UPGRADING OF TAYAN'S CRUDE BAUXITE USING ROTARY DRUM SCRUBBER

PENINGKATAN KADAR BAUKSIT TAYAN - KALIMANTAN BARAT, MENGGUNAKAN DRUM PUTAR PEMBERSIH

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ABSTRACT

Indonesia has abundant bauxite resources at Tayan, West Kalimanatan, where the reserve is relied more than 800 million tons. There were two types of Tayan's bauxite that have been used in the present research. One contains 34.63 % Al_2O_3 and 5.20 % reactive SiO_2 which is known as low grade ore, while the second type contains 47.30 % Al_2O_3 and 5.79 % reactive SiO_2 which is known as high grade ore. A Rotary Drum Scrubber (diameter 80 cm, length 200 cm, screen opening 2 mm) was applied to upgrade the crude bauxite ores. The research was started by crushing followed by scrubbing and screening. The scrubber is supported by water sprayer to achieve washed bauxite (+2mm of particle sizes) separated from tailing (-2mm of particle size). The researchs were conducted by varying the feed rate (300-2100 kg/hr), solid percentage (14-36%) and water flow rate (35-78 L/minute). The results show that feed rate and solid percentage have high impact to the quality of washed bauxite obtained. The higher is feed rate and solid percentage the lower is alumina content of the washed bauxite produced. An optimum condition is attained at1600 kg/hour of feeding rate, 25% solid and 8 minutes of residence time that is capable to produce washed bauxite with chemical composition of 45.25 % Al_2O_3 and 3.27 % reactive SiO_2 (when the crude bauxite as the feed is low grade type). On the other hand, the washed bauxite obtained with chemical composition of 55.50 % Al_2O_3, 0.47 % reactive SiO_2 and impurities content with particle sizes <2mm is approximately 2,1% (when the crude bauxite as the feed is typically high grade). The average increase of Al_2O_3 content in the washed bauxite is 6.63% and the average decrease of reactive SiO_2 is 2.87%. The washed bauxite produced is reliable as feed material for Bayer process.

Keywords : rotary drum scrubber, upgrading, bauxite, washing

SARI

Indonesia memiliki cadangan bauksit yang relatif besar di Tayan-Kalimantan Barat dengan jumlah sekitar 800 juta ton. Dua jenis bauksit Tayan digunakan dalam penelitian ini yaitu bauksit kadar rendah dengan komposisi kimia 34,63 % Al_2O_3 dan 5,20 % SiO_2 reaktif, serta bauksit kadar tinggi 47,30 % Al_2O_3 dan 5,79 % SiO_2 reaktif. Satu unit Drum Putar Pembersih (Rotary drum scrubber, garis tengah 80 cm, panjang 200 cm, lubang ayakan 2 mm) digunakan untuk meningkatkan kadar bauksit tersebut. Penelitian ini dimulai dari peremukan bauksit diikuti dengan pelumatan dan pengayakan yang dibantu dengan semprotan air untuk mendapatkan bauksit tercuci (ukuran partikel +2mm) yang terpisah dari limbah (ukuran partikel -2mm). Penelitian dilakukan dengan mem-variasikan laju pengumpanan (300-2100 kg/jam), persen padatan (14-36%) dan laju alir air (35-78 liter/menit). Hasil penelitian menunjukkan bahwa laju alir dan persen padatan sangat berpengaruh terhadap kualitas bauksit tercuci yang dihasilkan. Laju alir pengumpanan makin besar, persen padatan makin tinggi, maka kandungan alumina dalam bauksit tercuci yang dihasilkan semakin rendah. Kondisi optimum yang dicapai dalam penelitian ini adalah laju alir pengumpanan sebesar1600 kg/jam, persen padatan 25% dan waktu tinggal 8 menit, meng-hasilkan bauksit tercuci dengan komposisi kimia Al_2O_3 45,25 % dan SiO_2 reaktif 3,27 % (menggunakan bauksit kadar rendah) dan Al_2O_3 55,50 %, SiO_2 reaktif 0.47 % (menggunakan bauksit kadar tinggi) dengan kandungan

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pengotor (ukuran partikel -2mm) terkecil yaitu sekitar 2,1%. Peningkatan kadar alumina rata-rata dalam bauksit tercuci adalah 6,63% dan penurunan kadar silika reaktif rata-rata adalah 2,87%. Bauksit tercuci yang dihasilkan sudah memenuhi syarat untuk bahan baku proses Bayer.

Kata kunci : drum putar pembersih, peningkatan kadar, bauksit, pencucian

INTRODUCTION

Bauxite is basically a rock containing of hydrated aluminum oxides with some impurities such as silica, clay, silt, titanium and iron minerals. There are three types of bauxites namely gibbsite (γ-Al(OH)), boehmite (γAlO(OH)) and diaspore (a-AlO(OH)). The chemical composition of bauxite is various, it depends on its origin (Keith et al., 2005). Indonesia has huge of bauxite resources (gibbsite type) scattered in several areas such as at Bintan Island, West Kalimantan, Central Kalimantan and Bangka Belitung with total ore reserves 700,342,407 tons with chemical composition between 27-55% of alumina. The bauxite reserves in West Kalimantan is about 726.585.010 tons (Husaini et.al., 2012) with chemical composition 36-47% Al_2O_3, 7.6-13.6% Fe_2O_3, 5-6% reactive SiO_2, 10-25% free SiO_2, 15-31% total SiO_2 and 0.8-1.0% TiO_2 (Husaini et.al., 2012). Bauxite is a source of aluminum metal after extraction by Bayer process to produce alumina. About 90% of world bauxite is used for aluminum metal production and the rest of 10% for other products such as alum, polyaluminum chloride, refractories, cement, absorbents, abrasives, rubber, plastic, cosmetics, paints, paper, polishes, glass, enamel and ceramics. As a raw material for Bayer process, bauxite has to have a good quality in term of high alumina content and low reactive silica content, that contains at least 40% alumina (Shaheen et al., 2010.) and reactive silica <5%. The content of reactive silica in bauxite should be low, because it will react with sodium hydroxide from liquor (at least 1 mole NaOH per mole of reactive silica). The amount of reactive silica is one of the major factors determining quality and price of the ore (Keith at al., 2005). Bauxites with reactive silica contents greater than 8% by weight (Al_2O_3/SiO_2 = 6.25) are usually considered to be uneconomic (Smith, 2009). Furthermore, high impurities bauxite will produce amount of red mud, so it will increase cost of waste handling and disposal. Moreover, it contributes to environment and ground water pollution. Further, since the impurities are never fully removed during the manufacturing process, they directly affect end uses. The impurities also reduce the capacity utilization, productivity and efficiency of the plant. Impurities present in bauxite ore also increase the cost of mining, handling and transportation (TIFAC, 2013).

Due to the problems described above, hence the crude bauxite ore is necessary to be upgraded in order to remove such reactive silica, iron and other impurities (Saba, 2011). Most bauxite mining companies in Indonesia have been already implementing methods of washing by wet screening in trommel screen and vibrating screen after crushing the ore. Yield of the washed bauxite is between 40-50%. The rest (50-60%) is rejected as tailing (in India, more than 40% of the bauxite ore is rejected as low grade tailing. In terms of energy utilization, this process is inefficient and wasteful due to high water consumable.

In general, there are some methods for removing impurities from bauxite ore namely screening/ washing, gravity, flotation, and magnetic separation (Smith, 2009). Separation of impurities from bauxite ore is also conducted physically by hand (e.g. separation by color of the ore) or by mechanical sieving after crushing, because finer particles usually contain a higher percentage of silica, clay, and other impurities. Clay is usually agglomerated to the surface of crude bauxite particles (Figure 1a) and it needs energy to clean the surface of mineral particles. The energy is usually supplied in the form of water jets in a trommels screen. The washed bauxite >1190 µm (Figure 1b), which is rich in alumina and low in silica, is proceeded to the Bayer process plant feed. The washed fraction below 1190 µm is passed through a series of cyclones, screens and filter to remove clay with minimum amount of alumina loss with rejected clay (Ishaq, 2013).

Washing combined with screening is an effective method on separating silica mineral, since this mineral is preferentially concentrated in the fine particle size fractions (Parker, 2008). Batch wise scrubbing followed by screening to separate impurities of bauxite ore had been conducted (Husaini

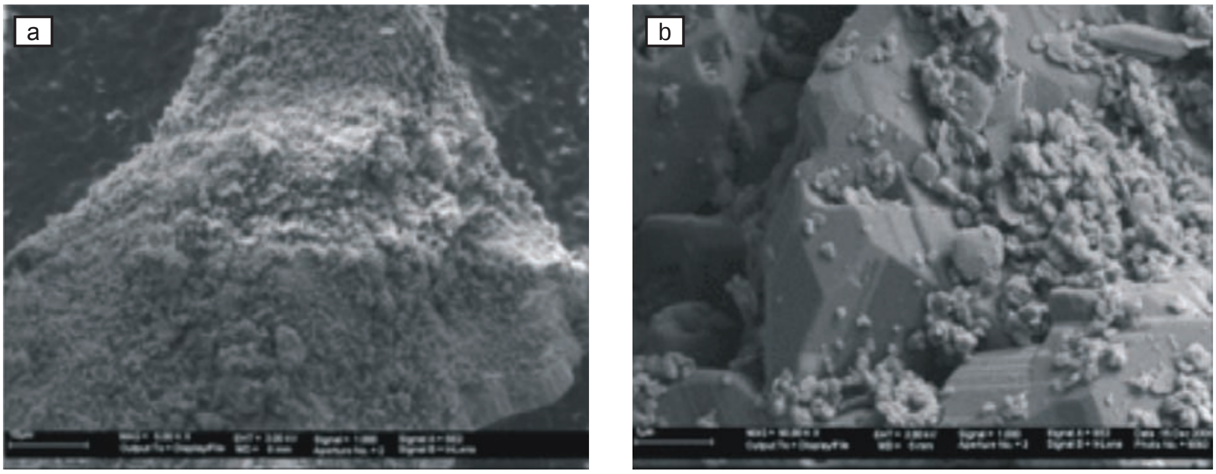

Figure 1. SEM image of bauxite sample (a) before washing, (b) after washing (Ishaq, 2013)

and Cahyono, 2011). The result shows that alumina content increased from 48% Al_2O_3 in crude bauxite to 55% Al_2O_3 in washed bauxite. On the other hand, reactive silica content decreased from 10% SiO_2 to 3% SiO_2. To continue this research, it is necessary to conduct crude bauxite washing process with RDS (Rotary Drum Scrubber) which could be operated continuously instead of batch method. Depending on the bauxite characteristic, and the grade required, the method for bauxite upgrading can follow some stages of processing including screening, scrubbing and washing, magnetic separation, drying and calcining. Magnetic separation is usually used for removing iron to produce high value, special grade bauxites (TIFAC, 2013). Other process for upgrading crude bauxite ore is begun by primary crushing (crushed to -5 cm), followed by secondary crushing (crushed up to 10 mm highest) then washing and screening, and grinding. The crushed coarse sizes (-3 mesh, -6 mesh, -8 mesh and -12 mesh) and ground powder sizes (-100 mesh, -200 mesh and -325 mesh) go through iron-removing magnetic separators (Xuanshi, 2013).

In this experiment a RDS of pilot scale was used for scrubbing and screening crude bauxite ore of Tayan, West Kalimantan to attain washed bauxite with high alumina content (47% Al_2O_3 min.) and low reactive silica content (3% max.). The RDS used in this experiment is modification of a trommel screen with some additional components including a screw set up on the surface of screen of RDS for conveying undersize, and tank located in the bottom of the screen for mixing of crude bauxite with water. Technically, the RDS has capability to separate crude bauxites of differing particles sizes in water medium under the influence of such water pressure, slope, and drum rotation to produce three fractions i.e. over sizes (>2mm), under sizes of -2mm+60 mesh and under sizes of -60 mesh. The eficiency of the separation depends on parameters of particle size distribution, solid percentage, feeding rate, and water flow rate. Therefore, the aim of this experiment is to study the effect of those parameters toward the quality/ grade of washed bauxite, recovery and yield of alumina content. The results of this study are presented in this paper.

METHODOLOGY

Crude bauxite ores (high and low grade types) that were taken from Tayan-West Kalimantan were consecutively dried, homogenized and weighed. The crude bauxite ore was crushed to attain -1 inch of particles sizes, then it was conveyed by belt conveyor to pass into feeder in order to control mass flow rate before entering into RDS. During the ore was being processed in the RDS, the ore was separated into three products namely washed bauxite (+2 mm particles size), tailing 1 (-2 mm +100 mesh) and tailing 2 (-100 mesh). Samples of each product were taken for chemical analysis prior to be charged into each tank. All samples (feed, washed bauxite, and tailing) were further dried, weighed and analysed to calculate yield and recovery of its alumina content. Chemical components to be analyzed were Al_2O_3, total

SiO_2, reactive SiO_2, Fe_2O_3, and TiO_2 using Atomic Absorption Spectrophotometer (AAS) method and other conventional chemical analysis method. Method of present bauxite upgrading is shown in Figure 2 and photo of rotary drum scrubber (RDS) is shown in Figure 3.

RESULTS AND DISCUSSION

Crude Bauxite Ore

Based on X-ray diffraction (XRD) and mineralogical analysis, Tayan crude bauxite ore contains minerals such as quartz, gibbsite, goethite, nacrite, and hematite (Table 5). The minerals composition are 38,04% gibbsite, 17,31% quartz, 27,52% clay, 16.62% iron oxide and 0.51% other minerals (Table 1). The major gangue minerals present are silica minerals in the form of quartz and as alumino silicate in the form of clay (nacrite). Nacrite is one of reactive silica ($R.SiO_2$) minerals. The presence of $R.SiO_2$ in bauxite would induce two major problems in the Bayer process, one it is easy to dissolve in caustic soda solution and the second it tends to re-precipitate as desilication product (DSP). This shows a loss of caustic soda and in turn affects the scaling of liquor pre-heaters used in digestion and liquor evaporation. This phenomena is costly. Therefore the removal of the $R.SiO_2$ is necessary (Ishaq, 2013). Figure 4 represents a photomicrograph of Tayan's bauxite sample (JC-15) that shows the position of fine particle size of gibbsite (G) is between both quartz sand (Q) particles and it occupies cracks of quartz sand.

Table 1. Minerals composition of crude bauxite ore

Mineral composition (%)				
Gibbsite	Quartz	Clay	Iron oxide	Other minerals
38.04	17.31	27.52	16.62	0.51

Particle size distribution of crude bauxite

Crude bauxite sample was applicated for the experiment that has a variety of particle sizes starting from fine particle (less than 60 mesh) up to lump with sizes more than 20 cm (Table 2). To analyse particle size distribution of crushed ore, a series of sieve mesh with aperture size of 1 cm, 0,5 cm, 12 mesh, 18 mesh, 28 mesh, 35 mesh, and 60 mesh were used for screening the samples. Result of particle size analysis is shown in Table 2. High grade crude bauxite contains particle size fraction of +2 mm (12 mesh) is 82.85% and low grade one is 81.39%. It means that particle sizes for both crude bauxites do not different. We focus on the particle sizes of +2 mm, because this value is put as cut-off size separation. Crude bauxite ore with particle size bigger than 2 mm will become a primary product (washed bauxite) after processing by using the RDS, on the other hand, size fraction of -2 mm in washed bauxite will decrease.

Chemical composition of crude bauxite

High grade and low grade of Tayan crude bauxites chemical composition is shown in Table 3. Low grade crude bauxite contains 36.09% Al_2O_3, 5.46% reactive SiO_2, 24.74% free SiO_2, 31.74% total SiO_2, 7.59% Fe_2O_3 and 0.85% TiO_2. While, high grade crude bauxite contains 47.00% Al_2O_3, 5.98% reactive SiO_2, 10.85% free SiO_2, 16.83% total SiO_2, 13.56% Fe_2O_3 and 0.97% TiO_2. Based on this data, Tayan crude bauxites ore must be upgraded because alumina contents are lower than 48% and reactive silica contents are higher than 3% as needed for Bayer process. Based on

Table 2. Particle size distribution of crushed crude bauxite

Particle size	+1cm	-1+0.5 cm	-0.5 cm+12#	-12+18#	-18+28#	-28+35#	-35+60#	-60#	Cummulative
Particle size distribution of high grade crude bauxite (%)	28.75	20.32	33.78	3.24	3.72	1.93	4.79	3.48	100.00
Particle size distribution of low grade crude bauxite (%)	37.97	20.79	22.63	4.59	3.84	1.69	4.89	3.60	100.00

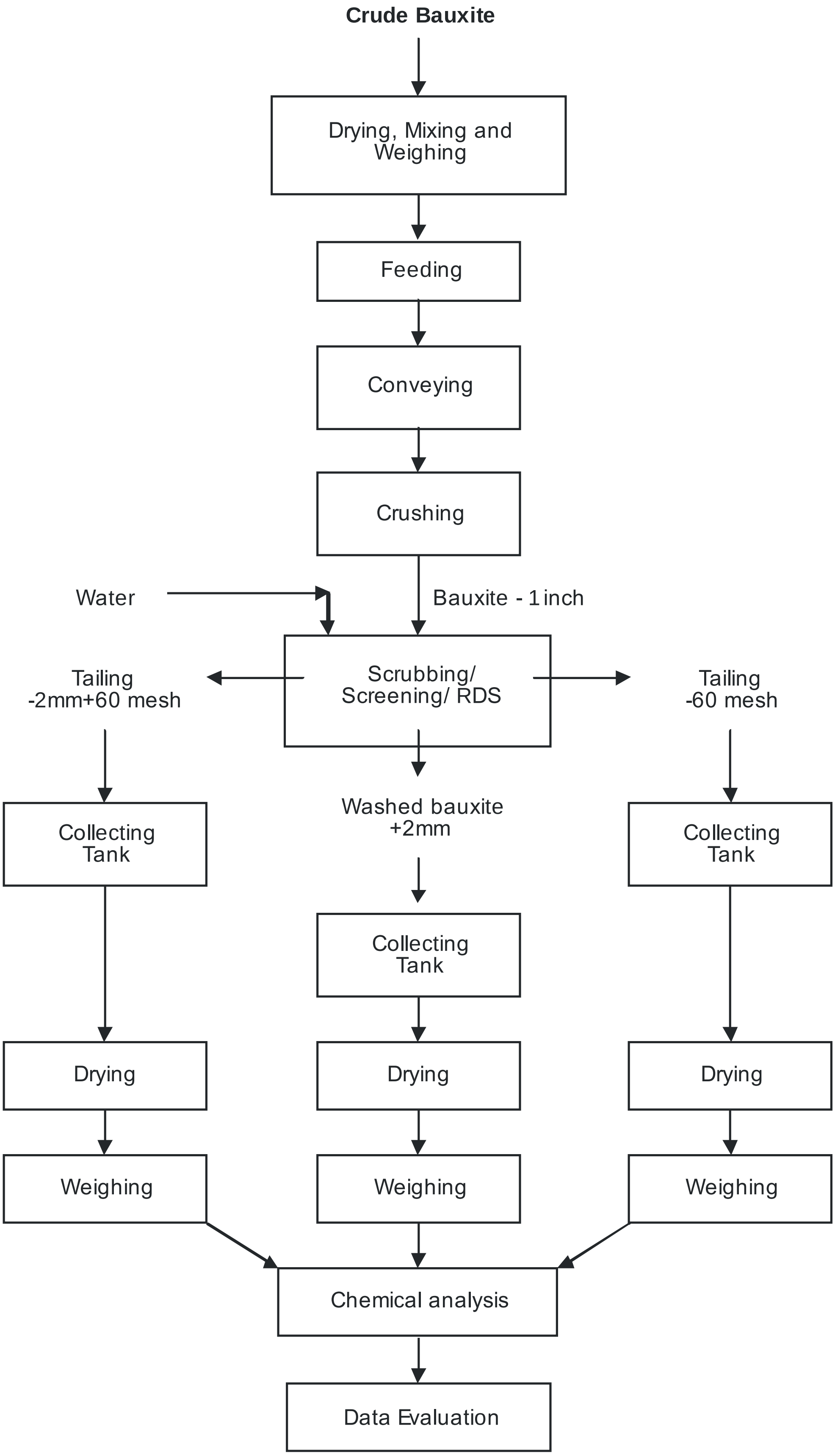

Figure 2. Flow diagram of bauxite upgrading

Figure 3. Photo of rotary drum scrubber (RDS)

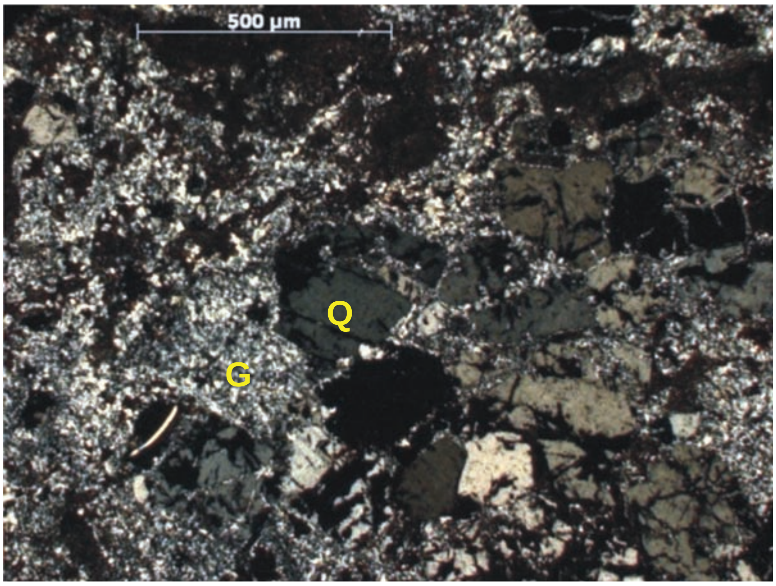

Figure 4. A photomicrograph of bauxite sample from Tayan, West Kalimantan

Table 3. Chemical composition of crude bauxite (high and low grade)

No	Chemical composition (%)					
	Al_2O_3	Reactive SiO_2	Free SiO_2	Total SiO_2	Fe_2O_3	TiO_2
Crude bauxite (high grade)	47.00	5.98	10.85	16.83	13.56	0.97
Crude bauxite (low grade)	37.55	5.72	23.08	30.12	8.27	0.87

Table 4 and Figure 5, the grade of Tayan crude bauxite decreases with decreasing particle sizes, on the other hand, the grade of reactive silica, free silica, total silica, and iron oxide increases. Whereas, titan oxide grade was fluctuated at a different particle size fraction. Based on particle sizes distribution and alumina content in each size fraction, opening screen cut-off for scrubbing process is 2 mm (12 mesh). It is shown that size fraction less than 2 mm, alumina content is significanly decreasing, on the other hand, impurities minerals (silica and iron) are increasing. Therefore, scrubbing process will be conducted by using screen with 2 mm of aperture size opening.

Results of Washed Bauxite Processing by RDS

Scrubbing process using RDS was aimed to increase alumina content by removing the impurities attached on the surface of crude bauxite ore. The impurities that must be removed are silica, clay, and iron minerals. This process produce three products with different particle sizes, those are washed bauxite (+2mm), sand tailing (-2mm+60 mesh) and fine tailing (-60 mesh). Operating variables used for this experiment were feeding rate (300 - 1600 kg/hour), solid percentage (14..25-36.38%), water flow rate (35-78 L/minute). These variables were carried out to achieve the

Table 4. Chemical composition of Low crude bauxite within size fractions

Particle size	Weight (%)	Total SiO_2	Free SiO_2	Reactive SiO_2	Al_2O_3	Fe_2O_3	TiO_2
+1 cm	54.86	25	20.8	4.2	40.2	8.59	0.88
-1+0.5 cm	19.95	29.6	22.5	7.1	38.3	7.79	0.8
-0.5 cm+12 mesh	11.97	36.2	25.2	11	35.9	7.14	0.75
-12+18 mesh	2.06	43.5	30	13.5	30	7.92	0.85
-18+28 mesh	1.60	44.5	30.3	14.2	29.2	8.44	0.97
-28+35 mesh	4.50	47.7	31.5	16.2	26.3	9.11	1.08
-35+60 mesh	2.51	56.4	40.8	15.6	20.1	7.51	0.93
-60 mesh	2.55	39	24.4	14.6	30.9	9.92	1.3
Cummulative	100.00	30.12	23.08	5.72	37.55	8.27	0.87

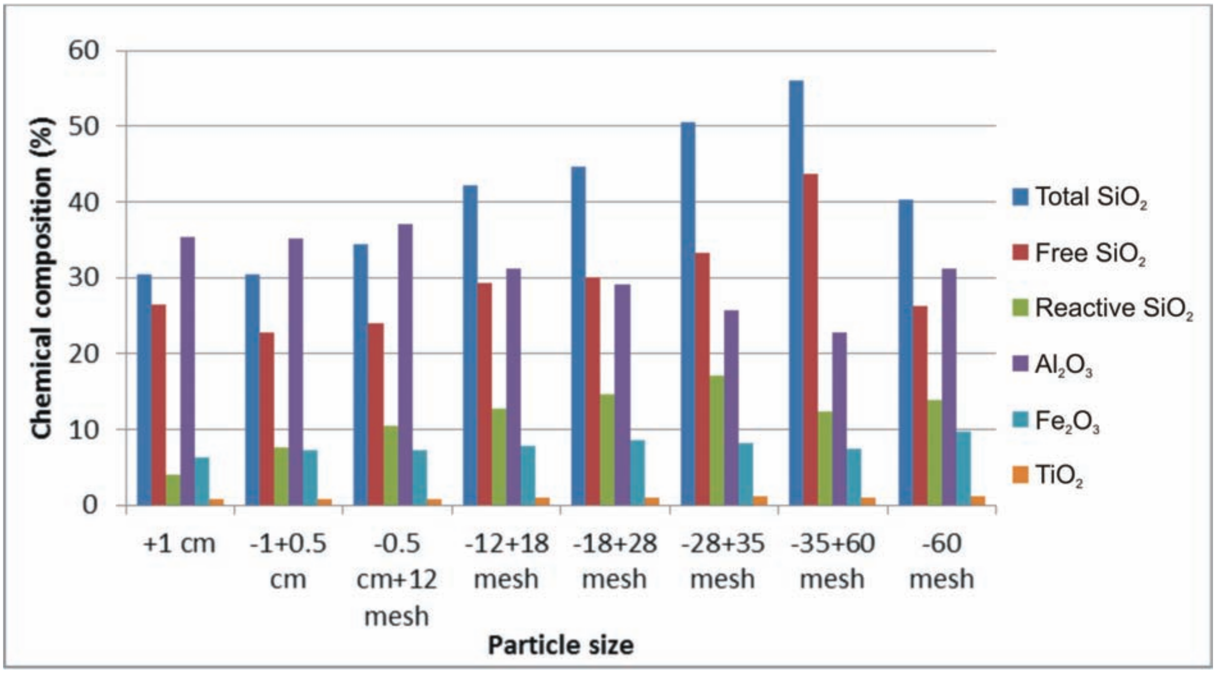

Figure 5. Chemical composition of low crude bauxite ore in each particle sizes

maximum capacity of the RDS and to study the effect of those variables on the quality, yield and alumina recovery from the washed bauxite.

Effect of solid percentage

Solid percentage has a significant effect to both grade and recovery of Al_2O_3. The quality of washed bauxite tend to decrease by increasing solid percentage. The optimum solid percentage for washing crude bauxite using RDS around 25.61% with alumina recovery 65.80% and grade 55.50% of Al_2O_3. Whereas. yield of washed bauxite (WBX) obtained is 55.55% with impurities (mostly having a particle size smaller than 2 mm) is 2.10% (Figure 6). This quality is suitable for Bayer process. The impurities attached or agglomerated to the surface of crude bauxite ore is difficult to be separated using high solid percentage. On the other hand. at lower solid percentage, it is much easier to remove impurities mineral attached on the crude bauxite surface as more sprayed and high water pressure being used as well as more dilute slurry in the tank (bottom part of the RDS for mixing). From Figure 5, it can be seen that by using solid percentage of 19.49%. recovery and grade of alumina produced were 61.82% and 54.40%. respectively. Then these values decreased to 61.32% and 52.20% after using solid percentage of 34.21%. If this data are compared to previous research which used batch scrubbing method. the yield is lower but the grade of alumina is higher. The previous results show that alumina recovery between 82.64-91.13% and yield of alumina between 74.35-82.64% (Husaini and Cahyono. 2010). This difference occurs because fine particle (-2mm) content in the recent research is higher than that of the previous one.

Effect of feeding rate

RDS used for this experiment has diameter around 80 cm and length 180 cm. The optimum capacity (feeding rate) of the RDS around 1600 kg of crude bauxite/hour. Therefore, feeding rate has significant effect to the recovery and grade of washed bauxite for feeding rate above that value. Feeding rate will relate to the residence time of bauxite in the RDS for constant slope and rpm (slope = 4.29 degree and rpm = 9). Increasing feeding rate will decrease residence time, as a result washed bauxite will contain higher impurities namely 2.64% for 2100 kg/hour, but only 1.02% for 1272 kg/hour of feeding rate. By using feeding rate between 1272-2100 kg/hour, recovery and grade of alumina are fluctuated between 51.5-67.07% and 50.40-55.50%, respectively. Whereas, yield of washed bauxite obtained is between 46.75-58.36% and impurities between 1.02-2.64% (Figure 7). The optimum recovery and grade of alumina are 65.80% and 55.50%, respectively, which is achieved at feeding rate around 1550 kg/hour to produce 55,55% of washed buxite, yield 2.10% and -2mm particle sizes content.

Effect of water flow rate

Water flow rate also has significant effect to recovery and grade of alumina. Recovery and grade tend to increase with increasing water flow rate. Higher water flow rate represent higher pressure of water spraying causes fine particles will be easier to separate. Water pressure gauge used for spraying was about 1.5 atm with water flow rate around 70,45 L/minute, when a little increase of water pressure to 1.55 atm, water flow rate was found around 73,63 L/minute. From

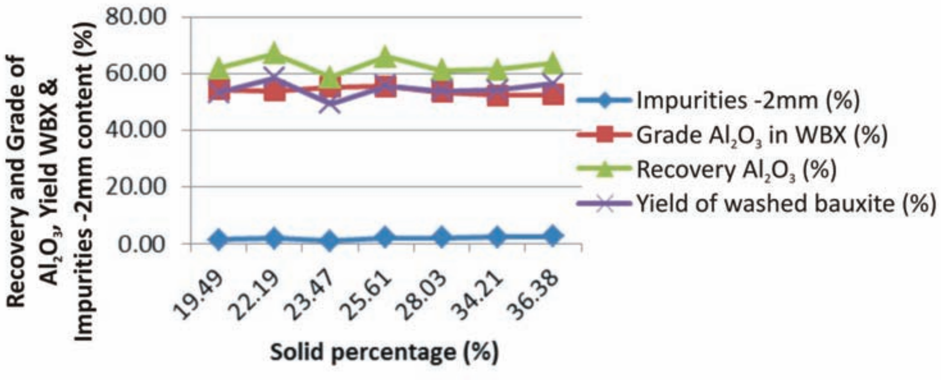

Figure 6. The effect of solid percentage on recovery, grade of Al_2O_3, yield and impurities

the Figure 7, recovery of alumina achieved is fluctuative between 51.50-67.07% and grade of alumina in washed bauxite is 50.40-55.50% by using water flow rate in the range of 43.49-78.02 L/minute (Figure 8). The optimum condition is achieved at 73.63 L/minute of water flow rate. Yield of bauxite obtained is in between 46.75-58.36% and impurities is in between 1.02-2.10%, when it uses water flow rate at the same range. In general, by increasing water flow rate, the yield of washed bauxite tend to increase. On the other hand, the impurities tend to decrese with increasing water flow rate.

sand tailing, but for fine tailing it contains nacrite as alumina silicate mineral in addition to four minerals mentioned earlier (Table 5). Nacrite mineral provides contribution to the reactive silica content explained by finding reactive silica in fine tailing is relatively high comparing to washed bauxite and sand tailing.

Chemical composition of washed bauxite

As mentioned in previous discussion, low grade crude bauxite had chemical composition of 36.09% Al_2O_3, 5.46% reactive SiO_2, 24.74%

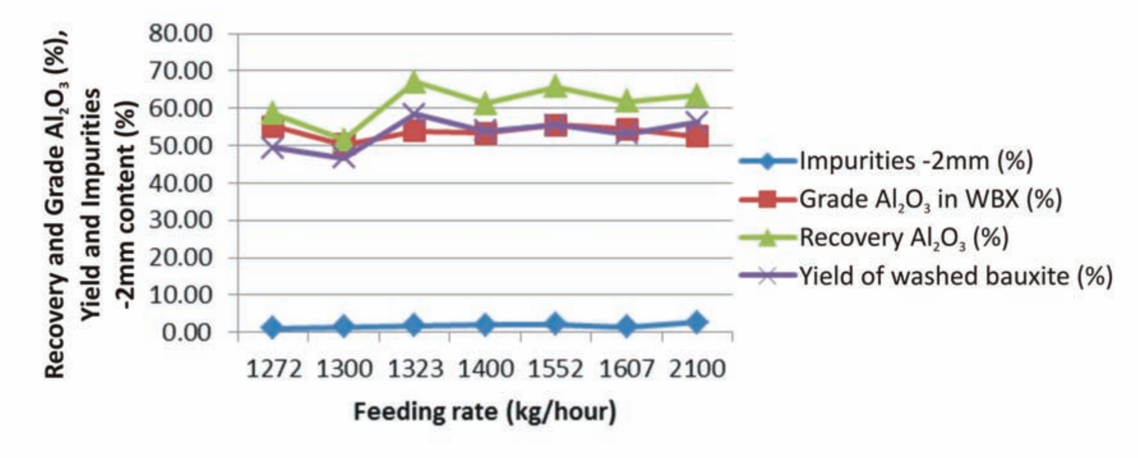

Figure 7. The effect of feeding rate on recovery, grade, yield and impurities

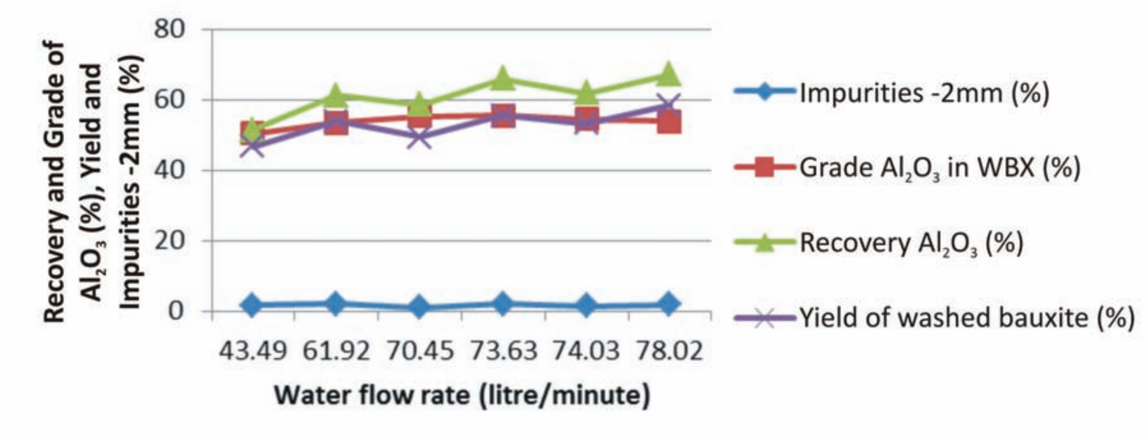

Figure 8. Effect water flow rate to on recovery, grade of alumina. yield and impurities

Mineral composition of washed bauxite

Mineral composition of products from scrubbing process (Code number 15) are quartz, gibbsite, goethite and hematite for washed bauxite and

free SiO_2, 31.74% total SiO_2, 7.59% Fe_2O_3 and 0.85% TiO_2 (Table 3). After scrubbing at around 70 L/minute of water flow rate using screen 2 mm of aperture size opening, the washed bauxite produced has chemical composition as follows:

Table 5. Mineral composition of some samples obtained from scrubbing product by XRD analysis

Code	Component	Mineral composition
JC-15	Crude bauxite	Quartz. gibbsite. goethite. nacrite. hematite
OS-15	Washed bauxite	Quartz. gibbsite. goethite. hematite
US-15	Sand Tailing	Quartz. gibbsite. goethite. hematite
OF-15	Fine tailing	Nacrite. gibbsite. goethite. hematite. quartz.
Quartz (SiO_2). gibbsite ($Al(OH)_3$). goethite (Fe+3O(OH)). nacrite ($Al_2Si_2O_5$). hematite (Fe_2O_3)		

44.35% Al_2O_3, 3.35% reactive SiO_2, 18.62% free SiO_2, 21.97% total SiO_2, 14.43% Fe_2O_3 and 0.68% TiO_2. Whereas, high grade crude bauxite that has chemical composition of 47.00% Al_2O_3, 5.98% reactive SiO_2, 10.85% free SiO_2, 16.83% total SiO_2, 13.56% Fe_2O_3 and 0.97% TiO_2 (Table 3) could be upgraded to produce washed bauxite with chemical composition: 53.13% Al_2O_3, 2.18% reactive SiO_2, 7.23% free SiO_2, 9.40% total SiO_2, 10.83% Fe_2O_3 and 0.61% TiO_2 by using the same condition of washing process (70 L /minute of water flow rate). In general, from this scrubbing process. the grade of alumina (low type crude bauxites) increases to 44.3-50.7% at +2 mm particle sizes. Reactive silica grade at the same size fraction (+2mm) decreases from 4-10.5% to 2.99-4.04%. Whereas, other impurities mineral such as iron oxide decreases from 6.37-7.3% (Figure 5) to 4.55-5.3%. titan oxide decreases from 0.72-0.83 to 0.5-0.57% (Figure 9). Cummulatively, alumina content in the bauxite increases from 34.63% to 45.25%. reactive silica decreases from 5.2% to 3.27% and iron oxide also decreases from 6.91% to 5.03%. Mineral composition of washed bauxite from XRD analysis data are quartz, gibbsite, goethite, and hematite. Nacrite is one of impurities in the crude bauxite, could not be found in the washed bauxite it means that nacrite has been completely removed from washed bauxite.

Sand tailing with particle size of -2 mm+100 mesh contains (in % weight) 92.46% of +100 mesh particle size 7.18% of (-100+200 mesh) and 0.36% of -200 mesh (Figure 10). Reactive silica is concentrated at -200 mesh with the value 19.47% but its amount is not significant. it is only 0.36%. Alumina content in -200 mesh size fraction was also high i.e. 37.1% dominated by aluminosilicate (nacrite) in addition to gibbsite mineral. By cummulative, chemical composition of sand tailing from the highest to the lowest were total silica 55.58%, free silica 47.18%, alumina 23.47%, iron oxide 6.44%, and titan oxide 0.52%. Mineral contained in sand tailing from XRD analysis data are quartz, gibbsite, goethite, hematite. Nacrite is not found from the XRD, because the content was very small as mentioned above.

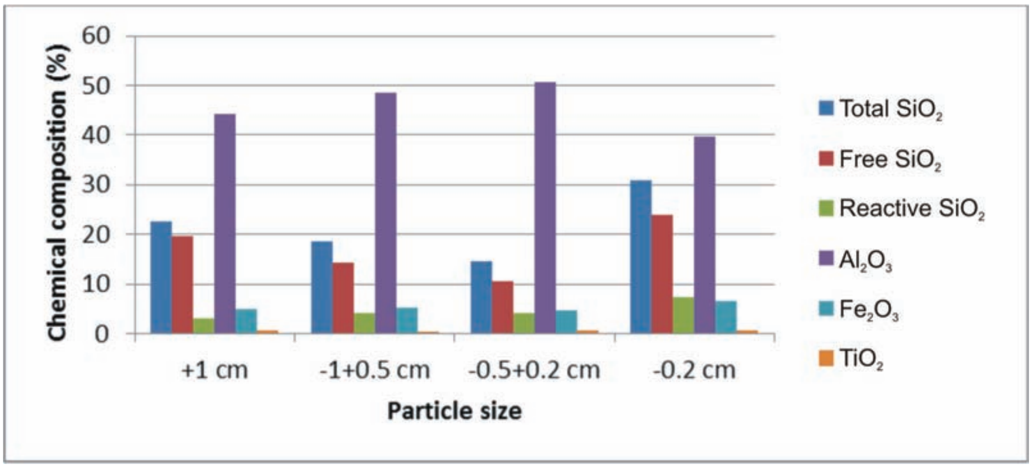

Figure 9. Chemical composition of over size bauxite ore in each particles size

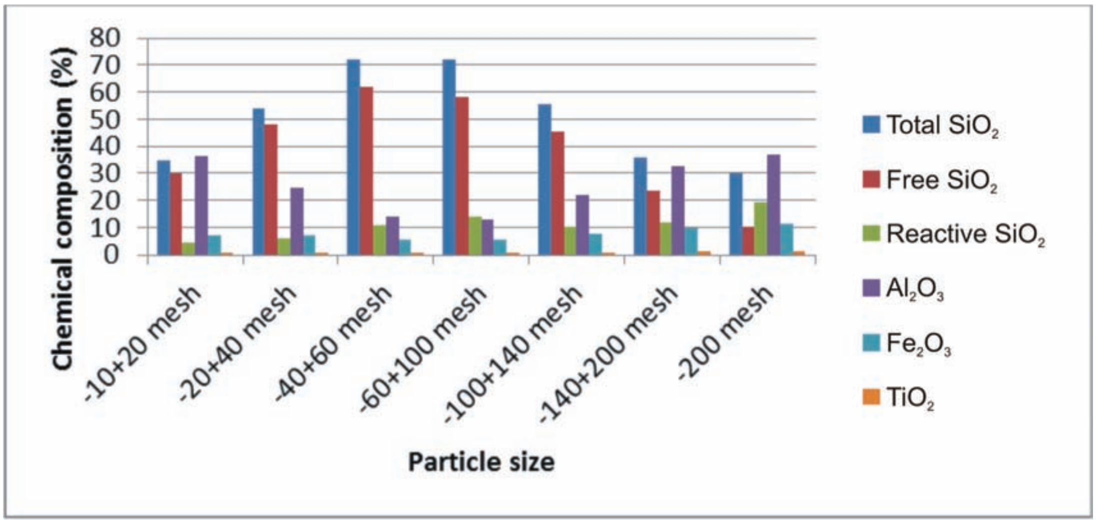

Figure 10. Chemical composition of sand tailing in each particles size

Fine tailing dominated by -100 mesh particles sizes contain reactive silica 18.59%, free silica 10.04%, alumina 36.10%, iron oxide 12.30%, and titan oxide 1.66% (Figure 11). Similar with sand tailing. particle size of -100 mesh is dominated by aluminosilicate (nacrite) as shown from the XRD analysis data. Mineral composition of fine tailing are nacrite. gibbsite. Goethite, hematite, and quartz. Its difference from sand tailing was the content of nacrite mineral in fine tailing was higher. Besides. free silica content in fine tailing is smaller than that of sand tailing. In the fine tailing, free silica content is 10.04%, but in sand tailing is 47.18%.

Particle size distribution

Particle size distribution of washed bauxite comparing to crude bauxite can be seen in Figure 12. Particle size above 0.5 cm in washed bauxite is higher than that of crude bauxite. On the other hand, particle size in between -0.5cm+12 mesh in washed bauxite is lower than that of crude bauxite. Impurities of bauxite (mineral with particle size less than 12 mesh) could be decreased from 17.15% down to 1.81% for high grade bauxite, similarly decrease from 18.61% down to 3.55% for low grade bauxite. These data show that upgrading of high grade bauxite could produce better quality than that of upgrading low crude bauxite.

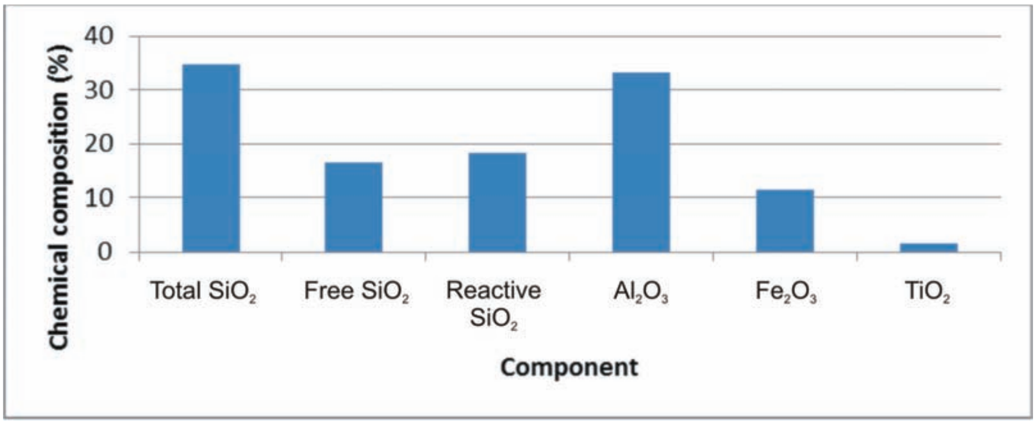

Figure 11. Chemical composition of fine tailing in each particles size

Particle size distribution of sand and fine tailing from a high grade crude bauxite comparing to that of a low grade crude bauxite can be seen in Figure 13. Sand tailing from high grade bauxite contained 17.35% of -200 mesh of particle size. On the other hand. particle size of -200 mesh from a low grade bauxite was only 1.21%. Similar to fine tailing. percentage of particle size of -200 mesh from high grade crude bauxite is higher than that of low grade crude bauxite. This shows that the content of fine mineral in high grade crude bauxite is higher than that of low grade one. but after scrubbing washed bauxite obtained from high grade crude bauxite has a better quality (lower content of -2mm of particle size) than that of low grade crude bauxite namely 1.81% comparing to 3.55%.

CONCLUSION

The minerals composition of Tayan's crude bauxite ore are gibbsite, quartz, iron minerals (such as goethite and hematite) and clay (nacrite). Upgrading of crude bauxite ore with RDS operation is affected by some factors such as solid percentage, feed rate and water flow rate. The conclusion may be summerized as follows :

1. Solid percentage of lump has significant effect of washing action within RDS to perform washed bauxite products. The higher is the solid percentage the lower is the washed bauxite quality obtained. The similar manner is that the higher is feeding rate the lower is washed bauxite quality, it is due to impurities minerals content

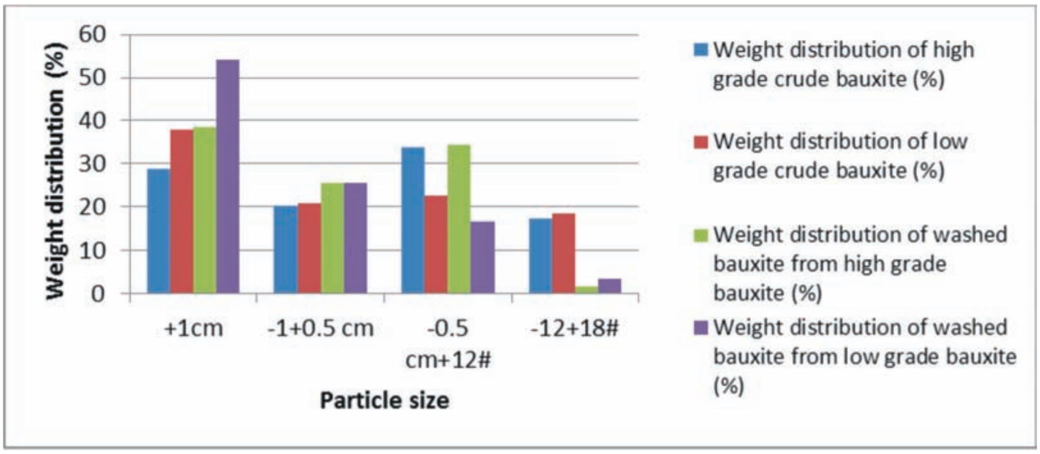

Figure 12. Particle size distribution of crude and washed bauxite ore of low and high grade

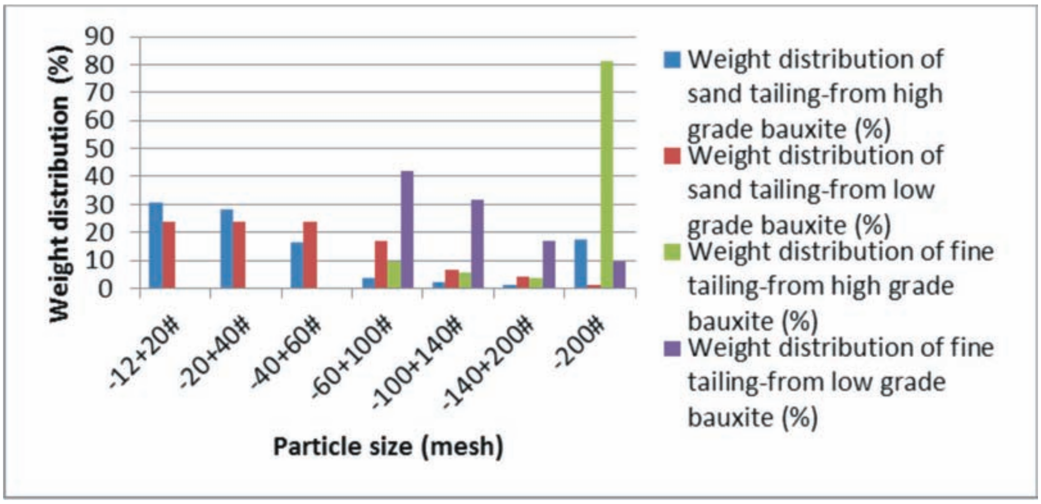

Figure 13. Particle size distribution of sand and fine tailing of low and high grades

in the washed bauxite tend to increase. On the other hand, the higher is water flow rate the higher is washed bauxite quality obtained.

2. Optimum condition of present experiment is found 1607 kg/hour of feeding rate, 25% of solid and 73.63 L/minute of water flow rate. The residence time of the separation proces is 8 minutes. Rotation speed of RDS is 9 rpm with screen aperture of 2 mm.

3. Low grade type of crude bauxite with 34.63 % Al_2O_3 and 5.20 % reactive SiO_2 could be increased to 45.25 % Al_2O_3 and 3.27% reactive SiO_2, respectively. The average increase of alumina content (for low grade bauxite) is 8.26% and the average decrease of reactive silica is 2.11%.

4. High grade type of crude bauxite that contains 47.30 % Al_2O_3 and 5.79 % reactive SiO_2 could be upgraded to 55.50 % of Al_2O_3 and 0.47 % of reactive SiO_2, respectively. The average increase of alumina content is 5% and the average decrease of reactive silica is 3.62%.

5. The yield of washed bauxite obtained from the present upgrading process is in between 46.75-56.26% with the impurities (particle less than 2mm) are in between 1.02-2.64%.

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