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Innovative hydromechanical cleaning of mine water sedimentation tanks in underground headings

In mines, water from natural inflows as well as process water from fire protection systems is usually stored in sedimentation tanks, located primarily at the lowest level of the mine. Such water usually contains mechanical contaminants, undergoing the process of sedimentation.
The article presents a method enabling the cleaning of mine water sedimentation tanks. The method involves jet mining, hydrotransport and segregation into sediment (i.e. the solid fraction) and water. The consistence of sediment obtained after segregation makes the former transportable (e.g. using an appropriate conveyor/feeder), whereas water can be reused subsequently in the jet mining of sediment. One of the solutions enabling the performance of the above-named process is a ZEKO series system.

Key words: *sediment, jet mining, hydrotransport, sedimentation*

1. INTRODUCTION

Water entering mines may come from the following sources:

- rock mass surrounding headings,
- open reservoirs located on the surface,
- technological processes.

Water flows into sedimentation tanks (i.e. the so-called drain-ways) usually located in the deepest part of mines, near the main pumping station. The number and the capacity of sedimentation tanks depends on the volume of water involved. Typically, there are two [1] sedimentation tanks in Polish mines, each having an approximate capacity of 2,000 cubic metres. The tanks are primarily used for the storage of water, prior to it being pumped up to the mine surface.

As water is significantly contaminated mechanically (i.e. with sediments having the form of coal, sand or dust particles), its cleaning takes place through sedimentation. The process of sedimentation may take up to several hours [2]. Depending on the level of water contamination, sedimentation tanks usually take several months to fill up.

The removal of sediment involves its initial "dehumidification". The process of "dehumidification" involves three stages. First, water must stop filling up a given sedimentation tank and, next, it must be pumped out.

The third stage involves the removal of "dehumidified" sediment (e.g. using spades or loaders) from the sedimentation tank followed by the transport of the former. It should be noted that transport-related solutions may vary depending on a given mine and its specific conditions.

Another method enabling the removal of sediment involves hydromechanical transport requiring the use of sludge pumps. Such a solution is usually based on the use of water from fire protection pipeline systems. Sediment, usually characterised by the high content of coal, is transported to the so-called old workings.

2. ZEKO – A CLASSIFYING AND DEWATERING SYSTEM USED IN MINES

Presented below is a ZEKO system-based method enabling the removal of sediment from sedimentation tanks. The system includes the hydromechanical transport of sediment to a place of its subsequent segregation into solid-state sediment and water. The solution involves the use of water as a sediment carrying medium.

The technology of jet mining (in previously "dried" sedimentation tanks), hydrotransport and the separation of sediment from water [3, 4] is presented in Figure 1.

The process is divided into two major stages, where the first stage involves the application of the ZEKO-S system [5], whereas the second phase is based on the ZEKO-Flok system [6].

The first stage involves the obtainment of transportable sludge from mine water sedimentation tanks and water containing particles having a granularity of approximately 0.2 mm. The stage includes three steps aimed to separate sediment from water.

Step 1 involves the removal of large amounts of water from sludge transported from mine water sedimentation tanks. Sludge is fed using pump P1 to a sieve classifier (SC). In the sieve classifier sludge is subjected to the process of segregation, leading to the obtainment of "dirty" water (containing particles having a granularity of below 2 mm) and thickened sludge. "Dirty" water is then transported to container 1, whereas thickened sludge is transported to a dewatering screen (DS).

Step 2 involves the additional filtering of thickened sludge located on the dewatering screen (DS), enabling the obtainment of transportable sediment. Afterwards, sludge is fed onto an "output" haulage conveyor.

Step 3 involves the further transport of water (using pump P2) to a group of hydrocyclones (HC) enabling the obtainment of sediment having a granularity of less than 0.2 mm. During this phase, thickened sludge is still in the liquid form. Afterwards, sludge is further transported to the dewatering screen (DS), where, along with remaining sediment, it is filtered off again and, finally, moved onto the "output" haulage conveyor.

At the second stage (involving the use of the ZEKO-FLOK system), after being processed by the hydrocyclones (HC), water containing sediment having a granularity of less than 0.2 mm flows into tank no. 2. Next, pump P3 feeds the aforesaid water to step 4 of the process. Water with sludge is then mixed with flocculant and transported to a thickener, where the sludge undergoes thickening and segregation into "pure" water and "wet" sludge. Afterwards, the sludge is fed into a classifier where the water is removed from sludge so that "wet" sludge can be obtained. Next, this transportable sludge is fed on the "output" haulage conveyor. At this point, cleaned water contains not more than 2% of sludge; sediment granularity being less than 0.2 mm. Water obtained in the above-presented process is reusable (e.g. in jet mining).

In the years 2005–2022, the ZEKO-S/M-based systems were implemented in ten coalmines [7]. The systems were adapted for zones being at risk of methane and coal dust explosions, as well as for zones free from the aforesaid hazards.

3. INNOVATIVE APPLICATION OF THE ZEKO-SUM CLASSIFYING AND DEWATERING SYSTEM

The year 2021 saw the development of an innovative solution enabling the jet mining of sediment/sludge in mine water sedimentation tanks. One of the advantages of such a solution is the possibility of "desludging" (pumping out hydrated sediment) a given tank without the necessity of removing water from it. The aforementioned solution involves the use of a floating system (the so-called SUM) along with necessary jet mining equipment including, among other things, one pump for churning up sediment/sludge and another one for its hydrotransport (performed in the identical manner as that discussed in the previously described technology). The primary difference is that a pipeline used for hydrotransport is laid (along with progressing "desludging") on the surface of water.

The design of the system makes it usable for cleaning sedimentation tanks during the mine's regular operations. The system is approximately 5.5 m long, 4 m wide, 1.4 m high and 0.5 deep (in water) [8]. The load carrying capacity of the system enables the simultaneous presence of four persons on its platform.

As progress in "desludging" is accompanied by a growing distance between the floating platform and the connection of the hydrotransport pipeline, it is necessary for operating personnel to move to/from the SUM. To address this need, the system has been provided with an extendable walkway (floating on the surface of water). An alternative solution could involve the use of a boat. In both cases, personnel movements must be consistent with related HSE regulations. The technology of jet mining and hydrotransport based on the SUM floating system as well as the separation of sediment from water are presented in Figure 2.

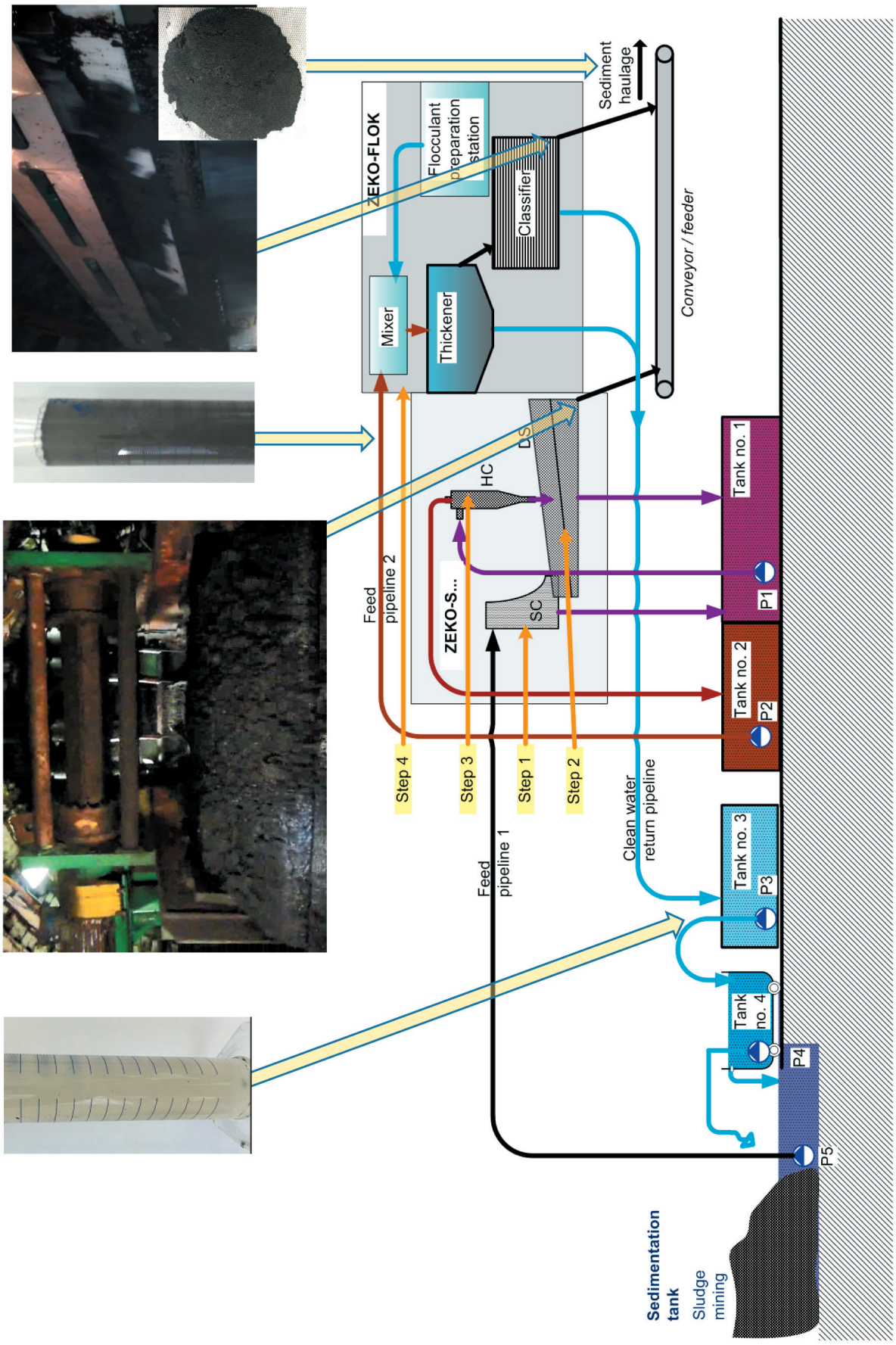

Fig. 1. Schematic diagram presenting the technological process of cleaning the sedimentation tank: P1–P5 – sludge pumps, SC – sieve classifier, HC – hydrocyclon

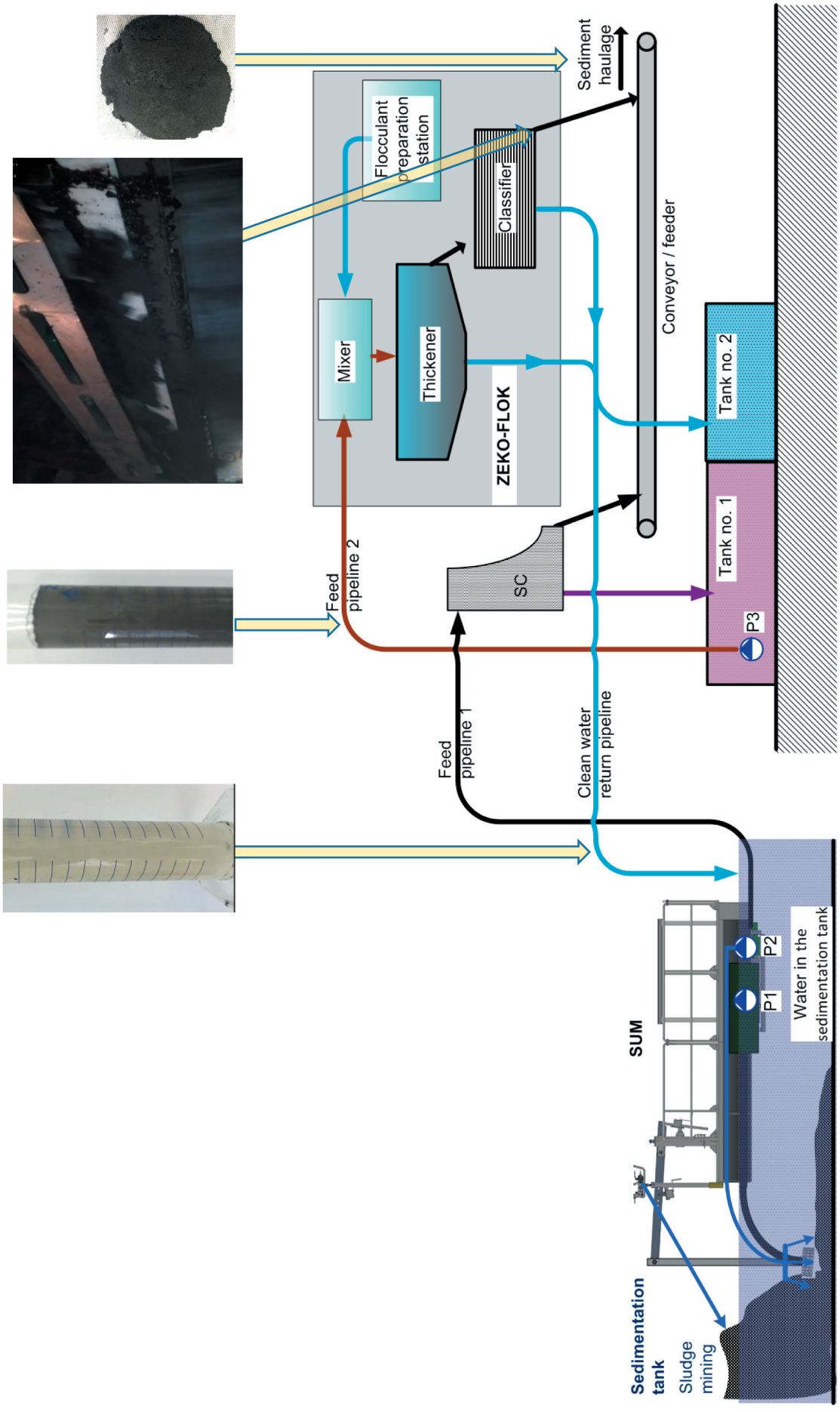

Fig. 2. Schematic diagram presenting the technological process of cleaning the sedimentation tank from the surface of water: P1–P3 – sludge pumps, SC – sieve classifier

The SUM and ZEKO systems can also be applied to clean mine water sedimentation tanks located on the earth's surface. Tests involving such an operation were successfully performed in the Ruda Ruch Halemba coalmine in 2021.

4. CONCLUDING REMARKS AND PROSPECTS

1. In many respects, the ZEKO system-based jet mining and hydrotransport of sediment/sludge from sedimentation tanks is, safer, more efficient and less costly than offered by other methods.
2. The ZEKO system should be located in the vicinity of sedimentation tanks and transport equipment (conveyors, cars, etc.). The hydrotransport of sludge between a sedimentation tank/drain-way and the ZEKO system should be performed using appropriate pipelines (e.g. DN 100).
3. In cases of problems with the drainage of sedimentation tanks/drain-ways, it is possible to remove sediment/sludge using the SUM system.
4. The system also makes it possible to clean mine water sedimentation tanks located on the earth's surface.
5. Jet mining, hydrotransport and the separation of sediment from water shortens and facilitates the cleaning of sedimentation tanks and, consequently, increases their actual capacity.

References

[1] Norma branżowa BN-78j 0444-03: *Główne odwadnianie kopalń głębinowych. Zasady projektowania*.
[2] Piecuch T.: *Technika wodno-mułowa. Urządzenia i procesy*. WNT, Warszawa 2010.
[3] Patent no. 235141: *Sposób i układ oczyszczania zbiorników wodnych, zwłaszcza podziemnych wyrobisk górniczych*.
[4] Patent application no. 429867: *Sposób i układ oczyszczania zbiorników wodnych, zwłaszcza podziemnych wyrobisk górniczych*.
[5] Specification sheet: *Zestaw klasyfikacyjno-odwadniający ZEKO-S40.*
[6] Specification sheet: *Zestaw klasyfikacyjno-odwadniający ZEKO-Flok*.
[7] Biel B.: *Hydromechaniczne oczyszczanie osadników dołowych*. XXVI Międzynarodowa Konferencja Naukowo-Techniczna TEMAG 2018. XV Międzynarodowe Warsztaty Techniczne [unpublished].
[8] Specification sheet: *Szlamujące urządzenie mobilne SUM*.

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