# Testing of Fluidized Bed Combustor for Foundry Sand Reclamation

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**Abstract -** *This paper studies thermal sand reclamation system. Also, study the need of compact thermal sand reclamation process for the smart foundry. This paper studies testing of newly developed fluidized bed combustor (FBC) for foundry sand reclamation. Here, chemically bonded No-bake Sand used for testing reclamation process. A fluidized bed combustor is a good alternative for small capacity foundry sand reclamation process. Fluidized bed combustor consists of inner-chamber, heating coil, insulation, nozzle and some standard size inlet and outlet pipes. This FBC system contains maximum 20 kg of foundry used sand which are chemically bonded No bake sand for testing. Testing of the system was done by using Taguchi technique. Process parameter selection for testing was temperature, sand holding time, and quantity of sand. And result checked for this three parameters was percent weight reduction of sand and required testing time or cycle time. By using Taguchi method we get optimum parameters combination to get the better result. We also test the required time to achieve temperature from atmospheric temperature to selected temperature for a test. We also check the grain size of reclaimed sand which comes from newly developed fluidized bed combustor.*

*The requirement of such reclamation unit is very important than a previously developed sand reclamation unit. It generates alternative for small foundry sand reclamation process.*

***Key Words***: thermal sand reclamation, chemically bonded No-bake sand, small capacity thermal sand reclamation unit (up to 20kg ), Taguchi method, time required to achieve temperature, grain size.

## 1. INTRODUCTION

Foundry sand reclamation is the techniques by which reuse of moulding sand again and again with minimum use of new sand. Existing foundry technologies consume huge quantity of fresh moulding and core sand. One to two tons of new sand is normally required per ton of the castings produced. It produces foundry used sand, it contain chemically bonded sand. This sand needs to be reuse for casting applications.

But small foundries not capable to invest large amount of money for sand reclamation process. So we develop small, compact, affordable sand reclamation unit. This reclamation unit also gives same result as like a large capacity reclamation unit.

## 2. DESIGN OF FLUIDIZED BED COMBUSTOR

For design of fluidized bed combustor, study of existing induction furnace, heating coil, insulation needed, as well as nozzle design to obtain bubbling movement of sand is done. According to required parameters and properties the design modification is done.

1. Design of fluidized bed combustor structure done by considering capacity of 20 kg sand and its bubbling effect.
2. Foundry used sand binder burning is done by using heating coil. Heating coil capable to develop temperature at about 800 $^0$ C. heating coil arranged over inner-chamber, which made up from kanthal. The capacity of the heating coil depends on the time required for the heating system. We chose a 9kw heating coil and reached the temperature in 25 minutes.
3. Nozzles design done by considering sand grain size and number of nozzle required to bubble 20 kg sand.
4. Inlet and outlet pipe diameter taken as a standard available pipe diameter.
5. Insulation thickness selection done by considering developed heat And thickness design formulas.

**Table -1:** Experimental details

| Sr no. | Parameters | Details |
|---|---|---|
| 1 | Dimensions of FBC heating chamber | Height 600 Diameter 300 |
| 2 | Nozzles | 96 |
| 3 | Heating coil, kw | 9 |
| 4 | Insulation ceramic wool, m | 0.100 |
| 5 | Capacity of blower, hp | 5 |
| 6 | Particle size, µm | 300 |
| 7 | Velocity of fluidization , m/s | 4-8 |

**Table -2:** Initial condition

| Sr no | Name | Initial condition of FBC |
|---|---|---|
| 1 | Max. Temperature, k | 1073 |
| 2 | Max .Sand volume, kg | 20 |

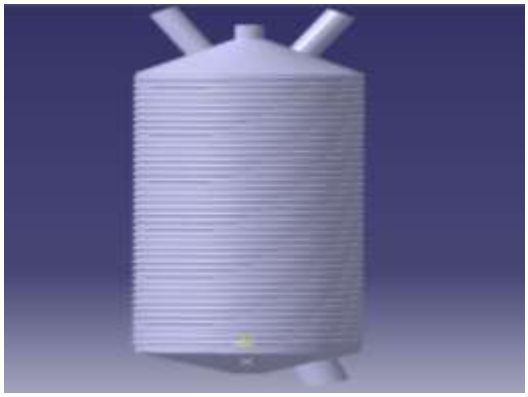

**Fig -1:** Inner-chamber and heating coil CAD model

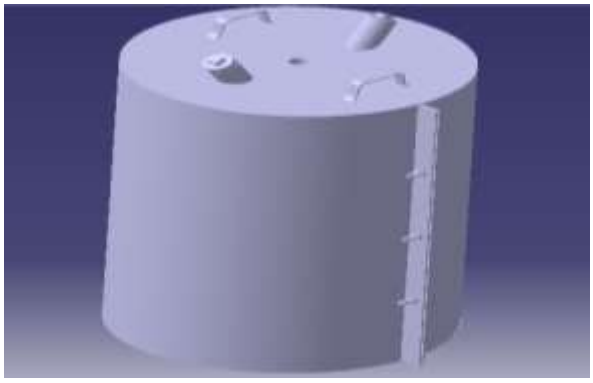

**Fig -2:** CAD model of FBC

**Fig -3:** developed FBC setup

**Fig -4:** Used Sand feeding arrangement

## 3. DESIGN EXPERIMENT AND TEST FLUIDIZED BED COMBUSTOR SYSTEM

The design of experiments (DOE) is the way of any task that describes to determine the relationship between factors affecting a process and the output of that process.

The Taguchi experimental design reduces time,cost, Improves quality, and provides optimum solutions. The advantages of Taguchi method over the other methods are that numerous factors can be simultaneously optimized and more quantitative information can be extracted from fewer experimental trials.

Design of experiments for fluidized bed combustor require some variables like temperature, sand holding time, sand quantity. By arranging these variables by using Taguchi method we get L9 array for testing fluidized bed combustor. Taguchi method gives best possible combinations and results.

Testing of fluidized bed combustor is task in which proper working of developed fluidized bed is carried out. Generally working of bed component like nozzle, heating coil, structure of system also time require for proper working of product, reclamation percentage and reclaimed sand size is observe in testing of fluidized bed combustor.

Developed system of sand reclamation is particularly used for chemically bonded no bake sand This type of foundry used sand binder is burn at temperature of $500^0$ c to $800^0$ c. during testing of system we consider temperature range $500^0$ c, $650^0$ c and $800^0$ c also holding time of sand in system and quantity of sand varies between 15 min, 20 min, and 25 min also 10 kg, 15 kg and 20 kg of sand respectively. With the help of above values optimum combination of temperature, time and quantity of sand is obtain.

We will see the test combination of developed fluidized bed combustor system by using Taguchi method is as follow

**Table -3:** Orthogonal Array with Control Factors

| test no. | Temperature (Degree c.) | Sand Holding time(min) | Quantity of sand (kg) |
|---|---|---|---|
| 1 | 500 | 15 | 10 |
| 2 | 500 | 20 | 15 |
| 3 | 500 | 25 | 20 |
| 4 | 650 | 15 | 15 |
| 5 | 650 | 20 | 20 |
| 6 | 650 | 25 | 10 |
| 7 | 800 | 15 | 20 |
| 8 | 800 | 20 | 10 |
| 9 | 800 | 25 | 15 |

According to above test sand reclaimed quantity and cycle time are as follows

**Table -4:** Testing result table

| Test no. | Quantity of sand (kg) | Reclaimed sand weight (kg) | FBC testing result | |
|---|---|---|---|---|
| | | | % weight reduction of reclaimed sand | Testing time (min) |
| 1 | 10 | 7.5 | 25 | 52 |
| 2 | 15 | 12 | 20 | 50 |
| 3 | 20 | 18 | 10 | 60 |
| 4 | 15 | 14.5 | 7 | 52 |
| 5 | 20 | 14.5 | 27.5 | 64 |
| 6 | 10 | 8 | 20 | 55 |
| 7 | 20 | 13.5 | 32.5 | 58 |
| 8 | 10 | 4 | 60 | 60 |
| 9 | 15 | 7 | 33.33 | 55 |

From above testing result table we get idea about percent reduction of reclaimed sand and time required to complete one working cycle with respect to temperature, time and sand quantity.

## 4. Results of tested fluidized bed combustor system

By using Taguchi method we get optimum result. Result obtain from Mini-tab software are as follows

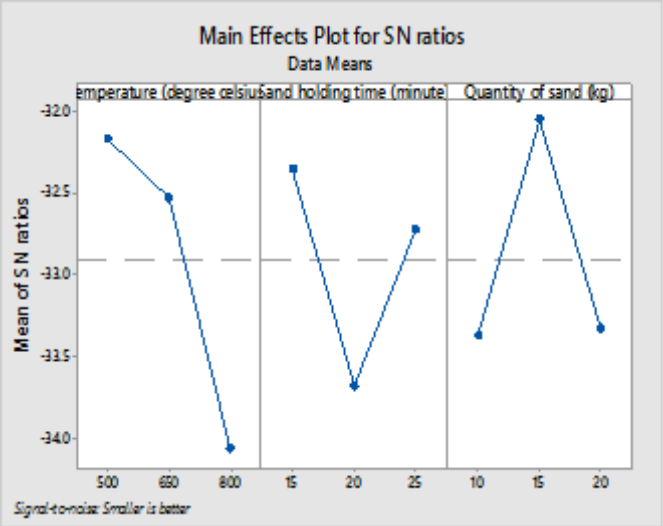


**Chart -1**: S N ratio graph for parameters

The factor levels corresponding to the highest S/N ratio were chosen to optimize the condition. From these linear graphs it is clear that the optimum values of the factors and their levels are as given table.

Optimum result obtained from various test combination here we use Taguchi method to obtain result. Result obtain by using Taguchi method is as follows

**Table -5:** Optimum values of factors and their levels

| Parameters | Temperature ($^0$ C) | Sand Holding time | Sand quantity |
|---|---|---|---|
| Optimum Value | 500 | 15 | 15 |

By testing this result parameters combination on actual setup we get,

**Table -6:** Optimum result from setup test

| % weight reduction of sand | Testing time(minute) |
|---|---|
| 18.66 | 55 |

**Table -7:** Reclaimed sand properties

| | |
|---|---|
| gfn No. | 49.64 |
| VM | 1.6% |
| LOI | 2.8% |
| Total clay | 0.540% |

Testing of fluidized bed combustor gives results like optimum temperature, time and sand quantity combination by using Taguchi method also suitable grain size for foundry application are obtained by testing fluidized bed combustor.

Following table shows the tested reclaimed sand grain size

**Table -8:** Reclaimed sand grain size

| Test no. | Reclaimed sand Grain fineness number |
|---|---|
| 1 | 45.55 |
| 2 | 52.23 |
| 3 | 45.64 |
| 4 | 47.8 |
| 5 | 46.9 |
| 6 | 45.47 |
| 7 | 59.12 |
| 8 | 56.87 |
| 9 | 53.25 |

Tested optimum combination grain fineness number is 49.64

The standard grain size of foundry sand ranges from 240-500 microns, ie 35-55 gfn

Our reclaimed sand grain size in the range of 240 µm to 500 µm so reclaimed sand is suitable for reuse as foundry sand.

Also the time required to achieve temperature from atmospheric temperature to 500, 650, and 800$^0$ C are as follows (without foundry sand i.e empty chamber)

We use 9 kw heating coil to achieve temperature. Average required time to achieve temperature vary according to atmospheric temperature.

**Table -9:** Time to obtain required temperature

| Sr no. | Temperature | Average required time ( form 20$^0$ C ) |
|---|---|---|
| 1 | 500 | 40 |
| 2 | 650 | 65 |
| 3 | 800 | 90 |

## 6. CONCLUSION

1. For the design of fluidized bed combustor for 20 kg of sand, numerical calculations and selection are done by using formulas and relations also some changes according availability, economy and safety. Inlet and outlet pipe diameter, insulation thickness, nozzle length and small cut for air outlet also changed according to availability, safety and efficiency.
2. The designed fluidized bed combustor is tested on manufactured setup with Taguchi method. Orthogonal array L9 are set for temperature, time and sand quantity for optimum result of fluidized bed combustor.
3. Tested reclaimed sand gives acceptable result for reuse as a foundry sand.

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