MODERN SAND RECLAMATION TECHNOLOGIES FOR ECONOMY, ENVIRONMENT FRIENDLINESS & ENERGY EFFICIENCY

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Abstract

Unlike green sand, chemically bonded sand cannot be used again and again without reclamation because in this system, the mixed sand gets it`s strength through chemical reaction which is irreversible in nature. Each sand particle is coated with this reacted chemical, which behaves like an inert element after usage once. This inert coating also called “Dead” binder needs to be removed from the used sand because it being brittle in nature gives rise to increased fines in the sand. “Dead” binder is present in the form of layers adhering to the surface of the sand grains. These layers if not removed changes the property of the sand and makes it totally unsuitable for further usage because proper strength would not be achieved even with higher chemical percentage.

Sand grain modification is another important aspect of reclamation. During reclamation rubbing take place between sand grains and also against surfaces of the various equipment of the reclamation system at different stages. As a result sharp corners of the original sand (which is available from the nature) get rounded causing reduced surface to volume ratio, which ultimately reduce binder demand. This obviously reduces the chance of getting defective casting due to formation of gas.

Main methods of Sand Reclamation are – (1) Mechanical Attrition Reclamation and (2) Thermal Sand Reclamation.

In Mechanical Attrition Reclamation rubbing of sand grains against each other take place by mechanical means like vibration, fluidization etc. This process cannot remove all the binder coatings. As a result about 10 to 20% fresh sand needs to be added with the sand to keep LOI value within limit. Generally such sand is reused for the same binder system.

Thermal Reclamation is actually a combination of Mechanical Attrition Reclamation and Thermal Reclamation. In this process, mechanically reclaimed sand is heated to a temperature of about 800 degrees C. Heating takes place in a specially designed furnace where the sand is both fluidized as well as heated. Thus rubbing of sand against sand takes place here, too.

Various equipment involved in a Thermal Reclamation System are – Lump Reducer, Pneumatic Transporter, Screw Feeder, Combustor with Sand Preheater and Air Preheater, Fluidized Bed Cooler and Dust Extraction System.

Of these equipments Combustor is the special furnace in which the mechanically reclaimed sand gets fluidized as well as heated. To utilize the waste heat both incoming sand as well as air is preheated with the help of waste flue gas coming out of the system. From the Screw Feeder mentioned above, mechanically reclaimed sand is fed to the Sand Preheater of the Combustor whereby the incoming sand to the furnace gets preheated. Afterwards, the sand is both fluidized as well as heated in the furnace itself. As a result rubbing of sand against sand as well as burning of dead binders, both are accomplished at the same place.

Thermally reclaimed sand is better than mechanically reclaimed sand as well as fresh sand from various aspects as follows :

(1) Thermally reclaimed sand undergoes lower thermal expansion causing better mould stability.
(2) Thermally reclaimed sand is better than fresh sand because it is more rounded in shape causing lesser binder demand.
(3) Irrespective of the binder system in the previous cycle, thermally reclaimed sand can be used with any chemical binder system in the subsequent cycle.
(4) As most of the sand is reused, almost no dumping is necessary resulting in safer environment.
(5) Conserves natural resources by eliminating requirement of new sand.
(6) This is a highly energy efficient process.

1. INTRODUCTION:

In green sand clay bonded, process the sand is used over and over again after some treatment of the used demoulded 'return' sand. The treatment includes sieving, removal of Iron particles, cooling, water and binder addition, mixing etc.

But in case of chemically bonded sand system the mould / core strength is developed by chemical reaction or thermal process. Contrary to the green sand system binder in chemically bonded sand is set by irreversible process. It does not remain 'active' and cannot take part in the bonding of sand in the next cycle. After the mould / core are set and casting is done the binder present in the system is totally dead and fresh binder must be added before the sand can be used in the next cycle. Reuse of sand this way, will result in accumulation of 'dead' binder in the system making the sand totally unusable.

The option, adopted by some, is to discard and dispose the used sand altogether after and start with new sand in every cycle. This is not a feasible proposition on economic and environmental consideration. The availability of dumping ground for used chemically bonded sand is becoming difficult day by day. Cost of dumping is also increasing exorbitantly. In addition to non availability of dumping ground and high dumping cost, the environmental problem is of critical concern. The dumped sand, being toxic, would pollute the atmospheric air as well as the ground water having long lasting effect on environment and plants. The government authority is becoming stricter on these issues.

On the other hand, availability of new sand is becoming a problem these days. Local authorities are imposing restriction in mining / extraction of sand altogether. Therefore supply of new sand to foundries shall be very little or it may even stop altogether. Therefore they will be compelled to survive on sand obtained by reclaiming used /de-moulded sand. In addition to above compulsion, there are other good technical reasons for reclamation of chemically bonded sand for re-use.

2. TECHNICAL REASONS FOR RECLAMATION

Removal of dead binder: The dead binder present in the used sand increases the 'fines' in the system sand. The fines having more surfaces to volume ratio require more resin / chemical to achieve desired level of bond strength. The increase of fines in the system sand also contributes to deterioration of sand properties. These fines, therefore, are to be removed from the system. Majority of the 'dead' binder, however, are present in the form of layers adhering to the surface of the sand grains. If these layers are not removed, the sand grain would be coated with multiple layers of such 'dead' chemicals in subsequent cycles. This deposit, being brittle, changes the sand property and would make the sand totally unsuitable for moulding as proper strength would not be achieved even with higher percentage of chemical.

The presence of residual 'dead' binder in the system is a determining factor in arriving at the required chemical percentage in the next cycle. The amount of this 'dead' organic binder, usually determined by "Loss On Ignition" (LOI), is very important in chemically bonded sand system. If the LOI changes in every cycle then percentage of chemicals to be added would also change in every cycle. This situation cannot be accepted as a good operating practice. In practical situation it is not possible to determine the required chemical percentage and add the same accordingly in every cycle. Therefore every attempt is to be made to keep the LOI figure more or less constant making the system 'stable'. 'Stability' means to attain the LOI figure of the reclaimed sand at the end of the cycle equal to the LOI figure of the sand before addition of binder in the beginning of the cycle. To attain this condition it often becomes necessary to add certain amount of NEW sand in the system. The percentage of new sand required to be added to reclaimed sand generally varies from 10 to 20%.

Sand grain modification: It is another important aspect in considering reclamation. During reclamation, due to grain-against-grain rubbing/abrading as well as grain rubbing against rubbing surfaces of various reclamation equipment at various stages of reclamation the sand grains get altered. The sharp corners get rounded, converting the sand grains from angular to sub-angular to rounded. This improves the desirable property of sand to a great extent. The surface to volume ratio gets reduced resulting in reduced binder demand. Due to this positive effect of reclamation the new sand, instead of adding to the system directly, is generally added in the lump breaking stage of the reclamation process so that grains are, to some extent, get modified before mixing and moulding.

3. HOW RECLAMATION IS DONE

Sand Reclamation can be termed as the process of reconditioning of used / demoulded sand in a foundry without lowering its original properties, which are particularly required for foundry application.

Reclamation may be done by various methods - namely:

- Attrition (Mechanical) Reclamation
- Thermal Reclamation
- Combination of the above
- Wet Reclamation

Attrition Reclamation process is capable of converting, at economic rate, the used recycled sand with low binder content, without foreign material and with even grain size distribution - all that are required for producing good quality mould / core. The reclaimed sand is delivered at sufficiently low temperature useable for core / mould making. Attrition reclamation is done by wearing binders from the sand grain through a series of mechanical processes. Since all the binder is **not** removed by this process, in most of the cases about 10 to 20 % new sand is added to keep the LOI within limit. Attrition-reclaimed sand of certain binder system can generally be re-used for the same binder system only. It cannot be for re-used in other binder system, in most of the cases, or as new sand because of presence of residual binder. For such requirements the Thermal Reclamation process is the only means by which this can be achieved.

Thermal Reclamation is the process in which the sand is heated to a temperature of about 800 deg. C, in a specially designed fluidized bed Combustor which is the main equipment of the thermal reclamation system. In the Thermal Reclaimer, the sand grains obtained from the lump breaker is generally pre-heated and fed into the combustor where it is fluidized by precisely controlled air flow at desired pressure. The fluidized bed also receives LPG / Natural gas at controlled rate which burns in the fluidized bed with oxygen available in the fluidizing air in the bed. The binder in the sand is totally burnt and hot reclaimed sand is obtained at the outlet of the Combustor.

However in the Wesman Thermal Reclaimer, the sand grains obtained after breaking the lumps are pre-heated in a heat exchanger and fed into the Combustor at a pre-determined rate. Here it is fluidized by precisely controlled preheated air. The fluidized bed of sand receives controlled stream of flame and hot products of combustion from a
specially designed combustion system. In this, apart from LPG / Natural gas, liquid fuel like **LDO / HSD** can also be used as source of heat. This is an added advantage as Natural gas is not available in many Foundry locations /clusters and LPG is very expensive, whereas LDO / HSD is available everywhere and are not as expensive as LPG.

Following equipment are included in Wesman Thermal reclamation unit.

1. **Lump Reducer** – Reduces the de-moulded sand lump in to sand grains in a vibrating unit fitted with unbalance motor.

2. **Pneumatic sand transporter** to deliver the de-moulded and reduced sand grains to the return sand storage silo.

3. **Screw Feeder** feeds this sand in to sand preheating unit.

4. **Sand preheating unit,** fitted at the inlet of the Fluidised bed combustor to preheat the incoming return sand by using waste heat in the flue coming out from the combustor.

5. **Air preheater** for further extracting waste heat from flue.

6. **Fluidised bed combustor** where the preheated sand is feed from the Sand pre-heater by a **screw feeder** and fluidised by preheated air. Preheated sand is further heated to about 800 ^{o} C by heat provided from the Wesman combustion system. The combustion system includes combustion air fan, Burner system suitable for Natural gas, LPG or liquid fuel like **LDO / HSD**, regulators and automatic controller.

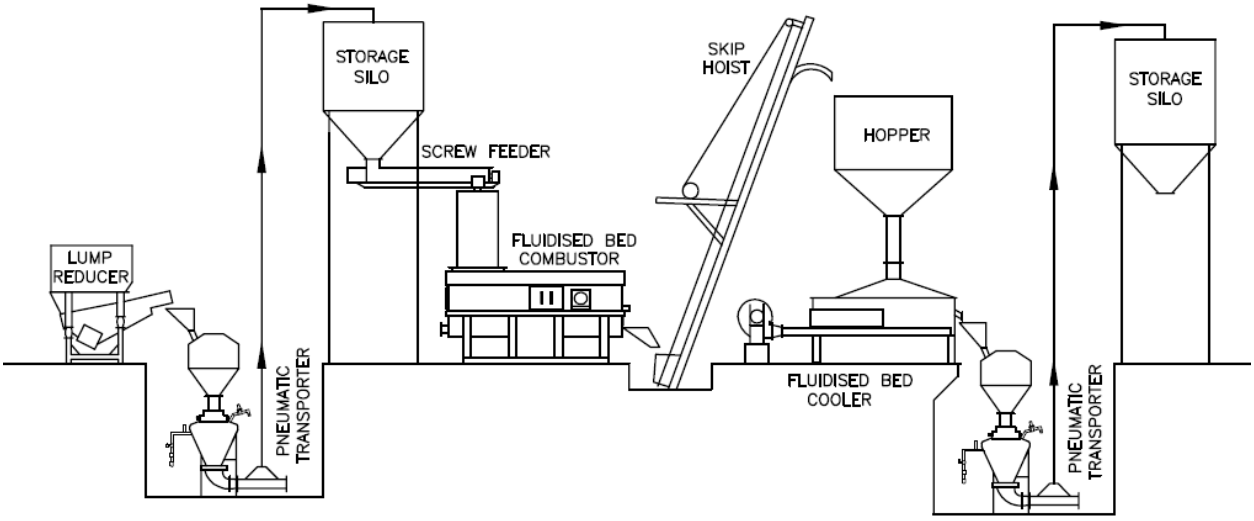
7. **Skip Hoist** for transporting hot reclaimed sand in to **hot sand silo** at the inlet of the cooler in a particular model. In other models the hot reclaimed sand flows directly into the fluidized bed cooler.

8. **Fluidized bed Cooler** where the hot reclaimed sand is cooled to usable temperature by means of fluidizing air as well as cooling coil.

9. **Pneumatic sand transporter** for delivering the cooled reclaimed sand to the sand storage silo for re-uses.

10. **Dust extraction system** having suction points at various stages of reclamation for removing dust as well as for classification of sand.

The schematic of the Wesman Thermal reclamation process is shown below.



For certain binder system further processing of the thermally reclaimed sand would be required. In these binder systems layer of burnt binder still remains adhered to the sand grains. Attrition / rubbing would be required for total removal of this burnt layer from the sand grain so that totally reclaimed sand, which is generally better than new sand, is obtained at the end of reclamation process.

4. ADVANTAGES

Thermal reclamation process is, in many ways, better than attrition (mechanical) reclamation process for the following reasons:

1. New sand has higher thermal expansion. During pouring, the mould expands excessively and causes distortion, instability and dimensional inaccuracy. When sand is heated above 600 Deg. C, the same undergoes phase change which is permanent in nature. This phase-changed sand has lower thermal expansion and, therefore, all the problems mentioned above are less and casting of more accurate shape and dimension is obtained.

2. Unlike mechanical reclamation, 100% sand, except those reduced to dust, is reclaimed to better-than-new condition.

3. In majority of the cases thermally reclaimed sand, irrespective of the original binder system, can be re-used in any system of sand – green sand or chemically bonded sand with any chemical binder. Thermally reclaimed

4. Chemically bonded sand can even be used for green-sand system and vice-versa.

5. Though generally Natural gas or LPG is used as fuel, Wesman's Thermal Sand Reclaimer can be fired with **Light oil** which is available everywhere. This is a great advantage as most of the locations where Foundries are located / clustered do not have supply of Piped Natural Gas, CNG or CBM. If they have to use Gaseous fuel, they would be forced to use LPG which is comparatively more expensive. Whereas oil is available everywhere and only about 8 to 10 Liters of oil would be required for reclamation of 1 MT of sand.

Wesman's Thermal Sand Reclaimer can be used for reclaiming Shell sand, Phenolic 2-part/3-part sand, Furan sand etc. Even Green sand may be reclaimed with additional downstream equipment

5. CONCLUSION

The thermal sand reclaimer eliminates air and ground water pollution from discarded sand which are chemically bonded and toxic. It also reduces / eliminates requirement for natural resource like new sand which is presently a scarce commodity. This would help conservation of natural resources. This is very important especially in view of restrictions imposed by Government for mining sand in some states.

It may be mentioned that just for drying of 1 MT of new sand 8 to 10 Liters of oil is required in well designed Fluidized bed sand dryer. Ordinary rotary sand dryer consumes at least 10 to 12 Liters of oil for drying 1 MT of new sand. Whereas for reclaiming 1 MT of used sand only 7 to 9 Kg of LPG or 8 to 10 Liters of oil would be required. Therefore one can obtain better than new sand at a cost of drying alone for the same quantity of sand. This is a highly ENERGY EFFICIENT process.

Thermal reclamation should be adopted by the foundry men as it

1. Is an economical proposition.
2. Eliminates cost of dumping of used sand.
3. Conserves natural resources by eliminating requirement of NEW sand.
4. Conserves energy spent in drying new sand as drying would not be required.
5. Conserves energy of transportation and eliminates related pollution.
6. Conserves natural environment by eliminating dumping of used toxic sand.
7. Is an ENERGY EFFICIENT process.