# KAOLIN RECOVERY FROM PROCESSING TAILS

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**Abstract**

*Research and development program was undertaken to develop a new technology for kaolin recovery from final processing tails. The technology combines granulometric separation in laminar flow and gravity classification in hydrocyclones. The three stages granulometric separation flowsheet includes Airlift separator, Reflux classifier and cluster of hydrocyclones. The full scale units were trialed in Vetovo processing plant of Kaolin AD for recovery kaolin from technological waste. Different variables technical and technological parameters are tested. The test data clearly demonstrate that the new tree stage technology is suitable for Bulgarian kaolin industry. The content of $Al_2O_3$ increases from 6 – 9 % in technological waste to over 30 % in the final kaolin product. There are possibilities to increase the kaolin recovery. The new technology was introduced in Vetovo processing plant decreasing the losses of kaolin in final tailings.*

**Key words:** *processing tails, recovery, kaolin, technology*

## 1. INTRODUCTION

The main raw material mined in the open pits of Kaolin AD and processed in the company's plants is quartz-kaolin sands. They are mined from several deposits situated in the eastern part of the Danube plain. This raw material is a mixture of quartz sand and kaolin in a ratio approximately 4:1. The geological structure of quartz-kaolin sand consists of carbonate sediments from the early Cretaceous period. In the subsequent raising, the erosion revealed Barramian and Aptian rocks on the earth's surface. These limestones formed a large pleokarstics complex with vast drops. As a result of some adjacent areas erosion, the lowerings were gradually with quartz and feldspar grains. The chemical weathering transformed this material into the now-existing weakly cemented quartz-kaolin sands. A layer of Quaternary red clay and loess covers all of these materials.

Kaolin AD is a company which main line of business is mining of non-metallic minerals. The company is a leader in industrial minerals production in Bulgaria. The main manufactured products are: different grades of kaolin, silica sand, chamotte, feldspar, carbonate fillers and ceramic read body. The quartz-kaolin sand separation has been performing by water washing technology. After combined wet sizing technology the raw material yields two products – washed kaolin (different grades) and quartz sand (different grades).

Research and development program was undertaken to develop a new technology for kaolin recovery from final processing tails. This paper describes the results on an experimental work in the frame of the research program and the development of new separation technology for kaolin recovery from final processing tails.

## 2. EXPERIMENTAL

In previous studies including the characterization of final tails it was established that there are some losses of kaolin in the final processing waste. The content of $Al_2O_3$ is in the frame of 6 - 9 %. The tails is fine product – fewer than 56 μm (Grigorova & Nishkov 2015). The prototypes of hydraulic Airlift separator and Reflux classifier were tested in Vetovo processing plant for kaolin recovery from technological waste. The technological waste treatment flowsheet is presented in Figure 1.

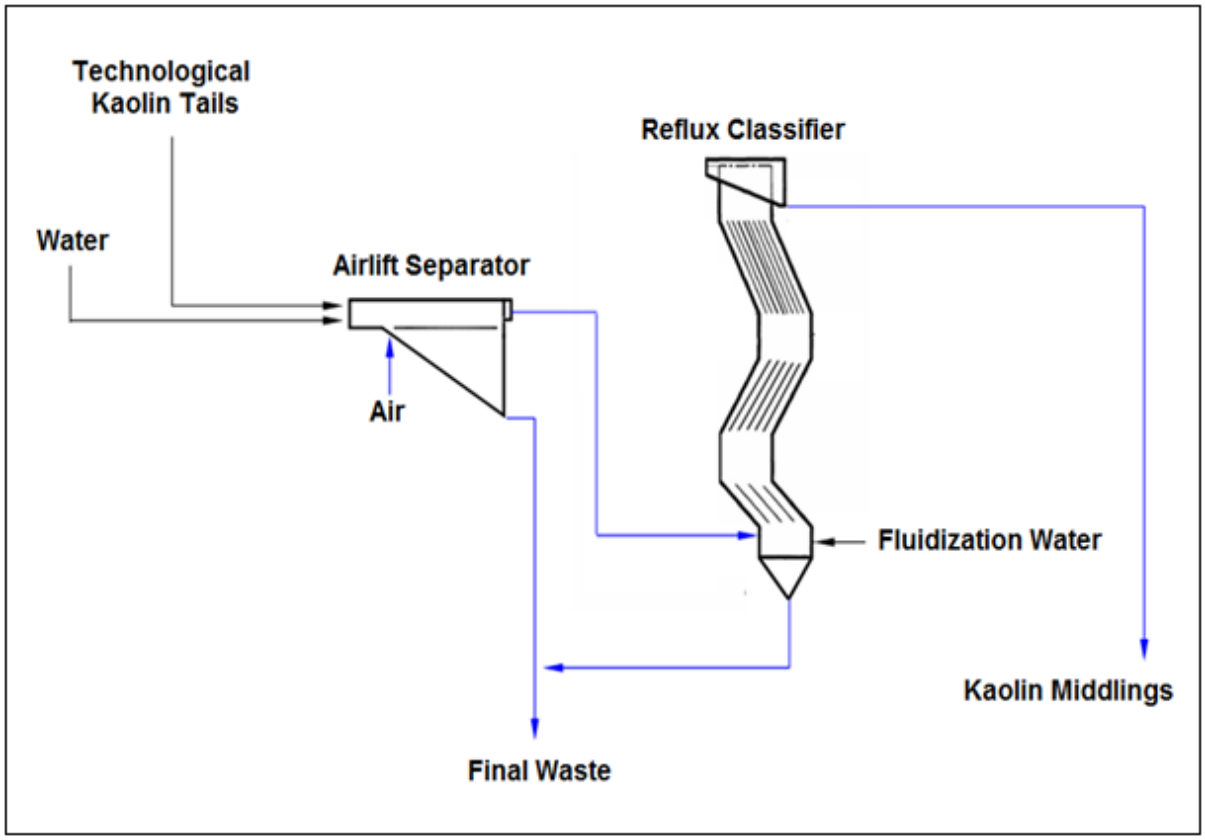



**Figure 1.** Two stages granulometric separation flowsheet

The final processing tails are introduced into a hydraulic Airlift separator. The fine particles are dragged into the boundary layers of the rising air bubbles and have been separated as an independent product – overflow. This product is fed to the Reflux classifier where the fine particles are extracted as an overflow – kaolin middlings. The both underflows from Airlift separator and Reflux classifier were combined as final technological waste.

The results clearly demonstrate that a granulometric separation in laminar flow has a potential. The content of $Al_2O_3$ in overflow of Reflux classifier increases more than 2.3 times, from 6 – 9 % in technological waste to over 21 % in the final product – kaolin middlings (Grigorova & Nishkov 2015). Test sample kaolin middlings has been produced. This product was tested in pilot hydrocyclone installation with three different hydrocyclones.

The results obtained in the pilot experiments with kaolin middlings are presented in Table 1, 2 and 3.

**Table 1.** Hydrocyclone test Ø45 mm

| Parameters | Feed | $D_{ov}$=15 mm; $D_{un}$=4 mm; p=0.3 mPa | |
|---|---|---|---|
| | | Overflow | Underflow |
| Chemical composition, % | | | |
| $SiO_2$ | 69.80 | 57.40 | 80.50 |
| $Al_2O_3$ | 20.25 | 29.15 | 12.51 |
| $Fe_2O_3$ | 0.68 | 0.92 | 0.44 |
| $TiO_2$ | 0.26 | 0.17 | 0.28 |
| CaO | 0.43 | 0.32 | 0.51 |
| MgO | 0.22 | 0.29 | 0.16 |
| $K_2O$ | 1.14 | 1.14 | 1.09 |
| $Na_2O$ | 0.11 | 0.13 | 0.10 |
| L.o.i. 1000 ºC | 7.06 | 10.34 | 4.21 |
| Particle size distribution, % | | | |
| < 45 µm | 96.6 | 99.2 | 92.4 |
| < 32 µm | 96.2 | 99.0 | 91.3 |
| < 20 µm | 89.9 | 98.8 | 78.4 |
| < 10 µm | 57.1 | 85.9 | 25.7 |
| < 7 µm | 42.1 | 72.1 | 12.3 |
| < 5 µm | 34.6 | 62.1 | 8.3 |
| < 2 µm | 24.1 | 44.0 | 4.5 |
| < 1 µm | 18.1 | 34.1 | 2.9 |
| < 0.5 µm | 13.0 | 24.6 | 2.8 |

**Table 2.** Hydrocyclone test RWS 105/XVI

| Parameters | Feed | $D_{ov}$=12 mm; $D_{un}$=10 mm; p=0.3 mPa | |
|---|---|---|---|
| | | Overflow | Underflow |
| Chemical composition, % | | | |
| $SiO_2$ | 69.80 | 52.10 | 73.80 |
| $Al_2O_3$ | 20.25 | 32.77 | 17.42 |
| $Fe_2O_3$ | 0.68 | 1.07 | 0.58 |
| $TiO_2$ | 0.26 | 0.19 | 0.28 |
| CaO | 0.43 | 0.30 | 0.43 |
| MgO | 0.22 | 0.32 | 0.20 |
| $K_2O$ | 1.14 | 0.95 | 1.15 |
| $Na_2O$ | 0.11 | 0.12 | 0.10 |

| | | | |
|---|---|---|---|
| L.o.i. 1000 ºC | 7.06 | 12.07 | 5.89 |
| Particle size distribution, % | | | |
| < 45 µm | 96.6 | 99.9 | 96.6 |
| < 32 µm | 96.2 | 99.6 | 95.9 |
| < 20 µm | 89.9 | 99.2 | 86.7 |
| < 10 µm | 57.1 | 94.6 | 44.4 |
| < 7 µm | 42.1 | 90.4 | 28.0 |
| < 5 µm | 34.6 | 86.9 | 20.7 |
| < 2 µm | 24.1 | 68.0 | 13.3 |
| < 1 µm | 18.1 | 53.7 | 10.0 |
| < 0.5 µm | 13.0 | 38.1 | 7.1 |

**Table 3.** Hydrocyclone test RWK 42 LI

| Parameters | Feed | $D_{ov}$=6 mm; $D_{un}$=5 mm; p=0.4 mPa | |
|---|---|---|---|
| | | Overflow | Underflow |
| Chemical composition, % | | | |
| $SiO_2$ | 69.80 | 49.50 | 75.00 |
| $Al_2O_3$ | 20.25 | 34.83 | 16.38 |
| $Fe_2O_3$ | 0.68 | 1.13 | 0.56 |
| $TiO_2$ | 0.26 | 0.20 | 0.26 |
| CaO | 0.43 | 0.27 | 0.48 |
| MgO | 0.22 | 0.32 | 0.21 |
| $K_2O$ | 1.14 | 0.95 | 1.17 |
| $Na_2O$ | 0.11 | 0.11 | 0.10 |
| L.o.i. 1000 ºC | 7.06 | 12.53 | 5.56 |
| Particle size distribution, % | | | |
| < 45 µm | 96.6 | 99.9 | 96.2 |
| < 32 µm | 96.2 | 99.8 | 96.1 |
| < 20 µm | 89.9 | 99.3 | 88.4 |
| < 10 µm | 57.1 | 98.5 | 45.4 |
| < 7 µm | 42.1 | 95.7 | 27.3 |
| < 5 µm | 34.6 | 92.2 | 18.7 |
| < 2 µm | 24.1 | 73.3 | 11.0 |
| < 1 µm | 18.1 | 58.5 | 7.5 |
| < 0.5 µm | 13.0 | 42.9 | 6.2 |

Based on experimental data the products mass balance was calculated. The products mass balance of hydrocyclone classification is presented in Table 4.

**Table 4.** Hydrocyclone classification products mass balance

| Parameters | Hydrocyclone Ø45 mm $D_{ov}$ = 15 mm; $D_{un}$ = 4 mm; p = 0.3 mPa | | | Hydrocyclone RWS 105 /XVI/ $D_{ov}$ = 12 mm; $D_{un}$ = 10 mm; p = 0.3 mPa | | | Hydrocyclone RWK 42 LI $D_{ov}$ = 6 mm; $D_{un}$ = 5 mm; p = 0.4 mPa | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feed | Overflow | Underflow | Feed | Overflow | Underflow | Feed | Overflow | Underflow |
| Slurry capacity, $dm^3/s$ | 1.637 | 1.526 | 0.111 | 1.222 | 0.699 | 0.523 | 0.278 | 0.200 | 0.078 |
| Solid content, $g/dm^3$ | 42.27 | 20.67 | 339.12 | 42.27 | 12.70 | 81.78 | 42.27 | 11.70 | 120.51 |
| Capacity, t/h | 0.32 | 0.146 | 0.174 | 0.32 | 0.055 | 0.265 | 0.32 | 0.064 | 0.256 |
| Capacity, t/y | 2531 | 1154 | 1377 | 2531 | 435 | 2096 | 2531 | 504 | 2027 |

The test data show that three stages granulometric separation is successful for kaolin recovery from processing tails. The combination of Airlift separator, Reflux classifier and hydrocyclone leads to obtaining the final kaolin product. This product is with high content of $Al_2O_3$ – from 29.15 to 34.83 %.

Based on the test data a new hydroclassification technology was developed. The technology combines granulometric separation in laminar flow and gravity classification in hydrocyclones.

The three stages granulometric separation flowsheet includes Airlift separator (I stage), Reflux classifier (II stage) and cluster of Φ 45 mm hydrocyclones (III stage).

The full scale units were trialed in Vetovo processing plant of Kaolin AD for recovery of kaolin from technological waste. Different variables technical and technological parameters are tested. The three stages hydroclassification flowsheet and the test data are presented in Figure 2.

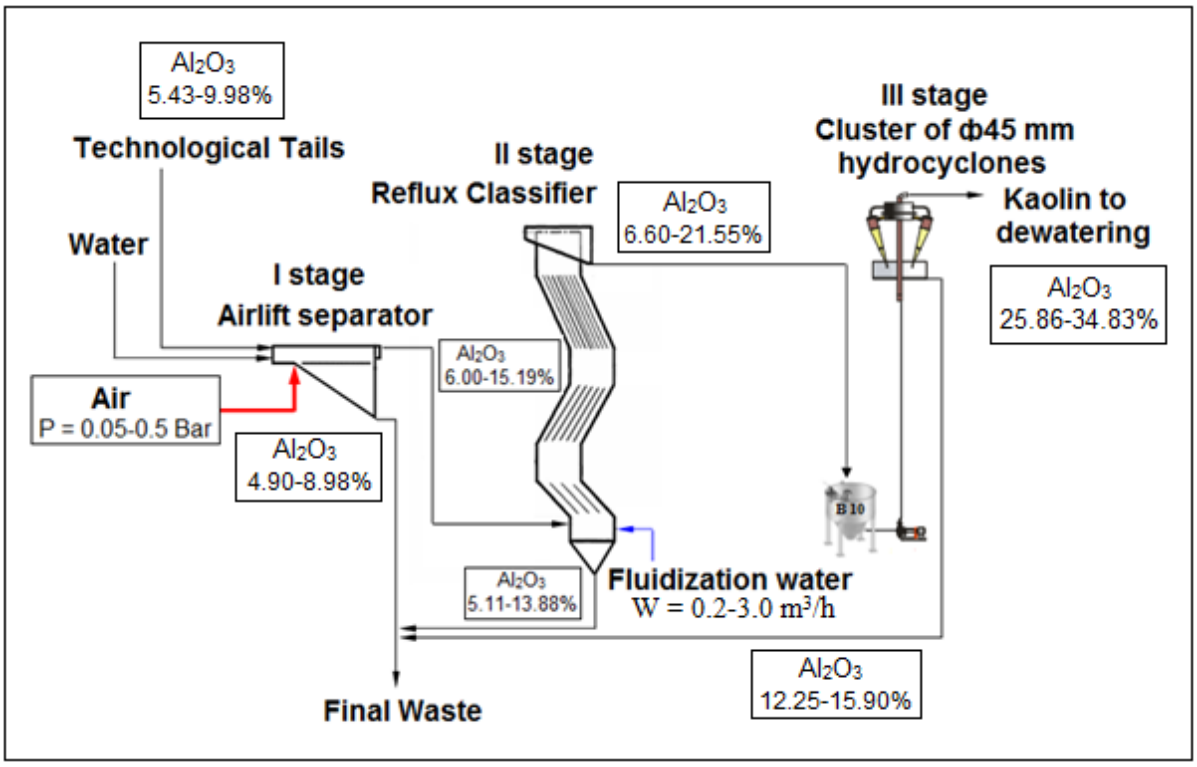



**Figure 2.** Three stages hydroclassification flowsheet

The test data clearly demonstrate that the new three stage technology is suitable for Bulgarian kaolin industry. The content of $Al_2O_3$ increases from 6 – 9 % in technological waste to over 30 % in the final kaolin product.

The combined technology for kaolin recovery was introduced in Vetovo processing plant decreasing the losses of kaolin in final tailings. There are possibilities to increase the kaolin production.

The technological tails treatment installation, working in Vetovo processing plant is shown in Figure 3.

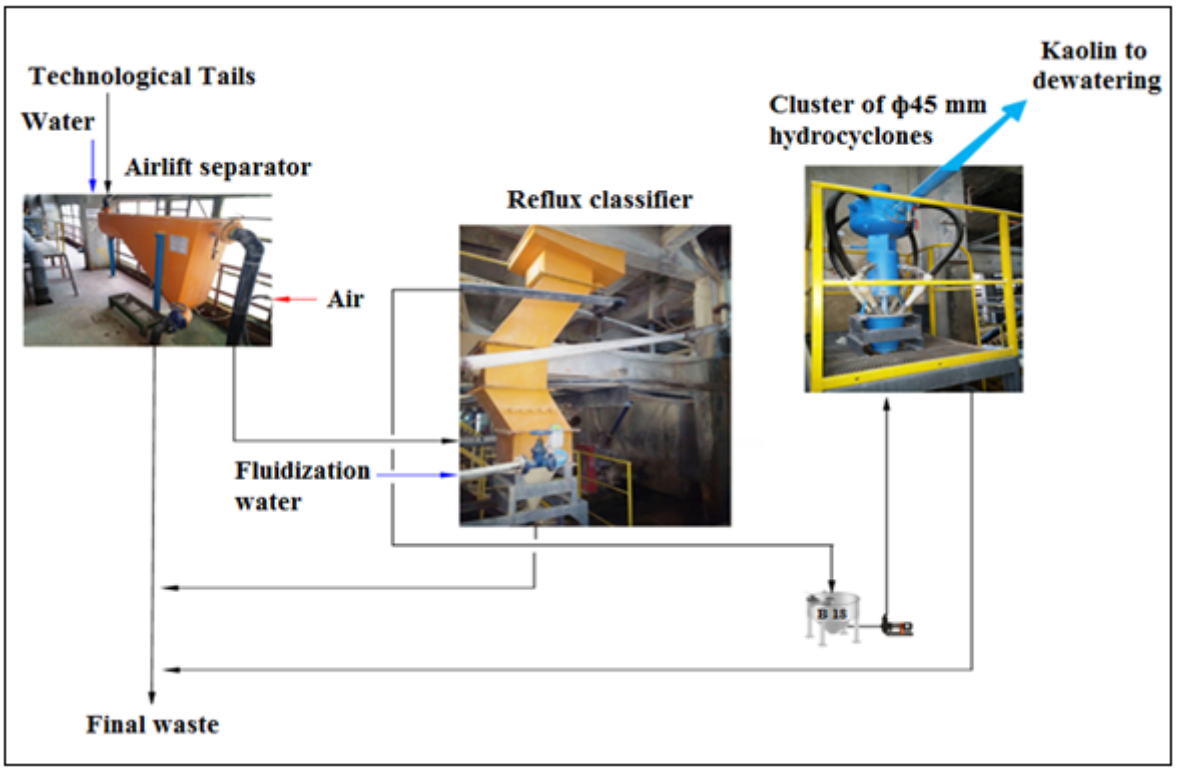



**Figure 3.** Three stages waste treatment installation working in Vetovo processing plant

The processing tails are introduced into a hydraulic Airlift separator. The fine particles are dragged into the boundary layers of the rising air bubbles and have been separated as an overflow. This product is fed to the Reflux classifier where the fine particles are extracted as an overflow – kaolin middlings. This product is pumped to the cluster of Φ45 mm hydrocyclones. The overflow hydrocyclone is a final kaolin product. The three underflows from Airlift separator, Reflux classifier and hydrocyclones were combined as final technological waste. Decreasing the losses of kaolin in final tailings leads to the increasing of kaolin production.

## 3. CONCLUSIONS

Three stages granulometric separation technology was developed. The new technology combines granulometric separation in laminar flow and gravity classification in hydrocyclones. The waste treatment installation working in Vetovo processing plant produces standard kaolin product from processing tails.

## ACKNOWLEDGEMENTS

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## REFERENCES

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