

Application of design projects developed by Foundry Research Institute in Krakow in construction of integrated stand for processing and reclamation of moulding sands

I. Izdebska-Szanda^{a*}, F. Pezarski^a, K. Stępniewski^b

^a Foundry Research Institute, ul. Zakopiańska 73, 30-418 Kraków, Polska

^b Foundry Chemar-Kielce

*Corresponding author. E-mail address: iod@iod.krakow.pl

Received 16.07.2007; accepted in revised form 24.07.2007

Abstract

The article is devoted to the description of a new integrated system for processing and reclamation of moulding and core sands using the equipment developed by Foundry Research Institute in Krakow. The idea and operation of a complex stand, which allows for co-existence of three routes of material circulation, i.e. system sand, new sand and reclaim, with maximum utilisation of the existing equipment have been presented. Various aspects, economical and ecological, of the proposed design have been discussed.

Keywords: Foundry sand system, Used sand, Reclamation, Waste management

1. The present state of the reclamation and waste management in Poland

There are, at present, in Poland about 390 foundry shops, including 180 iron foundries, 36 steel foundries and 245 foundries of non-ferrous metals (aluminium, copper, magnesium).

Moulding and core sands make the largest volume of the waste that is formed in casting processes. The share of this waste in total volume of the waste produced by foundries may go up to even as much as 80% [1,2]. The total annual weight of the waste produced by Polish foundries amounts to about 600 000 tons. About 70 % of this waste are the used bentonite sands, while the

remaining 30% are the waste moulding and core sands from the chemo-setting and cement technologies [2].

Altogether, in Poland, for the purpose of foundry activity about 700 thousands tons of new sand are used; the price of one ton of the sand in conversion to euro is 7-21,5 EUR and is lower from an average European level by about 1/3. The wide range of the sand prices is related with its quality and grade, with transport cost, and with the sand condition (dry or green sand). In preparation of conventional moulding sands, about 10 -15% of new sand is used; in preparation of core sands and chemo-setting sands - about 85% of new sand is used [2].

At present, the raising requirements of ecological and economic nature make the reclamation of waste sand a must. In synthetic moulding and core sands about 90% is the silica sand.

Due to the effect of high temperature of the metal when moulds are poured and irreversible chemical reactions, the moulding materials suffer a decrease of technological properties which makes constant introducing of new sand and binder into the system necessary to compensate for the suffered losses. Therefore, the economical and ecological factors impose the necessity of recovery and re-use of sand from the waste foundry mixture through its reclamation. Depending on the reclamation technique, the obtained reclaim replaces the new sand either in part or completely.

An important factor which supports the idea of introducing sand reclamation to a foundry are fees paid for the use of dumping grounds. An average cost of dumping the waste sand produced by an average foundry in Poland is between 12,5 to 61 EUR. The level of the fees for using a dumping ground depends on the type of waste and on the type of the dumping ground (municipal grounds, in-plant grounds, and own dumping grounds of the foundry shop) [2].

In spite of this, the number of foundries using reclamation process is still relatively small.

In the case of iron foundries, the reclamation process is used by about 10% of foundries, in the case of steel foundries by – 25%, foundries of non-ferrous metals use reclamation in – 10%.

2. The flow of materials at „Chemar” Foundry before reclamation

The production process utilised by “Chemar” Foundry is based on bentonite moulding sands and sands with sodium silicate and with an addition of refractory clay hardened with CO₂. 70% of the manufactured moulding sand are bentonite sands; 30% are the sands with sodium silicate. About 3/4 of moulding sands are the backing sands based on system sand, the remaining 1/4 of moulding sands are the facing sands prepared from new sand as a base material.

Core sands made from the new sand only are the compositions with resin of Novanol type hardened with CO₂, self-setting furan sands and thermosetting (hot-box) sands. In total volume of the sands produced, the core sands make about 20%.

The „Chemar” Foundry has a complete installation returning the knocked out sand to the system and a plant for sand processing equipped with roller mixers, type MK-060, for moulding sand preparation, and with paddle mixers, type MS-050 and roller mixers, type MK-030 – both for preparation of core sand.

Moulds made from sands with sodium silicate are knocked out separately, but the sand from both technologies is handled by a common transport route.

After knocking out on a shake-out grid, the moulding sand is handled on a belt conveyor to a drum crusher. On the belt conveyor there is an electromagnetic belt separator operating in a cross-wise system. From crusher the disintegrated sand is handled by a belt conveyor to a bucket elevator, and next by a belt conveyor and a system of scrapers it is transported to containers in the sand processing plant.

A fraction of the non-crushed sand residue is handled by means of a separate conveyor and elevator to the container of waste sand located outside the foundry hall.

The Foundry has also a post for drying of new sand in the fluidised-bed driers. The green sand supplied to the Foundry is charged by a crane to the drier and next, i.e. after having been dried, it is transported either to the tanks placed above the mixers, or to a silo from which it is periodically taken to the tanks above the mixers. All this makes a well-developed and fully flexible system of belt transport.

The volume of the used moulding and core sands disposed to the dumping ground ranges to about 4 200 tons per year. Together with the disposed waste sand there is an irrecoverable loss of a large fraction of the external chills (up to even 50%) used in production process and of other metallic parts, magnetic and paramagnetic. This means additional and measurable losses of both economic and ecological nature. Because of very low technological properties of the system sand, numerous moulds simply have to be rejected, which raises the cost of production and additionally increases the volume of the waste sand disposed to the dumping ground.

3. The concept of integrated processing and reclamation of moulding and core sands

To obtain further progress in production of new casting types for the domestic market and for export, to reduce the manufacturing costs, and to obtain castings of high quality, satisfying the every time higher requirements of the clients and the ever more stringent requirements of ecology and occupational safety, the “Chemar” Foundry, in cooperation with the Foundry Research Institute in Krakow, has undertaken the task of developing an innovative technology of making cast parts of industrial fittings in moulding and core sands based on the reclaim obtained in an integrated system of moulding and core sand processing and reclamation.

The main guidelines adopted in the concept of an integrated system of moulding and core sand processing and reclamation are as follows:

- output of the installation – 4 t/h,
- mechanical reclamation in the equipment designed by Foundry Research Institute in Krakow, consisting of a vibration crusher and a disk reclamation unit,
- maximum degree of utilisation of the sand processing plant, conveyor transport and the stand for drying of sand.

For reclamation will serve the knocked out sand returned to the processing plant on belt conveyors and elevator - after knocking out of moulds on a shake-out grid.

Starting the project, a conceptual idea of the knocked out sand reclamation was prepared in three versions, differing in arrangement and in degree of utilisation of the existing equipment. Finally, for project realisation, a variant has been

chosen according to which the reclamation plant consists of the following facilities:

- the newly purchased equipment, such as: vibration screen, two belt conveyors, vibration reclamation unit, disk reclamation unit, cloth filter, fan, two-way chutes, etc.,
- the existing (subject to previous repair and adjustments) fluidisation drier, whose individual assemblies after having been completed will serve for collecting the knocked out sand, its overdrying and feeding in batches at the successive stages of reclamation. The drier will remain in the same location,
- the existing and operating transporters and elevators, which - when provided with appropriate control system - will be alternately used for the needs of either the sand processing plant or the sand reclamation unit.

The concept of utilising the existing facilities considerably reduced the cost of purchase of new installations and, due to this, considerably reduced also the investment outlays.

4. Practical application of the design developed by Foundry Research Institute

The main reclamation will take place in two basic units of the equipment which are the design concepts developed by Foundry Research Institute [3-6], that is:

- in vibration-type reclamation unit (vibration crusher),
- in disk-type reclamation unit.

In both installations the clay envelope will be broken and separated from the sand grains. The separated clay binder will be removed from the reclaim by intensive dust extraction system.

Designing of the installations was done as a part of the research and development works and target projects carried out by Foundry Research Institute.

The vibration reclamation unit, type AKI -21/03, of the 6-8 t/h rated output is assigned for crushing the lumps of the knocked out moulding and core sands. To this unit is directed the waste sand having passed previously through the shake out grid of 120x100 mm mesh. A schematic diagram of this unit is shown in Figure 1.

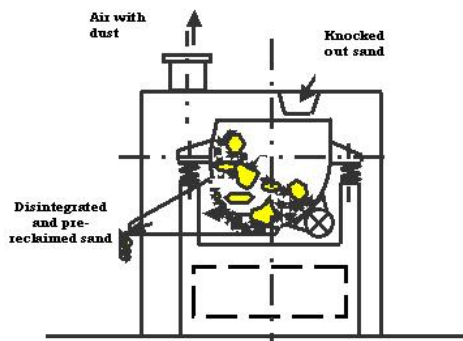


Fig. 1. Schematic representation of the vibration-type reclamation unit

In vibration reclamation unit the process of the sand lumps disintegration and partial sand reclamation take place (grains rubbing against each other due to vibrations within the entire working space of the crusher). After introducing the sand to a tank of the reclamation unit, it is disintegrated by vibrations produced by an electrovibrator. During this, vibration-induced, crushing, besides disintegration of the sand lumps, a very intensive removal by attrition of binder and other impurities from the sand grains takes place. The removed matter is collected and separated on a filter of the dust collecting unit. After passing through a perforated bottom and replaceable screen, the processed material disintegrated to single grains is fed through a chute to the next processing unit or to a tank. The inclusions, mainly metallic parts, are removed periodically.

The disk reclamation unit, type RTL-10, makes proper reclamation of the sand by dry mechanical method and plays the role of basic equipment in the whole plant for mechanical reclamation used for moulding and core sands of various types (Figure 2).

The RTL-10 reclamation unit consists of a cylindrical chamber with vertical axis and a set of rotating disks. In this reclamation unit, the combined effect of the moving blades, the disks rubbing against each other, impact forces, and rubbing against the surface of the side lining makes the envelope of binder break and get removed by attrition from the sand grains.

The pre-processed (disintegrated and screened) waste sand is fed from the top near the axis of rotation and is thrown by the action of centrifugal force towards the external edge of the disk, rubbing against its surface and against the blades of special design. Thrown away from the disk it next hits the working surface of the chamber and by a properly designed guide is directed to an area near the axis of rotation of the next disk. The operation is repeated the number of times corresponding to the number of the disks operating in the rotor. The separated binding material is taken off to the dust collecting installation in the upper part of the reclamation unit

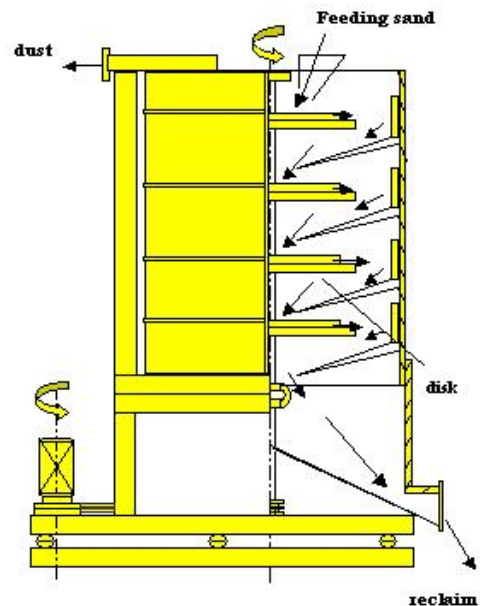


Fig. 2. Schematic representation of the disk-type reclamation unit

5. Materials circulation within the integrated system of sand processing and reclamation

Basing on detailed analysis of the current condition and potential capacity of the existing equipment, the final run of the reclamation process is shown on a flow chart in Figure 3.

The sand reclamation line integrated with the line of the returned sand transport, the plant for sand processing, and the stand for new sand drying and transport are a very advantageous design solution, enabling the Foundry keeping the investment costs reduced to minimum and cutting down the costs related with purchase of new sand and disposal of the waste sand to a dumping ground.

The integrated system of the knocked out sand processing and reclamation will be operating in the following mode [7]:

- the sand knocked out on a shake out grid, subjected to preliminary crushing in a drum crusher, after separation of metallic parts by the co-operating electromagnetic separator (with chills recovered) will be handled by a bucket conveyor and two-way chute installed on the elevator,
- the chute will direct the sand, alternatively, to either a rotary screen (as a return sand to the sand processing plant), or to a conveyor which will send it further to a reclamation unit,
- to the same conveyor will be directed the residue from the rotary screen, while the screened material will be moved on a next conveyor to the tanks of the system sand at the sand processing plant,
- for reclamation, the knocked out sand collected in an elevator will be directed, together with the residue from a rotary screen, by means of a belt conveyor system to a vibration screen located on the tank of a fluidisation drier,
- the sand disintegrated on the screen and free from the hard lumps will be collected in a tank until it gets filled; when the tank is filled, a flap operating in the two-way chute will change its position and now the knocked out sand will be handled to tanks located at the sand processing plant,
- the sand collected in a tank of the fluidisation drier will be dried and cooled in air jet and directed to the conveyor, and then by elevator of the dry sand and by a two-way chute it will go to the vibration reclamation unit (Figure 4).
- the sand, disintegrated to single grains and subjected to preliminary de-dusting, will go from a vibration reclamation unit on a belt conveyor to a disk reclamation unit in which the proper process of reclamation will take place through intensive attrition (Figure 5),
- then, through a chute with intensive dust collecting system, the ready reclaim will be taken to a silo or to appropriate tanks at the sand processing plant to serve as an addition to the facing and core sands, thus replacing the new material.

Both vibration reclamation unit as well as the disk reclamation unit are located at a zero level of the foundry hall, near the tanks of the sand processing plant, which ensures their stability and prevents vibrations from getting transferred to other installations and structures. The location of the reclamation units

should provide an easy access to their respective mechanisms to enable periodical emptying of the tank of a vibration unit from the uncrushed waste material and easy replacement of the worn out parts, i.e. the blades.

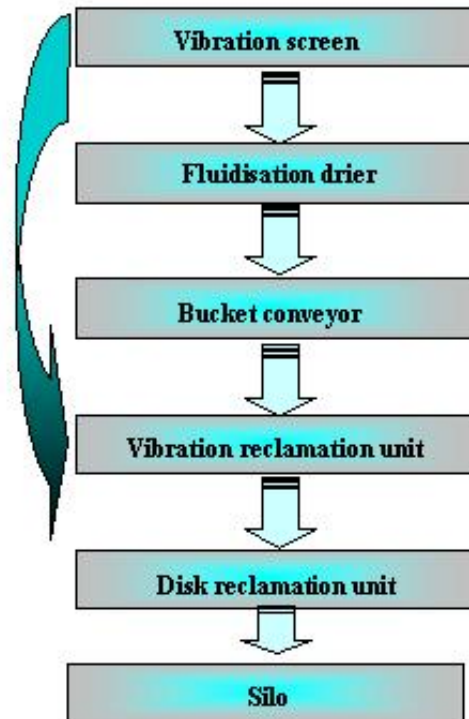


Fig. 3. Design outlay of the stand for reclamation of waste sand



Fig. 4. A vibration-type reclamation unit, type AKI 21/2002

By the side of the vibration reclamation unit, a cloth filter and a fan have been installed (Figure 6).

The dust retained on a cloth filter will be collected in bio-bags and disposed to the dumping ground. The uncrushed parts, like sintered lumps of core sand, pieces of wood, stones, etc. will be collected in the tank of a vibration crusher, wherefrom they will be periodically removed. At this point it should be emphasized that the volume of the collected waste will make a few percent only of the volume disposed up to now to the dumping ground.



Fig. 5. A disk-type reclamation unit, type RTL-10C



Fig. 6. A pulsatory filter

6. The economic and ecological aspects of the applied reclamation system

Basing on an analysis of the current data and production volume of “Chemar” Foundry it has been calculated that for the preparation of core sands and mould facing sands the expected sand consumption should reach about 4000 tons per year, while the volume of the moulding sand disposed to the dumping ground should amount to about 4200 tons.

Assuming now that the reclamation process shall cover the whole waste moulding and core sand, which means a volume of about 4200 tons during one year, this - at an assumed yield of 95% - should give the volume of about 4000 tons of the reclaim in a year.

The savings obtained on account of the application of a reclamation process will be due to the reduced cost of:

- purchase of new sand
- transport of new sand
- drying of new sand
- fees for the sand disposal to the dumping ground including transport
- purchase of bentonite
- purchase of ground clay

Hence it follows that total savings on account of the effectively introduced reclamation process can be estimated at about 600 thousand PLN during one year.

The next factor which enables cost reduction on account of the reclamation process effectively applied in new production will be an almost 100% recovery of chills, which will reduce the cost of their production.

Owing to the introduced system of integrated processing and reclamation of moulding and core sands, an improvement is also expected in the surface casting quality. This should reduce by about 25% the labour input required for the casting finishing operation.

The unmeasurable benefits for the ecology are also expected, like air dust level in foundry and in the fettling shop reduced by about 30%, lower cost of the land recultivation, reduced wear and tear of equipment, reduced fuel consumption and longer life of the road surface on account of less of the transport needed.

The start up of production of the new casting assortment is expected to increase the sales value and the rate of employment, which is a very important social factor in the Kielce region of Poland.

The sand reclamation should reduce the demand for new sand, the gas consumption rate, and the volume of the disposed waste.

References

- [1] M. Holtzer, I. Kargulewicz .: Possibilities to use waste moulding sands, IV Foundry Conference Technical 2001 Foundry XXI century , p. 33-40
- [2] Multi-author work: A guide for the best available techniques (BAT) – recommendations for foundry sector, Ministerstwo Środowiska, 2005, p. 202-212

- [3] F. Pezarski, Z. Maniowski, I. Izdebska-Szanda.: The processes of sand reclamation from the used moulding mixtures with sodium silicate developed by Foundry Research Institute and implemented in industry. Slévárenství nr 7-8/1998 str 297-300
- [4] I. Izdebska Szanda, F. Pezarski, Z. Maniowski, E. Smoluchowski.: Experience of Foundry Research Institute with resin bonded sand reclamation in small and medium foundries, „International Conference - Moulding Materials and Cost Reductions for Casting”, vol. 8 (ISBN 80-02-01725-0), p. 119-124
- [5] F. Pezarski, I. Izdebska-Szanda, Z. Maniowski.: Testing the reclamability of used foundry sands by a vibration method, „Materials engineering” nr 3/2003, Vol. X, p. 275-278 Žilina (SK), ISSN 1335-0803
- [6] T. Bogacz, M. Młyński, F. Pezarski, Z. Maniowski, I. Izdebska-Szanda.: Polish technical solution implemented in the firm METALODLEW S.A. as pattern for another european foundries, Przegląd Odlewnictwa no 7-8/2006, (PL ISSN 0033-2275), p. 364-369
- [7] I. Izdebska-Szanda, Z. Maniowski, F. Pezarski.: Integrate system of reclamation moulding sand, „Materials engineering” nr 3/2006, Vol. XIII, p. 59-62 Žilina (SK), ISSN 1335-0803