Improving gravel and crushed aggregates washing technology efficiency through application of high pressure washer

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Abstract. Removal of fine clay impurities is the most common method of mineral aggregates processing. Various washing devices operate with different effectiveness and capacities. The paper concerns the investigations of aggregate washing operations by using high-pressure washers. A comparative analysis of two types of washers, that is log washer and high pressure washer, shows that the second device operates at much higher effectiveness measured through the percentage of removal of clay impurities. The energy consumption is also more favorable for the high pressure washer.

1 Introduction

In the year 2011 in total over 300 million Mg of gravel and crushed aggregates were produced. In subsequent years the trend has been downward and currently reaches a stable level of about 200 million Mg of rock minerals annually. The market value of mineral aggregates mainly depends on the quality of raw material. Therefore, production is increased by application of various mechanical processing operations, like crushing, screening, liberation and separation of undesirable fractions such as clay and organic impurities [1, 2].

One of the most commonly used method to improve the aggregates quality is removal of fine clay impurities through application of washing operations. In this process various devices such as vibrating screens equipped in water spraying systems (wet screening), drum washers - vibratory and rotary, log washers (trough, single and multi-shafts), turbo-washers and high pressure washers can be utilized [3]. All of these devices operate with different technological efficiencies, and hence it is not always possible to produce aggregates with required qualitative characteristics. The article presents issues related to operations of high pressure aggregates washing and their influence on the efficiency improvement of aggregates refining process, by removing clay components.

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2 Methodology and results

Principle of operation is based on high pressure water stream (jet), which energy is assumed to be greater than clay fractions adhesive forces. Water penetrating the feed layer, breaks adhesive forces and causes liberating the minerals from impurities. In addition, by rotating of washing rotor equipped with nozzles, the feed particles are put into the motion, and therefore the mechanical friction effect is obtained. It assists liberation of raw material and increases the process efficiency [4-5]. Distribution of working layers has been presented in Fig. 1.

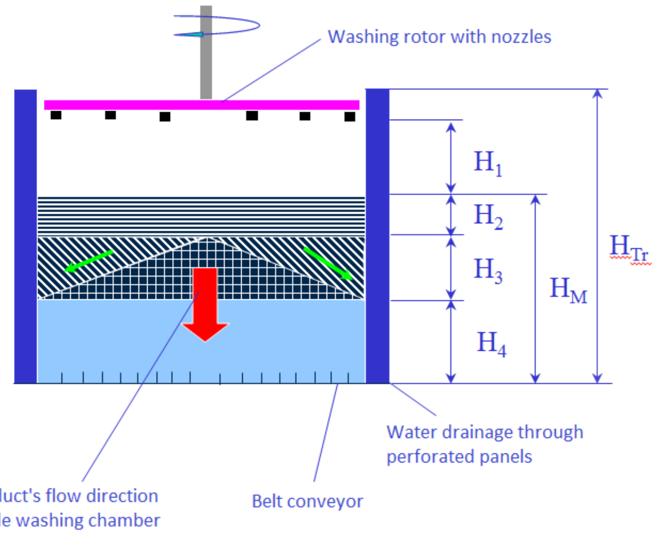

Figure 1. Functional diagram of high pressure washer and layers distribution inside the device, where: H_{Tr} – height of washing chamber, H_M – height of washed-bed material, H_1 – distance between washing nozzles and material, H_2 – washing area, water stream penetration depth, H_3 – dewatering area, H_4 – height of transported material's layer.

Washing tests of aggregates in the semi-industrial washer, for three size fractions that is 0–16, 0–31.5 and 0–40 mm, were carried out. The working capacity of the washer corresponds to about 80 Mg/h of capacity for the industrial-scale device and the working pressure at nozzles was 140 bar. Table 1 presents content of clay fractions for each material before and after washing. The washing results for the log washer device, are shown in Tab. 1.

Table 1. Clay impurities contents obtained for feed and washing products.

Particle size fraction	Content of clay in feed, %	Content of clay in product, %
0 – 16	24.6	0.5
0 – 31.5	14.5	0.4
0 – 40	12	0.4
Log washer 0 – 31.5	19	4.1

Comparing the results obtained by using both technologies, it can be seen that the aggregates washed in high pressure washer contained ten times less dust at the water consumption level between 1–1.2 m^3/Mg/h. Energy consumption for the high pressure washer was 1.08 MJ/Mg. At the same time, log washer circuit consumed 1.7 m^3/Mg/h of water and 1.80 MJ/Mg of energy. The log washer circuit demands an application of additional screening operation in order to separate the size fractions 0-2 mm and above 80 mm. The high pressure washer capacity was also 30% higher, comparing to the log washer circuit.

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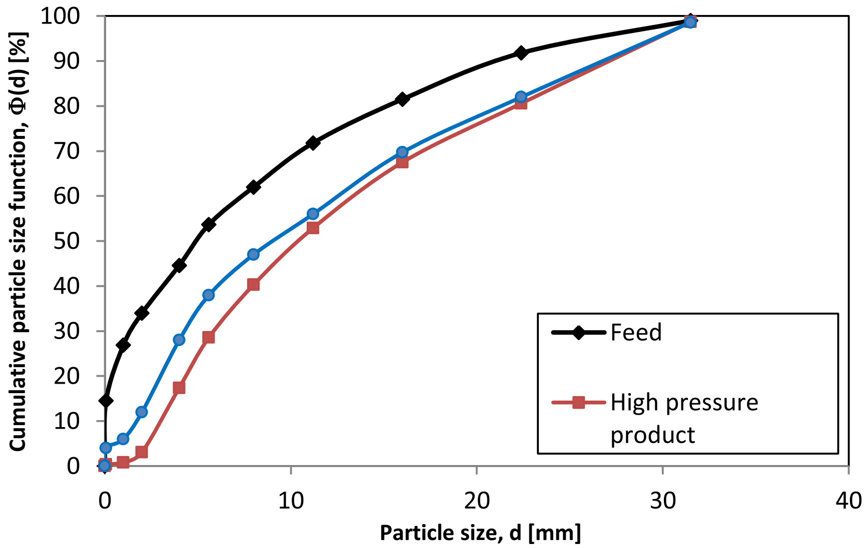

Figure 2. Particle size distribution of feed and washing products in particle size fraction 0 – 31.5 mm.

3 Conclusions

The results of the paper show that application of the high pressure washing technology into aggregate processing circuits significantly influenced effectiveness and capacity of the washing technology for natural and broken aggregates. The detailed analysis of results show that regardless of particle size composition of the feed, the effectiveness of washing process was high both for narrow and wide particle size ranges. However, it should be noted that the type of impurities significantly affected the course and effectiveness of the washing process. Clays, which mainly consist of the dusty fractions, due to their total surface area were more difficult to dissolution and, as a result, required a higher water consumption during the process, comparing to clays containing coarser particles. Nevertheless, the high-pressure washer was capable to remove these impurities in a very efficient way.

Despite the above, the high pressure washer, on average, generated lower processing costs through lower water and energy consumption. From technical point of view, the high pressure washer installation required much less building area and lower number of associated facilities. Combining the high effectiveness of operation of high pressure washers with a potentials of control of their work [3] it should be highlighted that high pressure washing technology was of a major significance in improvement of crushed aggregates quality. Further investigations, especially in terms of more effective control and modelling of work of washing devices, may be helpful within this issue.

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