Geometallurgical Modelling of Comminution Indexes of Blends from the Main Lithologies Present at Chapada Mine

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ABSTRACT

Comminution is one of the main processes in ore processing plants. At Chapada mine, its relevance is more significant as the grinding circuit consists of the main bottleneck of the overall circuit. The existent variability of the different ore types regarding rock hardness brings a constant challenge to production planning reliability. In addition to the ore variability, the hardness for the blends fed into the circuit may not present an additive behaviour, bringing another source of deviation in the predicted hardness in the plant feed. In this work was made an evaluation to identify an additive or non-additive behaviour in the main comminution indexes for different binary blends made with the main ore types currently processed at Chapada Mine. With this, it is intended to determine correlations that describe the behaviour of these variables, which will help in the elaboration of the unit's production strategies and reduce the deviations between the planned and the real production of the circuit.

INTRODUCTION

The main areas of the production chain of a mining project are geology, mining, processing plant, metallurgy, and tailings management. Traditionally these areas work separately, and the integration from geology to the final processes is called geometallurgy (Lishchuk et al., 2019). With this integration between the different stages of the process, geometallurgy seeks to reduce risks and improve the production plans of mining projects, allowing better strategic decisions and increasing the profit of operations (Schneider, 2014; Lishchuk et al., 2019).

Traditionally, block models include information regarding the grades of the elements of interest, densities and spatial information. In the geometallurgical model, other relevant information is included regarding the characteristics of the ore (Schneider, 2014), such as Axb, BWi, metal recovery, among others, which must be correlated with the properties of the process (Lishchuk et al., 2019).

According to Campos et al. (2019), not all properties of ores when subjected to blends are additive, so they can't be determined by the weighted average of the values of the individual properties of each lithology, having as weights the percentage of each lithology present in the sample.

In work conducted by Campos et al. (2019) for blends in different proportions of two ores A and B, the BWi property did not behave in an additive way, with the values obtained for mixtures far from the theoretical calculated from the proportions of the individual minerals, as shown in Figure 1.

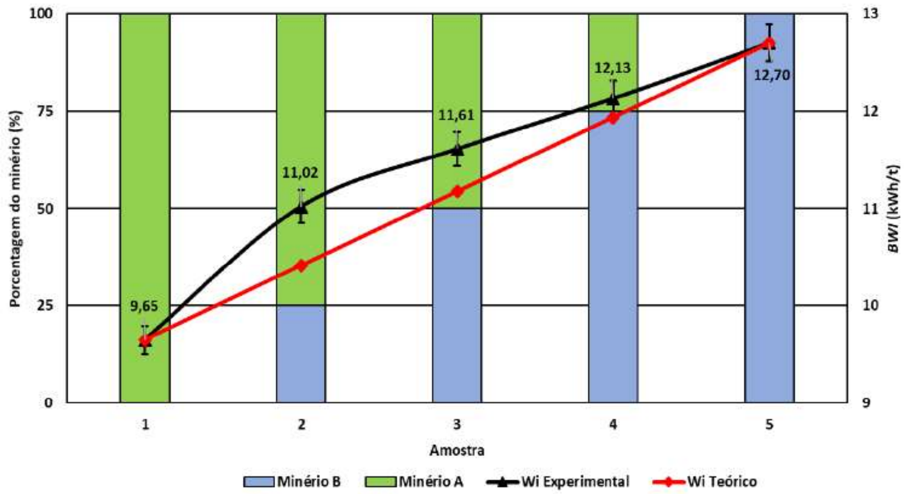

Figure 1 Experimental and Theoretical BWi Values (Campos et al., 2019)

Studies conducted by Yan et al. (1994) and Celik (2010) also for BWi showed similar results, showing that there were interactions between the evaluated materials that influenced the values found for the mixtures, as shown in Figure 2 and Table 1.

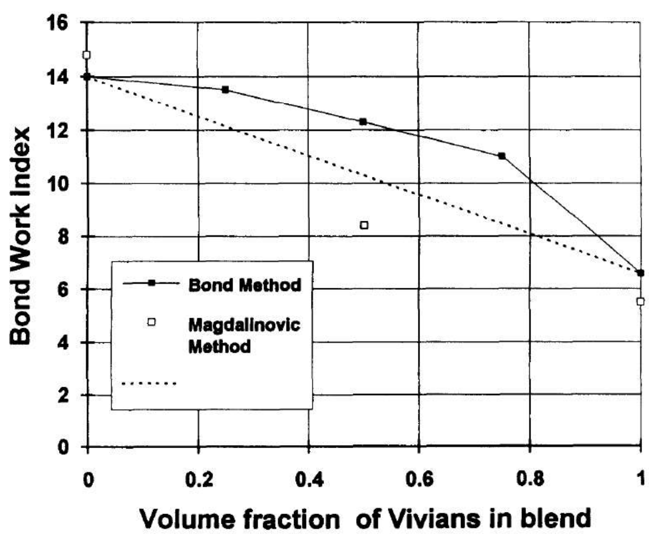

Figure 2 BWi variation with blend composition (Yan et al., 1994)

Table 1 Results of Bond grinding tests for ceramic materials (Celik, 2010)

	F_{80} (µm)	P_{80}* (µm)	G_{bp}* (g/rev)	Experimental W_i* (kWh/t)	Calculated W_i (kWh/t)
Kaolin (K)	2447	81,67	2,029	10,38	-
Quartz (Q)	2976	125,48	2,176	12,49	-
Feldspar (F)	2800	112,48	2,155	11,85	-
1K : 1F	2620	120,11	2,103	12,71	11,11
1K : 1Q	2736	93,45	1,595	13,55	11,43
1F : 1Q	2875	112,32	2,046	12,31	12,17
1K : 1Q : 1F	2744	101,32	1,776	13,04	11,57
2K : 1Q : 1F	2668	90,34	1,593	13,33	11,27
3K : 1Q : 1F	2624	83,38	1,443	13,79	11,09
1K:2Q:2F	2798	115,31	2,113	12,23	11,81

*Average of five tests

There is a greater influence of the ore with higher BWi on the result of the blend, what according to Yan et al. (1994), occurs due the methodology of the Bond method for determining the work rate, which occurs in closed regime. Since ore of higher BWi is expected to be grinded at a lower rate, this causes a greater proportion of this to occur in the sieving oversize. With this, this material of greater hardness increases in proportion to the circulating load.

In a study carried out by Todorović et al. (2017), the result obtained was different. Although in the initial cycles of the Bond test, behaviour similar to that obtained in the studies presented above was observed, the final result shows an adherence between the test results and the calculated values. In this study, more homogeneous materials were used, which may have influenced the final result obtained. Table 2 presents the results of this study.

Table 2 BWi values obtained by standard Bond procedure and values calculated according to the mass fraction of the components (Todorović et al. 2017)

Sample	Test sieve, µm	W_i, kWh/t	W_i calcul., kWh/t	Difference, %
Limestone : andesite 100 : 0	74	13.90	/	/
	105	12.77	/	/
	150	12.63	/	/
Limestone : andesite 75 : 25	74	14.51	14.95	3.02
	105	13.91	13.81	-0.72
	150	13.59	13.48	-0.85
Limestone : andesite 50 : 50	74	15.50	16.00	3.19
	105	14.60	14.85	1.71
	150	14.26	14.32	0.42
Limestone : andesite 25 : 75	74	17.03	17.04	0.07
	105	16.41	15.89	-3.17
	150	15.13	15.17	0.23
Limestone : andesite 0 : 100	74	18.09	/	/
	105	16.93	/	/
	150	16.01	/	/
Mean difference				1.49

Obtaining different results in different works indicates that the additive or non-additive nature of the variable is still not completely understood.

In this way, this work evaluated the behaviour of the variables Axb and BWi for blends composed by three different lithologies present in the Chapada mine, regarding their additive or non-additive character.

METHODOLOGY

Three samples were used referring to the main lithologies currently processed at the Chapada mine, which correspond to more than 90% of all the ore currently treated in the beneficiation circuit. Samples were collected from mining fronts for each evaluated lithology. Table 3 presents the lithologies used in this study.

Table 3 Lithologies evaluated in the study

Lithology	Description
BTOS	Silicified Biotite Schist
QSRT	Quartz Sericite Schist
GNS	Gneiss

The samples were crushed, quartered and composed in binary blends between the lithologies, with different proportions between the components (0%, 25%, 50%, 75% and 100%). Table 4 summarizes the blends evaluated.

Table 4 Blends evaluated

Teste	%BTOS	%QSRT	%GNS
01	100,00	-	-
02	-	100,00	-
03	-	-	100,00
04	75,00	25,00	-
05	50,00	50,00	-
06	25,00	75,00	-
07	75,00	-	25,00
08	50,00	-	50,00
09	25,00	-	75,00
10	-	75,00	25,00
11	-	50,00	50,00
12	-	25,00	75,00

Samples were sent to an external laboratory for SMC and BWi testing. The different blends between lithologies and pure samples were tested in the proportions shown in Table 4.

RESULTS AND DISCUSSION

Table 5 shows the results of Axb and BWi for the blends evaluated.

Table 5 Axb and BWi results for the evaluated blends

Teste	%BTOS	%QSRT	%GNS	Axb	BWi
01	100	-	-	135,51	6,95
02	-	100	-	70,34	11,31
03	-	-	100	53,91	12,38
04	75	25	-	116,37	9,55
05	50	50	-	92,61	10,52
06	25	75	-	70,60	10,30
07	75	-	25	111,36	9,21
08	50	-	50	69,19	11,21
09	25	-	75	80,53	11,73
10	-	75	25	51,27	11,23
11	-	50	50	57,88	11,66
12	-	25	75	57,62	14,46

The results for the mixture BTOS x QSRT, BTOS x GNS and QSRT x GNS are shown in Figures 3, 4 and 5 respectively.

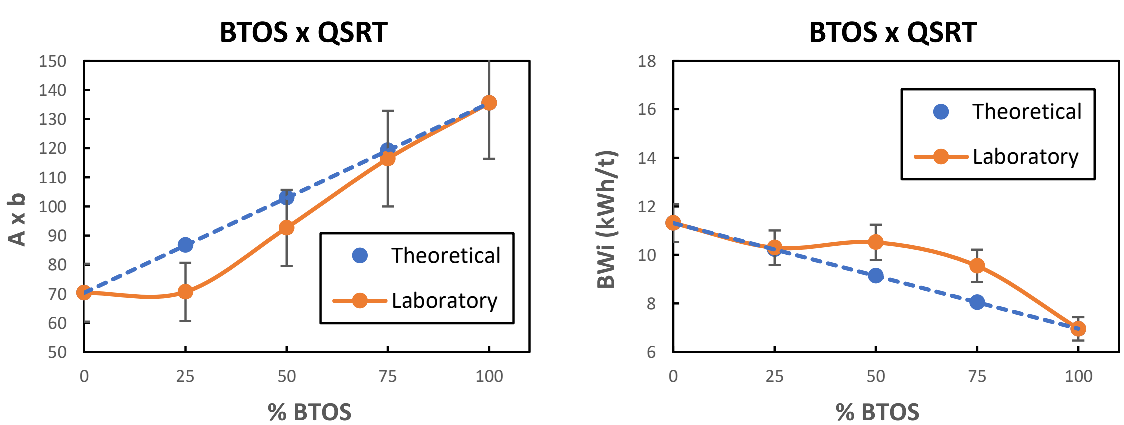

Figure 3 Comparison of theoretical and experimental Axb and BWi results for the blend BTOS/QSRT

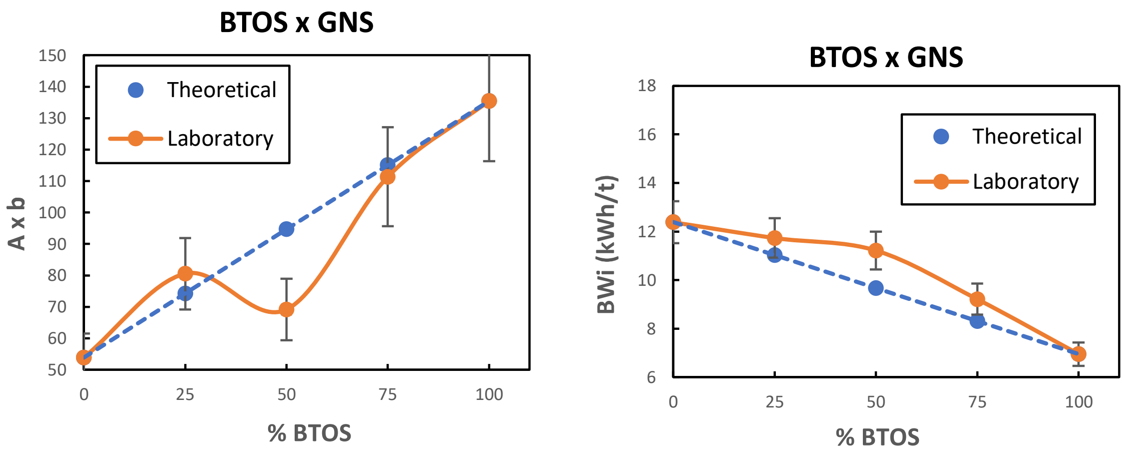

Figure 4 Comparison of theoretical and experimental Axb and BWi results for the blend BTOS/GNS

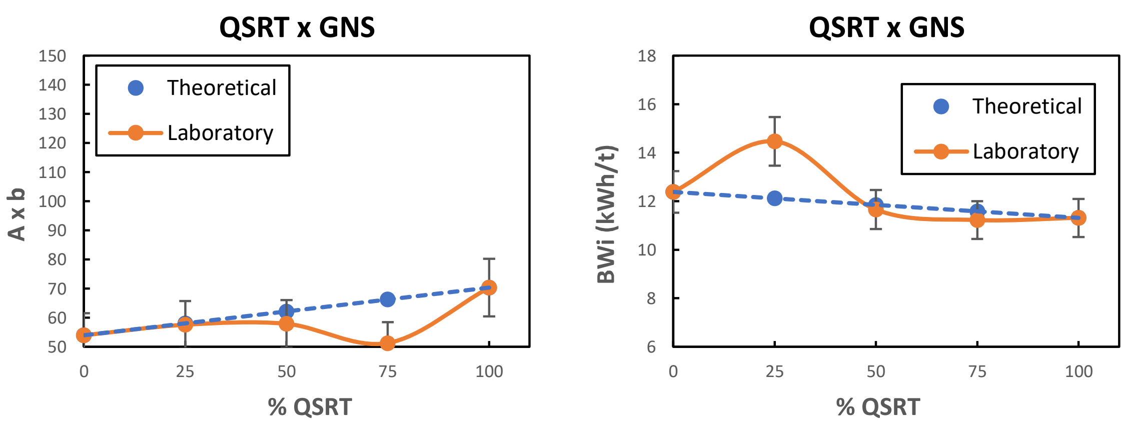

Figure 5 Comparison of theoretical and experimental Axb and BWi results for the blend QSRT/GNS

The BWi results demonstrate a non-additive behaviour of the blend, with a tendency to the occurrence of a higher energy consumption of the blend when compared to the theoretical value. This behaviour is similar to that obtained in previous studies carried out by Campos et al. (2019), Yan et al. (1994) and Celik (2010).

It was observed that the Axb parameter has a similar behaviour to BWi, with higher energy consumptions in the blends when compared to the theoretical values, also showing the non-additive behaviour of this parameter.

CONCLUSION

The results obtained show that both studied comminution indices (Axb and BWi) behave in a non-additive way for the evaluated mixtures, and that the indices measured for the mixtures present a higher energy consumption when compared to with the theoretical values calculated from the composition of the blends.

NOMENCLATURE

BWi	Bond Work Index
SMC	Steve Morrell Comminution

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