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EXAMPLE OF DENSE MEDIA CYCLONE SELECTION

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Abstract
Dense medium cyclones separate particles based on their density due to centrifugal force induced by the swirling flow. They are usually used in the coal industry to separate lighter coal from denser ash, but can be used for other raw materials, such as lead-zinc ore. There are several methodologies used to select and calculate DM cyclones. This paper deals with two methods related to the selection and calculation of DM cyclone capacity on the example of lead-zinc ore preconcentration.

Keywords: *DM cyclone, device selection, capacity*

1. INTRODUCTION

The main idea behind dense medium separation (DMS), a beneficiation technique that separates valuable minerals from waste material, is to separate low-density material from high-density material. This separation is accomplished by using a dense medium. After being employed in a separation vessel, the medium is subsequently recovered [1]. DMS is utilized extensively in coal preparation, and are also used as the first concentration step in diamond recovery, iron ore concentration, base metal pre-concentration, and some industrial minerals. The application will determine the operating medium density [2]. Ferrosilicon is utilized as the medium in the ore processing of heavy metals like iron and lead [1].

A circuit for dense medium separation is shown in Fig. 1.

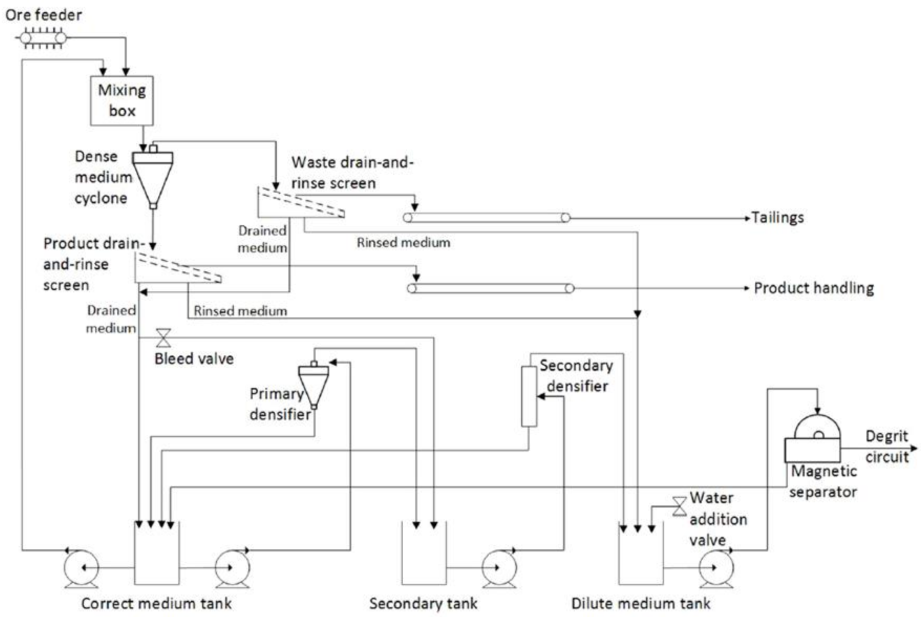

Figure 1. Diagram of a dense medium separation circuit [1].

When properly sized ore is fed into a dense medium cyclone (DMC), lower density waste form the overflow and higher density valuable material constitute the cyclone's underflow. The cyclone's overflow is sent to a drain-and-rinse screen. After being drained from the waste, the medium slurry is transferred to the appropriate medium tank. After that, the leftover waste in the screen is rinsed, and the rinsed medium is sent to the tank of diluted medium. Conveyor belts carry the waste from the screen's overflow to the tailings dump. Additionally, the cyclone's underflow (concentrate) is directed to a drain-and-rinse screen. After being drained from the concentrate, the medium slurry is transferred to the appropriate medium tank. Wash water is used to rinse the leftover concentrate particles from the screen. The diluted medium tank receives the washed medium slurry. Conveyor belts are used to move the concentrate in the screen overflow to product stockpiles. The medium is regenerated through a separate system of devices and returned to the beginning of the process [1].

Operating principle of dense media cyclone (DMC) can be briefly explained as follows (Figure 2). DMC separates the heavy and light particles on basis of density difference under the influence of centrifugal forces. Medium with ore particles fed tangentially through the cyclone inlet where the centrifugal forces are produced due to which the heavier density particles moves towards the wall and passes through underflow as reject. Lower density particles moves along the forced vortex and passes through overflow due to drag dominance [3].

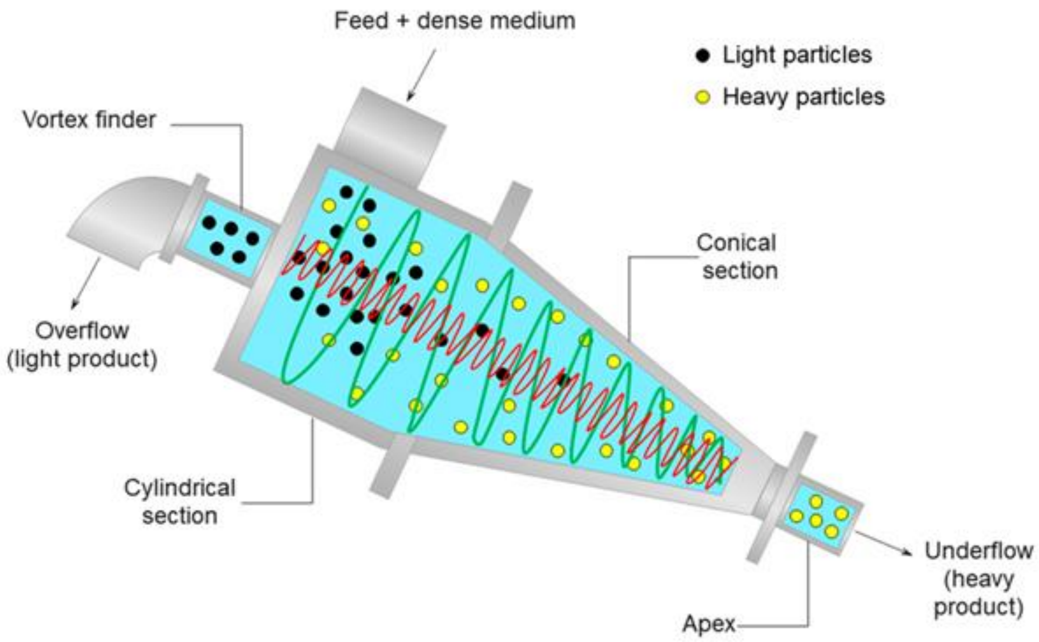

Figure 2. Scheme of a conventional dense-medium cyclone [4].

2. SELECTION OF DMC

Selection and calculation of DMC depends on its operating conditions. Different methodologies are used for the selection and calculation of DM cyclones, and in this paper an example of selecting a DMC based on two methodologies is given: (1) JKMRC method [5] and (2) DSM method [6]. The calculation was made based on the assumed process capacity of 500.00 m^3/h, for the separation of lead-zinc preconcentrate from tailings. The assumed medium is ferrosilicon.

The basic data required for the calculation of the DM cyclone are:

- Pulp volume flow at the dense media cyclone inlet . . . . $V_p = 500.0\ m^3/h$
- Fluctuation coefficient . . . . $k = 1.2$
- Increased pulp volume flow at DMC inlet due to fluctuations . . . . . $V_{pmax} = 600.0\ m^3/h$
- DMC diameter . . . . $Dc = 900$ mm

- Length of the rectangular section of the inlet pipe . . . . a = 160 mm
- Width of the rectangular section of the inlet pipe. . . . . b = 180 mm
- Equivalent inlet pipe diameter* . . . . *Di* = 191.5 mm
- Overflow pipe diameter . . . . *Do* = 440 mm
- Underflow pipe diameter . . . . *Du* = 370 mm
- Pressure at the DMC inlet expressed in diameters . . . . P = 11 D
- Pressure at the DMC inlet . . . . P = 9.5 m
- Etalon head (etalon pressure at the DMC inlet) . . . . *He* = 10 m
- A factor that depends on the DMC diameter . . . . f = 0.76

* It is counted as $Di = \sqrt{4ab/\pi}$

According to ***JKMRC methodology***, DMC capacity (Q_c) is calculated based on the following equation:

$$Q_C = 2.87 \cdot 10^{-5} \cdot D_c^{2.30} \cdot P^{0.46} \cdot \left(\frac{D_u}{D_o}\right)^{0.17}$$

Where:

D_c – DMC diameter [mm]
D_o – overflow pipe diameter [mm]
D_u – underflow pipe diameter [mm]
P – operating pressure of the pulp at the DMC inlet, expressed in diameters of the DMC

Accordingly,

$$Q_C = 2.87 \cdot 10^{-5} \cdot 900^{2.30} \cdot 11^{0.46} \cdot \left(\frac{370}{440}\right)^{0.17} = 523.5\ m^3/h$$

By the ***DSM methodology***, the first should calculate the capacity of the reference DM cyclone (Q_{CE}), i.e. capacity of DM cyclone operating at the inlet pressure of *He* = 10 m:

$$Q_{CE} = f \cdot \frac{D_o \cdot D_u}{100} = 0.76 \cdot \frac{370 \cdot 440}{100} = 640.35\ m^3/h$$

Where:

f – a factor that depends on the diameter of the DMC [6]. For the given case, D_c = 900 mm, is adopted f = 0.76

Actual capacity of DM cyclone (Q_C) is calculated based on the equation:

$$Q_C = Q_{CE} \cdot \sqrt{\frac{P}{H_e}} = 640.35 \cdot \sqrt{\frac{9.5}{10}} = 624.14\ m^3/h$$

Where:

P – operating pressure of the pulp at DMC inlet expressed in meters
He – etalon operating head [m], *He* = 10 m

Based on the obtained results, it is concluded that by application of the first methodology (JKMRC) selected DMC does not provide a satisfactory outcome for the maximum capacity that can occur in the plant (2 DMCs are needed). On the other hand, according to the DSM method this DM cyclone has satisfactory performances (1 DMC is enough). Given the conflicting results, the equipment manufacturer's recommendation should be taken into account when choosing a device.

3. CONCLUSION

The selection and calculation of the dense media cyclone was carried out on the example of pre-concentration of lead-zinc ore, by means of two methodologies based on the assumed capacity and type of medium. According to one methodology, the performance of the selected cyclone is satisfactory and one DMC is sufficient for operation in the plant, while according to another methodology it is necessary to adopt two DMCs for smooth operation of the plant. For the final decision on the choice of device, it is necessary to consult the equipment manufacturer.

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