University of Belgrade
Technical Faculty in Bor,
Mining and Metallurgy
Institute Bor

54th International October Conference on Mining and Metallurgy

PROCEEDINGS

Editors:
Ljubiša Balanović
Dejan Tanikić

18-21 October 2023, Bor Lake, Serbia

PROCEEDINGS,

54th INTERNATIONAL OCTOBER CONFERNCE

on Mining and Metallurgy

Editors:

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University of Belgrade, Technical Faculty in Bor

Technical Editor:

M. Sc. Miljan Marković

University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Dean Prof. dr Dejan Tanikić

Circulation: 200 copies

CIP - Каталогизација у публикацији Народна библиотека Србије, Београд

622(082)(0.034.2)
669(082)(0.034.2)

INTERNATIONAL October Conference on Mining and Metallurgy (54 ; 2023 ; Borsko jezero)
Proceedings [Elektronski izvor] / 54th International October Conference on Mining and Metallurgy - IOC 2023, 18-21 October 2023, Bor Lake, Serbia ; [organized by] University of Belgrade, Technical Faculty in Bor and Mining and Metallurgy Institute Bor ; editors Ljubiša Balanović, Dejan Tanikić. - Bor : University of Belgrade, Technical Faculty, 2023 (Niš : Grafika Galeb). - 1 USB fleš memorija ; 1 x 1 x 5 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 200. - Preface / Ljubiša Balanović. - Bibliografija uz svaki rad.

ISBN 978-86-6305-140-9

a) Рударство -- Зборници b) Металургија -- Зборници

COBISS.SR-ID 126659849

Bor Lake, Serbia, October 18-21, 2023

Conference is financially supported by
The Ministry of Science, Technological
Development and Inovation
of the Republic of Serbia

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,
Prof. dr Ljubiša Balanović
Љубиша Балановић

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THE ROLE OF WING TANK IN DMS PROCESS. SUSPENSION VELOCITY THROUGH THE SEAL LEG ORIFICE – CASE STUDY

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Abstract

Wing tank represents a specifically designed sump of centrifugal slurry pump, that has a special role in the dense media separation process. The common case is that the mixture of ore and media (suspension) is pumped from the wing tank into the DM cyclone, where the raw material is further separated into heavy and light fractions. This paper provides a brief overview of the function of the wing tank, as well as the calculation of several possible variants of media flowrate and velocity through the seal leg of wing tank. In this way, the potential distribution of material was determined, that is, the amount of medium that will go into the further separation process, or will be separated in the overflow, at a variable height of the overflow threshold.

Keywords: *Dense media separation, wing tank, suspension velocity*

1. INTRODUCTION

In heavy-media separation (also called dense media separation, sink-and-float separation), the medium used is a suspension in water of a finely ground heavy mineral (such as magnetite) or technical product (such as ferrosilicon). Such a suspension can simulate a fluid with a higher density than water. When ground ores are fed into the suspension, the gangue particles, having a lower density, tend to float and are removed as tailings, whereas the particles of valuable minerals, having higher density, sink and are also removed. The magnetite or ferrosilicon can be removed from the tailings by magnetic separation and recycled [1, 2]. Separation of materials is performed in devices of different constructions such as: dense media drum separator, separation cone, Daniels dense medium vessel, DM Cyclone, dyna whirlpool, etc. By far, the most widely used centrifugal dense media separator is DM cyclone whose principle of operation is similar to that of the conventional hydrocyclone. The ore is suspended in the medium and introduced tangentially to the DM cyclone, usually by centrifugal slurry pump. The dense material (product in the case of ore) is centrifuged to the cyclone wall and exits at the apex. The light product "floats" to the flow around the axis and exits via the vortex finder [3]. For the proper operation of the DM cyclone, it is necessary that the DM cyclone pump feeds it with material at a constant flow and pressure. This is achieved by the appropriate design of the receiving sump – wing tank, which enables the reception of mineral raw materials and suspension (medium) and can work with a constant liquid level [4].

Wing tank is a tank designed to consistently feed medium and ore to the DMC pump at the desired head to supply sufficient velocity for a sharp separation in the DM cyclone. The wing-side of the wing tank was called this because it is shaped like a wing, running into the side of the tank. Wing tanks are designed to continuously overflow so that head to the pump is kept at a constant level when ore is being delivered to the DM cyclone. When no ore is present, the wing tank will typically operate just below the overflow [5]. The schematic view of the wing tank is given in the Figure 1, and the system wing tank – DMC pump – DM cyclone flowsheet in the Figure 2.

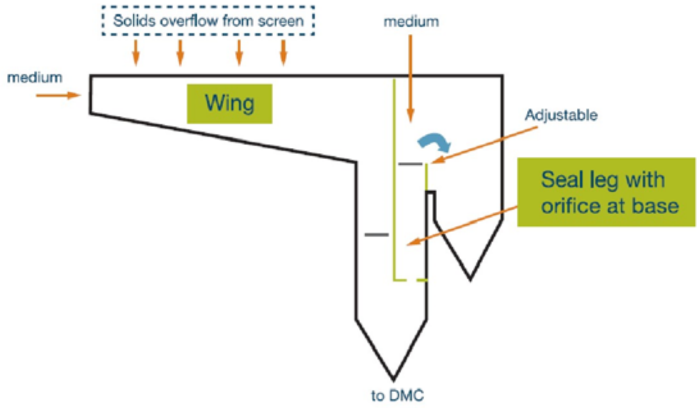

Figure 1 – Wing tank design (adapted from [4])

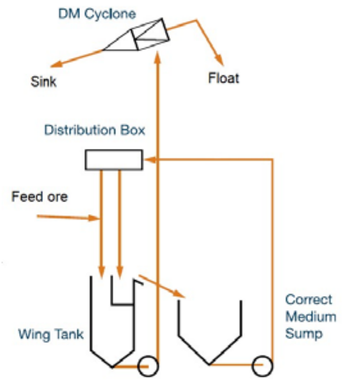

Figure 2 – Typical flowsheet of wing tank – DMC pump – DM cyclone system (adapted from [4])

2. THE WING TANK DESIGN AND ROLE

The wing tank is designed to meet two key objectives [4]:

1. To receive the incoming feed solids and medium such that it can operate at a constant level to enable the dense media cyclone to be pump fed at a constant pressure and flowrate. This is achieved by splitting some of the incoming medium directly to an overflow box mounted at the top of the wing tank, from where excess medium overflows to the sump for correct medium.
2. Ensure that all solids that come to the wing tank descend directly to the pump inlet. Due to the buoyancy effect of the medium, coarser, low density particles will tend to ‘raft’ to the surface of the sump; therefore it is critical to ensure that there is a uniform downward velocity of the slurry over the full cross section of the main body of the wing tank. According to literature, this uniform downward flow rate should be about 0.2 m/s in order to counter the tendency for the coarse, light particles to raft to the top.

Wing tank is narrow in shape, with minimal residence time, compared to the normal residence time of many other plant sumps (1–2 minutes). If the downward velocity is insufficient, the coarser, low density grains that raft to the surface will accumulate, displacing volume, and are likely to eventually ‘back up’ the feed particles to block the new feed solids flowing into the wing tank. Rafting and worn orifice plates can also cause the solids carrying over to the correct medium sump, bringing blockages in the bleed valves and trash screens on magnetic separators. Therefore, maintenance procedures in the DMS plant should include a scheduled check on the dimensions of the orifice in the wing tank [4].

Unlike the most other process plant sumps that have residence times ranging from 1 to2 minutes of pumping, the typical residence time in the wing tanks (for the ore plus medium section, on the wing side, above the orifice level) is about 10 seconds and this normally gives just enough time to de-aerate the slurry while still ensuring a suitable downwards velocity. The flow rate through the orifice is often about 1–2 m/s but this will vary depending on the combination of levels and design flow rates [4].

Cross-sectional schematics presentation of a wing tank with the overflow box, orifice plate and overflow weir for two extreme operating cases is given in Figure 3 and Figure 4. Dense medium circuit is designed for Q = 1,000 m^3/h slurry flowrate. Considering this, "feed off" case assumes the wing tank is set up such that the medium is just over-flowing into the correct medium sump and there is no solids (ore) in the system. On the other hand, "feed on" case assumes the designed volume of solids Q = 200 m^3/h within the same slurry flowrate, considering the plant has been designed for a 4:1 medium:ore ratio [4, 5].

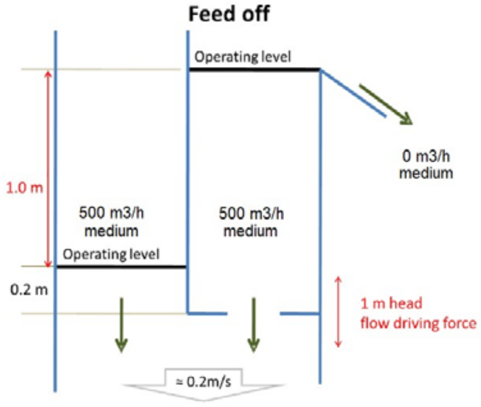

Figure 3 – Schematic of wing tank cross-section for ore feed off; 1,000 m^3/h medium (adapted from [5])

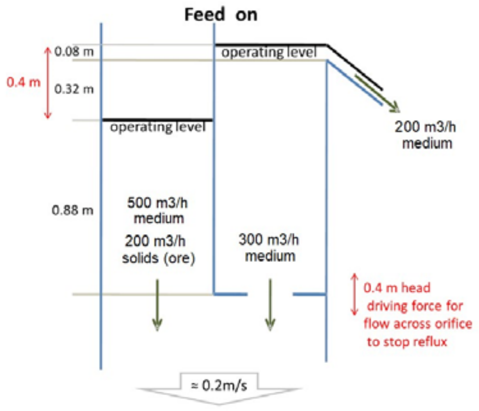

Figure 4 – Schematic of wing tank cross-section for ore feed on; 800 m^3/h medium + 200 m^3/h solids (adapted from [5])

3. DETERMINATION OF SUSPENSION VELOCITY THROUGH THE SEAL LEG ORIFICE

Given that during the regular operation of each plant there are significant variations in the amount of raw material that reaches the process, the change in the suspension velocity through the seal leg orifice is considered in this paper. The differential head between the ore-side and the seal-side of the wing tank is significant in driving the flows through the orifice plate and therefore determining the orifice velocity. The flow rate of suspension through an orifice is calculated according to equation (1) [4,5]:

$$Q = C \times a \times \sqrt{2gH} \tag{1}$$

Where: Q is flow rate in m^3/s; H is differential head in m; a is area of orifice opening in m^2 ($a = d^2\pi/4$, and d is orifice diameter); g is gravity constant ($g = 9.81$ m/s^2); C is constant depending on the orifice shape.

From the orifice flowrate, the velocity through the orifice (V) can be calculated according to equation (2):

$$V = Q/a \tag{2}$$

During the velocity calculation, the following conditions were applied: (1) total volumetric capacity of the slurry was considered unchanged (Q = 800 m^3/h); (2) volumetric flow rate of the ore was variable, and therefore media flow rate through the seal leg was variable; (3) wing tank geometry (height to volume relationship) was not taken into account in the calculation, but considered as normal case; (4) orifice hole diameter is adopted as $d = 0.25$ m and therefore $a = d^2\pi/4 = 0{,}049$ m^2; (5) C = 0.6 for a submerged square profile circular hole; (6) total flow rate of the suspension that reaches the seal leg is assumed to be $Q_m = 400$ m^3/h.

4. RESULTS AND DISCUSSION

Table 1 shows the results of calculation of suspension velocity through the seal leg orifice, based on mentioned conditions.

Table 1 – Suspension flow parameters in the seal leg of wing tank

Component	Case I	Case II	Case III	Case IV	Case V
Flow rate of the ore, m^3/h	0	100	125	150	175
Flow rate through the orifice, m^3/h	400	300	275	250	225
Suspension overflow, m^3/h	0	100	125	150	175
Differential head, m	0.72	0.41	0.34	0.28	0.22
Velocity through the orifice, m/h	2.26	1.70	1.56	1.41	1.27

Considering the presented results, it can be seen that in the case of such orifice design (i.e. $d = 250$ mm), the ore capacity cannot be increased much further, because the velocity of the suspension through the orifice decreases rapidly, and must be greater than 1 m/s. In the same time, differential head tend to reach a very small value, which also is not acceptable. Here, the question arises about the reducing size (diameter) of the seal leg orifice or the change in the overall slurry flow rate, if the process design allows such a modification.

5. CONCLUSION

In accordance with the presented research, the following conclusions can be drawn:

- Wing tank is a pump sump of the specific design, which ensures uniform feeding of DM cyclones in DMS plants.
- Wing tank should provide a uniform small downward flow rate of material to the DMC feed pump and disable low density particles to ‘raft’ to the surface of the sump.
- Correct design of the wing tank geometry, as well as the sizing of the seal leg orifice is the crucial for the proper operation of the DMC pump – DM cyclone system.

ACKNOWLEDGEMENTS

This work was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Grant No. 451-03-47/2023-01/200052.

REFERENCES

[1] W.S. Khan, E. Asmatulu, Md. N. Uddin, R. Asmatulu, Recycling for Sustainable Developments, (2022), 49-68.

[2] https://www.britannica.com/technology/heavy-media-separation

[3] B. A. Wills, T. Napier-Munn: Dense medium separation (DMS), Chapter 11 in: Wills' mineral processing technology: An introduction to the practical aspects of ore treatment and mineral recovery, seventh edition, Elsevier, Butterworth-Heinemann, (2006), 246-266.

[4] H. Crowden, B. Atkinson, C. Clarkson, B. Firth, M. O’Brien, D. Wiseman, C. Wood: ACARP Dense Medium Cyclone Handbook, Australian Coal Preparation Society, (2013), 328

[5] N.J.C. Scott: Dynamic Analysis of Dense Medium Circuits, PhD Thesis, The University of Queensland, Julius Kruttschnitt Mineral Research Centre, (2017), 268