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An Attempt to Reduce the Time Consumed By A Gas Cleaning System Used In Steel Industry

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***Abstract*— In a steel industry there are LD shops where conversion of steel from molten hot metal takes place. During decarburization process, a large amount of off gas are released which is stored in gas holder or released to atmosphere after burning. For the cleaning purpose of the off gases, gas cleaning system is used which requires monthly cleaning.**

The cleaning time of gas cleaning system takes almost 16 hours. During this period the plant is kept shut down and production remains closed.

In the present work it has been attempted to provide a method which can overcome the problem of monthly cleaning. The activities, which takes place during cleaning process has been studied and completion time of each activities has been calculated by CRITICAL PATH METHOD (CPM). The activities which take longer time, has been listed.

A slight change in design of gas cleaning system can eliminate this problem. A magnetic field region is provided in the hood, which attracts the magnetic particles and a considerable amount of particles are filtered at the entrance. Hence only small percentage of particles passes through the cleaning system and hence its monthly cleaning can be extended to 2 months and simultaneously productivity increases.

***Index Terms*— critical path method, decarburization, magnetic field, off-gases**

I. INTRODUCTION

Starting from iron ore, BOF crude steel is produced via the production of hot metal in a blast furnace and its following conversion to crude steel in a basic oxygen furnace.[1]

The operation of a top-blown BOF is as follows: a supersonic oxygen jet is blown onto the surface of the molten iron through a water-cooled vertical lance. [2]. As top-blown oxygen reaches to the surface of the liquid bath, it reacts with carbon dissolved in the metal and forms a mixture of CO and CO_2 gases as product. .[3]. These gases also contains huge amount of impurities. Thus, the off-gas stream cannot be directly discharged into the atmosphere, due to pollution considerations. The off-gas stream also has a substantial heating value, and may be employed as fuel.[4]. For this purpose the released off gas has to be cleaned first and accordingly a gas cleaning system is provided.
The hot process gas leaving the basic oxygen furnace (BOF) vessel mouth, which is heavily laden with iron oxide dust particles as well as other particles from the slag, flux charge and hot metal, will be collected by the movable skirt of the lower hood, flow up the hood under the influence of ID fan and cooled down to approximately 100℃ at the cooling stack outlet. Then the gas will pass initially through the water spray section, the quencher, where the temperature will be reduced to 75℃ and a large portion of the particulate will be removed. The design of the quencher is such as to eliminate back flow of scrubbing water into the cooling stack.

Following the quencher, the gas will pass through an adjustable throat venturi scrubber and a moisture separator. Here the remaining of the particulate and the excess water will be removed.
The cleaned gas will be discharged to the atmosphere through a clean gas stack equipped with a flare burner head with pilot burner or recovered via the gas switch over station into the gas holder. The scrubbing water will carry the removed dust via an open through to the water treatment facility as a slurry.
The gas cleaning and discharge system is monitored by the concerned instrumentation equipment.
The control of the total gas flow in the suppressed combustion system is made by closing the gap between the vessel and the inlet of the hood by means of a movable skirt, which is lowered to the vessel mouth during the process. This reduces the entrance of combustion air while enhancing the collection of process gas and ducts emitted from the vessel mouth.
When the movable skirt is lowered down to vessel, the access of air to the gas is reduced but the negative pressure control will maintain the desired gas flow rate regardless of the skirt position.

The gas discharge system consists of an ID fan and the flare stack. The ID fan which is situated downstream of the scrubber tower provides the required draft for extracting the converted waste gases through the cooling stack. The main fan is driven by 6.6 KV motor and the speed control is performed by a hydraulic coupling.

During idle period, the hydraulic coupling of the ID main fan motor sets the fan in low speed to minimize the power consumption of the HT-motor.

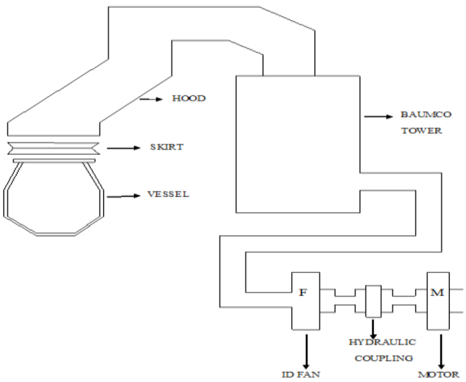

Fig. 1. Schematic view of a gas cleaning system

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II. CALCULATION

After calculating the total completion time of each activity during cleaning of the gas cleaning system, it is tabulated below:

Table: 1.

Sl No.	Activity	Time(hours)
1	ID fan	15.5
2	Slag car	5.25
3	Tapping side door	5.75
4	Charging side door	3
5	Tilt drive	2
6	Ferro alloy	4
7	OLP	1
8	Wire feeder	1
9	Monocon	1
10	Ferro alloy	2
11	Skirt hydraulics	2
12	Flux system	8.5
13	Baumco tower	13

The Pareto chart of above table is as shown below:

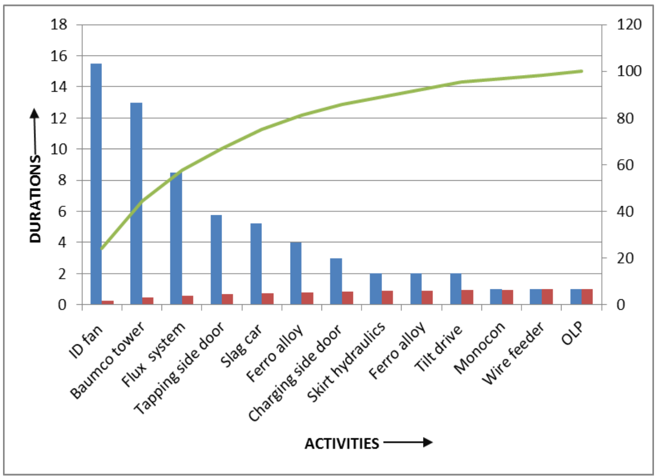
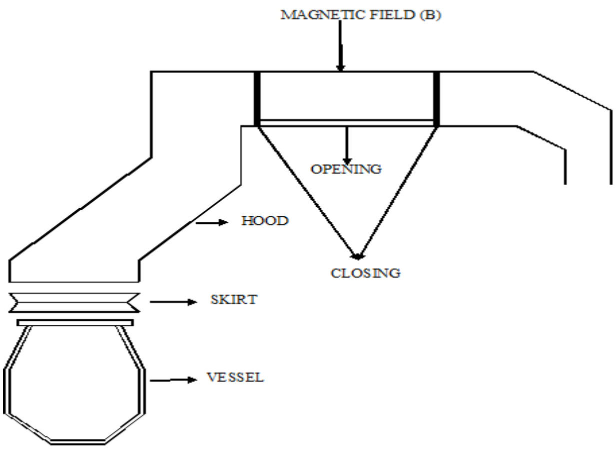


Fig. 2.Pareto chart of all activities during cleaning period

III. SUGGESTED CHANGE IN DESIGN

A simple change in design of hood can create a large difference and extend the monthly cleaning process by 2 months. Following change in design has been suggested in order to filter the magnetic particles:



An electromagnetic field will be applied into a portion of horizontal part of the hood as shown in fig. As the off-gases pass through it, it will attract magnetic particles. As major portion (about 40%) of particles are separated here, only those particles, which are non-magnetic, will move forward. Thus rest portion of the cleaning system will come into contact with lesser amount no. of dust particles. Thus it will not require monthly cleaning.

An opening has been provided at the below portion of the hood, as shown in fig. When the amount of ferrous particles exceeds the limited value, the closing of both ends closes the flow of gas and opening door will be opened. The magnetic field will be removed by power cut off. Thus the ferrous particles, which were attracted by magnetic force, will fall down due to force of gravity. This process should be done during non-blowing period because during that period flow of gas will be minimum.

Here in the design a horse shoe magnet with required capacity has been attached to the horizontal portion of the hood. There are two major reasons for attaching the electromagnet in this area:

(i) Due to the horizontal face, when there will be power cut off, the major portion of particles will be fall vertically downward due to force of gravity.

(ii) Below that portion the temperature of the gas and particles are very high (above Curie Temp) which affect the magnetic property of the particles.

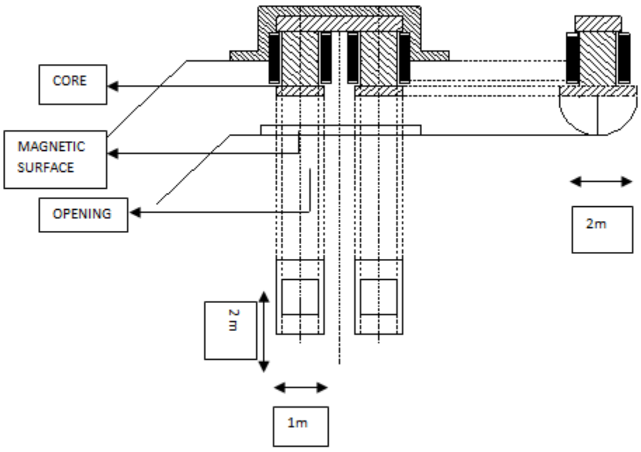


fig.3. change in design of the hood with magnetic field implementation

IV. CALCULATION OF THE REQUIRED MAGNETIC FORCE:

Gas inlet at the hood = 83000 m^3/h

= 1383 m^3/min

Amount of dust particles in the inlet gas = 230 gms/m^3

40 % of these particles are magnetic particles.

Thus, magnetic particles passing per m^3 through the hood

= 230×0.4

= 92 gms/ m^3

Magnetic particles passing per minute through the hood

$= 92\times1383$ gms/min

= 127236 gms/min

= 127.236 kg/min

Magnetic particles passing through hood during blowing period (16 min) = 127.236×16 kg

= 2035.8 kg

Magnetic force required to hold these particles

$= 2035.8\times9$

= 19971 N

=19.71 KN

= 20 kN (approx..)

V. DESIGN OF ELECTROMAGNET

Surface area = $2\times1\times2$ (for two surfaces)

$= 4\ m^2$

The magnetic force can be given by the formula

$F = B^2 \times A/2\mu_0$

Where, B = magnetic flux density (wb/m^2)

A = Magnetic surface area

μ_0 = permeability of air = $4\pi \times 10^{-7}$

Equating the above two forces we get,

$20{,}000 = B^2 \times A/2\mu_0$

Where,

$A = 4\ m^2$

$\mu_0 = 4\pi \times 10^{-7}$

Putting these values we get,

$B^2 = 0.0126$

B = 0.112 wb/m^2

Magnetic flux density B = μ_0 H

Therefore , H = B / μ_0

H = 89127 A/ m

Where H = magnetizing force

H = NI / L

Where, N = no. of windings

For a magnet with no. of winding N = 3000 and length of magnetic circuit L = 1.5 m,

$89127 = 3000 \times I / 1.5$

Thus, **I = 44.5 A**.

Thus a horse shoe magnet with magnetic surface area of **4 m^2**, magnetic circuit length of **1.5m** and **3000 turns** with a current of **44.5 A** can be used for the above purpose.

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