A Quick Method of Estimating Batch Digester Charge

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SUMMARY

A graphical method for quick estimation of various materials required at the time of charging a batch of digester has been discussed. Necessary material balance equations have been given to enable the individual mills to prepare their own charts corresponding to their operating conditions. These charts are easy to use by the pulp mill personnel. This will ensure unifrom pulp quality from batch to batch.

Normal digester operation includes charging a known quantity of chips of a given moisture content into a digester of known volume. A fixed percentage of active alkali on the dry raw material is charged. The volume of the white liquor (W/L) to be added is determined based on the required amount of active alkali and the concentration of active alkali in the white liquor. In very few cases corrections for sulphidity are made. Finally bleck liquor is added to obtain the desired liquor to raw material ratio (Bath ratio) in the digester so that the transport and distribution of chemicals and heat in the digester will be facilitated in the best way.

The variations in moisture content, active alkali concentration and sulphidity of white liquor result in fluctuating quality of pulp from batch to batch. Further, operations like periodic make-up sulphur addition, washing and cleaning of evaporators by caustic lye or excess loss of sodium or sulphur due to any reason result in varying sulphidity and active alkali in white liquor.

The present paper deals with a simplified graphical procedure to estimate the correct quantities of active alkali, sulphur (either as elemental sulphur or as sodium sulphide) and black liquor to be charged to the digester based on available laboratory data and desired operating levels.

For the use of this procedure the process parameters

and laboratory analysis as shown in tables 1 and 2 are required.

TABLE-1 PROCESS OPERATING PARAMETERS.

S No.		Normal range
1.	" Digester volume (m ³)	40—80
2.	Oven dry raw material charged per unit vol- ume of digester, (t/m ³).	0 230 35.
3, .	Voidage of chips, percent	t 50—60
4.	Apperent density of raw material. kg/m ³	500-800
5.	O D. chips loaded per digester charge	can be calculated as the product of voidage, app- erent density and the digester volume or an
		average value obtained from the material bal- ance of raw material over a number of cooks.
6.	Percent active alkali on o.d. raw material	14-17.
7.	Bath ratio (m ^a liquor/t, raw material)	2.5 - 3.5

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TABLE 2- DATA FROM LABORATORY

S No		Normal range
1.	Moisture content in the ramaterial, percent	w 10–25
2.	Active alkali concentration of the white liquor, (as Na ₂ O), gpl,	on 65–100
3.	Sulphidity of white liquor, persent	18–30

The attached graphs are prepared based on material balance calculations which are shown in Appendix. The graph A indicates mass of raw material loaded for a known moisture content. From this, the quanity of active alkai to be charged is estimated in graph B knowing percentage of active alkali requied. If the white liquor analysis gives a lower sulphidity than the desired level the necessary amounts of either Na₂S or sulphur addition may be assessed from graph C-1 or graph C-2 respectively. Similarly, if the white liquor sulphidity is higher than the desired value, the volume of 100 gpl caustic ley to be added can also be assessed from graph C-1.

The volume of white paper to be chrged is estimated from graph D knowing the active alkali concentration of white liquor (gpl). If sulphidity adjustments are made by adding Na_2S or NaOH the active alkali charged through white liquor is reduced by that amount. On the other hand if elemental sulphur is added the quantity of white liquor is increased to charge the desired active alkali. The corresponding corrections are shown on graphs C-1 and C-2

The graph E indicates the total quantity of the liquor to be charged for a given bath ratio. This is used to calculate the black liquor to be charged as under—

$$V_{\mathsf{BL}} = V_{\mathsf{T}} - V_{\mathsf{WL}} - (M_{\mathsf{W}} - M)$$

A typical sequential procedure is shown on the graphs

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For 18 tonnes o. d. raw material, M² containing 15% moisture, the amount of raw material loaded, M_w, is given by graph A to be 21 2 tonnes (M_w). The active alkali required at 15% alkali charge is 2 7 tonnes (as Na₂O) from graph B. If the sulphidity of the white liquor is 18% and the desired value is 22%, then the amount of Na₂S to be added is estimated from graph C-1 to be 175 Kg. A correction, f, to be subtracted from the active alkali at the time of calculating white liquor volume is also seen from graph C-1 as 0.14 tonnes. The volume of white liquor to be charged is then obtained corresponding to 2.7–014 i.e., 2.56 t active alkali. The volume is obtained from graph D as 39.5 m³.

The volume of total liquor for a bath ratio of 3 is obtained as 54 m^3 from grap E. The volume of black liquor to be added is calculated as under.

$$V_{BL} = 54 - 39.5 - (21.2 - 18)$$

= 11.3 m³

Thus we see that the procedure quickly yields the values of the variables as shown in table-3.

TABLE-3 THE VARIABLES OBTAINED BY THE GRAPHS :

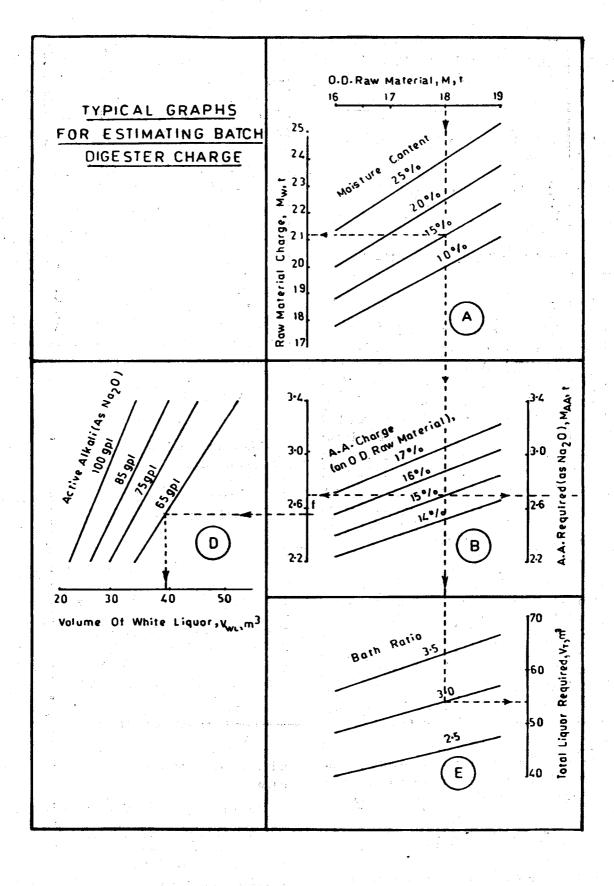
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S.No.	Variable
1.	Weight of raw material, M _W
2. 3.	Total active alkalio to be charged, MAA Volume of white liquor required, V _{WL}
4 .	Amount of sulphur, Na ₂ S, or NaOH to be added for sulphidity corrections.
5.	Black liquor make up, V _{BL}

The graphs drawn here are valid under the assumption of negligible amodnt of alkali in the black liquor

Similar graphs can be developed for non sulphur soda process using agricultural residues by omitting graphs C-1 & C-2. Individual mills can develop these graphs specific to their mill conditions for routine control of digester charge. Such graphs will be clear and simple with only one or two lines in each figure.

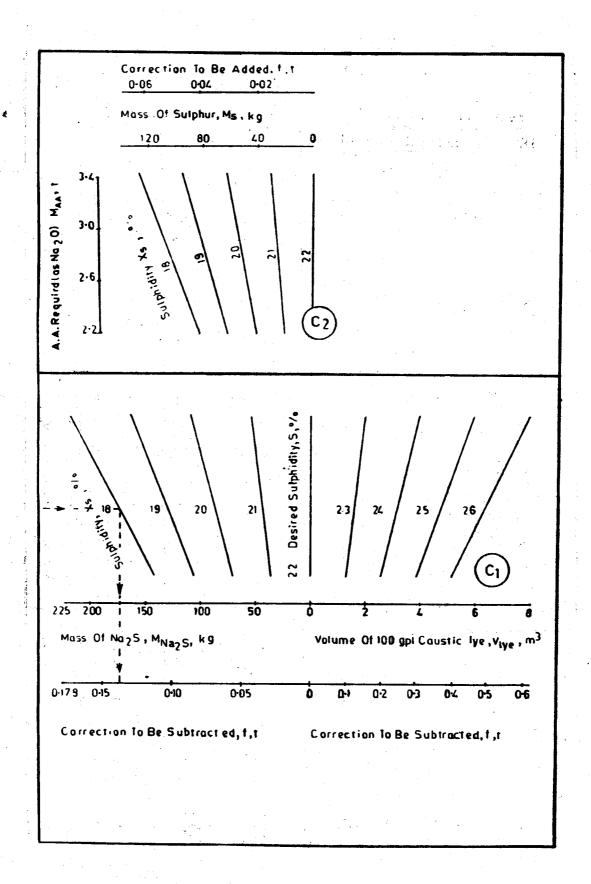
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APPENDIX

A-1 MASS OF THE RAW MATERIAL :

Let M be the mass of Oven Dry raw material load to the digester per charge, then the mass of the raw material along with the moisture content, M_w will be

 $M_w = M/(100-x)...$ (1) Where x=percent moisture in chips.

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A-2 ACTIVE ALKALI REQUIRED :

Amount of active alkali required M_{AA} will be given by

 $M_{AA} = (x_{aa}/100) M \dots (2)$ (expressed as Na₂O)

Where x_{aa} = percent active alkali on raw material (as Na₂O)

Let S be the level of sulphidity of W/L, in percentage, desired to be controlled, and x_8 be the percentage sulphidity of the white liquor obtained from laboratory analysis then a suitable chemical is added to correct the deviation. If the sulphidity is lower than the control sulphidity, either sodium sulphide (Na₂S or elemental sulphur is added to the system. If the sulphidity value is higher (in rare cases), the caustic lye should be added so as to ensure sufficient effective alkali for a given amount of active alkali charged.

A-3 ADDITION OF Na_2S :

Mass of
$$Na_2S$$
 to be added is given by
 $M_{Na_2S} = \underbrace{(S-x_8)}_{100-S} \underbrace{M_{AA}}_{(as Na_2O)}$
(3a)

Where $x_8 =$ Sulphidity of the white liquor

A-4 ADDITION OF ELEMENTAL SULPHUR :

For the calculation of the amount of elemental sulphur for the correction in sulphidity deviations the following commonly accepted stoichiometric relation can be used (1)

 $6NaOH + 4S = 2Na_2S + Na_2S_2O_3 + 3H_2O$ (4a) Mass of sulphur to be added can be found out

$$M_{s} = 2.0645 \frac{(S-x_{s})}{(S+200)} M_{AA} \dots (4b)$$
(as sulphur)

A-5 ADDITION OF CAUSTIC LYE :

If the sulphidity x_s is higher than S then the amount of caustic soda to be added to control sulphidity is given by

Volume of 100 gpl caustic lye will be

$$v_{lye} \neq 12.9 / \frac{(x_s-S)}{S} M_{AA} (m^3)$$
 (5b)

When M_{AA} is used in tonnes

A-6 VOLUME OF THE WHITE LIQUOR :

The amount of white liquor to be added can be calculated from

$$V_{wL} = \frac{1000.}{C_{wL}} (M_{AA} - f) (m^3) \dots \dots \dots \dots (8)$$

Where C_{wL} is the active alkali concentration of white liquor in g/l and M_{AA} is expressed in tonnes.

A-7 CORRECTION/FACTOR :

To be able to charge exact amount of active alkali required, the volume of white liquor should be calculated after subtracting the amount of alkali added as Na₂S or NaOH for sulphidity corrections. In case of the use of elemental sulphur for these corrections, additional quantity of white liquor is added to take into account the NaOH consumed in reaction (4a). The correction factor f is given by

$$f=0.7948 M_{Na_{s}S} \dots (9)$$

$$f=0.775 M_{NaOH} \dots (10)$$

$$f=-0.4843 M_{s} \dots (11)$$

NOTATION

f

 $C_{wI_{*}} = Active alkali concentration of white liquor, gpl$

- = Correction to the substracted from M_{AA} while estimating volume of white liquor, tonnes.
- M = Mass of o.d. raw material, tonnes.
- $M_{AA} = Mass of active alkali required (as Na₂O), tonnes.$
- $M_{Na_2S} = Mass of sodium sulphide to be added for sulphidity control, kg$
- $M_{NaOH} = Mass of caustic soda to be added for sul$ phidity control, kg.

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- ⁸M = Mass of sulphur to be added for sulphidity control, kg.
- M_w = Mass of raw material alongwith its moisture content, tonnes.

S = Control sulphidity, percent.

 V_T = Total volume of liquor, m³

 $V_{iye} = Volume of 100 gpl caustic lye equivalent$ to M_{NaOH},^{m³}

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AUDICIVES

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DISPERSALT

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= moisture content in the raw material, percent.

= active alkali charged on o.d. raw material,

= Sulphidity of white liquor, percent.

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1. Casey, J.P., "Pulp and Paper-Chemistry and Chemical Technology, vol. I, IIIrd edition, John Wiley & sons (1981) [see beased to be a start platent when the second control of the second start when the second of 2. Rajan, T.N.S., IPPTA 25(2), 1-22(1988) [seconds musical produces with control of victor of the second cut of second start second start with the second start cut of second start when the second start of the second of the official second start with the second start second start when the second start start of the second start when the second start start of the second start when the second start start of the second start start and start start start start second start starts and start start start start with second start starts and start starts the start with second start starts and start starts the start work is set with start starts and start starts and the start work is start start, a 1 a second start of starts of starts of starts

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