Importance of optimum moisture in Sinter raw mix to increase the Sinter strength

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ABSTRACT:

Development of basic infrastructure is the key to the growth of a Nation and Steel industry is a part and parcel of it. To establish the most modern sintering plant in the sub-continent, deliver super-fluxed sinter fulfilling the requirements of customer in terms of quality, quantity, and cost and optimize recycling of all solid wastes. Thus, contribute towards resource conservation. The main challenge faced by any sinter plant in the present scenario is minimization of sinter return generation and optimization of moisture in sinter raw mix to increase the productivity. Optimum moisture is solely responsible for the formation of best granules to increase the sinter permeability. Previously carryover moisture for individual material is measured manually except for coke and resultant carryover moisture is calculated based on individual material flow rate. Set value for the water addition is calculated by considering the initial moisture in the raw material and the required moisture. If moisture control does not function properly then there are chances of more water addition and formation of slurry raw mix.

Presently carryover moisture for individual material is measured OFF-LINE except for coke and iron ore is measured ON-LINE. As it is observed that for Sinter making iron ore is the most important material and it also contributes more than 75% of carryover moisture in the sinter mix. Hence any variation of moisture in Iron ore fines plays a major role in resultant carryover moisture in sinter raw mix. Once carryover moisture is known, then better moisture control can be achieved through feed forward and feed back control. Thus we are able to convert non-linear control system to a perfect linear control system. Further modifications will be done in our future work, using Genetic algorithm. The task of genetic algorithm is to find optimal model parameters for each process.

Keywords:

Burn through point, Permeability.

1 INTRODUCTION:

Sinter plays a vital role in Iron making particularly when quality and cost of hot metal production are to be kept in focus. The main purpose of sintering is to convert weakly bound granules into a partially fused porous sinter cake suitable for feeding to the blast furnace. Historically, sintering of iron ore was developed as a means to utilize the iron ore fines which otherwise cannot be directly charged into the Blast Furnace. The function of the Sinter Plant is to supply the blast furnaces with sinter, combination of blended ores, fluxes and coke, which is partially 'cooked' or sintered. In this form, the materials combine efficiently in the blast furnace and allow for more consistent and controllable iron manufacture.

Fig:1 shows the simple form of Sintering plant where materials enter the sinter plant from storage bins. They are mixed in the correct proportions. The weighed materials pass along a conveyor belt to the mixing drum where water is added. Water is added in order to assist the raw mix in obtaining optimum permeability for achieving higher sinter strength and lower electricity consumption. This sinter raw mix material is fed onto the strand from the hopper by a roll feeder and is ignited from top using mixed gas (coke oven gas, blast furnace gas and sometimes natural gas) of constant calorific value. Suction is done from the bottom at 1400 mm WC; this helps in traveling the burning zone in the vertical direction. The progress of the process and the speed of the sinter machine must be coordinated, such that the process finishes at a predefined position at the end of the sinter strand called Burn Through Point (BTP).

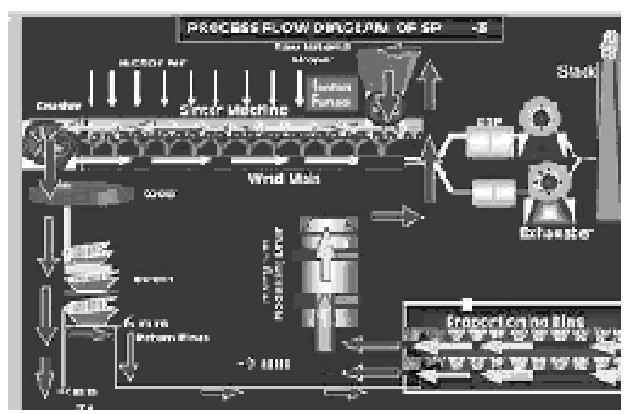

Figure:1 Simplified form of Sinter plant

The burn-through point, it is the point where the burning zone touches the bottom layer of bed material. Cooled sinter is screened and is classified as sinter product, hearth layer and sinter return. Undersized sinter which is not suitable for blast furnace is recycled to the return fines bin. A certain quantity, usually 15-25 mm is screened out, and is serves as a hearth layer, protecting the great bars of the pallets during the sintering process. For environmental safety or for effective dust collection an Electrostatic precipitator (ESP) is used. The moisture in the raw mix is one of the most important parameter for improving the quality and quantity of the sinter by stabilizing the burn through point. Optimum moisture in the sinter raw mix plays a key role for the balling effect (formation of balls) inside the mixing cum nodulising drum. If moisture in the raw mix is low, then formation of balls will not take place and similarly if more then optimum moisture is added to the raw mix then formation of slurry will take place and again it will reduce the permeability. Hence running the sintering machine at an optimal and constant speed is possible only if optimum moisture level is maintained in the sinter raw mix.

2 PROCESS CONTROL MODEL FOR MOISTURE

2.1 Initial Moisture calculation:

Lets assume that total material required is 692tons/hr effective moisture in raw material is calculated as given below:

2.2 Table1: Initial Moisture Calculation

Raw Materials	Material quantity in tons/hr	Initial Moisture in each raw material (%)	Individual effective moisture (%)	Individual moisture present in Sinter raw mix (%)
Iron Ore	359.4	7.4	3.84	((3.84 /4.85)*100) =79.2
Mill scale	0.0	5.0	0	0
Burnt Lime	6.7	0.0	0	0
Return Fines	154.3	0.0	0	0
Flux	111.5	2.2	0.3544	((0.3544/4.85)*100) =7.3
Flue Dust	0.0	10.0	0	
Coke	36.6	12.46	0.659	((0.659/4.85)*100) =13.58

Total carryover moisture is equal to sum of effective moisture (3.84 + 0.3544 + 0.659) is 4.85 %.

2.3 Description of Past Scheme:

The individual moisture is measured manually except for coke, which is measured online. The carryover moisture for all the material is calculated as shown in above Table1. It is experimentally proved that the permeability is best if the moisture in the raw mix is between 7 to 8%. The set value of moisture required in raw mix is fed by the operator as per requirement. Water flow set point is generated based on the set value given by the operator and the carried over moisture present in the material.

2.4 Set point calculation for Past scheme

Except for coke moisture, all other raw material's moisture was measured off-line by collecting sample in every 8 hrs. Weight of wet sample was taken and again weighing was done after drying the sample in the oven. The difference in the weight is the amount of moisture present in that particular sample. Calculation of additive moisture is dependent on required moisture and initial moisture present in the material. Mathematical Equation is used for set point calculation of water addition.

2.5 Mathematical Equations are:

$A_M = (Q_M / (Q_M + X))*100$

$A_M = (SV_M - B_M)$

From above Equations

$SV_M - B_M = (Q_M / (Q_M + X))*100$

$(SV_M - B_M)*(Q_M + X) = Q_M*100$

$(SV_M * Q_M - B_M * Q_M + SV_M * X - B_M * X) = Q_M*100$

$(SV_M * X - B_M * X) = Q_M*100 +$

$B_M * Q_M - SV_M * Q_M$

$(SV_M - B_M)* X = Q_M*(100 + B_M - SV_M)$

$Q_M = (SV_M - B_M)* X / (100 + B_M - SV_M)$

$X = T_D + X * B_M$

$X - X * B_M = T_D$

$X (1- B_M) = T_D$

$X = T_D / (1- B_M)$

From above equations

$Q_M = (SV_M - B_M)* T_D / (100 + B_M - SV_M)*(1- B_M)$ or $Q_M = (SV_M - B_M)* X / (100 + B_M - SV_M)$

$Q_1 = ((SV_M - B_M)* T_D / (100 + B_M - SV_M)*(1- B_M))*\alpha$

$Q_2 = ((SV_M - B_M)* T_D / (100 + B_M - SV_M)*(1- B_M)) *(1- \alpha)$

Where

Q_M	=	Total additive water (T/H)
SV_M	=	Moisture Set Value (%)
B_M	=	Carried over moisture (%)
X	=	Total feed set rate (T/H)
A_M	=	SV_M - B_M (%)(want additional moisture more
T_D	=	Total dry feed rate
Q1	=	Water addition at Inlet (Mixing Part)
Q2	=	Water addition at Outlet (Nodulising Part)
α	=	The additive water ratio from inlet (0.6)
PV_M	=	Process Value Moisture

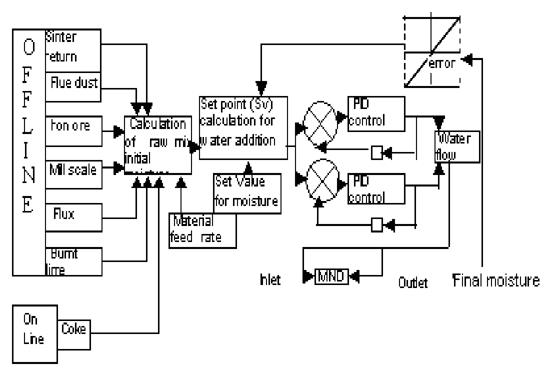

Figure 2: Past scheme for water addition in MND

Separate PID feedback control block has been used for both inlet and outlet. 60% of the total water is added from inlet and 40% of the water is from outlet of the MND as shown in fig:2 Continuous monitoring of final moisture present in sinter raw mix is measured with the help of Infrared moisture sensor installed after MND. If ($Sv \neq Pv$) then there will be incremental change in the set point of water addition else no need of adding water. As the effect of water addition in the MND is observed only after 7-8 minutes by moisture sensor installed at the outlet of MND but the loop is continuously checking the difference between the set point and final moisture and PID action is taken. Due to this there is a time lag of 7-8 minutes. Thus fluctuation occurs due to time lag in water addition and moisture measurement.

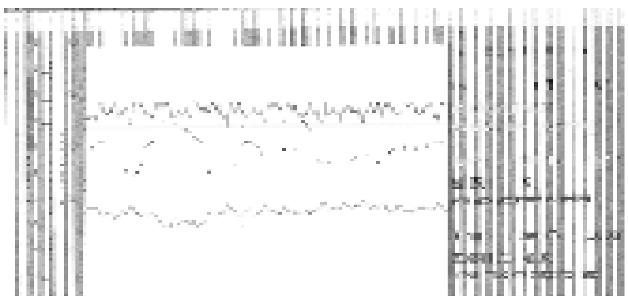

Figure 3: Results observed after water addition for Past Scheme

From Fig. 3 it is observed that due to the time lag difference between (S_V - Pv) creates lot of fluctuations. These fluctuations are shown in Green colors (Pv) Yellow color (S_V). To avoid these fluctuations it was suggested to measure ON-LINE moisture for both Iron Ore and Coke.

2.6 Description Of Present Scheme

The present scheme is the improved version of past scheme, where both iron ore and coke moisture is calculated on-line by using moisture sensor installed in the field as it has been proved that 85% to 90% of initial moisture is due to coke and Iron ore fines and rests all other raw materials moisture is measured and fed off-line. In this scheme we are installing two Moisture sensors for measuring moisture present in iron ore of 8 bunkers and denoted by M1 and M2.If both moisture sensor are OK then (M1+M2)/2 and if M1 sensor is faulty then take the reading of M2 moisture sensor else vice versa. As shown in Fig4 Two separate PID controllers with feedback path (F) are used to check the flow of water in the MND. Let error E =Sv-Pv

If $L1<E<L2$ then, water added =0,

If $E>H1$ then add a constant k

Again, if $E<H2$ then, subtract constant k

The amount of water added in constant limit as $\{T_D * (S_V - PV_M)\}/\{(100-(S_V - PV_M)\}$

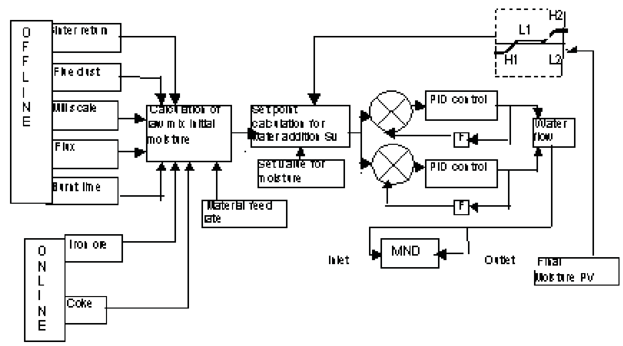

Figure 4: Present Scheme for water addition in MND

In Present Scheme, by installation of Moisture Sensor for Iron Ore and Coke the carry over moisture are not taken as any arbitrary value. The IR Sensor gives the result of final moisture present in raw mix after water addition in 7-8 minutes. So until and unless the difference (S_V - PV_M) is within the specified range, water is added up-to certain limits. After implementing the new scheme moisture fluctuation has been reduced to large extent and now it is more or less under the permissible tolerance limit as shown in Fig.5

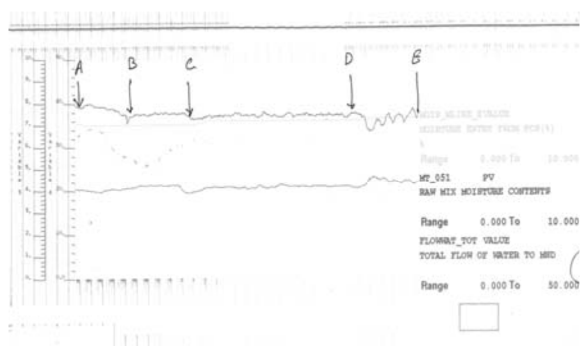

Figure 5: Results observed after water addition for Present Scheme

3 CONCLUSION :

With the implementation of new scheme sinter strength improved and sinter return generation goes down, thus converting a non-linear system into linear system.

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