Moulding Sand Reclamation-A Brief Review

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Abstract- The main concern of every foundry unit is processing required quantity of sand to impose the required characteristics on it to yield castings of sound quality. Every day huge quantities of molding sand are being handled in the foundries world over. The increased cost of moulding sand and concern over hazards of dumping the spent sand made the topic of moulding sand reclamation focused. In view of the technical ,environmental and the economical importance of the subject of molding sand reclamation author attempted to portray various sand reclamation methods in vogue and their comparison. It is concluded that the type of reclamation to be adopted for a specific molding sand depends on the type of binder coat that is adhered to the sand grains

I. INTRODUCTION

Every day huge quantities of moulding sand are being handled in the foundries across the globe. One to two tons of new sand are normally required per ton of the castings produced [9].Sand is seemingly among the most abundant materials on earth, yet like many other things that used to be inexhaustible, it is beginning to have an increasing value. Sand is not just sand to the foundry man but a specialized material that must be at the right place at the right time. This degree of speciality, plus material handling, the timing factor and the cost to discard it are factors that give foundry sand a meaning and a cost. To stand in the international market it is necessary to produce the castings of superior quality at the least possible cost. As the cost of the fuel, labour and raw material is galloping high the only area that needs to be concentrated is sand Further dumping of the spent sand causes environmental pollution. In this situation the problem of moulding sand reclamation has gained importance and started attracting the attention of researchers and foundrymen.

Sand reclamation refers to the treatment of 'used' moulding sand so that it regains its original condition and can be reused again and again, with minimum addition of new sand. There are mainly three types of foundry sand reclamation i) Dry Reclamation ii) Wet Reclamation iii) Thermal Reclamation. In view of the importance to foundry sand reclamation, this paper essentially reviews various methods of foundry sand reclamation.

II. FOUNDY SAND RECLAMATION BY WET METHOD

P.C Will & R.H Shurmer [2] built up a pilot plant used to reclaim the foundry sands. This plant mainly consists of lump breaker, sand sump tank, sand pump, primary classifier and secondary classifier etc. Hundreds of waste foundry lands from Grey Iron, Steel and Non ferrous foundries are tested in this pilot plant .A hydraulic hindered type primary classifier is the key part in this system. The slum retention time in the scrubber is varied depending on type of sand and the type of material adhering to grain surface. He observed that the retention time for waste sands from steel foundry is much less that that of gray iron foundry. this can be attributed to amount and nature of additive material and also to the greater angularity of base sand used in gray iron foundry .It is further reported that i) the reclaimed sand shows a slightly lower green strengths than new sand ii) the baked tensile strength is equal for both reclaimed and new sands iii) Loss on ignition value of reclaimed sands is slightly higher iv) Permeability of both green and baked sands is more. Perhaps the inability of scrubber system to remove the carbonaceous additives entrapped in surface imperfections of sand grains could be the reason for this behavior. However in some cases these surface depressions of sand grains filled with additives could be put to advantage because the reduced surface area of sand grains require less binder to coat the grains without impairing the physical properties.Fig2 reflects the photo micro graphs of waste sand in as received condition, reclaimed sand and new sand. The gray colour of the reclaimed sand is a result of carbon deposit in surface imperfections of some of the grains rather than complete coating of grains .This investigations concluded that i) casting finish of new sand and reclaimed sand is same ii) grain distribution of reclaimed sand can be controlled more closely iii) colour of reclaimed sand will not match to that of new sand, however the gray color observed did not yield any undesirable effects on physical properties of molding sand iv) sintering point of reclaimed sand is not lowered

The utility of wet sand reclamation in steel foundry is reported by H. Johnson et al[3].They recognized that a wet reclamation unit established by them would not be panacea for all the problems involved, indeed it has injected other problems in to the picture such as securing moisture control of the reclaimed sand to the required

extent. If the reclaimed sand could be used inter changeably with new sand with no detrimental effects in casting quality and the sand could be reclaimed at least cost, the economic and operating benefits would be very attractive. It is reported that the synthetic binder (phenol formaldehyde) used for core sand does not have any influence on efficiency of washing operation and can be used interchangeably with new sand.

The waste sand put through the lump breaker is washed with a stream of water in a revolving barrel. This type of washing doesn't remove clay and other inert material on sand grains and in addition considerable amount of extra synthetic resin is required for further bonding. Hence H.H ..Johnson et al [3] emphasized the need of scrubber. This allows grain-to-grain contact and the abrasive action scrubs off much of the adhering fine material on sand grain .Effective control over the grain distribution of the reclaimed sand is possible due to the operation in the classifier, where in the sand settles down against the rising current of water with controlled velocity and is turn effective separation of coating fines. For comparison purpose the photo micro graphs of new sand, return sand and reclaimed sands from the reports of P.c will et.al[2] and H .Johnson et.al [3] are given in fig 1. Fig.2 respectively. It is clear that reclamation unit proposed by H.H Johnson et al is less effective in removal of sand coat than that of P.C will [3] are given in Fig. 1 and Fig.2 respectively. It is clear that reclamation unit proposed by
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Fig.1 Comparison of sand graying shape of waste sand as received, reclaimed sand and new sand

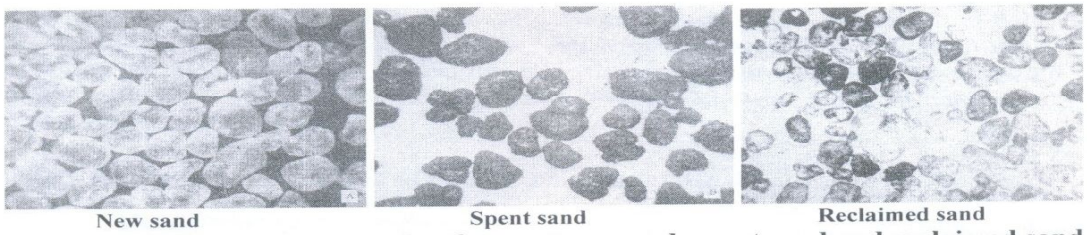

Fig. 2 Photo micro graphs of new ottava sand, spent sand and reclaimed sand

The grain distribution of wet reclaimed sand and base sand was given in Fig.3 .It can be observed that majority of sand grains of both base sand and reclaimed sand are between 40 mesh and 100 mesh and a similar observation is reported by P.C will also.

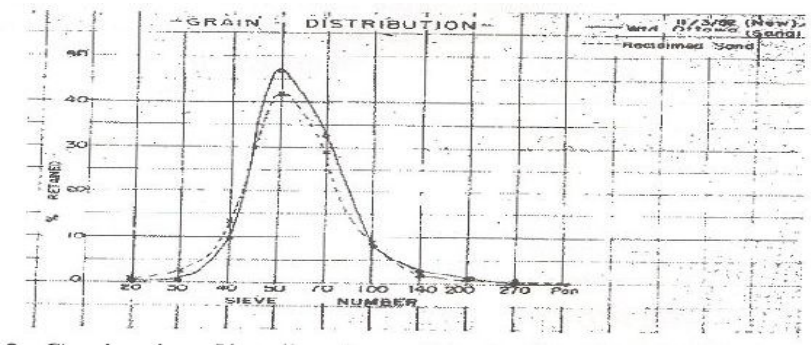

Fig-3 Grain size distribution of base sand and reclaimed sand.

Howard and Jenni[4] pointed out that "one of the most important effects resulting from the contact of the compounded mould or core sand with molten steel is the coating of sand grains with a firmly adhering film of clay binder and carbonaceous matter. At the temperature of molten steel the water of crystallization of clay compounds is drive off and the clay of bentonite film on the grains has distinctly different properties from the original binder. Much of the grain coating is an inert clay material but some of it is combustible. It is necessary to measure AFS clay and combustible matter present in sand coat. The general acceptable level of combustible matter is less than 0.35%
Investigations of H. Johnson [3] reported satisfactory cleaning of even resin bonded sands. In the point of view of flowability and ease of ramming the wet reclaimed sand is reported to be superior than that of new sand. Apparently the little spots(Fig 2) on sand grains act to key the bonded grain together more filmy than do the smoothed cores. It is concluded that the wet reclaimed sand ram more easily than new sand and casting surface finish may improve by its use .Wet reclamation may than new sand and although it is commonly held that the investment and operating costs are higher ."Preliminary trails" by Atterton[18]"on a laboratory scale showed that all of the residual also shows analysis for "soluble" and "insoluble"' Na2o contents in shakeout sands; the hardened sand, washed-not too thoroughly ,water soluble Na2O reduced from 0.437 to 0.10 and Na_2Co_3 from 0.525 to 0.099,Implying the possibility of reclamation by washing the sand when bonded with normal addition of binder were found to compare very favorably with new sand".

III. DRY METHOD OF RECLAMATION OF SILICATE BONDED SANDS.

The development of carbon dioxide process of molding and core making about four decades ago marked the advent of an epoch making era in foundry practice. It is a well known fact that CO_2 molding process eliminates the need for drying or baking of the mould and the metal can be immediately poured. Despite its superiority in mould properties Co_2 process suffers with a major setback of poor collapsibility.

It is very difficult to reclaim sands hardened with carbon-di-oxide and sodium silicate. In 1964 Sarkar [16] said : " so far not much attempt has been made to reclaim the used sand and the bulk of the returned silicate bonded sands is thrown away. In 1972 in the UK has shown that of the 1-1/2 million tons of silica sand used, usually very little CO_2 hardened sand without scrubbing the residual binder from the grains have resulted in a continual decline in the strength properties of the sand as it is used over and over. It was reported that with the addition of a suitable amount of water before re bonding .the around the filler grains are not removed, the residual binder is best removed by either dry or wet scrubbing. Wet scrubbing washes the sand with water and dry scrubbing Sarkar[16] describes a dry scrubbing arrangement where the reclaimed sand could be used with 15 to 25 % new sand added. This however seems to be too optimistic Nicholas describes a dry reclamation plant in the United Kingdom where only 405 reclaimed sand was used to get comparable properties with those of new sand.

Horse field has reported that "successful" reclamation of CO_2 hardened sand is possible by purely mechanical means. Changing from a lump crushing and air classifying unit to a shot blasting and separation unit, It is considered that "the reclaimed sand is now cleaner and therefore the percentage addition of reclaimed sand used on the facing sand has been increased from 40 percent to 50 percent. Build –up of the low melting point constituent in the sand mix would progressively reduce the refractoriness of the mold material. Possible difficulty in shakeout because of the accumulated amounts of sodium silicate and resulting increased retained strength is also pointed out.
Zifferer's [19] patent attempts to do away with not only the need to scrub the used sand but also need to use any binder after the initial addition It claims that by mixing the shake out and crushed sand with a "predetermined" quantity of sodium hydroxide solution, it is possible at 'reconstitute' all of the binder left on the sand from previous use. Also "the function of the alkali is to lower the viscosity of the silicate bond on the sand to such an extent that the lumps are progressively readily reduced to grain size."
Zifferer's hypothesis runs like this. On treating the silicate bonded sand with CO2 gas, the Na2Co3 by product…. Is precipitated as a separate and distinct phase from the sodium Silicate solution and that increasing quantities of Na2Co3 in sand mix will have no effect on the bonding strength of the reconstituted silicate solution. A progressive build –up of Na2CO3 can change certain properties of the sand mix such as flowability, green strength, permeability and sintering point. The Na2CO3 in the sand mix can, however be selectively controlled to any desired concentration to suit the conditions and practices of a given foundry. When a quantity of Na2CO3 which is deemed excessive, accumulates on the sand mix, the Na2CO3 which is deemed excessive, accumulates on the sand mix ,the Nq2CO3 and silicate can be removed by treating the sand with a dilute solution of NaOH."
Murton along similar lines, could rejuvenate CO2 hardened reclaimed sand with the addition of 0.5% 5N NaOH.Sand ,which was causing many casting defects because of its poor flowability and which could tolerate only

25% of reused sand was made to work satisfactory and to accept 50% of reused sand when the above addition was made.

Mac Donald[20] while pointing out that CO2 hardened silicate sand are hard to shake out and reclaim, pleads that, on the contrary, sands hardened with powder and liquid hardeners can be reclamation easily. He mentions that of "three foundries using the silicate-cement process ,all have sand reclamations units. None of these foundries have experienced difficulty in reclaiming these sands" He also mentions that sand hardened with sodium silicon fluoride and (liquid) organic catalysts are easy to reclaim," One foundy uses 100 percent wet claimed sand as a facing in their iron foundry" Depending "on metal sections,pouring temperatures and metal type " he suggests that 70of sand may be recycled.

Warneke undertook to study the reclaimability of clay hardened silicate sands. , using casting surface defects and dimensional tolerance as a references .Steel castings were made with sand molds bonded with 4% sodium silicate, hardened with 2% kaolin clay. Shakeout sand was reclaimed by mechanical means either with a pneumatic scrubber or an aerated muller. Eighty percent reclaimed sand, added to 20% new sand, was once again bonded and used. This process was repeated five times. Besides showing that the sand could be recycled five times he concludes that " a sand bonded with sodium silicate will provide greater dimensional stability and smaller as cast tolerance ranges than will the conventional green sand practice."

Caldeira and Roberts report an in-plant application where shakeout sand from a clay bonded system. on drying could be bonded with sodium silicate with a proprietary hardener. Polasek et al[5] reported in 1981 about their work with respect to reclaiming sodium silicate bonded sand and state quite clearly that wet reclamation is more effective than any kind of dry reclamation. However he also states that dry reclaimed sodium utilized in a foundry operation.A number of pouring cycles were attempted with new sand and reclaimed sand in 1:1 ration

Vernay (6) pointed out specifically that "in order that the reclamation operation remain financially interesting one must rule out wet method and retain only dry process .This work also clearly points out the need to remove moisture from sand grains in order to embrittle the binder and make it mare readily removable. It is further mentioned that is emphasized that it may play a role with respect to refractoriness of sand and must remain bellow 1 % .A publication by Foseco referring to practical reclamation results, reported introduction of 20 to 30% new sand at mixer.

Testing carried out in early 1983 indicated that there was indeed no firm relationship between bonding characterstics ,specifically tensile strength and residual soda of reclaimed silicate bonded sands. Rather a correlation was detected between bonding strength and LOI with tensile strength. increasing with decreasing LOI values. These LOI values are generated by both moisture content as well as residual organic substances ,which may be added to the binder system for either shakeout improvement or for catalytic purpose .It was concluded that if there was indeed a relationship between investigate this D.S Leidal[8] carried out investigation on tensile strength of reclaimed silicate bonded sands reclaimed at three different temperatures. He reported that for the same temperature at lower attrition rates the residual Na2O(Acid demand value) is high .No correlation is reported between LOI and Tensile strength Interesting a correlation is established between LOI and Tensile strength. It is confirmed by D.S Leidal [8] that a temperature threshold influence of Na2O with respect to refractoriness of sand is to be established with one cycle of reclamation. Hence Liedel evaluated dry reclamation process through number of reclamation and subsequent rebonding cycles. He concluded temperature in excess of 100^0C are required to remove water from sodium silicate molecule embrittling the binder to a degree where it can be readily binder savings are reported .

In dry reclaimed sand not only the content of residual binder coat on sand grains is important but also the surface area of sand grains covered by binder coat. Hence Acid demand value test, through provides information about residual Na2O content doesn't give spectroscopy (EDS) is an appropriate technique that provides information about percentage of area of sand grains covered by residual binder coat.

IV. THERMAL RECLAMATION

A novel type of thermal reclamation system using an electrically heated fluid bed is described by Vogel[14].Brown et al[13] discussed various thermal reclamation plants including gas fired fluid bed system

Zircon sand with Furan polymer resin binder used with SO_2 gas hardening system have been proved satisfactory for 99.8% reused .It is further reported by Bogel et al [14] that SO2 binder system is particularly sensitive to organic and acidic contaminants in recycled sand and is therefore a searching test for the effectiveness of reclamation

M.D Malone et al [1] compared mechanical and thermal reclamation systems of ester-cured phonetic bonded sands. Thermal reclamation is reported to be superior to that of mechanical reclamation system for the purpose. The reasons are 1) 100% output sand from reclamation unit can be directly utilized and 11) thermal

reclamation offers most effective route to achieve sand conservation. Surface characteristics of new sand. and thermally reclaimed sand are given in Fig.4

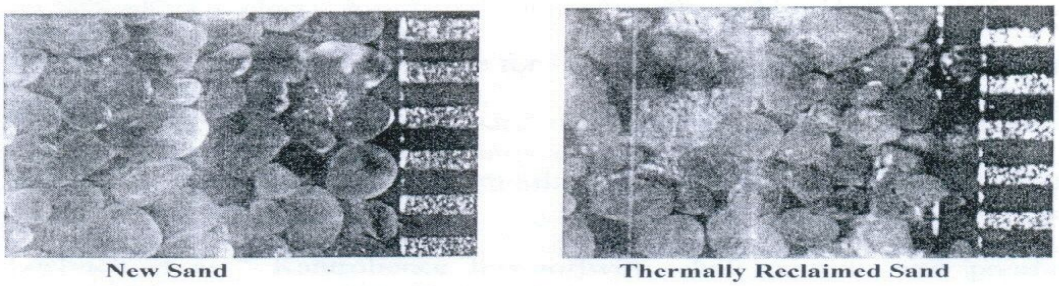

Fig.4. Comparison of base sand and thermally reclaimed sand grains.

It can be observed that the new sand and thermally reclaimed sand grains appear clean round shaped and free of organic contaminants

V. CONCLUSION

Earlier many foundries practiced Sand reclamation. But the main concern is the degree of utility of the reclaimed sand. For this purpose the properties of the reclaimed sand and in turn it's bonding ability for further processing is to be established. Several methods of reclamation methods are available but one has to judiciously choose the appropriate one .In case of organic binder system thermal reclamation is superior than dry reclamation system. Dry reclamation system is a desirable one when the binder coat on sand grains is brittle. Not much change in grain size and shape is observed in wet reclamation and thermal reclamation system .It is concluded that the type of reclamation to be adopted for a specific molding sand depends on the type of binder coat that is adhered to the sand.

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