SOILS PROTECTION BY INTERN RECYCLING OF USED SANDS IN FOUNDRIES

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ABSTRACT
Until recently, in the economies of the western and those of less developed countries, the storage in dumps of used sands, resulted from the production activities in foundries, is was not considered an important matter. As a result of the fast increase of the environmental protection interest at the level of world community, and in each country apart, the removal of used sands on soil (by making dumps, more or less ecological) has become an important problem. Consequently, foundries have to recycle the sands, especially in the sectors where great quantities are used. Also, they have to search for possibilities of reutilization of used sands that can't be recycled. The recycling of used foundry sands is possible by sand regeneration. According to this, the foundries are seriously taking in account the development of used sands regeneration capacities, based on efficient technologies in what concern the economic costs. After presenting the sand regeneration methods, in this paper it is indicated the way of choosing the adequate system, that will be done through a detailed analysis, depending on the specific conditions in foundries, also considering: the type of sand and core sand used, the expected efficiency, the investment and exploitation cost.

1. INTRODUCTION

The soil degradation represents an important threat upon society on long term. The soil, by its nutritive substances that it contains, has a major role in the growth of most alimentary and fibrous plants. Besides, it contributes to maintaining of the air and water quality. So, its aim is essential to population health. In the lasting development concept, the ensurance of environmental protection in industrial areas is a complex obligation (charge) that belongs both to manufactures, to specialists in conception and to those that monitories the environmental factors.
In the year 2003 in România the number of operating foundries was 135 (cast irons), 63 (steel) and 107 (nonferrous). The total iron and steel castings production in the year 2003 was 217.100 tons and non-ferrous metal castings 36.010 tons [1].
When manufacturing castings, for their casting there are used sand-moulds and cores.
There are mainly used two types of sands:

- sands with natural mineral agent (green sand), clay or bentonite in percentage up to 10%;
- sands with synthetic organic agents (phenol, furan, polyurethane, epoxy resins)

For the first category, the elimination of used foundry sands don't induce great pollution risks for the environment.
Contrary, in case of sands with synthetic organic agents, there are distinguished:

- Burnt sands by melt metal casting (1400^{0}C); the thermic shock destroys the synthetic organic agents in most part;
- Unburnt sands, that were not in contact with melt metal, and so, polluted by synthetic agents, these are the losses and the rejects of sands-moulds and cores, the surplus (excess) of sands used in process of moulding, that creates serious problems of environmental pollution.

The used foundry sands represent approximate 70-80% in the total wastes in foundries. In Romania the most used sand types are the green sand, furan/phenol resin sand and sodium silicate sand.

Sands wastes resulted from the applying of processes based on synthetic resins, containing traces of phenolic compounds and polyaromatic hydrocarbon (PAHs) compounds, are toxic and because of that they compulsory have to be stored in specially arranged dumps.

The costs of eliminating the wastes out of foundries are increasing, they due both to strict reglementations in environmental protection and high taxes on wastes. Consequently, foundries have to recycle the sands, especially in the sectors where great quantities are used. Also, they have to search for possibilities of reutilization of used sands that can't be recycled. For example, the use as a raw material in the production of Portland cement, Portland cement concrete, asphalt concrete pre-cast concrete products, flowable fills (low strength concrete), road construction, mineral fibres, landfill liners and composted soil [2].

2. THE SANDS REGENERATION FROM USED-SANDS

The recycling of used foundry sands is possible only if after the utilization, they pass through a process of sand regeneration.

Nowadays, there are mainly used these sands regeneration systems in foundries:

- mechanical regeneration
- thermic regeneration
- thermo-mechanical regeneration.

The mechanical regeneration. The principle of this type of regeneration is attrition, that is a physical action which allows the separation of particles through abrasion and/or shock. The method, applied to sands with natural mineral agents or with synthetic resins, either is about sands proceeding from the moulds or cores making, allows the elimination of the oolitic layer, that includes the sand granules, with the purpose of recycling either in moulding sand or in core sand.

The oolitic layer contains all the agents residues and moulding additives, degraded and calcinated through the thermic action caused by metal casting in mould. Its volume, in comparison with that of sand granules, is of 15-30 %. This layer, very adherent to sand grains, has to be the best eliminated, because it leads to considerable increase of grain specific surface. Uneliminating the oolitic layer on the sand grains makes impossible the sand recycling and reusing at sands and core sands preparation. So, the attrition must be very energetic, this stimulates the forming of fine fractions (fragments) in important quantities and may lead to sand grains smashing.

The attrition may be made by abrasion drum, by an abrasive wheel, a pneumatic method, combined methods or hydraulic method.

The thermic regeneration. The sand regeneration by thermic method consists in warming up the sand at temperatures between 550 – 800 ^{0}C, cooling it and separating it in air current.

Generally, thermic regeneration produces sand of a superior quality than the new one's, this is explained by the fact that:

- in comparison with the new sand, the regenerated sand doesn't contain fine particles;
- the sand grains covering is uniform, because the sand grains'margins are more rounded;

- the thermic regeneration stabilize the sand, while the sand is more uniform, the necessary agent quantity is easier to be controlled, leading to the obtaining of an improved quality sand;

There are used different techniques for the sand thermic regeneration:

- the fluidization bed technique, that is adopted at the majority of exploited installation at industrial scale;
- the calcination solution in rotating furnace;
- the gas contact process, the principle is based on the direct injection of the used sand in the flame of a special burner.

Thermic regeneration is especially used in regeneration of sand that proceeds from used sand with synthetic organic agents.

The most important advantage of mechanical-pneumatic regeneration installations is the reduced energy consumption of about 8…10 KWh/sand ton, in conditions of adequate environmental protection.

The thermic regeneration has a great disadvantage of being very expensive, there are consumed between 150…400 kWh/sand ton.

The thermic regeneration may be combined with mechanical one in order to improve the system's global efficiency. In this context, selecting a regeneration process evidently depends on the used moulding process (the type of sand), but economic aspects interfere: the investment level and exploitation costs connected to the necessity of ensuring a profitableness in each foundry in comparison with the new sand's costs and the elimination, as a waste, of the used sand at the deposition.

3. CHOOSING THE MOST ADEQUATE REGENERATION SYSTEM IN A FOUNDRY

Choosing the adequate sand regeneration from the used-sand system is based on the "efficiency factor" E % that is proper to each installation.

The efficiency factor may be defined such as the ratio between the percentage R of eliminated impurities at each regeneration cycle and the quantity of present impurities after the previous sand preparation cycle. Determining the efficiency factor is possible through this relation [3]:

$$E\% = \frac{\left(\frac{T}{100}\cdot R^{n-1} + Q\right) - R^{n}}{\frac{T}{100}\cdot R^{n-1} + Q}\cdot 100 \qquad (1)$$

in which:

R is the quantity of eliminated impurities at each cycle, in%;

T – the reusing degree of regenerated sand, in %;

Q – the quantity of impurities brought by the necessary agent at the sand preparation, in %;

n – the number of regeneration cycles.

When achieving a stabilized regime, a regeneration installation functioning may be characterized by the enrichment ratio:

$$R/Q = \frac{100 - E}{100 - \frac{T}{100}(100 - E)} \qquad (2)$$

Knowing the enrichment ratio has importance in practice, allows avoiding some uncertainties such as: some installations apparently gave satisfaction in first recycling cycles and then they proved inadequate in the period of stabilized regime.

The evolution of the R/Q ratio, depending on the regeneration efficiency and the sand reusing degree, determined in a recent study on the main types of installations, is presented in Figure 1 [3]. The results of this study shows that:

• **in case of sands with organic agents**, the thermic regeneration at high temperature easily allows achieving an efficiency of 100% (installation A); an influence over the regeneration efficiency has the casting temperature, the duration of cooling the piece in the mould, the sand/liquid metal ratio, the agent nature (in Figure 1 it may be seen the efficiency of some simple installations B, C, D, E – without an energetic attrition system, installation F – with an energetic attrition system);

• **in case of sands with sodium silicate**, the agent being purely mineral, we cannot benefit by the thermic destruction effect, the regeneration efficiency depends only on the proper installation performance (In Figure 1, it may be seen some installations efficiency G - old, H, I – modernized);

• **in case of sands with mineral-natural agents (bentonite or clay)**, the regeneration installations must respond to two situations in foundries: the sand regeneration in homogeneous system (that enters in the sand preparation for moulds circuit) and the regeneration in heterogeneous system with the purpose of recovered sand reusing at the cores manufacture; the regeneration in homogeneous system is possible by using pneumatic installations of medium efficiency; for the regeneration in heterogeneous system it is compulsory that the recovered sand not to have the content in impurities over 0,2 % (as the new sand), so the regeneration installation must have an efficiency almost of 100 % (in Figure 1, installation K is a thermo-mechanical installation that makes possible a calcination at 700^{0}C, pneumatic treatment and energetic dedusting – ensures the expected efficiency).

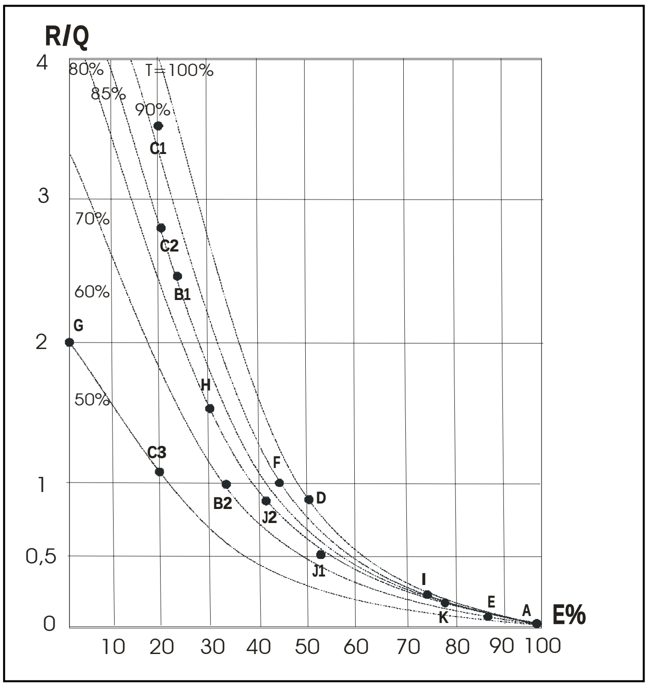

*Figure 1. The Evolution of the R/Q Ratio Depending on the Regeneration Efficiency **E** and the Sand Reusing Degree **T**.*

4. CONCLUSION

The used sand represents approximate 70-80% in the total wastes in foundries. Big quantities of used-sands, with high toxicity degree, that have to be stored in special arranged dumps, create an important impact on environment and especially on the soil.
The reduction of used-sands quantity, that are conducted to waste depositions, by sand regeneration is the solution that must be adopted by all foundries.
Choosing the adequate sand regeneration from used-sands system will be done through a detailed analysis, depending on the specific conditions in foundries, also considering: the type of sand and core sand used, the expected efficiency, the investment and exploitation cost.

5. REFERENCES

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