong and allow release of adsorbate from the surface of the adsorbent, which is manifested as a decrease in adsorption capacity [8].

Regardless of the possibility of desorption, waste mold sand can be used for the removal of acetic acid at all the studied parameters. This is supported by the facts related to the chemical and mineralogical composition. The mold mixture consists of 90% SiO_2 (Table 1, Figure 2), a binder (bentonite clay) and various additives. Each of these components is a good adsorbent. Addition to the mentioned components, waste mold sand contains a certain amount of scale which also enhances its capability of adsorption [9].

3. Conclusion

The adsorption of acetic acid from the aqueous solution on waste mold sand can take place in the tested conditions.

The largest adsorption capacity was achieved when the ratio of adsorbent/adsorbate was 25 g/100 mL for all three contact times.

The increase in contact time adsorbent/adsorbate resulted in a decrease of adsorption capacity. Dynamic equilibrium was achieved within 15 minutes at all amounts of the adsorbent.

LITERATURE

[1] Jorstad J., Krusiak M. B., Serra J. O., Fay V. L., Aggregates and Binders for Expendable Molds, chapter in ASM Handbook, Volume 15, Casting, Ohio, ASM International, Materials Park, 2008., 528 - 548.

[2] …. Green Sand Molding, chapter in ASM Handbook, Volume 15, Casting, Ohio, ASM International, Materials Park, 2008., 549 - 566.

[3] Brown, R., Foseco Ferrous Foundryman's Handbook, England, Butterworth-Heinemann, 2001.

[4]http://eurlex.europa.eu/legalcontent/EN/TXT/?uri=celex%3A52007DC0059

[5] Back, E., Klussman, H.G., Walter, N., New development of furan cold resins, Giesseri, 86(4), 1999, 107-108.

[6] Lindsay, B. J., Logan, T.J., Agricultural Reuse of Foundry Sand, Journal of Residuals Science & Technology, 2(1), 2005, 3-10.

[7] Štrkalj, A., Glavaš, Z., Brnardić, I., Application of Foundry Waste for Adsorption of Hexavalent Chromium, Chemical and biochemical engeenering quarterly, 27 (1), 2013, 15—19.

[8] Aarden, F. B., Adsorption onto heterogeneous porous materials: equilibria and kinetics, Technische Universitei Eindhoven, Eindhoven, Netherlands, 2001.

[9] Glavaš, Z., Štrkalj, A., Određivanje efikasnosti adsorpcije pojedinih komponenti kalupne mješavine, *Proceedings book of International Conference MATRIB 2015*, 25-27.06.2015., Zagreb, Hrvatsko društvo za materijale i tribologiju, 146-150.