Application of Linear Programming in Carbide Plant Input Mix

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ABSTRACT

Third most widely produced polymer is Poly (Vinyl chloride). It is used in construction because of more effective than other traditional materials like copper, Iron or Wood. Calcium Carbide route is generally preferred by organizations for production of PVC. In this paper linear programming approach has been used for deciding optimal carbide plant mix. Optimal result shows that minimum cost is Rs 6.64 per kg. Carbide of quality/ grade is 311 Acetylene/kg Carbide. The application is explained by an example.

Keywords: Linear Programming, Optimization.

1. INTRODUCTION

A Fertilizers and chemicals company manufactures Urea, Caustic Soda and some other heavy chemicals. For manufacturing PVC the company uses Calcium Carbide route. Calcium Carbide is manufactured from lime and carbonaceous material in electric furnaces. The cost of different sources of lime and different carbonaceous materials vary very largely .However the furnace lining, electrical conductivity, material resistivity, permissible impurity level in carbide etc produces various constraints in the input mix for the furnace .Under the circumstances, an attempt has been made to formulate the minimum cost input mix to obtain the desired quality of carbide by using linear programming techniques.

Calcium carbide is manufactured by the reaction of Lime (CaO) with carbon in an electric furnace.

$$CaO + 3C = CaC_2 + CO$$

Or

$$2CaO + 5C = 2CaC_2 + CO_2$$

The lime is obtained by calcinations of limestone in the lime Kiln of SFC or purchased from country Kilm owners. The carbon is obtained from any of the following:

2. PROCESS

1. Petroleum Coke (Pet Coke)
2. Keco

3. Charcoal
4. SLV Coal
5. Hard Coal

The power supply of two furnaces (20 MVA and 12 MVA) is from RSEV. The process can be operated from 30%-100% capacity but best and economic operation is between 70% - 100% Carbide quality/Design Specifications:

The furnaces are capable of giving the following grade of carbide:

Grade: 311 lit Acet/kg. Carbide for which the requirements are

Effective Lime - 1.5 kg
Fixed Carbon - 0.7 kg
Electricity - 5.54 kwh

Provided

Total Moisture	5% by weight
ASH content	7%by weight
Under burnt lime	10% by weight
Furnace Load	70% capacity

In case the above conditions vary, the additional input is

Add. Input	Unit	Moisture	Ash	Underburnt
Electricity	Kwh/kg	2.71	5.00	1.34
Fixed carbon	Kg/kg	0.66	0.61	0.19
Effective Lime	Kg/kg	0.4	0.73	0.13

Mix resistivity, carbide tapping operation, crust formationand silica brick lining life have been factors constraining input mix to have

MGO	1% of total input
Carbon as charcoal	20% of total carbon material
Cas Keco	20% of total carbon material

The Acetylene quality required for avoiding VC Hanover* and Polymerization catalyst poising are

Phosphorous	0.08% of PHz
Sulphur	0.75% as H2S

3. LIME CARBON ANALYSIS

The constituents of lime and carbon vary from 10-30% from batch to batch and have seasonal factors, differences depending and source of apply. Input prices also vary as such the mix is likely to vary with change in any of the major factors given above.

However for the present formulation and determination of mix the analysis of the existing lots of raw material and their costs have been considered.

Input Sources	Elect.power	LIME			CARBON			
Constituents	RSEB	Own Kiln	Country Kiln	Pet Coke	Keco	Charcoal	Slv Coal	Hard Coal
	1	2	3	4	5	7	7	8
Effective lime (L)	-	82.9	64.9	-	-	-	-	-
Fixed Carbon ©	-	-	-	-	88.3	75	65.2	59.2
Electricity (E)	100	-	-	-	-	-	-	-
Moisture(M)	-	-	-	5.1	6.1	10	4.7	7.2
Ash (A)	-	5	5	1.3	11.1	12.3	21.8	38.8
Underburnt (U)	-	10	30	-	-	-	-	-
Phosphorous (P)	-	0.002	0.002	0.02	0.005	0.12	0.1	0.01
Constituents	RSEB	Own Kiln	Counter Kiln	Pet Coke	Keco	Charcoal	Slv Coal	Hard Coal
	1	2	3	4	5	7	7	8
Sulphur(S)	-	0.1	0.01	1	1	0.2	0.4	0.4
Mgo (G)	-	-	-	0.1	1	0.8	0.3	0.3
Rates/unit (Rs)	0.83	0.7	0.85	3.2	1.9	2.8	1.1	1.4
Variables (unit quantity)	XE	XKO	XKC	XP	XL	XC	X	XH

4. REMARKS

Constituents do not add up to 100% as other irrelevant/insignificant constituents have been omitted.

Constraint Evaluation:

Weight is measured in kg and Electricity is given in kwh. Various constraint percentages have been expressed in KGS.

Approximate Quantity of Input:

Lime: The workable mix of own kiln and country kiln having effective lime of 79% is usable. Thus

Lime quantity = 1.5/0.79= 1.898

Carbon: carbon mix having fixed carbon of 63% as usable

Carbon = 0.7/ 0.63 = 1.111

Total weight of input: 1.898 + 1.111 = 3.009 kgs or 3kgs (approx.)

For correct quality of input having moisture, ash and underburnt upto maximum limit to use mionimum effective lime, fixed carbon and electricity will be as follows:

Moisture: 5 % of 3 kgs= 0.15kgs

Ash 7%of 3kgs = 0.21kgs

Under burnt: 10 % of 3kgs = 0.3 kgs

The other *output constraints are

MGO: 1% of 3 kgs = 0.03 kgs

Phosphorous: 0.08 %of output

3 kgs of input gives one kilogram carbide and balance as sludge/ crust and gas.Sludge/crust is 1.28 kg/kg pf carbide. Therefore in a.28 kg input will produce 0.08%P i.e.

(3 x 0.08%)/ 1.28 = 0.00188 kg P

It is assumed that P will evenly go as PH3 Ash and remain in carbide sludge/crust.

Similarly Sulphur S = 0.75%of output = (3 x 0.75%)/ 1.28 = 0.0175 kgs

Linear programming problem formulation for decision making

Objective Function:

Min.(Total cost)Z $=R_1X_E + R_2\ X_{KO} + R_3X_{KC} + R_4X_P + R_5X_L + R_6X_C + R_7X_S + R_8X_H = 0.83X_1 + 0.7X_{KO} + 0.85X_{KC} + 3.2X_P + 1.9X_{XL} + 2.8X_L + 1.1X_S + 1.4X_H$

Effective Lime Constraint:

$L_2X_{KO} + L_3\ X_{KC} = 1.5 + 0.4(M_4X_P + M_5X_L + M_6X_C + M_2X_{KO} + M_3X_{KC} + M_7X_5 + M_8X_H - 0.15) + 0.73(A_2X_{KO} + A_3X_{KC} + A_4X_P + A_5X_L + A_6X_C + A_7X_5 + A_8X_H - 0.21) + 0.13 (U_2X_{KO} + U_3X_{KC} - 0.3)$

Fixed Carbon Constraint :

$C_4X_P + C_5X_L + C_6X_C + C_7X_5 + C_8X_H = 0.7 + 0.66(M_4X_P + M_5X_L + M_6X_C + M_7X_5 + M_8X_H - 0.15) + 0.61(A_2X_{KO} + A_3X_{KC} + A_4X_P + A_5X_L + A_6X_C + A_7X_5 + A_8X_H - 0.21) + 0.19(U_2X_{KO} + U_3X_{KC} - 0.3)$

Electricity Constraint:

$X_E = 5.45 + 2.71(M_2X_{KO} + M_3X_{KC} + M_4X_P + M_5X_L + M_6X_C + M_7X_5 + M_8X_H – 0.15) + 5.0(A_2X_{KO} + A_3X_{KC} + A_4X_P + A_5X_L + A_6X_C + A_7X_5 + A_8X_H – 0.21) + 1.34 (U_2X_{KO} + U_3X_{KC} – 0.3)$

Phosphorus Constraint:

$P_2X_{KO} + P_3X_{KC} + P_4X_P + P_5X_L + P_6X_C + P_7X_5 + P_8X_H \leq 0.00188$

Sulphur Constraint:

$S_2 X_{KO} + S_3X_{KC} + S_4X_P + S_5X_L + S_6X_C + S_7X_5 + S_8X_H \leq 0.0175$

Mgo Constraint:

$G_2X_{KO} + G_3X_{KC} + G_4X_P + G_5X_L + G_6X_C + G_7X_5 + G_8X_H \leq 0.03$

5. MINIMUM CHARCOAL CONSTRAINT

$X_C \leq 0.2(X_P + X_L + X_C + X_5 + X_H)$

$0.8X_C – 0.2(X_P + X_L + X_5 + X_H) \leq 0$

Minimum Keco Constraint :

$X_L \leq 0.2 (X_P + X_L + X_C + X_5 + X_H)$

$0.8X_L – 0.2(X_P + X_C + X_5 + X_H) \leq 0$

Min. Electricity Constraint:

$X_E \leq 5.54$

MinEffective Lime Constraint :

$L_2X_{KO} + L_2X_{KC} \leq 1.5$

Min Fixed Carbon Constraint :

$C_4X_P + C_5X_L + C_6X_C + C_7X_5 + C_8X_H \leq 0.7$

6. RESULT

The minimum cost mix for existing constituent analysis and present cost of input is :

Electricity	4.54 kwh
Lime own kiln	1.0818kg
Carbon Keco	0.1052 kg
SLVCoal	0.7377 kg
Charcoal	0.2107 kg

The minimum cost is Rs 6.64 per kg. Carbide of quality/ grade is 311 Acetylene/kg Carbide.

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