An addition to reporting A and b values

-The SAG Circuit Specific Energy (SCSE)

For a little over 20 years, the results of JK Drop Weight tests and SMC Tests have been reported in part as A, b and t_a parameters. A and b are parameters which describe the response of the ore under test to increasing levels of input energy in single impact breakage. A typical t_{10} v E_{cs} curve resulting from a Drop Weight test is shown in Figure 1.

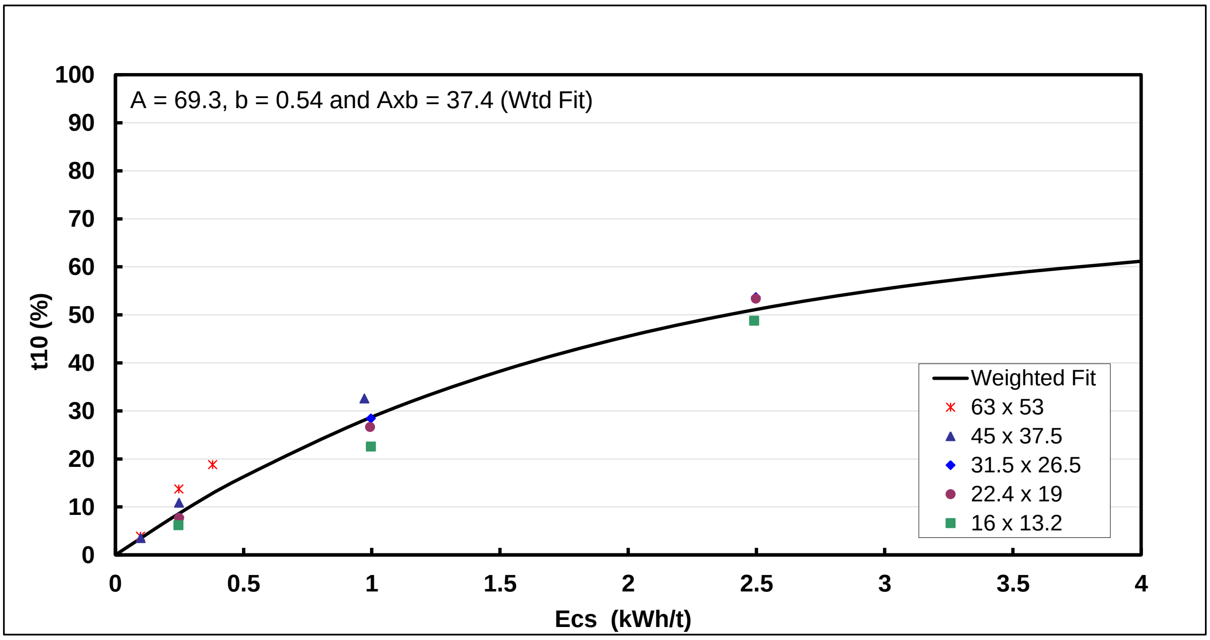

Figure 1: Typical t10 v Ecs curve

The curve shown in Figure 1 is represented by an equation which is given in the equation below

$$t_{10} = A * (1 - e^{-bE_{cs}})$$

The parameters A and b are generated by least squares fitting the above equation to the JK DW test data. The parameter ta is generated from a tumbling test.

Both A and b vary with ore type but having two parameters describing a single ore property makes comparison difficult. For that reason the product of A and b, referred to as A*b, which is related to the slope of the t10 – Ecs curve at the origin, has been universally accepted as the parameter which represents an ore's resistance to impact breakage.

The parameters A, b and ta have no physical meaning in their own right. They are ore hardness parameters used by the AG/SAG mill model in JKSimMet which permits prediction of the product size distribution and the power draw of the AG/SAG mill for a given feed size distribution and feed rate. In a design situation, the dimensions of the mill are adjusted until the load in the mill reaches 25 % by volume when fed at the required feed rate. The model predicts the power draw under these conditions and from the power draw and throughput the specific energy is determined. The specific energy is mainly a function of the ore hardness (A and b values), the feed size and the dimensions of the mill (specifically the aspect ratio) as well as to a lesser extent the operating conditions such as ball load, mill speed, grate/pebble port size and pebble crusher activity.

There are two drawbacks to the approach of using A*b as the single parameter to describe the impact resistance of a particular ore. The first is that A*b is inversely related to impact resistance, which adds unnecessary complication. The second is that A*b is related to impact resistance in a non-linear manner. As mentioned earlier this relationship and how it affects comminution machine performance can only be predicted via simulation modelling. Hence to give more meaning to the A and b values, JKTech Pty Ltd and SMC Testing Pty Ltd have developed a "standard" simulation methodology to predict the specific energy required for a particular tested ore when treated in a "Standard" circuit comprising a SAG mill in closed circuit with a pebble crusher. The flow-sheet is shown in Figure 2.

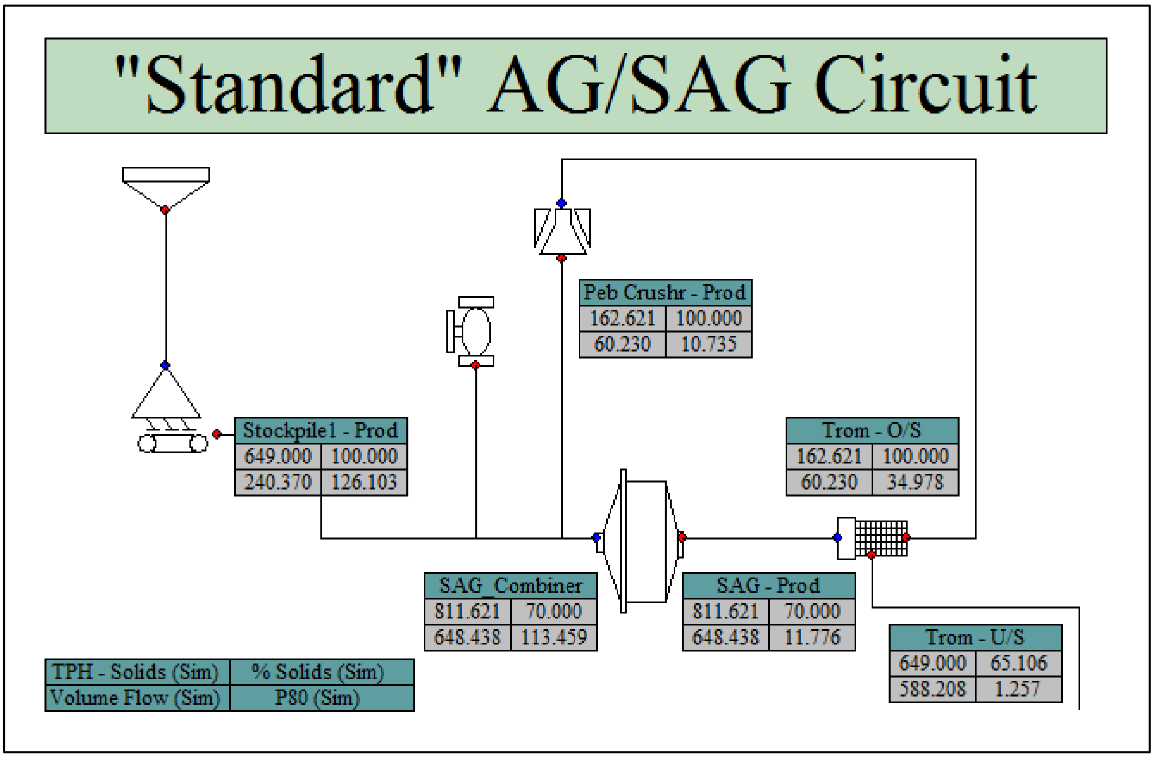

Figure 2: Flowsheet used for "Standard" AG/SAG circuit simulations

The specifications for the "standard" circuit are:

- SAG Mill
    - inside shell diameter to length ratio of 2:1 with 15 ° cone angles
    - ball charge of 15 %, 125 mm in diameter
    - total charge of 25 %
    - grate open area of 7%

    - apertures in the grate are 100 % pebble ports with a nominal aperture of 56 mm
- Trommel
    - Cut Size of 12 mm
- Pebble Crusher
    - Closed Side Setting of 10 mm
- Feed Size Distribution
    - F_{80} from the t_a relationship given in the equation below.

The feed size distribution is taken from the JKTech library of typical feed size distributions and is adjusted to meet the ore specific 80 % passing size predicted using the Morrell and Morrison (1996) $F_{80} - t_a$ relationship for primary crushers with a closed side setting of 150 mm given in the equation below.

$$F_{80} = 71.3 - 28.4 * ln(t_a)$$

Simulations were conducted with A*b values ranging from 15 to 400 and t_a values ranging from 0.145 to 3.866. For each simulation, the feed rate was adjusted until the total load volume in the SAG mill was 25 %. The predicted mill power draw and crusher power draw were combined and divided by the feed rate to provide the specific energy consumption. The results are shown in Figure 3.

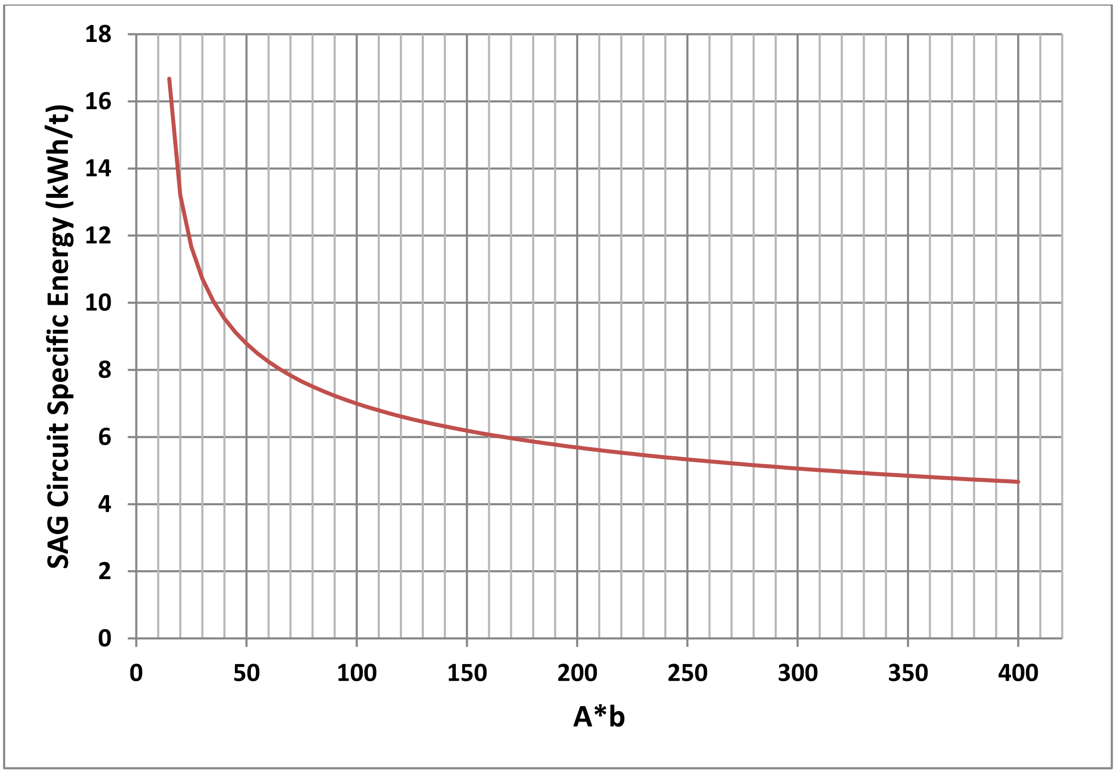

Figure 3: The relationship between A*b and specific energy for the "Standard" circuit

From now on, JKTech Pty Ltd reports of JK Drop Weight and SMC test results will include the specific energy value for the "standard" circuit in addition to the A, b, ta and crusher matrices which are currently reported.

It is of note that the relationship between Specific energy and A*b for the "standard" circuit is very similar to the specific energy – A*b relationship for operating mills published in Veillette and Parker, 2005 and reproduced here in Figure 4.

Of course, the specific energy value quoted for the "Standard" AG/SAG circuit will not necessarily match the specific energy required for an existing or a planned AG/SAG mill due to differences in the many operating and design variables such as feed size distribution, mill dimensions, ball load and size and grate, trommel and pebble crusher configuration. However, the "Standard" circuit specific energy can be used in a relative manner to compare the expected behaviour of different ores in AG/SAG milling in exactly the same way as the Bond laboratory ball mill work index can be used to compare the relative grindability of different ores in ball milling (Bond, 1961 and Rowland and Kjos, 1980)

To use the Bond ball mill work index to determine the ball mill specific energy required for a particular grinding task, the Bond equation must be used and the various relevant efficiency factors applied. In an analogous manner, to use the A and b parameters to determine the AG/SAG mill specific energy required for a particular grinding task, a simulation of the proposed circuit must be conducted in JKSimMet. Guidelines for the use of JKSimMet for such simulations were given in Bailey *et al*, 2009.

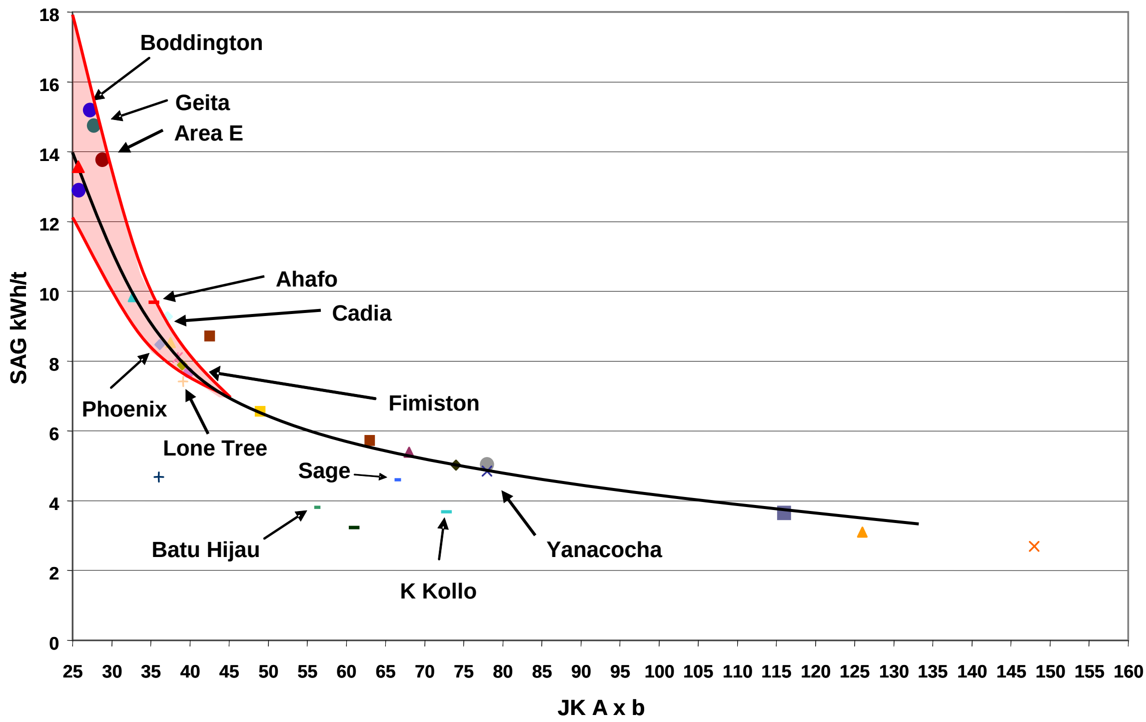

Figure 4: A*b vs SAG kWh/t for operating AG/SAG mills (after Veillette and Parker, 2005)

References

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