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Consumption of Desulphurization compound in a steel plant – VE approach

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Abstract

In order to meet the final level of Sulphur in finished steel, it is normally removed in basic oxygen furnace during steel making. Such a process puts an unnecessary level on basic oxygen furnace. Such a process puts an unnecessary load on the basic oxygen furnace. The alternative of this is to produce low Sulphur hot metal, but world over such practices have not been found to be cost effective. It has been established that desulphurization of the metal prior to its introduction in the basic oxygen furnace is the optimum method of Sulphur removal. The optimization of quantity of chemicals used for desulphurization is the subject of this study.

Introduction:

External Desulphurization of hot metal

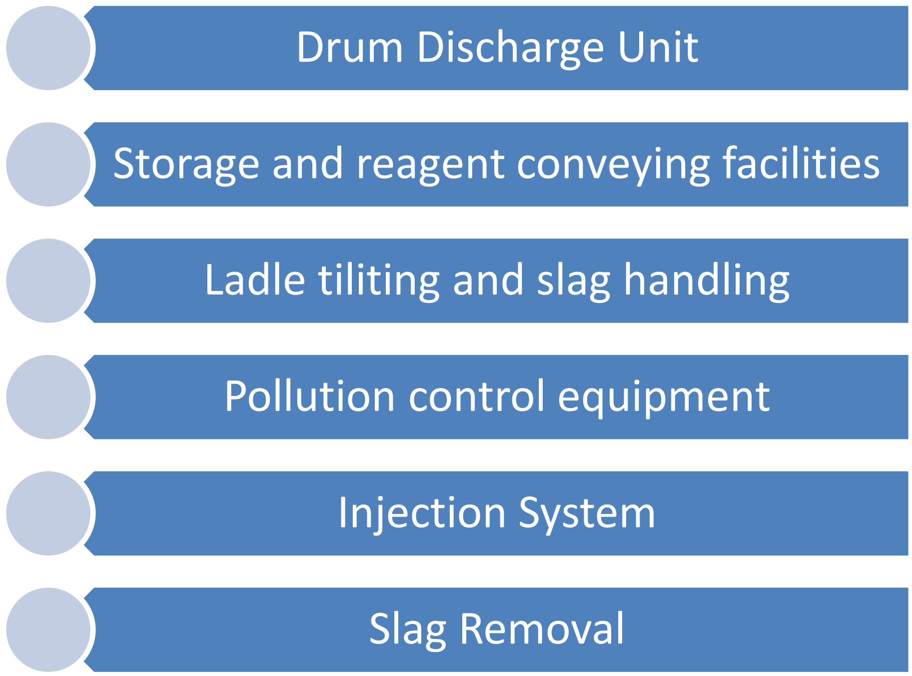
Steel making shop #1 has an external desulphurization unit. The process of desulphurization involves the injection of essentially calcium carbide through a top blown lance into the ladle of hot metal. The composition of the powder is shown in the table below.

Item	Analysis
CaC_2	55 - 60 %
$CaCO_3$	15 - 20 %
CaO	10 - 15 %
Free C	3 - 4 %
Rest	Balance

Brief Description of the present System

ISSN:0971-1260
Vol-22-Issue-37-December -2019

External Desulphurization of hot metal for production of quality steel is now an essential process for an integrated iron and steel plant. The facility is also expected to help blast furnaces in improving performance in terms of productivity and coke rate. The hot metal desulphurization plant was commissioned at Steelmaking shop#. The technological knowhow was supplied by the Thyssen Engineering. The following facilities have been provided in the plant and a schematic layout has been shown in Figure 1.



The ladle to be desulphurised is placed on the tilting stand and the fume hood is lowered subsequent to this ladle is tilted and the blast furnace slag is skimmed off using the slag raking machine. After the raking is complete the ladle is tilted back to the vertical position and temperature, sample is taken. The analysis of the sample obtained is done for the Sulphur in the unit itself. The input Sulphur value is fed to the P.L.C through the operating console which decides the amount of injecting required based on the weight of the hot metal and the final Sulphur required. After this the injection process is started using a command given through the operating console. Once the specified amount of regent has been injected the injection automatically terminates. After the injection is complete the ladle is again tilted and the process slag generated is again skimmed off. Once the skimming operation is complete another temperature and sample is taken to check if the aim Sulphur has been achieved. Subsequent to these operations the fume hood is lifted and the ladle of hot metal is released for steel making operation

ISSN:0971-1260
Vol-22-Issue-37-December -2019

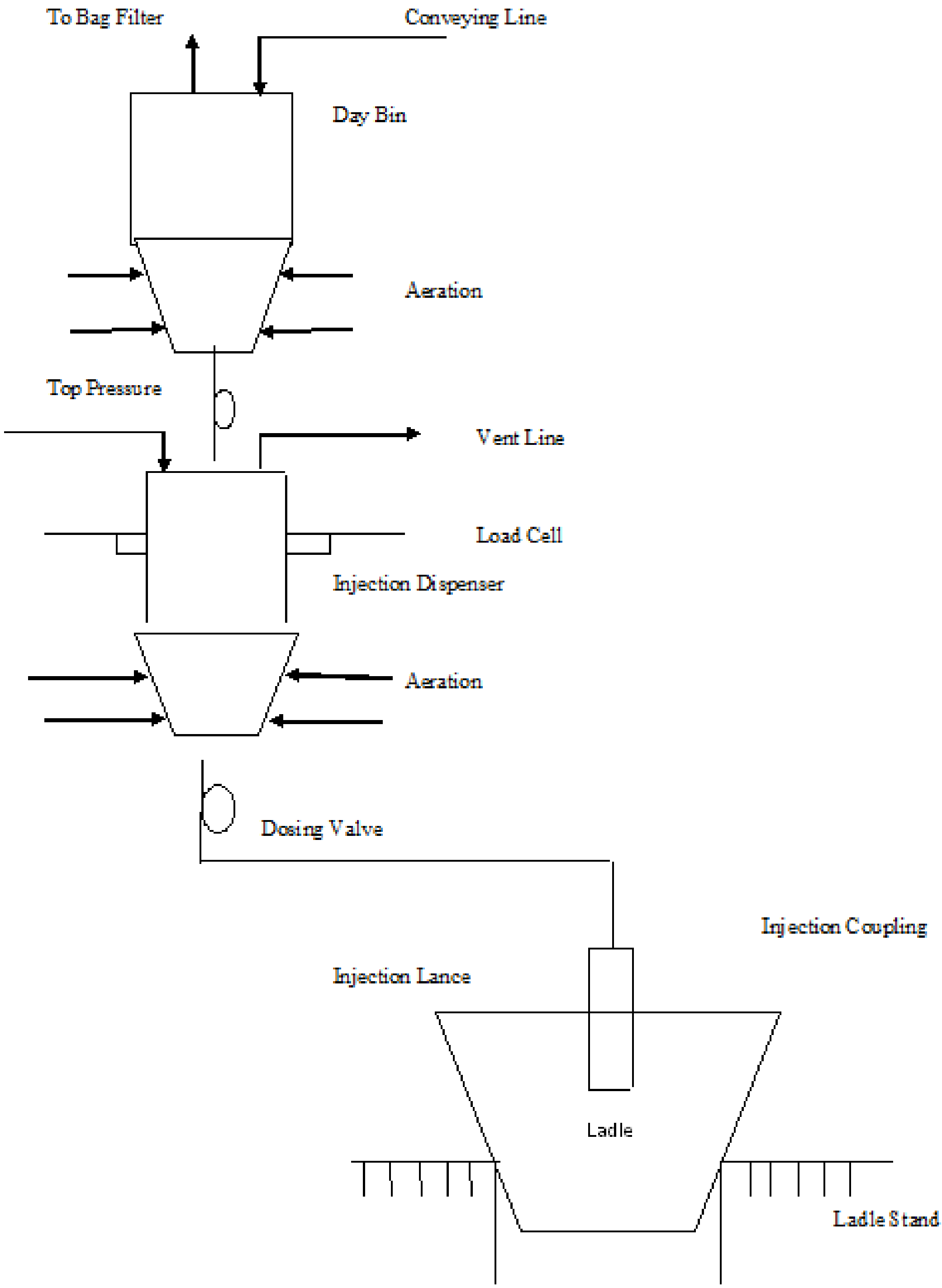


Figure 1 : Schematic of the Injection System

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Information Phase

Data Analysis

Data was collected for a period of six months prior to the start of the investigation. Relevant performance indices were calculated and tabulated for easy reference as shown below. It should be noted that only very specific data is being depicted while the actual analysis was carried out on a larger data set.

A few selected data has been shown in the form of a graph in the figure 2

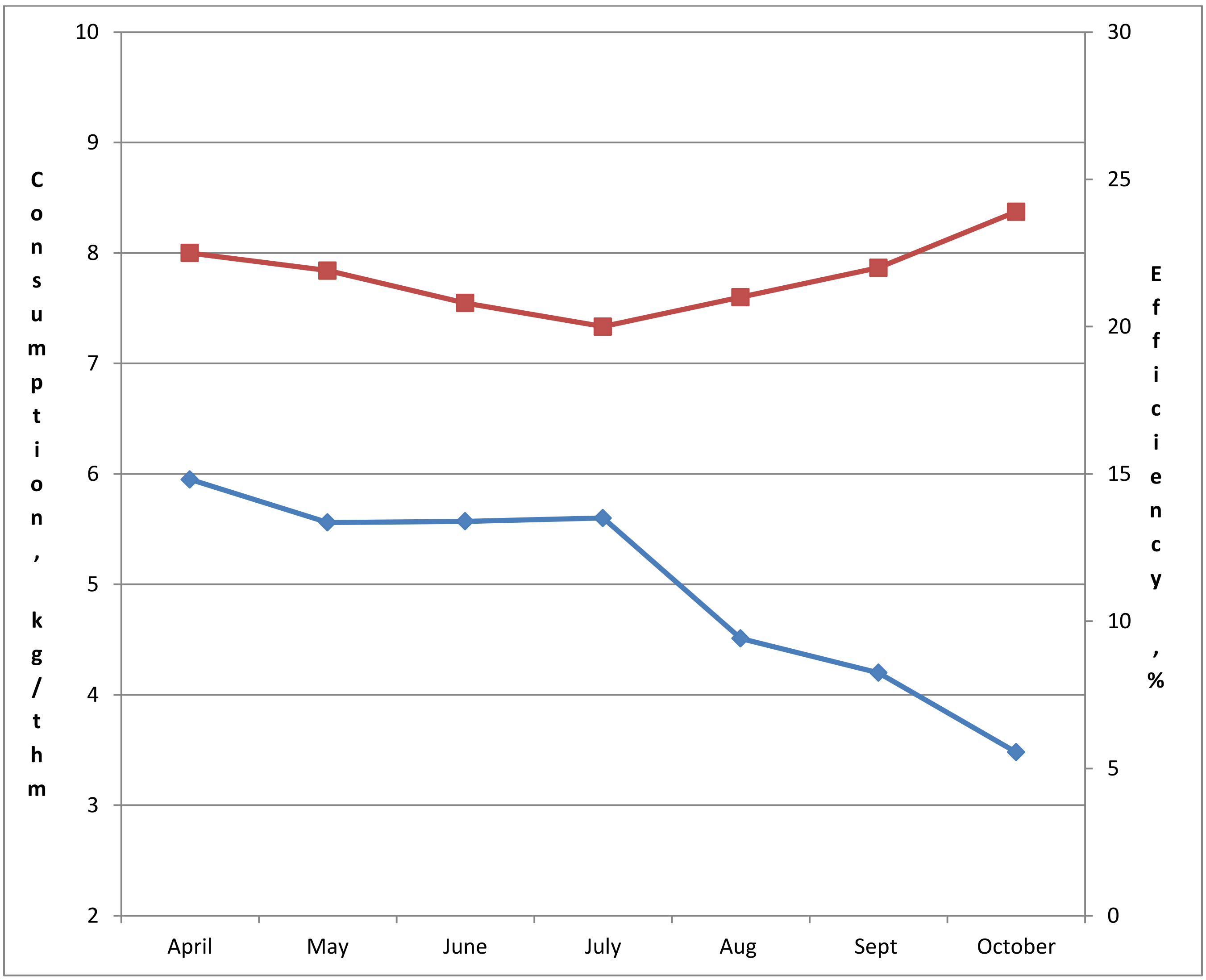


Figure 2. Performance of D.S unit

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Factors affecting High consumption

Various factors contribute to the consumption of the D.S powder and the relevant ones are shown in the table below.

1.0	Flow Rate of Injecting gas
2.0	Flow rate of powder
3.0	Quality of calcium carbide and granulometry
4.0	Material losses through leakage
5.0	Initial hot metal Temp.
6.0	Initial hot metal Sulphur

Out of the above six factors as numbered will be studied.

Functional Phase

Functional Analysis Component wise

The component wise analysis is shown in the table below :

S. No	Component	Function		Basic / Sec
		Verb	**Noun**	
1	D.S compound addition	Facilitates	Desulphurisation	B
		Facilitate	Mixing	S
		Creates	Turbulence	S
		Improve	Efficiency	S
		Reduces	Temp	S (u)
		Consumes	Compound	S (u)
		Increases	Cost	S (u)
2	Flow Rate of transport Gas	Transport	Powder	B
		Facilitates	Residence time	S
		Cleans	Jams	S
		Reduces	Temp	S
		Increases	Consumption	S
3	Quality of Calcium Carbide	Facilitates	Desulphurisation	B
		Causes	Jams	S
		Increases	Consumption	S
4	Material Leakage	Increases	Consumption	B
			Environment	S
			Safety	S

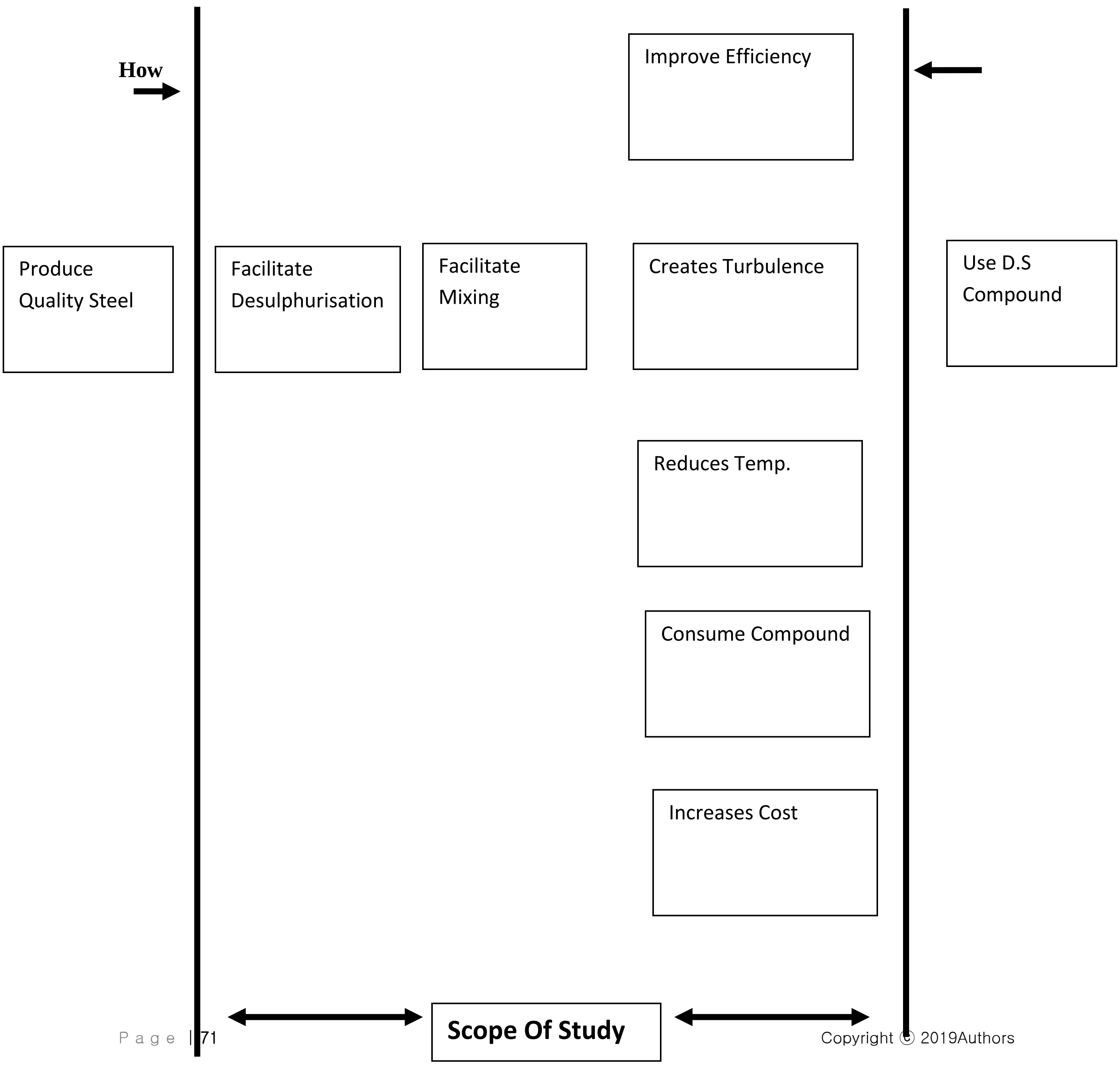
Function Cost- Worth Analysis

The cost worth in lakhs is shown in the table below

ISSN:0971-1260
Vol-22-Issue-37-December -2019

S.No.	FUNCN	Allocated Cost	Worth Cost (W)	Basis for Worth	V.Gap (C-W)	V-Index C/W
1	Facilitates desulph	50	41.2	Consume 15 % less.	8.8	1.2
2	Facilitates mixing	3	0.50	Alternate process	2.5	6.0
3	Creates turbulence	5	2	Simply purged N2	3	2.5
4	Improve Efficiency	50	40	Less powder consumption	10	1.25
	Total	108	83.7		24.3	1.29

Fast Diagram for D.S Compound Addition



ISSN:0971-1260
Vol-22-Issue-37-December -2019

Creative Phase

Function to be performed

A brain storming session was conducted to find out various ways to reduce the consumption of desulphurization compound and about twenty ideas were generated. Out of this the following ideas were selected for further study.

- Inject less amount of D.S compound
- Use powder with higher CaC2 Content
- Reduce nozzle size of closing valave
- Reduce wastage
- Increase transport gas flow
- Reduce flow rate of CaC2
- Increase hot metal temperature
- Reduce sulphur in hot metal
- Increase Fluidisation of CaC2
- Improve de-slagging
- Introduce co-injection
- Reduce CacO3 In powder

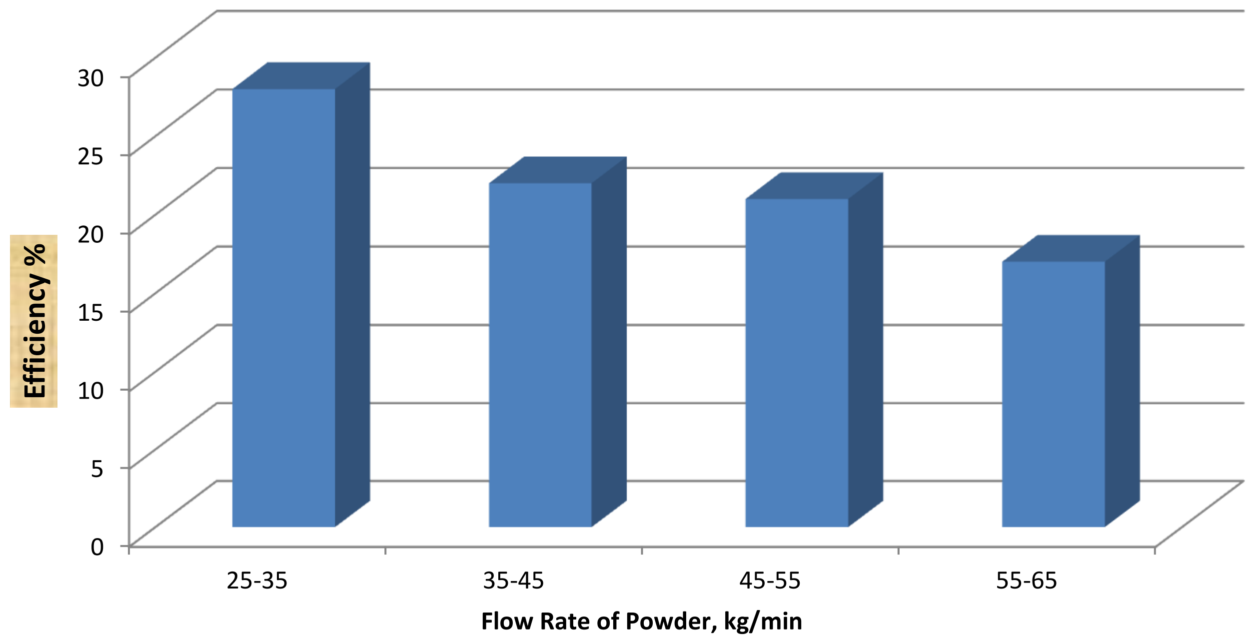
Some items were further studied with the help of the statistical analysis of plant data. It was found as shown in Figure 3 that the efficiency of the powder usage is strongly linked to the flow rate of the powder. The apprehension that the lower flow rates would adversely affect the cycle time was allayed by showing that increased efficiency of powder usage would reduce the total amount of powder to be injected, keeping the injection period more or less unaffected.

The following list of recommendation needs to be implemented**.**

Item	**Action**
Flow Rate of Powder	Reduce flow rate from 55 kg/min to 35 kg/min
Quality of CaCO3	Reduce CaCO3 from 17 % to 13 % in DS compound Obtain clean material to control granulometry
Material Leakage	Reduce from 0.1 % to 0.07 %

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Fig 3 : Dependence of the efiiciency on the flow rate of powder



Evaluation Phase

Identification of Criteria for selection

Identity	Criteria	Score	Rank
A	Ease of Implementation	1	IV
B	Reliability	6	II
C	Maintainability	3	III
D	Safety	7	I

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Paired Comparison

	B	C	D	Score
A	B3	C2	D2	0 + 1 =1
	B	B2	D1	5 + 1 = 6
		C	D3	2 + 1 = 3
			D	6 + 1 = 7

Decision Matrix

Desired Criteria		**Ease of implementation**	**Reliability**	**Maintainability**	**Safety**	**Score**
Proposal	**Weightage for criteria**	**A**	**B**	**C**	**D**	
		1	**6**	**3**	**7**	
1. Flow rate of powder		5/5	5/30	5/15	3/21	71
2. Quality of CaC2		3/3	5/30	3/9	4/28	70
3.Material Leakage		4/4	3/8	4/12	5/35	69

(Note : Scale Excellent 5, Very Good 4 , Good 3, Fair 3 , Poor 1)

Recommendation Phase

Recommendation

Short Term : The following short term measures need to be adopted

1. Reduce flow rate of powder from 55 kg/ min to 35 kg/ min by adopting the following steps :

- Reduce nozzle size of dosing valve from 16 – 18 mm to 12 - 14 mm.
- Increase the aeration in the aeration pad/cone value / dosing valve by regular cleaning of pipes.
- Ensure uniform flow of transport gas by increasing the top pressure.
- Introduce regular cleaning of impulse line and back blowing of injection dispensers.
- Reset close loop data by an iterative process.

2. Reduce $CaCO_3$ from 17 – 20 % to 13 _ 15 %

3. Reduce material leakage from 0.1 % to 0.07 % by adopting the following measures.

- Controlling the granulometry of the D.S compound.
- Increase the aeration in the aeration pad/ cone valve / dosing valve fo improved fluidization.

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Long Term : Adequate availability of dosing valve, three way valve and distribution valave should be ensured.

Implementation plan was made and implemented timely.

Expected Saving

The expected savings is around 25% of the existing cost.

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