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The effect of cyclone geometry and operating conditions on spigot capacity of dense medium cyclones

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Abstract

Dense medium cyclones separate particles primarily according to their differences in density, and are used in the beneficiation of coal, iron ore, and diamonds, amongst others. The cyclone can, however, be constrained by the ore carrying capacity of the spigot, especially for ores in which a significantly large proportion of the feed particles need exit through the sinks stream. Currently, the spigot capacities used in the sizing and selection process for dense medium cyclones are based mainly on those capacities provided by the original developers of the dense medium cyclone, Dutch State Mines (DSM). Further, it is not clear which parameters, other than the spigot diameter, have an influence on the spigot capacity of dense medium cyclones.

The influence of the cyclone geometry and operating conditions on the spigot capacity of dense medium cyclones was investigated, and parameters of importance in this regard were identified. An empirical model that quantifies the effect of the various parameters on the spigot capacity is presented in this paper. Furthermore, the spigot capacities determined experimentally in this study are compared with those given by DSM.

Keywords: Dense medium cyclone; Spigot capacity; Spigot overloading; Rope discharge; Magnetite

1. Introduction

Dense medium cyclones separate particles primarily according to their differences in density, and have the ability to achieve sharp separations and high capacities at the same time. Typical applications of dense medium cyclones include the beneficiation of coal, iron ore, and diamonds, amongst others. A schematic diagram depicting the geometry of a cyclone is presented in Fig. 1. The cyclone can, however, be constrained by the ore carrying capacity of the spigot, especially for ores in which a significantly large proportion of the feed particles exit through the sinks stream. These capacities are usually supplied by cyclone manufacturers. Currently, the spigot capacities used in the sizing and selection process for dense medium cyclones are based mainly on those capacities provided by the original developers of the dense medium cyclone, Dutch State Mines (DSM).

A distinction needs to be made between spigot loading and spigot capacity. Spigot loading refers to any amount of ore (or slurry) flowing through the spigot per unit time, whilst spigot capacity is the maximum ore (or slurry) flowrate through the spigot; that is, the maximum spigot loading. The spigot capacity of a dense medium cyclone has previously been illustrated to be reached at the onset of

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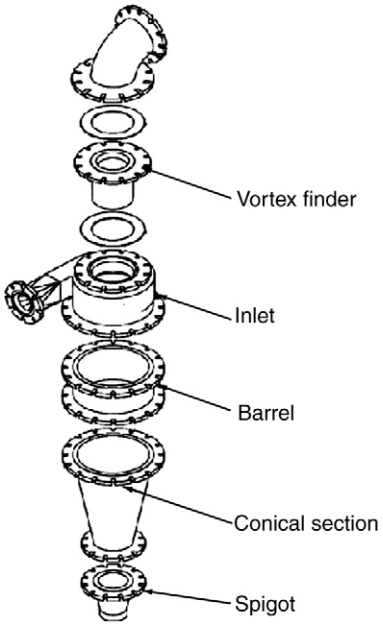

Fig. 1. Schematic diagram depicting the geometry of a cyclone.

rope discharge at the sinks stream (Magwai and Bosman, 2007). Upadrashta and Venkateswarlu (1982), and Stas (1957) have also previously expressed the same view.

Similar behaviour has been reported for classification cyclones: Plitt et al. (1987) assumed that the spigot capacity is exceeded when a rope discharge is prevalent at the spigot, and so did Heiskanen (2000). Jull (1972), on the other hand, measured spigot capacities of hydrocyclones just "short of roping".

Once a rope discharge is prevalent at the spigot of a dense medium cyclone, the spigot capacity is independent of changes in the feed ore concentrations for given cyclone geometry and set of operating conditions (Magwai and Bosman, 2007).

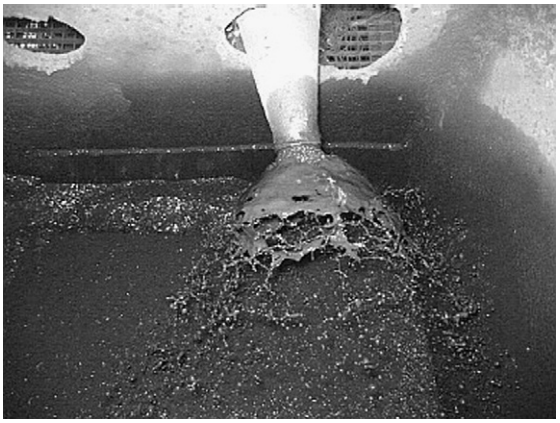

Fig. 2. Spray discharge at the sinks stream of a 350 mm dense medium cyclone.

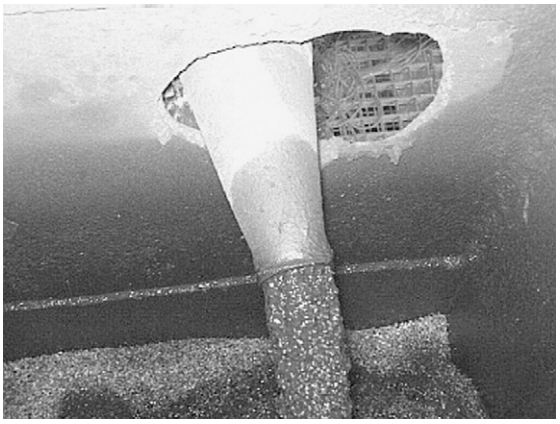

Fig. 3. Rope discharge at the sinks stream of a 350 mm dense medium cyclone.

A dense medium cyclone is typically operated with a spray discharge at the spigot (Fig. 2). Rope discharge is obtained at the sinks stream of a cyclone when the ore concentration within the cyclone, more specifically at the spigot, is excessive (Fig. 3). A semi-rope discharge, which is a combination of spray and rope discharges, is obtained at intermediate ore concentrations. During semi-roping the stream at the spigot continuously switches between spray and semi-rope discharges. Rope discharge has previously been associated with misplacement of ore particles that were supposed to exit at the spigot to the vortex finder. This behaviour has been reported for both classification (Fahlstrom, 1963; Trawinski, 1976; Kelly, 1991; Neesse et al., 2004; etc) and dense medium cyclones (Stas, 1957; Upadrashta and Venkateswarlu, 1982; Magwai and Bosman, 2007). Coarse particles are misplaced to the fines stream in the case of classification cyclones, whilst the heavier sinks particles are misplaced to the floats stream in dense medium cyclones.

A number of mathematical expressions describing the relationship between spigot ore capacity and spigot

Table 1
Spigot diameter–spigot capacity relationships in literature

Source	Cyclone type	Parameter k_o	Exponent m
Jull (1972)	Classification	2.3	2.19
Plitt et al. (1987)	Classification	1.563	2.35
DSM (coal at 9D)	Dense medium	0.9	1.94
DSM (other minerals)	Dense medium	– [a]	2.05

[a] Dependent on head.