Journal of Mining and Metallurgy, 44 A (1) (2008) 17 - 23

Journal of
Mining and
Metallurgy

PROPOSITION OF NEW INDICES AND PARAMETERS FOR GRAIN SIZE CLASSIFICATION EFFICIENCY ESTIMATION

Dragoslav Randjic#

Vidikovacki venac 98/I-7, 11090 Belgrade, Serbia

(Received 10 July 2008; accepted 4 December 2008)

Abstract

In the paper are presented some from us proposed and defined new indices and parameters for technological efficiency estimation, applied to grain size classification operations. In the same time some today in the theory and praxis frequently used indices and parameters are comparatively short reviewed. Also, it is pointed out on the possibilities for use of new defined indices in the classification or separation process quality analysis and for investigations and control of production processes.

Key words: *classification efficiency, ideal cut size particle diameter (d_{mi}), index of classification efficiency (IE_C).*

1. Introduction

Technologic operations of particles classification and separation have very bread industrial applications. Always we have one unhomogeneouse particle poly-dispersion (in the sense of very variable physical, chemical, and mineralogical properties and composition), which we have to separate on the basis of grain-size criteria in two or more products. The consequence from this is that the real particle classification by expected grain size is not enough sharp and also can be technologic inefficient. Beside this, some other processing factors influencing the sharpness and efficiency of separation and classification by grain size.

Especially, from us proposed and defined indices for efficiency estimation are best applied for hydraulic grain size classification.

Corresponding author: *dragora@sezampro.yu*

2. Review of some indices for technologic efficiency expression and estimation

In the literature it is proposed and applied a very large number of indices for process efficiency estimations by grain size classification, on a different manner defined. Also it exist an inconsistency by different manner of efficiency definitions.

In this paper we will to begin with a short review of expressions for technologic efficiency and sharpness of classification which are based on the very known Tromp curve (also named as "grade efficiency curve", "partition curve", "performance curve" , "Tromp-curve",…) [1], [2], [3], [4].

One presentation of Tromp (partition) curve for the grain-size classification is given on the Fig. 1, on which the indices and parameters for process sharpness and efficiency can be defined.

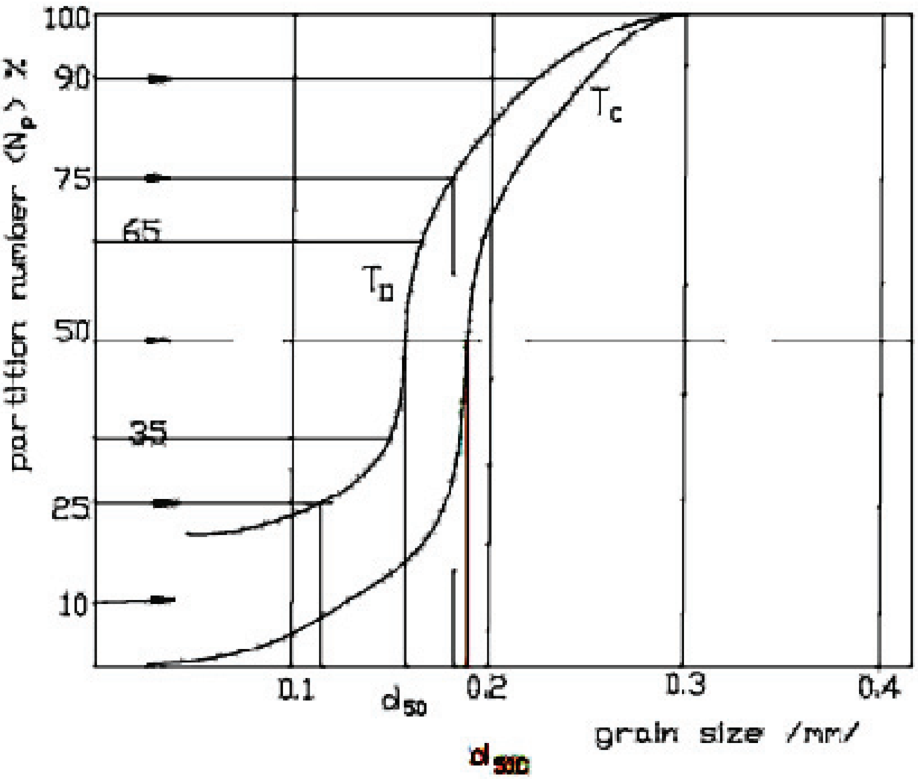

Fig. 1. Determination of indices of sharpness and efficiency of grain-size classification based on Tromp (partition) curve

T_O - uncorrected T-curve

T_C - corrected T-curve

2.1. Characteristic parameters of grain-size classification (based on T-curve)

d_{50} – uncorrected cut size particle diameter (defined as particle mesh size diameter which correspond to the partition number N_p = 50% on Tromp curve)

d_{50C} - corrected cut size particle diameter (corresponding to N_p = 50 % on the corrected T_C curve)

d_{25}, d_{75} – particle size corresponding to the partition numbers 25% and 75%

d_G - (assigned on the Fig. 2), particle size corresponding to the partition number G, equal to percent mass part of coarse classification product [5], [*].

[*] Grain sizes which are greater (coarser) than d_G are more concentrated in the coarse product ("sand") as in the feed in classification. Contrary, grain sizes below d_G are concentrated in the fine product (overflow) of classification [5].

2.2. Indices of separation sharpness for grain size classification (based on T-curve)

Some of indices taken from T-curves, which are much known, arte listed below:

$$E_p = (d_{75} - d_{25}) / 2 \quad (1)$$

$$I_p = (d_{75} - d_{25}) / 2d_{50C} \quad (2)$$

$$k = d_{65} / d_{35} \quad (3)$$

3. Inconveniencies of indices for sharpness and efficiency of classification defined on Tromp partition curve

Real obtaained T-curves can remarkably deviate from ideal S-shape and very oft start not from partition number N_p = 0. Many authors are sugested procedures for correction the T-curve shape and also the indices and parameters so obtained. [6], [7]. In this our paper we d'ont closely explain these procedures.

The must common used indices (E_p , I, …) for expression of sharpness and efficiency of classification based on Tromp curve can be inconvenient for some classification processes, for example for hydraulic classification of polymineral granulated mixtures with different grain density, shape, and components grain size distributions.

The indices (E_p, I,…), determined from only one part (segment) of the T-curve, some authors are evaluated as in-sufficiently representative. [8], [9], [10]. Also, on the inconveniency of indices taken from Tromp curve some authors are former pointed out [5], [6], [7]. From these reasons some authors are proposed the "integral" indices, by which the entire classification range is considered. [8], [9], [10].

One example of inconveniency of T-curve for estimation of classification efficiency is given on the Fig. 2.

This T-curve is obtained from the results of investigation on the copper ore classification in hydrocyclone which is working in closed circuit with ball mill [5].

The curve T_o is considered for copper ore feeding the hydrocyclone; the curves T_S and T_F are valid for the sink and float fraction obtained with Sink/Float analysis in the TBE (which has a density of 2960 kg/m^3) on the all classification products of Bor Copper mine ore.

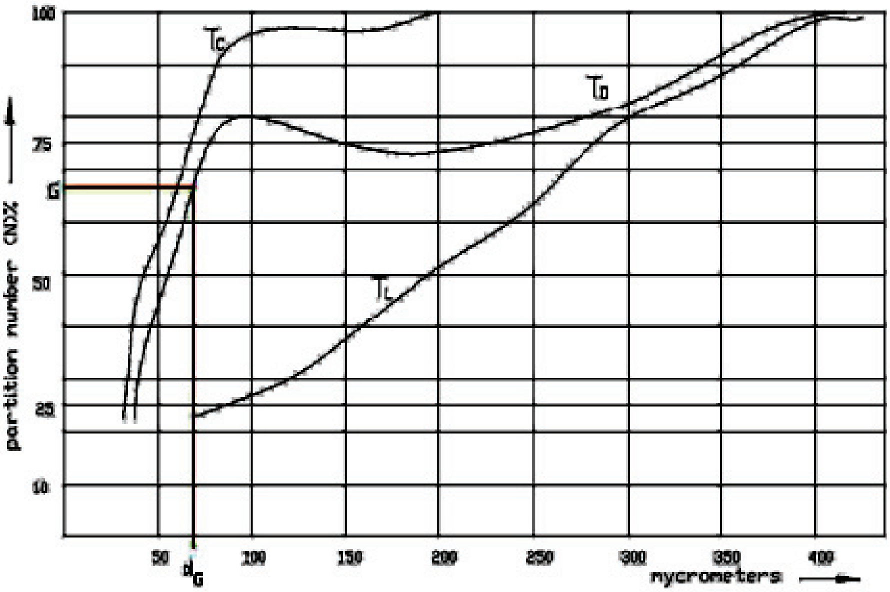

Fig. 2. Inconvenient shape of T-curve for classification efficiency indices estimation (T-curve is obtained for Bor copper ore classification in closed grinding circuit with ball mill)
T_O - T-curve for copper ore feeding the hydrocyclone
T_C - T-curve for sinking ore fraction (particles density over 2960 kg/m^3)
T_L - T-curve for swimming ore fraction (particles density under 2960 kg/m^3)

The curve T_S is valid for heavy fraction of copper ore (density over 2960 kg/m^3), while the T_F responds for the float fraction (density below 2960 kg/m^3). On the curve T_o is clear visible the deviation from the ideal S-shape of partition curve - this curve has three intersections with the line N_p = 75%. This deviation from the normal shapes T-curve F.W. Mayer is called as distortion or anomalies [6]. Such T-curve is unclear and inconvenient for obtaining the indices for classification efficiency expression.

Our statement is that this shape of T-curve is the result of interference of all partial T- curves which we can distinguish for each density fraction (component) represented in the granulated mineral mixture in the ore feeding the classification. The partition number (N_O) for the ore (as mixture of mineral fractions with different density) is the sum of partial partition number (N_i) of all density fractions [5]:

$$N_O = SUM\ (f_i * N_i) /100 \qquad (4)$$

where is:

f_i - mass percent of each density fraction related to the mass of grain size class for which the partition number N_O are calculated.

4. Proposition for the determination of parameters and indices which express classification efficiency

On the Fig.3 are presented the particle size cumulative distribution curves for one example of grain size classification process, experimentally obtained. From this curves we can obtain:

- characteristic diameter $\mathbf{d_{mi}}$, and
- index of efficiency of classification $\mathbf{IE_C}$.

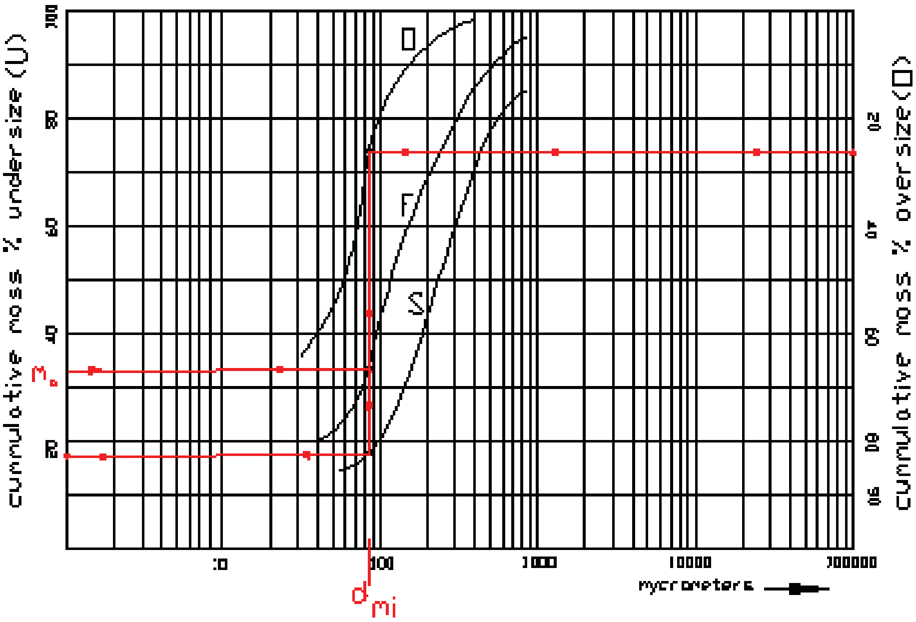

Fig. 3. Definition and estimation of characteristic cut-size particle diameter (d_{mi}) and index of classification efficiency (IE_C)

4.1 Method of definition and estimation of d_{mi} and IE_C

On the Fig.3 is presented the method for estimation of these parameters. For the on the Fig.3 presented example we have:

m_o - percent mass of solids in overflow related to the mass of solids in hydrocyclone feed as 100% (in our example $\mathbf{m_o = 33{,}46}$ %); m_o is calculated from the grain size distributions for the feed and products of classification (or otherwise determined),

d_{mi} - particle diameter in the classification feed corresponding to the cumulative undersize percent mass of m_o = 33,46% (intersection of line U = 33,46 % with granulometric curve F.

From the curve F for the percent mass of overflow of 33,46% we obtain for ideal cut particle size:

$\mathbf{d_{mi}}$ **= 83 mycrometers.**

Our definition for the new classification efficiency index (titled as IE_C) is given with next equation:

$$IE_C = 100\ \% - [m_o * (+d_{mi}\ \%)_O/100 + (100-m_o)\ (-d_{mi}\ \%)_U/100\ ],\ \% \qquad (5)$$

where is:

$(+d_{mi}\ \%)_O$ - cumulative mass percent of particles in the overflow which size is coarser than d_{mi}

$(-d_{mi}\ \%)_U$ - cumulative mass percent of particles in the underflow (sand) which size is finer than d_{mi}

The amount of $(+d_{mi}\ \%)_O$ corresponds to the mass of incorrect classified coarse particles to the overflow, the amount of $(-d_{mi}\ \%)_U$ corresponds to the mass of incorrect classified fine particles to the underflow, related to the d_{mi} as cut size particle diameter.

4.2. Procedure for determination of $(+d_{mi}\ \%)_O$ and $(-d_{mi}\ \%)_U$

On the Fig. 3 from the point m_o start the line until the intersection with curve G, than following the line $d=d_{mi}$ up and down until the intersections with curves O and S, and finally draw the lines to the oversize (O) and undersize (U) axes (left and right).

4.3. Example of calculation for IE_C

In our example (presented on the Fig.3) for the Index of Classification Efficiency (IE_C) the calculated value is:

$\mathbf{IE_C}$ = 100 – [33,46*26,82/100 + (100-33,46)*17,51/100] = 100 – (8,97 + 11,64) = **73,39 %**

5. Discussion

Indices and parameters derived from partition T-curve can not always enough accurate and convenient express the sharpness and efficiency of particle size classification [8], [9], [10].

Especially in the milling and classification circuits of ores with very variable mineralogical composition. In such cases (as shown on the Fig. 2) the T-curve can very much differs from idealized S-shape and identification of sharpness parameters (i.e. E_p, I_p …) can be not clear single-valued.

For the classification of milled ores, with mineralogical heterogeneous composition, obtained T-curves are resulting from the partial T- curves for each kind of mineral fraction presented in the ore. On the shape of each partial fractional T-curve and its position in the diagram, the influence of particle density is dominant. The resulting T-curve for the milling-classification circuits of ores is obtained as ponderised mean of all single curves for each density fraction present in the ore.

We can say that in such conditions along with particle size classification it exist a remarkable heavy-media separation, with pushing the light fractions to "swim" [5].

The advantage of use the parameters d_{mi}, IE_C is in the fact that we have not the need to calculate the partition numbers and draw the T-curve for estimation the classification efficiency indices.

From us proposed indices d_{mi} and IE we can obtain only from the data of particle distributions (given as graphic or regression) for all classification products.

It exist the possibility for use of indices d_{mi}, and IE_C as criteria for milling circuits optimization. The change of indices d_{mi}, and IE_C for a given production capacity in milling circuit can assign to some disturbance in the technologic process and processing conditions.

6. Conclusion

For the expression and estimation of classification efficiency two characteristic parameters are proposed:

d_{mi} - characteristic, idealized cut size particle diameter, and

IE_C - index of classification efficiency.

These two parameters can enough accurate represent the classification efficiency, can be very convenient for use, enable simple determination, and can be used as representative parameters for quality estimation of particle classification process and its optimization.

7. References

1. Svarovsky L., Solid-Liquid Separation, Fourth Edition, Butterworth/Heinemann, (2000).
2. Wills B.A. Factors affecting hydrocyclone performances, Mining Magazine, (1980).
3. Trawinski H., Theory, applications, and practical operation of hydrocyclones, E/MJ, (1976).
4. Barsky L.A., KozinV.Z., Systems analysis in the row materials enrichment, (Rusian), Nedra, Moscow, (1978).
5. Randjic D.R., Master of Science thesis, (Serbian), University of Belgrade, (1976).
6. Mayer F.W., The partitions curve and their most important anomalies, (German), Bergakademie N^{O} 1, (1951).
7. Eder T., Problems of separation sharpness, Aufbereitungstechnik, (1961).
8. Mayer F.W., Computation of new expressions for separation sharpness from partition numbers, Aufbereitungstechnik, (1971).
9. Pethoe S., New expressions for sharpness of separation, Aufbereitungstechnik, (1971).
10. Randjic D.R., Proposition of new expression for sharpness of classification, (Serbian), Tehnika, Faculty of mining and geology Beograd, (1978).