

## Extending the Use of the SMC Test<sup>®</sup> - Predicting the Specific Energy of Coarse Crushing and HPGR Circuits

New crushing and HPGR data have been recently acquired which have provided the opportunity to enhance the range of applications covered by the SMC Test<sup>®</sup>, notably size reduction of relatively coarse feeds. This is achieved through the addition of a size-dependent ore hardness term (S) which takes account of the reduction in rock strength that becomes significant in crushers handling run-of-mine feeds, though is also apparent in secondary crushing applications as well. Analysis of these new data indicates that this coarse particle ore hardness parameter (S) can be described by the general form shown in equation 1, and not only improves the accuracy of specific energy predictions of relevant crushing circuits but also those of full scale HPGR circuits. For conventional crushing the parameter should be used in primary and secondary crushing circuits. In the case of tertiary and AG/SAG mill pebble crusher circuits its use should normally not be necessary. For HPGRs the parameter should improve accuracy in cases where the circuit feed P80 is in excess of 20-25mm.

$$S = K_s (x_1, x_2)^{-0.2} \quad (1)$$

Where

S = coarse ore hardness parameter

K<sub>s</sub> = machine-specific constant that takes the value of 55 for conventional crushers and 35 in the case of HPGRs

x<sub>1</sub> = P<sub>80</sub> in microns of the circuit feed

x<sub>2</sub> = P<sub>80</sub> in microns of the circuit product

The specific energy equation for conventional crushers is predicted using the equation:

$$W_c = S_c K_2 M_{ic} 4 \left( x_2^{f(x_2)} - x_1^{f(x_1)} \right) \quad (2)$$

Where

$W_c$  = specific energy of the circuit (kWh/tonne)

$S_c$  =  $55.(x_1.x_2)^{-0.2}$

$K_2$  = 1.0 for all crushers operating in closed circuit with a classifying screen. If the crusher is in open circuit, eg pebble crusher in a AG/SAG circuit,  $K_2$  takes the value of 1.19.

$M_{ic}$  = Crushing ore work index and is provided directly by SMC Test<sup>®</sup>

$f(x_j)$  =  $-(0.295 + x_j/1000000)$

For HPGRs the specific energy is predicted using:

$$W_h = S_h K_3 M_{ih} 4 \left( x_2^{f(x_2)} - x_1^{f(x_1)} \right) \quad (3)$$

Where

$W_h$  = specific energy of the circuit (kWh/tonne)

$S_h$  =  $35.(x_1.x_2)^{-0.2}$

$K_3$  = 1.0 for all HPGRs operating in closed circuit with a classifying screen. If the HPGR is in open circuit,  $K_3$  takes the value of 1.19.

$M_{ih}$  = HPGR ore work index and is provided directly by SMC Test<sup>®</sup>

$f(x_j)$  =  $-(0.295 + x_j/1000000)$

## WORKED EXAMPLES

To illustrate the use of the S parameter the following worked examples are provided:

### 1. Primary Crushing Circuit.

The objective is to predict the specific energy necessary to reduce a run-of-mine feed with a P80 of 400mm to a product size with a P80 of 100mm in an open circuit primary gyratory crusher. An SMC Test<sup>®</sup> on a representative rock sample has provided a  $M_{ic}$  value of 7.2 kWh/t.

With reference to equation 2:

$$S_c = 55*(400000*100000)^{-0.2}$$

$$= 0.417$$

$$K_2 = 1.19$$

$$W_c = 0.417 * 1.19 * 7.2 * 4 * \left( 100000^{-0.295+100000/1000000} - 400000^{-0.295+400000/1000000} \right)$$

$$= 0.15 \text{ kWh/t}$$

## 2. HPGR Circuit.

The objective is to predict the circuit specific energy necessary to reduce a secondary crusher circuit product with a P80 of 35mm to a P80 of 4mm in a closed HPGR circuit. An SMC Test<sup>®</sup> on a representative rock sample has provided a  $M_{ih}$  value of 14.2 kWh/t.

With reference to equation 3:

$$S_h = 35*(35000*4000)^{-0.2}$$

$$= 0.822$$

$$K_3 = 1.0$$

$$W_h = 0.822 * 1.0 * 14.2 * 4 * \left( 100000^{-0.295+4000/1000000} - 400000^{-0.295+35000/1000000} \right)$$

$$= 2.43 \text{ kWh/t}$$