

Spigot Capacity of Dense Medium Cyclones

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by

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Summary

Dense medium cyclones are used extensively in the mineral processing industry to beneficiate various minerals including coal, diamonds and iron ore, amongst others. According to Reeves (2002), “the cyclone has been installed in over one-quarter of the coal preparation plants worldwide”. Dense medium cyclones have the ability to achieve high capacities, and simultaneously obtain sharp separations and high separation efficiencies. However, this piece of equipment does have a shortcoming in that its capacity is constrained by the solids carrying capacity of the spigot. This is termed the spigot capacity. There is uncertainty on whether the spigot capacities specified by DSM (Dutch State Mines), the original developers of the dense medium cyclone, can be increased or not, and how these capacities were determined. The purpose of this study is to establish a methodology to determine the spigot capacities of dense medium cyclones, and determine the parameters that influence these capacities.

In order to illustrate the significance of increasing the capacity of dense medium cyclones, the following coal example is used: In 2005, South Africa produced about 245Mt of coal valued at R35.86 billion. A significant proportion of this coal is beneficiated through dense medium cyclones. Therefore, an increase in the cyclone capacity, even if relatively small, represents a large number in terms of tonnages of coal produced or monetary gains.

It has been established clearly in this investigation that the maximum spigot capacity is reached at the onset of roping. A critical sinks ore concentration at which spigot overloading occurs has been observed. The simplest and best indicator of possible spigot overloading has been established to be the sinks ore concentration, measurement of this parameter could, however, prove challenging on most industrial cyclones. Further, spigot overloading of a dense medium cyclone can be detected visually by observing the discharge type at the sinks and monitoring particle misplacement to the floats stream.

A regression model that quantifies the spigot capacity, in terms of ore and slurry, has been developed. Various parameters were considered in the model, these include: cyclone geometry, feed head, medium density, and medium grade. Parameters that influence the spigot capacity of dense medium cyclones have been established, and their effect on the spigot capacity has been quantified.

The spigot capacity values obtained in this investigation were compared with those specified by DSM, and it was concluded that there is large potential to increase the 'spigot capacities' specified by DSM.

Keywords: Dense medium cyclone; Hydrocyclone; Dense medium separation; Spigot capacity; Spigot loading; Roping.

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Nomenclature

A-inlet – $70 \times 25 \text{ mm}^2$ ($D_i = 47 \text{ mm}$).

B-inlet – $70 \times 10 \text{ mm}^2$ ($D_i = 30 \text{ mm}$).

Bl – barrel length (mm).

C – Coarse grade magnetite with 75% (by mass) passing $45 \mu\text{m}$.

C_v – the volume fraction of the FeSi and ore in the feed.

C_{vf} – volumetric percentage of ore in the feed (applicable to DMS cyclones).

$C_{vf(+p50)}$ – volumetric percentage of ore in the feed with densities above the separation density (applicable to DMS cyclones).

C_{vo} – volumetric percentage of ore in the floats (applicable to DMS cyclones).

C_{vu} – volumetric percentage of ore in the sinks (applicable to DMS cyclones).

C_{mvu} – volumetric percentage of ore in the sinks during roping (applicable to DMS cyclones).

D – cyclone diameter (mm).

D_i – Inlet diameter (mm).

D_o – Vortex finder/overflow diameter (mm).

D_u – Spigot/underflow diameter (mm).

d_{ore} – particle size or size range (mm).

d_u – mass median (50% passing) size of the underflow solids.

d_{50} – cut-size (μm).

EPM – Escart Probable Moyen.

F – Fine grade magnetite with 95% (by mass) passing $45 \mu\text{m}$.

Gr – medium grade, expressed as mass percentage passing $45 \mu\text{m}$.

g_u – solids recovery in the underflow/sinks (by mass).

H – Feed Head (D).

M – Medium grade magnetite with 85% (by mass) passing $45 \mu\text{m}$.

O/F – Overflow or floats.

P – feed pressure (kPa).

Q_o – flow-rate of ore through the floats (l/hr ore).

Q_{os} – flow-rate of slurry through the floats (l/hr slurry).

Q_U – flow-rate of ore through the sinks (l/hr ore).

Q_{US} – flow-rate of slurry through the sinks (l/hr slurry).

Q_{UM} – the maximum ore carrying capacity of the spigot (l/hr ore).

Q_{USM} – the maximum slurry carrying capacity of the spigot (l/hr slurry).

Q – flow-rate of slurry through the feed (l/hr slurry).

R_f – water split to the sinks.

R_m – volumetric medium split to the sinks.

RD – Relative Density.

S – volume split during spray discharge (Q_{US}/Q_{OS}).

S_R – volume split during roping (Q_{USM}/Q_{OS}).

SG – Specific Gravity.

U/F – Underflow or sinks.

$\%V_{MSU}$ – volumetric percentage of solids in the underflow during roping (applicable to classification cyclones).

$\%V_{SF}$ – volumetric percentage of solids in the feed (applicable to classification cyclones).

C_i^+ – the percentage weight of solids in the feed coarser than the separation size.

α – cone angle (degrees).

ρ_{med} – feed medium density (kg/l).

ρ_{ore} – ore density (kg/l).

$\rho_{OF(med)}$ – floats medium density (kg/l).

$\rho_{UF(med)}$ – sinks medium density (kg/l).

ρ_F – the relative slurry density in the feed.

ρ_O – the relative slurry density in the floats stream.

ρ_U – the relative slurry density in the sinks stream.

σ_{est} – Standard error of the estimate.