Mechanics Transport Communications ISSN 1312-3823 (print)
ISSN 2367-6620 (online)
volume 17, issue 1, 2019
Academic journal http://www.mtc-aj.com article № 1748

MODELING OF TEST-RIG FOR PURIFICATION OF MINING WATER

Rositsa Velichkova, Martin Pushkarov, Iskra Simova
rvelichkova@tu-sofia.bg;martotoo@abv.bg, iskrasimova@gmail.com

Technical University of Sofia, Sofia 1000, 8 Kl. Ohridski Ave, BULGARIA

Key words: *mining water treatment, test-rig, mining industry*
Abstract: *The mining water is considered to be the biggest ecological concern associated with mining industry. In presented work a test-rig for mining water treatment is proposed. The principle of operation of the system as well as the elements hydraulic sizing calculations are explained.*

INTRODUCTION

The mining operations are associated with an environmental responsibility, i.e. protection of the air, land, and water in particular [1-2]. Mining water is considered to be the biggest ecological problem associated with mining industry. This water is polluted by a process related to the oxidation of pyrite and other sulphide minerals, resulting in acidic waters that contain sulfuric acid, dissolved heavy metals and suspended iron sludge. The main sources of acidic mine water are the open and underground mines, waste rock dumps and poor ore, industrial waste, stored sulphide concentrates and pyrite-rich coal and uranium mines. Besides iron and other heavy metals, acid mine water from uranium mines contains radioactive elements such as uranium and radium. Toxic elements such as arsenic (As) and antimony (Sb) are other essential components of acid mine water dissolved from mineral raw mineral materials containing these elements.[3]

Mixing acid waste water with natural river and lake water causes a serious deterioration in the quality of the water. Such contaminated waters are unsuitable for most aquatic organisms, for human consumption and for industrial use. Soils along the water path are also polluted and become unusable for agricultural purposes. Therefore mine water treatment is of crucial importance for the environment and society [4-5].

The aim of the present work is to suggest a model of a test–rig for mining water treatment.

TECHNOLOGICAL SCHEME OF THE TEST-RIG

The technological process of water treatment is as follows.

Neutralization with a 10% barley milk solution – the process is carried out in first flow reactors from A1 to A2-6 and for second flows from B1 to B2-6. The barley milk is fed into A1 at first flow and B1 for a second flow. The reactors are equipped with electric propeller stirrers, which have gearboxes and three blades on their vertical axis. According to the system proposed the water purification process is in the range of pH = 9.5 ÷ 10.5.

From reactors A2-5 and A2-6, the first-flow water enters the reactor A3, respectively from second flows in reactors B2-5 and B2-6, into reactor B3. Reactors A3 and B3 are supplied with a flocculants solution that is equipped with propellant stirrers with a reducer. The feed flocculent does not change the pH of the treated water, as its purpose is to accelerate the sedimentation processes and to purify the water supplied to the station after further separation of the flocculated suspension of calcium sulphate and insoluble metal hydroxides by removing the treated water in the form of the clear top fusion, and the concentrated sludge in the form of a lower slurry in the first flow tube precipitators A4-1 and A4-2 and the second stream B4-1 and B4-2.

The sludge free water is directed to a first flow reactor A6 and a second flow reactor B6 after that. In vessels A6 and B6, 93% sulfuric acid is fed to bring the pH to 6 ÷ 9.

The precipitated in the primary sedimentation sludge is released by the hydrostatic pressure and flows into the reactor A5 for the first flow and B5 for the second flow. In these reactors, a flocculent is added as a 0.5% solution and the treated sludge is fed to first-flow sedimentation A8 and second flow B8 where the sediment is compacted before it is fed to the drying fields. The separated clear slurry is directed to a first flow pit A9 and a second flow B9, and through two pumps together with the drainage water from the dehumidifier fields is fed to a first flow reactor A6 and a second stream B6. After neutralization process in reactors A6 and B6, the treated water from the plant is directed to the receiving waters.

The process of preparation and dosage of the limewater, the flocculent, as well as sulfuric acid is automated. Monitoring of the reactors level as well as the operation of electric stirrers are also automated.

When the raw water supply is stopped, all the facilities included in the purification scheme are intended to be emptied gravitationally or by first-flow pump aggregates located in pits A9 and for a second flow in pit B9.

The scheme is given at Figure 1 and Figure 2

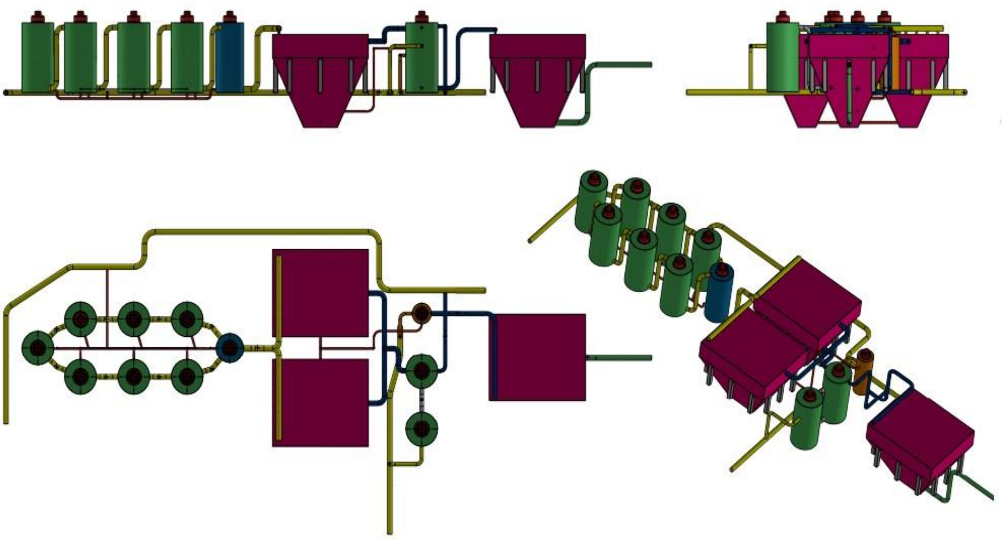

Figure 1 – Technological scheme for whole process

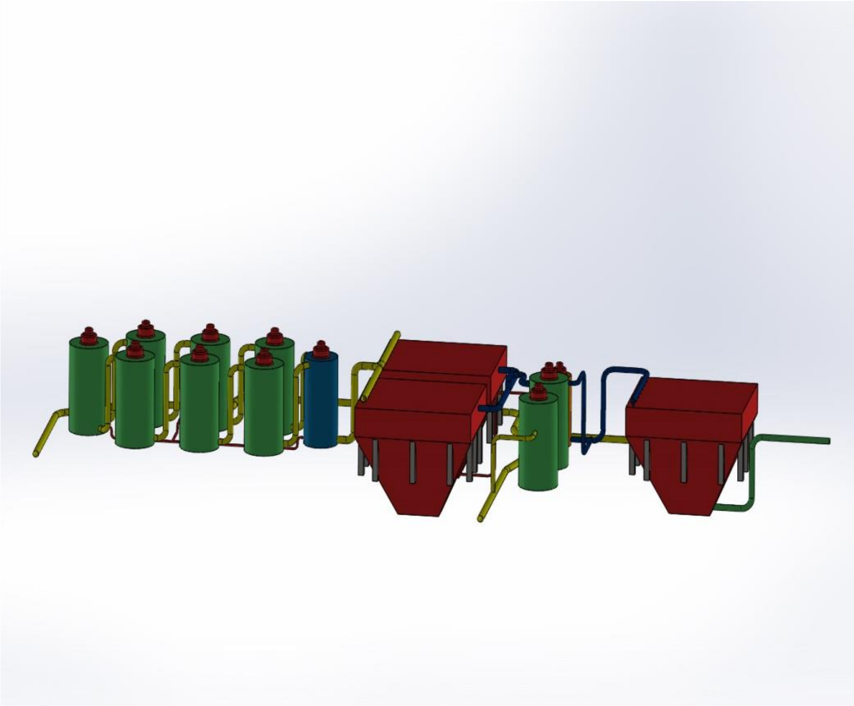

Figure 2-Technological scheme front view for one process

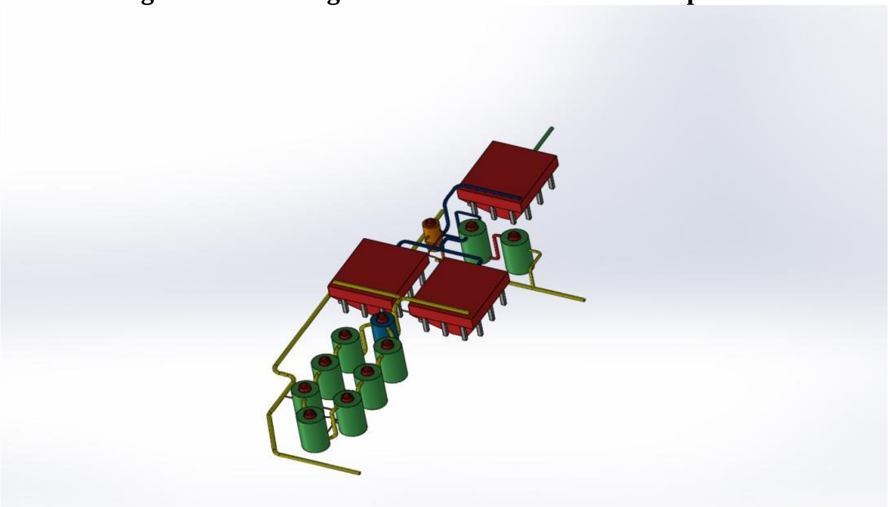

Figure 3- Technological scheme top view for one process

HYDRAULIC SIZING CALCULATIONS OF WATER LEVELS IN EACH FACILITY

The water purification facilities are arranged in two completely symmetrical flows with a flow rate of $600m^3$ / h, which after the addition of lime milk is $611m^3$ / h. Each flow after the first mixing vessel A1 is divided into two equal portions that are collected in vessel A3. Monitoring levels between vessels A3 and A1 is done for $611+2,4=613,4m^3/h$. After the flocculent is added, the total flow is $611+2,4=613,4m^3/h$ which means that for each of the primary precipitants A4-1 and A4-2 will be loaded with $306,7m^3/h$.

From the level of the precipitates to the exit vessel A3:

-exit of vessel A3- the velocity of water leakage from the vessel is $V=1,36m/s$.

$$\Delta h = 0,5\frac{V^2}{2g} = 0,5\frac{1,36^2}{19,62} = 0,05m \tag{1}$$

-three elbow 90^0

$$\Delta h = 3.0,33\frac{1,36^2}{19,62} = 0,06m \tag{2}$$

-hydraulic losses at length for 6m are $\Delta h = 0,034m$
-junction for splitting the flows

$$\Delta h = 0,53\frac{1,36^2}{19,62} = 0,05m \quad (3)$$

-at length for $L = 6m \rightarrow \Delta h = 0,01m$
-elbow $\Delta h = 0,33\frac{0,89^2}{19,62} = 0,15m$
-junction $\Delta h = 0,53\frac{0,89^2}{19,62} = 0,02m$
The difference at water level between vessel A3 and settlers A4(the same is for the second flow between vessel B3 and settlers B4) will be:

$$\Delta H = 0,05 + 0,05 + 0,06 + 0,01 + 0,02 + 0,03 + 0,015 + 0,035 = 0,27m \quad (4)$$

Between vessels A2-5 (A2-6) hydraulic losses will be:
-exit from vessels A2-5 (A2-6); $V = 0,89m/s$

$$\Delta h = 0,5\frac{0,89^2}{19,62} = 0,02m \quad (5)$$

-two elbow at 90^0

$$\Delta h = 2.0,33\frac{0,89^2}{19,62} = 0,03m \quad (6)$$

-submerged leakage $\Delta h = 1,68\frac{0,6^2}{19,62} = 0,03m$
-losses at length for L=5m $\Delta h = 0,015m$
Total for the vessels

$$\Delta H = 0,02 + 0,03 + 0,03 + 0,015 = 0,095m \quad (7)$$

Starting from the water levels in the primary settlers, which, with respect to the floor of the premises where the facilities will be located, are assumed for $\pm 0,00$ will be +5.2m (the settling boards are at elevation +5.5m), determined by their source spillways and the water layer above the receiving collectors, the levels in the mixing vessels and the contact between the limemilk and the raw mining water will be:
-in vessel A3:+5,2+0,25=+5,45m;
- in vessels A2-5 и A2-6: +5,45+0,09=+5,54m;
- in vesicles A2-3 и A2-4: +5,54+0,09=+5,63m;
- in vesseles A1-2 и A2-2: +5,63+0,09=+5,72m;
-in vessel A1, which will also be installed 0.2m above the floor the level will be + 5.72 + 0.09 = + 5.81m and the difference between it and the top edge of the container: + 6.2-5.81 = + 0,39m
Secondary settlers will be located on a floor that is 1.3m below elevation ± 0. The elevation of the secondary settling boards will be +3 and the water levels below them at + 2.7m.
Between the mixing vessel in which the sludge from the primary settlers of one stream flows with a flow rate of $166m^3$ / h with a pipe diameter of 200mm
-exit from the vessel $\Delta h = 0,5\frac{1,38^2}{19,62} = 0,05m$
-three elbows $\Delta h = 3.0,33\frac{1,38^2}{19,62} = 0,09m$
-at length L=3,5m $\Delta h = 0,05m$

-underwater drainage and distribution $\Delta h = 1,68\frac{0,9^2}{19,62} = 0,07m$

-at length L=3m $\Delta h = 0,04m$

$$\Delta H = 0,05 + 0,09 + 0,05 + 0,07 + 0,04 = 0,3m \quad (8)$$

The vessel will have a height of 4 m and will also be located on the lower floor with an elevation of 1.3 m. The board of the vessel will be at elevation + 3,5m above elevation $\pm 0,00$ while at water level of: + 2,7 + 0,3 = 3m.

CONCLUSION

In the study presented a test-rig for mining water treatment is proposed. The hydraulic dissemination of the elements of the test – rig are derived. Such test-rig will contribute to the environmental impact of the mining industry and can be directly applied in practice.

Acknowledgment: The paper is published with the support of the project No BG05M2OP001-2.009-0033 "Promotion of Contemporary Research Through Creation of Scientific and Innovative Environment to Encourage Young Researchers in Technical University - Sofia and The National Railway Infrastructure Company in The Field of Engineering Science and Technology Development" within the Intelligent Growth Science and Education Operational Programme co-funded by the European Structural and Investment Funds of the European Union and contract for helping PhD students 192ПД0024-02 “Development of a specialized test-rig for experimental study of mining waters”

REFERENCES

[1] http://www.pollutionissues.com/Li-Na/Mining.html#ixzz5hn6sK5Kr
[2] https://www.moew.government.bg/bg/vodi/
[3] Stoyan Grudev, Irena Spassova, Marina Nikolova ,Module II "Generating, Prevention and Treatment of Mining Water"; University of Mining and Geology;; Sofia 2005
[4] Todor Angelov, I. Grigorova, Iv. Nishkov, A review of the techniques for treatment of sewage drainage waters, Collection of Scientific Confrontation with International Participation "Science in the Globalization Conditions", Kardzhali 2014, pp. 617-621
[5] Gergov L., V. Ivanov. Z. Gergova, I. Ganev, Rectifier 13kA for electrolysis with two reactors, IV Scientific Conference EF2012, Sozopol, 28 September-1 October 2012, Collection of Reports - vol.2, p.54-60.

МОДЕЛИРАНЕ НА ИЗПИТВАНЕТО ЗА ПРЕЧИСТВАНЕ НА МИННИ ВОДИ

Росица Величкова, Мартин Пушкаров, Искра Симова
rvelichkova@tu-sofia.bg;martotoo@abv.bg, iskrasimova@gmail.com

Технически университет – София, София 1000, бул. „Климент Охридски“ 8 БЪЛГАРИЯ

Ключови думи: *пречистване на минни води, тестова площадка, минна промишленост*
Резюме: *Минната вода се счита за най-голямата екологична грижа, свързана с минната индустрия. В представената работа се предлага тестова площадка за пречистване на минни води. Обяснени са принципът на работа на системата, както и изчисленията на хидравличното оразмеряване на елементите.*