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Research Article

Communition Circuit Flowsheet Development for Optimum Performance of Iron Ore Processing, in the Case of Sekota, Wagehemira, Northern Ethiopia

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Abstract

Comminution flow sheet design is a critical process in the production of iron ore. In this study, the flow rate was fixed at 150 t/h with the Crusher specification of a Cedarapids JC24x36 jaw crusher model and a Nordberg Hp 300 S/M cone crusher. Based on the mineralogical information and ore properties provided the Agg Flow Version 460.22 software is used to conduct, a comprehensive comminution flow sheet design to achieve the desired particle size distribution. In the comminution of primary crusher stage Iron ore at top size of 42 inches or (1066.8 mm) generates 5 different ranges of materials, the first is at a size of 45 mm, the second at 10 mm, and the third is at 8 mm, between 15 and 8 mm and between 23.5 and 15 mm. The primary crusher, a Cedarapids JC2436 Model Jaw crusher, was required to reduce the feed size with closed side setting of 69.85 mm to a manageable size of end product 21 Mtph for further processing. The Nordberg Hp 300 S/M cone crusher was used as a secondary crusher with closed side setting (CSS) of 28 mm to further reduce the particle size to 26 Mtph. To complete the task several choices analyzed and as final design used 1 jaw crusher Cedarapids Jc 2436, and two cone crushers Nordberg HP 300 S/M. some screening and conveyors placed in the design to increase the reduction ratio of the equipment.

Keywords

Comminution, Crusher, Flow Sheet

1. Introduction

In the crust of the Earth, iron is the fourth most common metal, and its ore minerals include hematite, goethite, magnetite, siderite, ilmenite, and various sulfides [1]. Particle size reduction for mineral processing is a crucial area of emphasis since it may have a big influence on costs for downstream processing [2]. To maximize recovery and product grade in the specific case of iron ore, an efficient comminution (size reduction) circuit must be developed [3].

Hematite is commonly thought to form from oxidation of magnetite in the near surface environment although [4] demonstrated that the transformation of magnetite to hematite or vice versa can also be achieved via a pH shift without a redox reaction.

Martite is a commonly used textural term to denote hematite pseudo-morphs after primary magnetite where the octagonal outlines of many of the original magnetite grains are

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preserved [5]. Goethite is an iron oxyhydroxide (α-FeOOH), believed to be the most common iron ore mineral n sedimentary and near-surface, and altered meta-sedimentary iron ore deposit [5].

A crusher with a 150 tph iron ore crushing capacity and an annual run-of-mine capacity of is anticipated to be used in Sekota's proposed iron ore mining operation, 432,000 t of iron ore will be the mine's maximum capacity. The purpose of comminution circuits is to reduce the size of the ore so that the valuable minerals can be distinguished from the waste minerals [4]. It is an important stage in the processing of ores because it has an impact on the release of the minerals and the effectiveness of subsequent processes like flotation and leaching. In order to reduce energy, an efficient comminution circuit is also crucial [5].

The goal of comminution modeling is to estimate the needed comminution energy as well as the size and liberation distribution of mineral particles [6]. With no comprehensive understanding of how the mineral grade changes by size or the product liberation distribution, the most recent state-of-the-art comminution models do not calculate particle size distribution, grinding energy, or throughput dependency [7]. The underlying breaking processes, which are influenced by modal mineralogy and mineral texture (micro structure), have an impact on the liberation of mineral grains [8].

The heterogeneity of the mineral particle features, such as the organization and composition of the grains, has made it difficult to model comminution systems in order to determine the ideal energy and size for greater mineral liberation [9]. On the one hand, predicting size distributions (cumulative distributions) of each individual mineral grain (i.e., degree of mineral liberation) as a function of particle size and crushing energy is the main goal of modeling comminution processes [10].

The design and development of a comminution flow sheet for the processing of iron ore and create a comminution circuit that increases end product recovery and grade while reducing energy use and environmental effect for Sekota, Ethiopia is the major goal of this research [11].

2. Materials and Methods

2.1. Materials and Equipment's

Iron ore samples used in test

Sieve for particle size distribution analysis

Aggflow software for designing

X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy (SEM) for chemical and mineralogical analysis.

2.2. Methods

2.2.1. Sample Collection

The iron ore sample used in this study was collected from Sekota, Waghemeira zone at different localities including (Shakura Locality, Shenaba Locality, Mildave locality and Lewanzeba).

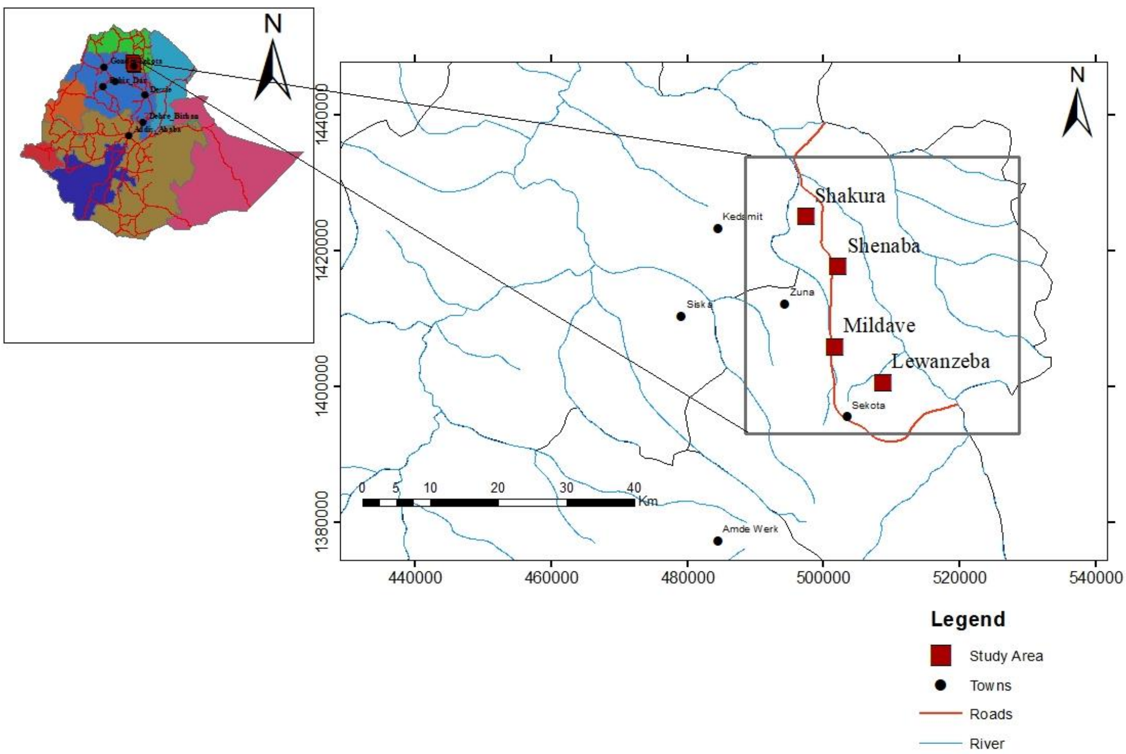


Figure 1. *Sampling localities of study Area.*

2.2.2. Sample Preparation

Samples were prepared for chemical and mineralogical analysis for determination of elemental or modal chemical composition and mineralogical constituents of an ore deposit. In addition, samples were prepared for particle size distribution analysis.

2.3. Approach and Methodology

The development of a flow sheet for the processing of iron ore typically begins with an investigation of the mineralogy and chemical composition of the ore.

This can be done through techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy (SEM).

Mineralogical and chemical composition data of the ore have been used for comminution circuit development. To achieve the target objective, the following steps were followed.

1. Analyze the data - Use the data obtained from the literature review and web search to identify common themes, patterns, and trends. Note any discrepancies or limitations in the data.
2. Refine the comminution flow sheet - Based on the analysis of the secondary data sources, make modifications or improvements to the initial comminution flow sheet.
3. Conduct simulations or modeling studies - Use software Aggflow software to simulate and model different aspects of the comminution process.

3. Result and Discussion

3.1. Iron Ore Processing Simulation

Ore from the mine will be delivered by Truck-Feed by haul trucks and goes to deck inclined screen and to different components of crusher. The main components of crusher are screen, conveyor belts, crushers and storage pile.

The ore delivered will be fed to the hopper using front end loader. The ore will be conveyed to the screen, the undersize materials will be conveyed to stockpile, whereas the oversize material will be conveyed to the jaw crusher and conveyed to the Screen and here also the undersize conveyed to stockpile and the oversize conveyed to the cone crusher.

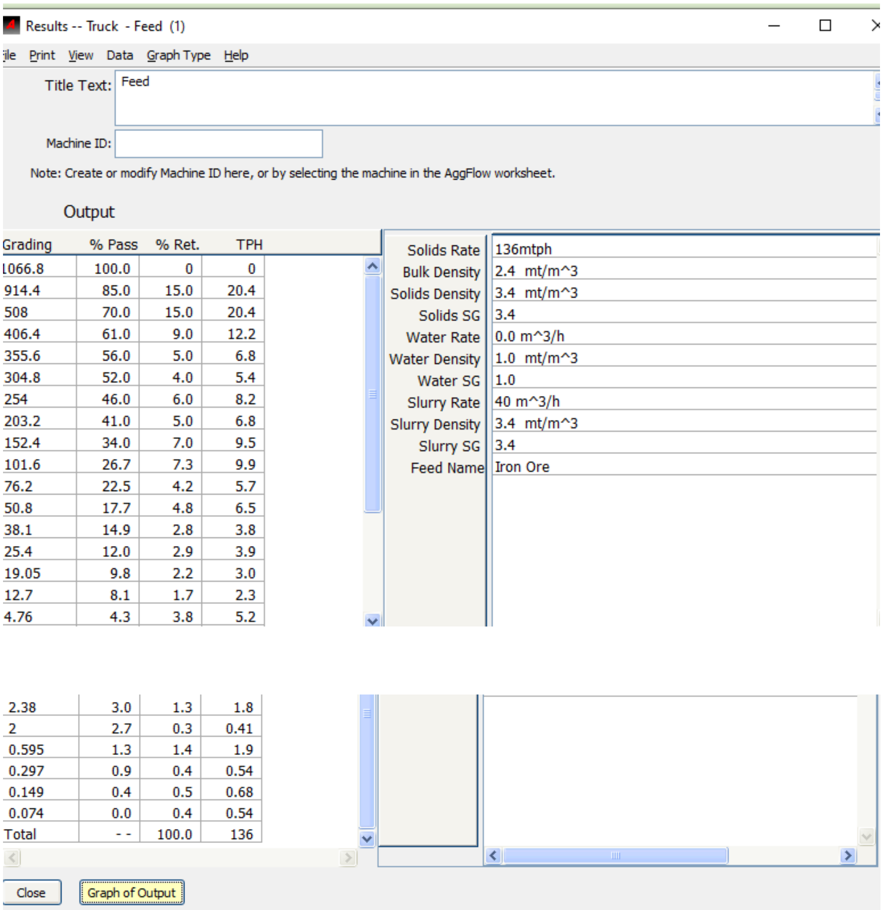


Figure 2. Material being loaded.

3.2. Primary Crusher

A 2-Deck Inclined screen is placed right after the load point with cutting size of Deck 1 and Deck 2 as show below (figure 3). The overflow with a size of (-1066.8+0.074 mm) will be goes to the jaw crusher and pass through the belt to the secondary crusher stage to run the secondary crusher stage.

While the second deck screen with 80 mm mesh size will meet to the jaw crusher through the belt to the secondary crusher stage to run the secondary crusher while the under-deck screen of 45 mm directly goes to the product stockpile.

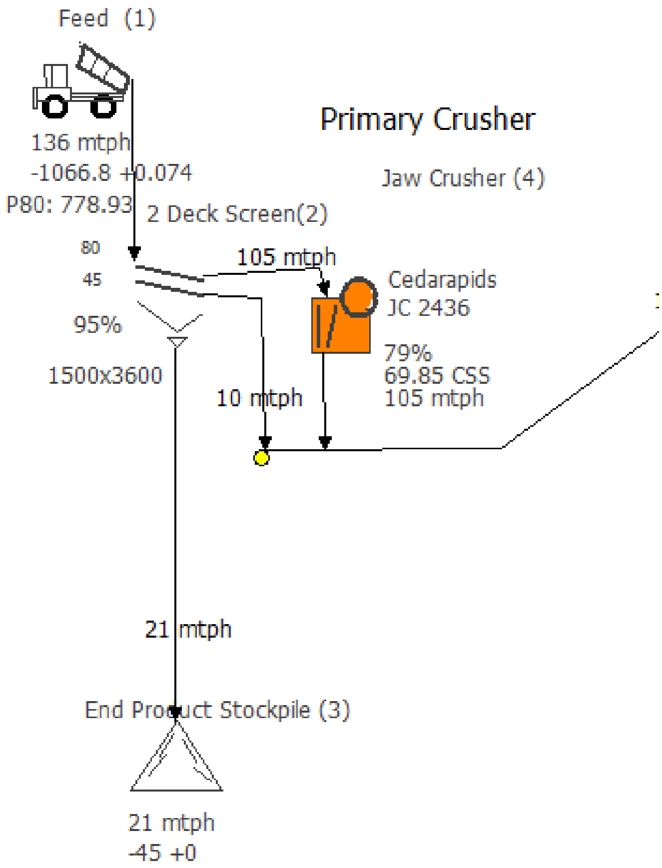


Figure 3. Primary Crushing.

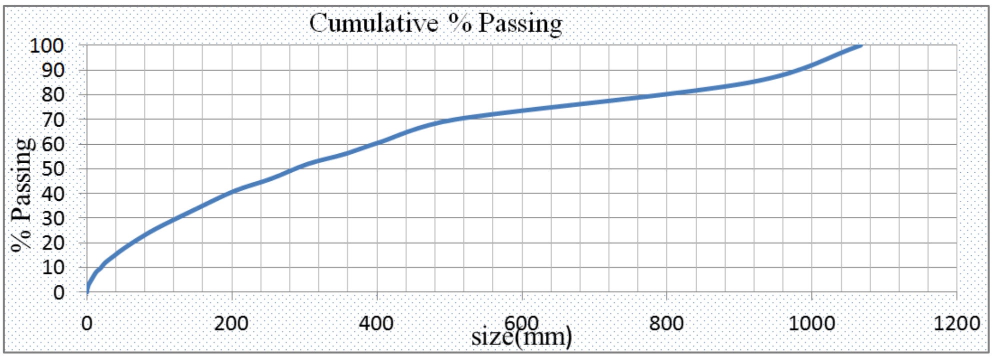


Figure 4. Feed Cumulative Passing curve.

From the graph above, cumulative percent pass graph on comminution flow sheet development of iron ore represents the percentage of material that has passed through a particular screen or sieve size in the given comminution circuit. In summary, the cumulative percent pass graph is a valuable tool that helps in optimizing and designing comminution circuits for iron ore processing.

The cumulative percent pass graph on comminution flow sheet development of iron ore with P80 of 778.93 mm shows the percentage of material that has passed through a particular screen or sieve size in a given comminution circuit to achieve a product size with a P_{80} of 778.8 mm (meaning 80% of the material has passed through a particle size equivalent to or smaller than 778.8 Mtph).

The P80 value is critical in the design and optimization of comminution circuits as it represents the particle size at which 80% of the material passes through. The cumulative percent pass graph with a P80 of 778.8 Mtph allows for a clear interpretation of how much material needs to be processed achieving the desired final product size, as well as how much material is outside the desired size range [12, 14].

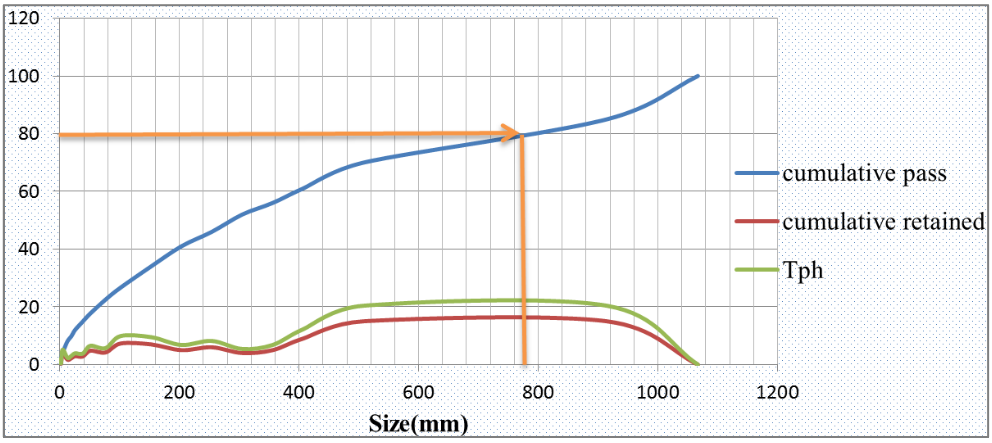


Figure 5. *Feed Graph.*

Table 1. *Deck 1 Screen Data on primary crusher.*

2 Deck Inclined Screen 2 Deck Screen (2) - Deck 1			
Grading	**% Pass**	**% Ret.**	**TPH**
1066.8	100	0	0
914.4	80.5	19.5	20.4
508	61	19.5	20.4
406.4	49.3	11.7	12.2
355.6	42.8	6.5	6.8
304.8	37.6	5.2	5.4
254	29.8	7.8	8.2
203.2	23.3	6.5	6.8
152.4	14.2	9.1	9.5
101.6	4.7	9.5	9.9
80	0	4.7	4.9
76.2	0	0	0
Total	- -	100	105

From the table 1 above in the size distribution of 1066.8 mm size the oversized material which is (+80 mm) screen size of iron ore material will loaded to the jaw crusher for crushing (size reduction) with an input distribution of a total of 105 mtph and the percent passing graph will be shown below.

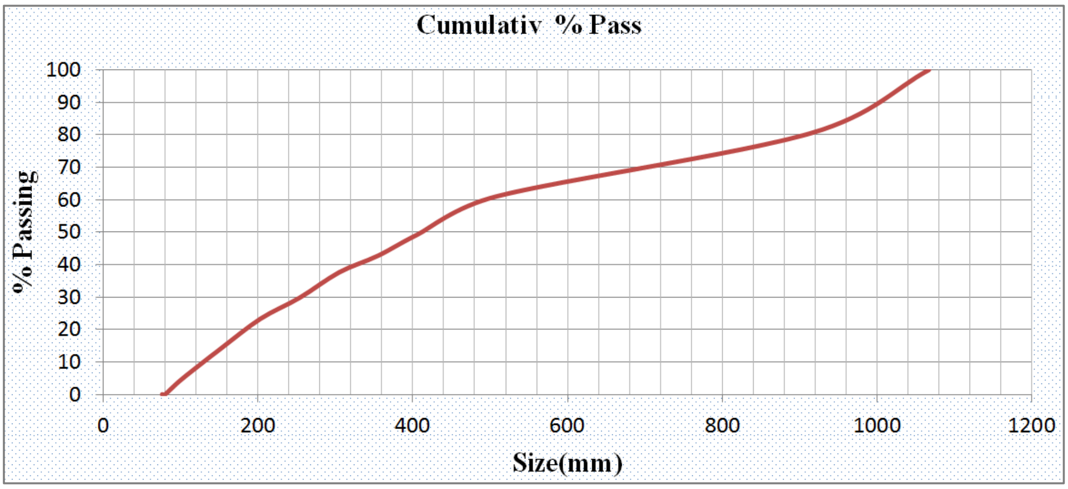


Figure 6. Screen Deck 1 cumulative pass graph.

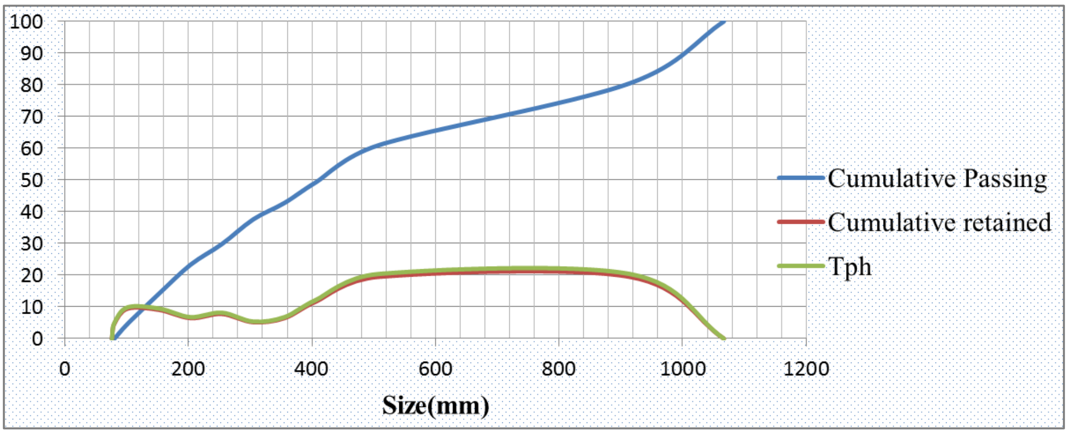


Figure 7. Screen Deck 1 graph.

Table 2. Deck 2 Screen Data on Primary Crusher.

2 Deck Inclined Screen 2 Deck Screen (2) - Deck 2			
Grading	**% Pass**	**% Ret.**	**TPH**
80	100	0	0
76.2	91.7	8.3	0.85
50.8	27.8	63.9	6.5
45	10.7	17	1.7
38.1	8.2	2.5	0.26
25.4	4.5	3.7	0.38
19.05	2.6	2	0.2
12.7	1.5	1.1	0.11
4.76	0.2	1.3	0.14
2.38	0	0.2	0.02
Total	- -	100	10.2

In the table 2 deck 2 screen data on primary crusher, since in the primary crusher there is 2-deck screen from the above table (-80 mm) mesh screen size distribution has been tabulated.

The undersize in the 80 mm goes to the conveyor belt and feed to the next secondary crusher stage with a total of 10.2 mm and the percent passing and retained graph has plotted below.

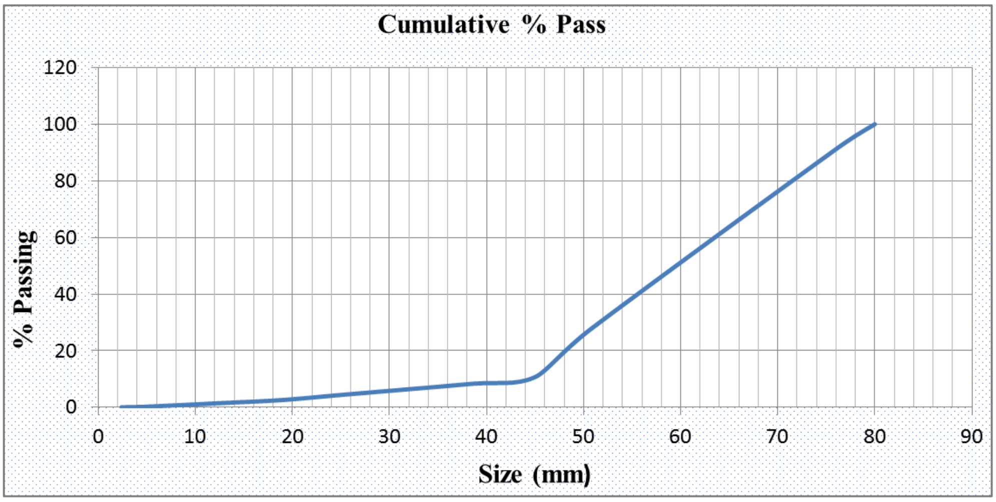


Figure 8. *Screen Deck 2 cumulative pass graph.*

Table 3. *Stock pile Output data of on primary Crusher.*

2 Deck Inclined Screen 2 Deck Screen (2) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
45	100	0	0
38.1	91.5	8.5	1.8
25.4	74.7	16.8	3.6
19.05	61.5	13.1	2.8
12.7	51.1	10.4	2.2
4.76	27.4	23.7	5
2.38	19.2	8.2	1.8
2	17.3	1.9	0.41
0.595	8.3	9	1.9
0.297	5.8	2.6	0.54
0.149	2.6	3.2	0.68
0.074	0	2.6	0.54
0	0	0	0
Total	- -	100	21.2

From the table 3 above the size distribution table shows in the primary crusher the (-45 mm) deck size screen or the bottom deck screen the material which is under size will goes to the end product stockpile and the percent passing graph plotted below.

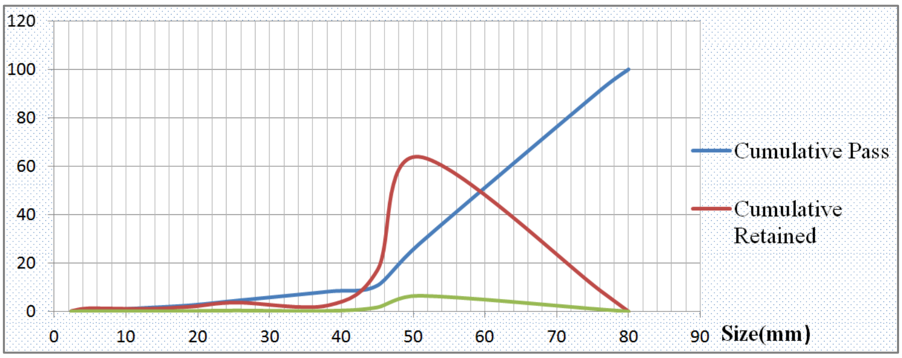


Figure 9. Screen Deck 2 graph.

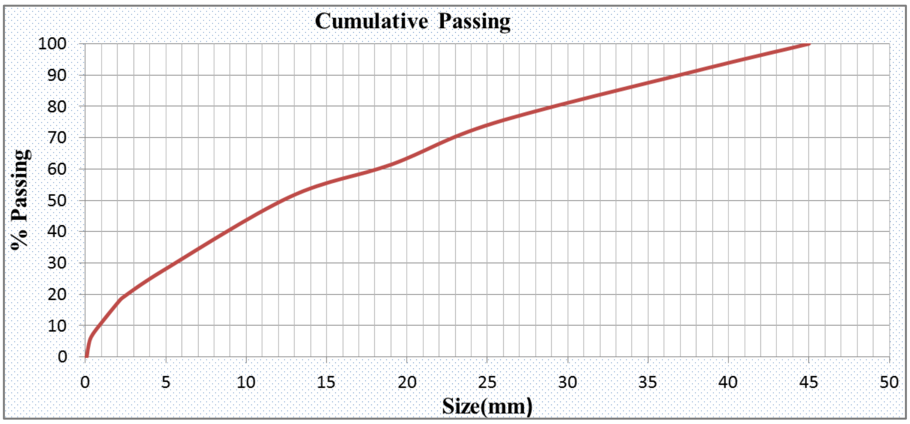


Figure 10. Primary crusher end product stockpile Cumulative passing graph.

Table 4. Jaw Crusher Output Data On primary crusher.

JC 2436 Jaw Crusher (4) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
127	100	0	0
101.6	90	10	10.5
88.9	81	9	9.4
76.2	72	9	9.4
69.85	67.5	4.5	4.7
63.5	62.5	5	5.2
57.15	58	4.5	4.7
50.8	53	5	5.2
44.45	48	5	5.2
38.1	42	6	6.3
31.75	37	5	5.2
25.4	31	6	6.3
22.23	28	3	3.1
19.05	22.5	5.5	5.8
15.88	21	1.5	1.6

JC 2436 Jaw Crusher (4) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
12.7	18	3	3.1
9.53	13.7	4.3	4.5
7.94	12.3	1.4	1.5
6.35	10.3	2	2.1
4.76	8	2.3	2.4
2.38	4.6	3.4	3.6
2	3.9	0.7	0.73
1.19	3.4	0.5	0.52
0.595	1.4	2	2.1
0.42	1.2	0.2	0.21
0.297	1	0.2	0.21
0.149	0.5	0.5	0.52
0	0	0.5	0.52
Total	- -	100	105

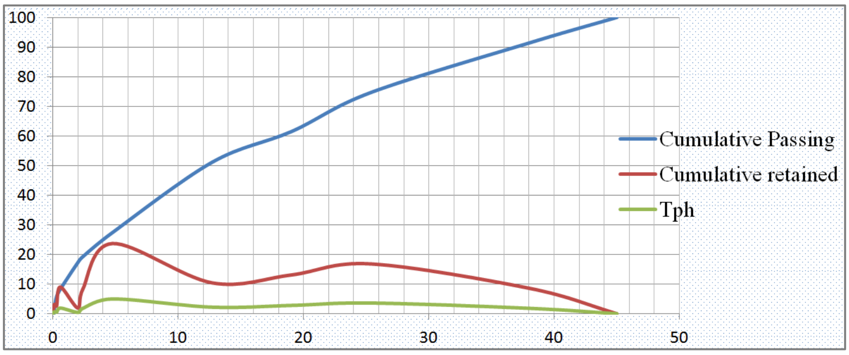


Figure 11. Primary crusher end product stockpile graph.

In the primary crusher which is feed from the truck feed and the oversized material of (+80 mm) has feed to the jaw crusher with assize distribution described above with a total of 105 mtph.

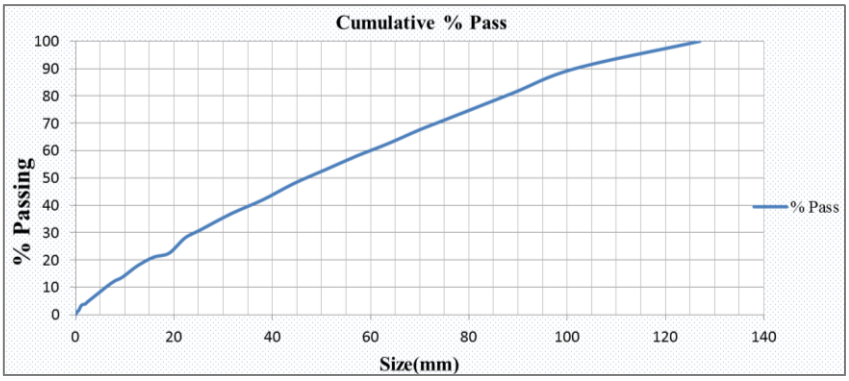


Figure 12. Jaw Crusher output passing graph.

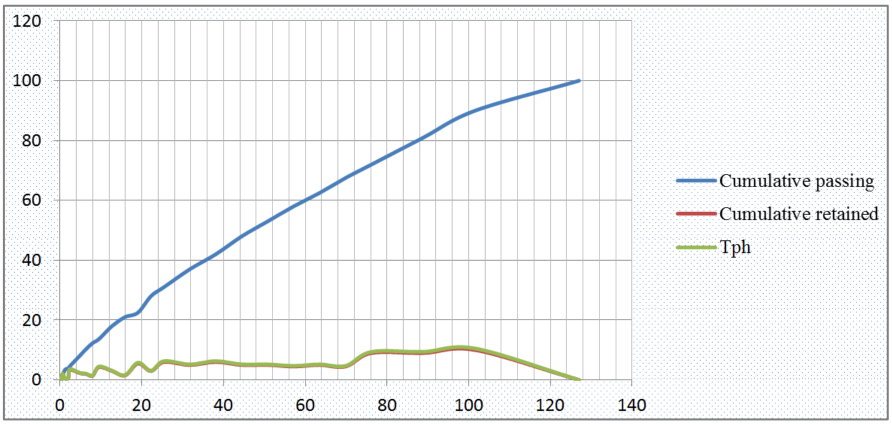


Figure 13. Jaw Crusher output graph.

3.3. Secondary Crusher

The product of the primary crusher on the 2-Deck screen of Deck-1 and Deck-2 generated by the belt conveyor passes through the 3-Deck screen to the cone crusher. The product on the 80 mm meshes size deck and the flow stream generated as a material to the second crusher with the total of 115 Mtph.

The overflow bigger than 56 mm mesh screen will be placed to the con crusher and goes to the recycled belt conveyor and back to the 3 Deck inclined screen.

On the second crusher stage the first Deck-1 (56 mm) and second deck Deck-2 (25 mm) will be placed to the belt conveyor to run the next tertiary stage, while the bottom deck (Deck-3) of 10 mm mesh size placed directly to product stockpile.

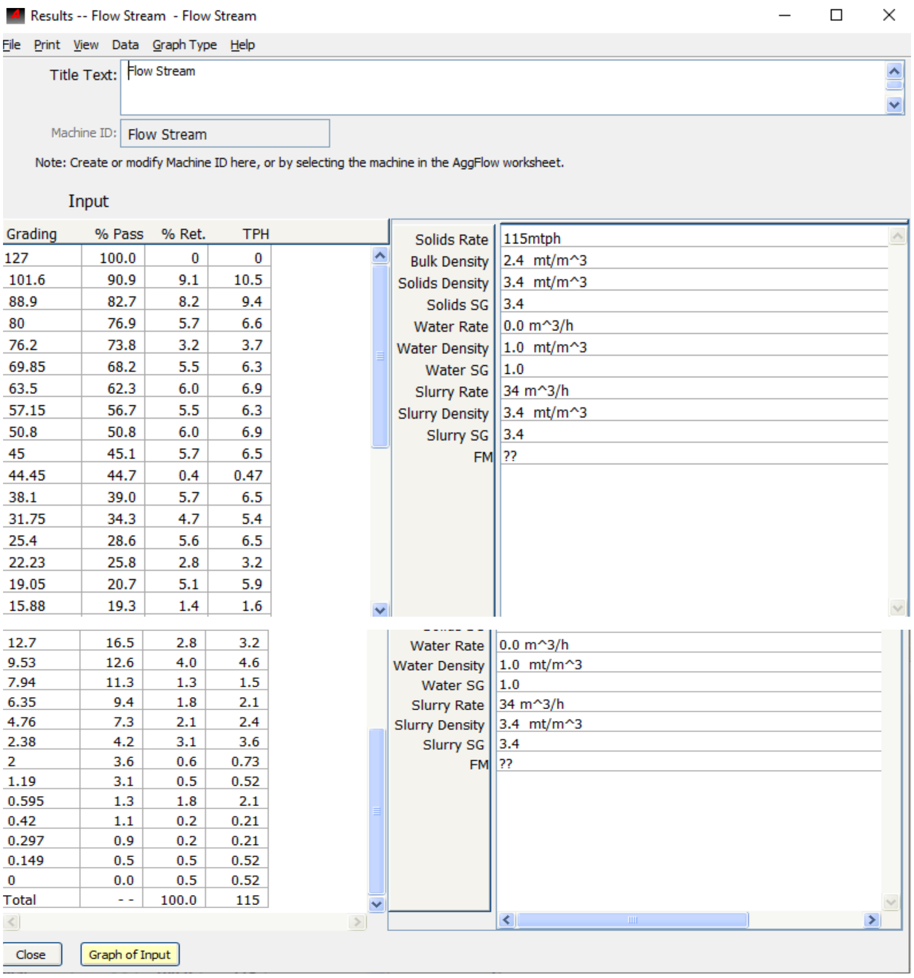


Figure 14. Flow stream from the primary crushing.

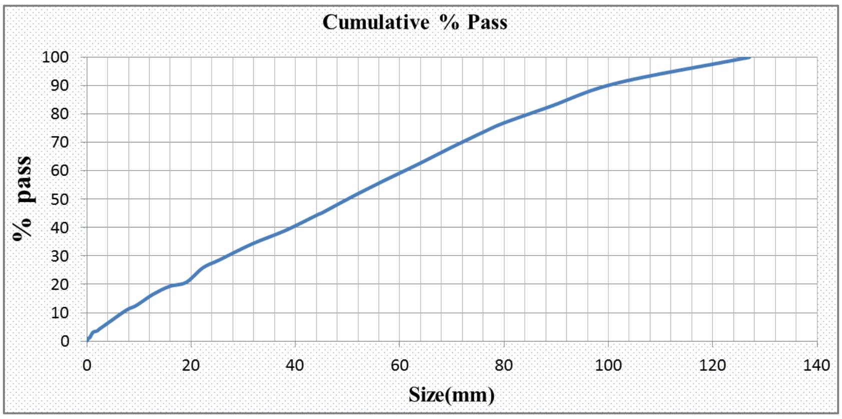


Figure 15. Secondary crusher flow stream passing graph.

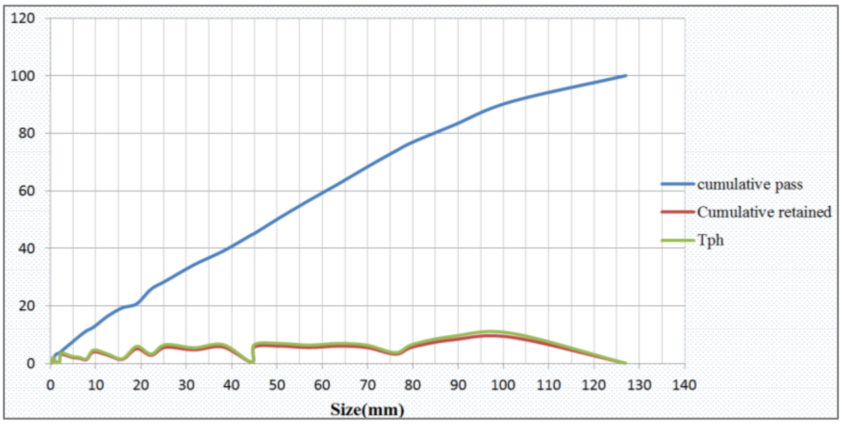


Figure 16. Secondary crusher flow stream graph.

Table 5. Flow Stream to Cone Crusher Data.

Conveyor Flow Stream – Input			**(to cone crusher)**
Grading	**% Pass**	**% Ret.**	**TPH**
127	100	0	0
101.6	81.7	18.3	10.5
88.9	65.2	16.5	9.4
80	53.7	11.5	6.6
76.2	47.3	6.4	3.7
69.85	36.2	11.1	6.3
63.5	24.2	12	6.9
63	23.3	0.9	0.5
57.15	12.6	10.7	6.1
56	10.3	2.3	1.3
51	9.2	1.1	0.64
50.8	9.2	0.1	0.03
45	7.8	1.3	0.77

Conveyor Flow Stream – Input			**(to cone crusher)**
Grading	**% Pass**	**% Ret.**	**TPH**
44.45	7.7	0.1	0.05
38.1	6.6	1.2	0.67
38	6.5	0	0.01
32	4.7	1.8	1.1
31.75	4.6	0.1	0.04
25.4	2.9	1.7	0.99
25	2.8	0.1	0.05
22.23	2.1	0.7	0.38
22	2.1	0.1	0.04
19.05	1.4	0.6	0.36
19	1.4	0	0
16	1	0.5	0.27
15.88	1	0	0.01
13	0.6	0.4	0.22
12.7	0.5	0	0.02
10	0.3	0.3	0.16
9.53	0.2	0	0.03
8	0.1	0.1	0.06
7.94	0.1	0	0
6.35	0	0.1	0.05
6	0	0	0.01
Total	- -	100	57.2

In the secondary crusher since the secondary crusher part is used for crushing a material that is not crushed in the primary crusher. in the secondary crusher we have 3-deck inclined screen to handle the input feed from the primary crusher (input feed from the primary) with a size of 127 mm or oversized material will go to the cone crusher for size reduction and stored as an end product of 57.2 mtph.

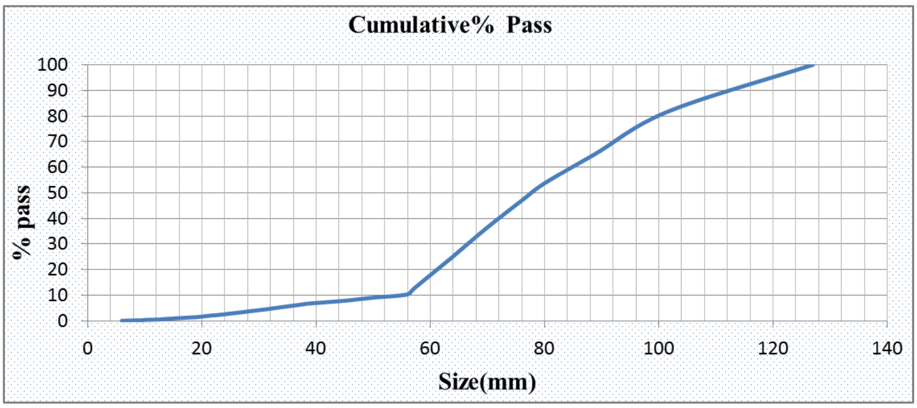


Figure 17*. Flow Stream to Cone Crusher Cumulative Passing graph.*

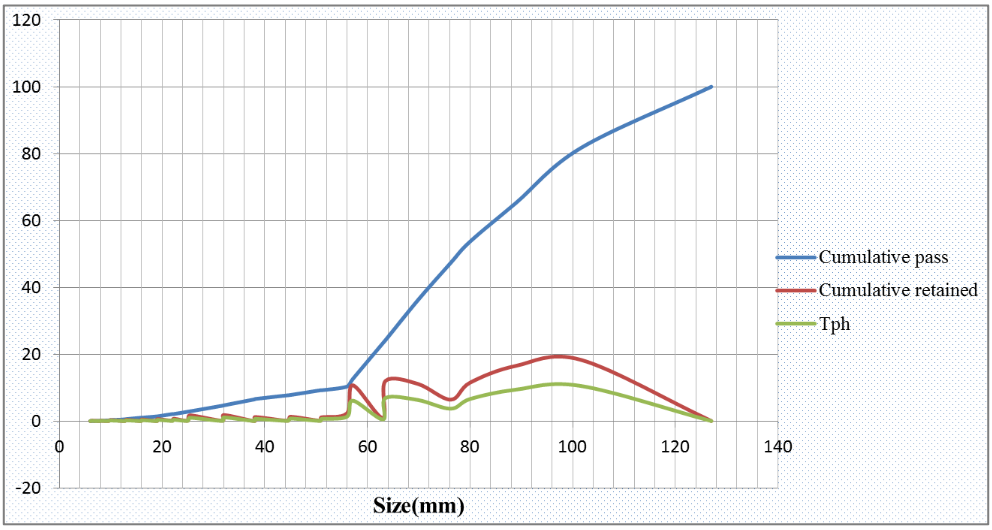


Figure 18. *Flow Stream to Cone Crusher graph.*

Table 6. *Deck Size with cut size (50 mm) Deck screen to belt conveyor Data.*

Conveyor 01 Stream – Input			
Grading	**% Pass**	**% Ret.**	**TPH**
56	100	0	0
51	90.5	9.5	5
50.8	90.1	0.4	0.22
45	77.3	12.8	6.8
44.45	76.3	1	0.52
38.1	63.1	13.2	7
38	62.9	0.2	0.09
32	37.9	25	13.2
31.75	36.9	1.1	0.56
25.4	7.9	29	15.3
25	6	1.8	0.97
22.23	4.7	1.3	0.7
22	4.6	0.1	0.07
19.05	3.3	1.3	0.66
19	3.3	0	0.01
16	2.3	1	0.5
15.88	2.3	0	0.02
13	1.5	0.8	0.42
12.7	1.5	0.1	0.03
10	0.9	0.5	0.29
9.53	0.8	0.1	0.05
8	0.6	0.2	0.11

Conveyor 01 Stream – Input			
Grading	**% Pass**	**% Ret.**	**TPH**
7.94	0.6	0	0
6.35	0.4	0.2	0.1
6	0.4	0	0.02
4.76	0.2	0.2	0.08
4	0.1	0.1	0.04
2.38	0	0.1	0.06
2	0	0	0.01
Total	- -	100	52.7

In the secondary crusher there is a 3-deck screen mesh size of (56 mm, 25 mm and 10 mm), the mesh size of +56 mm which is oversized in the 56 mm will goes to the conveyor belt to transfer the material to the next crusher stage with an end product of 52.7 Mtph.

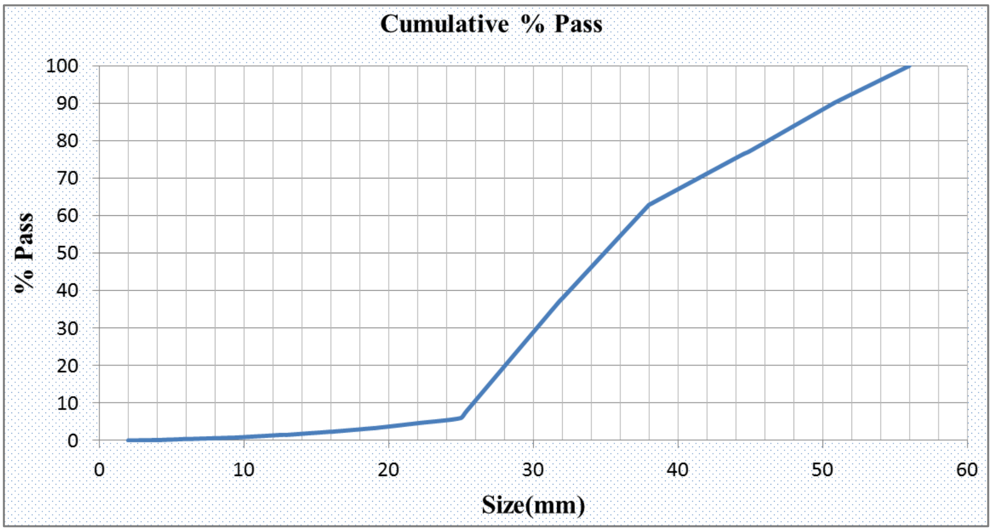


Figure 19. Cut size (50 mm) Deck screen to belt conveyor passing graph.

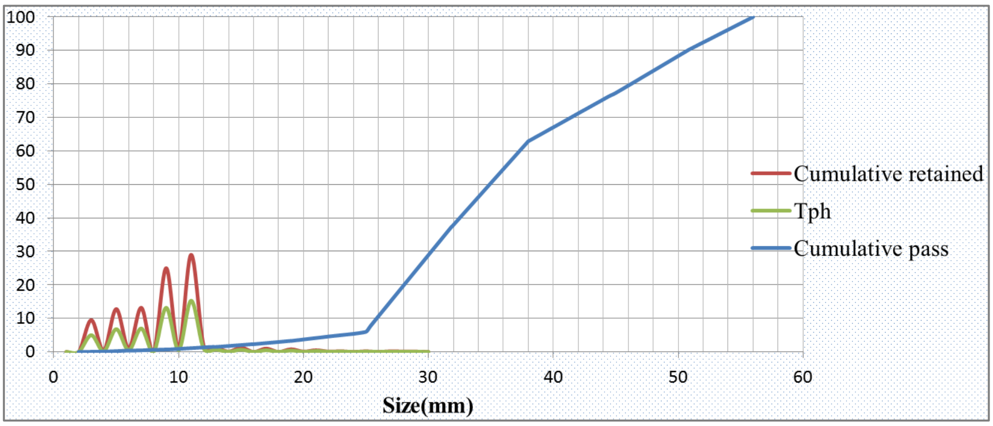


Figure 20. Cut size (50 mm) Deck screen to belt conveyor relation graph.

Table 7. Deck Size with cut size (25 mm) to Belt conveyor.

Deck with 25 mm mesh			
Conveyor Flow Stream – Input			
Grading	**% Pass**	**% Ret.**	**TPH**
25	100	0	0
22.23	81.8	18.2	6.5
22	79.8	1.9	0.69
19.05	59.5	20.3	7.2
19	59.4	0.2	0.06
16	41.2	18.1	6.5
15.88	40.6	0.6	0.23
13	22	18.6	6.6
12.7	20.5	1.5	0.54
10	3.6	16.8	6
9.53	3.3	0.4	0.13
8	2.4	0.8	0.3
7.94	2.4	0	0.01
6.35	1.7	0.8	0.27
6	1.5	0.2	0.06
4.76	0.9	0.6	0.22
4	0.6	0.3	0.11
2.38	0.1	0.5	0.17
2	0	0.1	0.03
Total	- -	100	35.6

In the deck size of 25 mm mesh screen the material with a size distribution described above has been placed to the conveyor belt to transfer to the next stage for further crushing and storing.

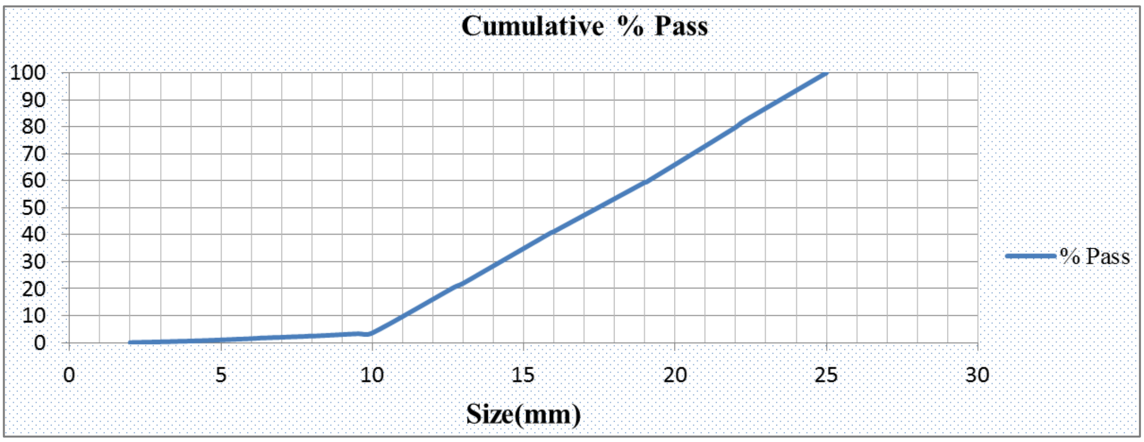


Figure 21. Cut size (25 mm) to Belt conveyor passing graph.

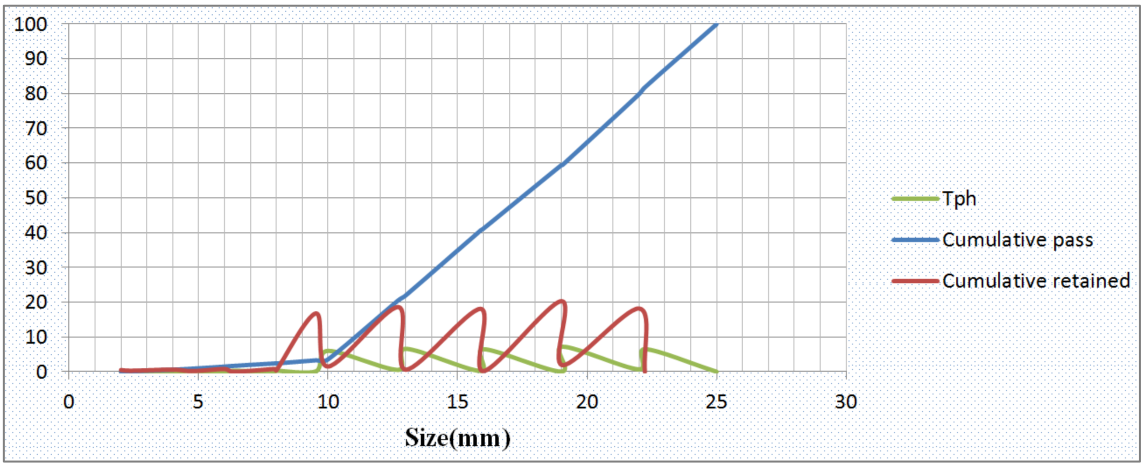


Figure 22. Cut size (25 mm) to Belt conveyor graph.

Table 8. End product Stockpile Product on secondary crusher data.

Product Pile End Product Stockpile (7) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
10	100	0	0
9.53	96.1	3.9	1
8	85.9	10.3	2.7
7.94	85.5	0.4	0.1
6.35	73.9	11.6	3.1
6	71	2.8	0.75
4.76	58.2	12.8	3.4
4	50.3	7.9	2.1
2.38	33.2	17.1	4.5
2	28.5	4.7	1.2
1.19	21.3	7.3	1.9
0.595	9.4	11.8	3.1
0.42	7.5	1.9	0.51
0.297	5.9	1.6	0.42
0.149	3	2.9	0.78
0	0	3	0.78
Total	- -	100	26.3

The fine particle which is the undersize material will be stored as a stockpile with assize of 10 mm (bottom deck screen) with a total end product of 26.3 mtph and the size distribution data has been tabulated above.

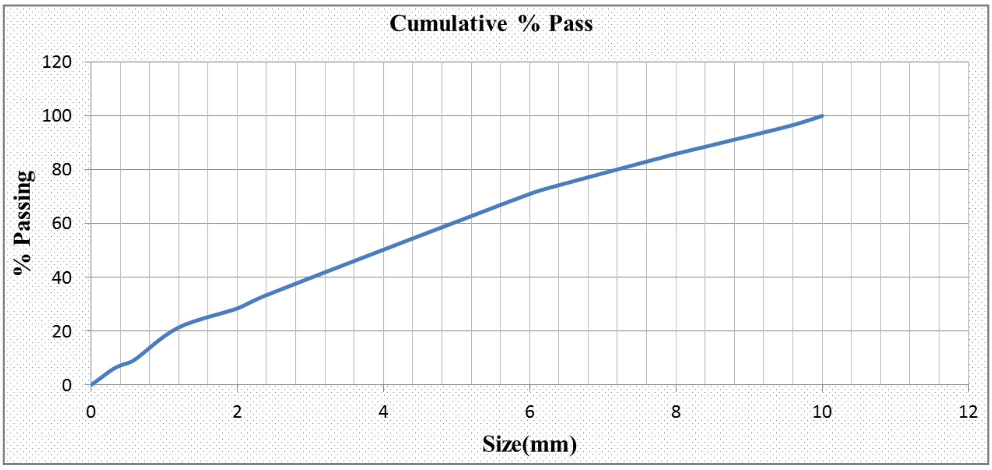


Figure 23. End product stockpile result on secondary crusher.

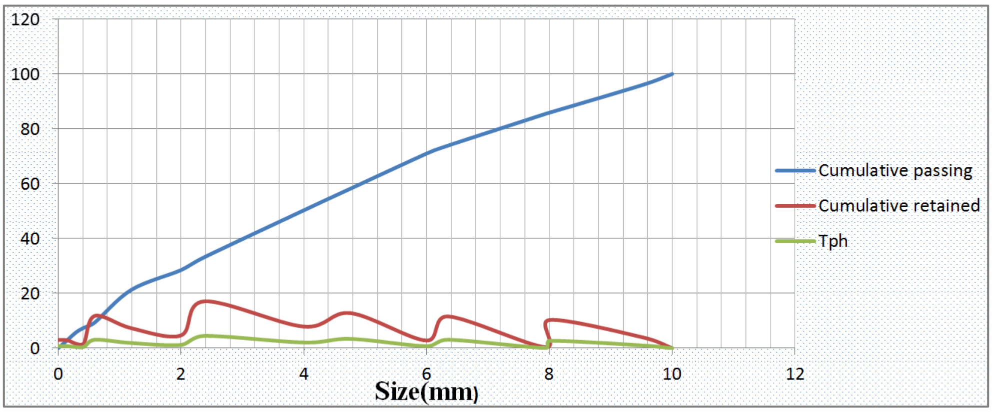


Figure 24. End Product stockpile graph on secondary crusher.

3.4. Tertiary Crusher

In the tertiary crusher the product of the First deck and second deck on the secondary crusher will goes to the inventory surge pile to the next stage of tertiary crusher and placed to the cone crusher with total of 88.3 Mtph.

The tertiary crusher is responsible for further reducing the size of the material that was already processed by the secondary crusher. The product from the secondary crusher enters the tertiary crusher with a total throughput of 88.3 Mtph. The tertiary crusher has a closed side setting of 28 mm and uses a Model Standard Head/Fine liner (SH/F Hp 300/F). This crusher distributes the material to three different deck screens. The deck screens have a cut size of 23.4 mm, 15 mm, and 8 mm, respectively [13].

Based on the screen cut sizes, the end product stockpiles are as follows:

1) 39 Mtph with a size of 8 mm
2) 27 Mtph with a size of 15 mm
3) 22 Mtph with a size of (-23+15 mm)

These end products will be stored in stockpiles for further downstream processing or shipment.

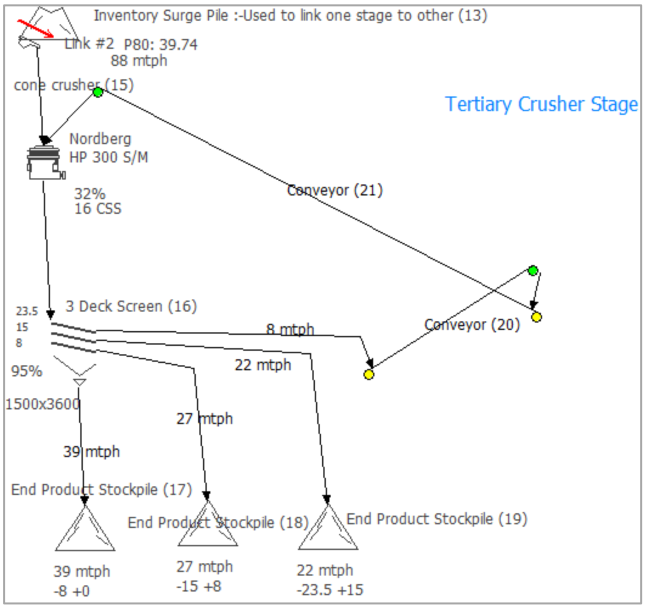
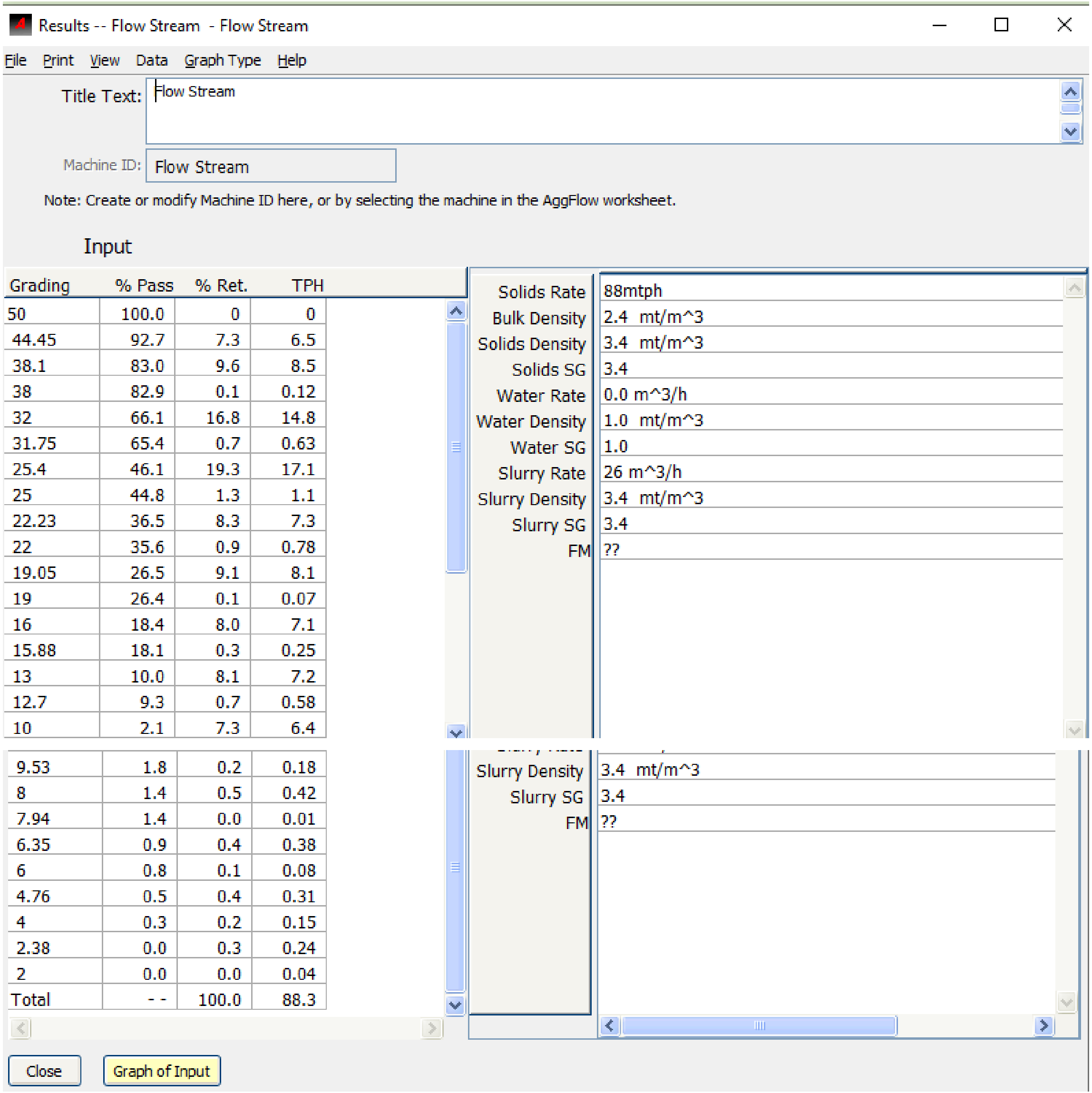


Figure 25. Tertiary Crusher.



Grading	% Pass	% Ret.	TPH
50	100.0	0	0
44.45	92.7	7.3	6.5
38.1	83.0	9.6	8.5
38	82.9	0.1	0.12
32	66.1	16.8	14.8
31.75	65.4	0.7	0.63
25.4	46.1	19.3	17.1
25	44.8	1.3	1.1
22.23	36.5	8.3	7.3
22	35.6	0.9	0.78
19.05	26.5	9.1	8.1
19	26.4	0.1	0.07
16	18.4	8.0	7.1
15.88	18.1	0.3	0.25
13	10.0	8.1	7.2
12.7	9.3	0.7	0.58
10	2.1	7.3	6.4
9.53	1.8	0.2	0.18
8	1.4	0.5	0.42
7.94	1.4	0.0	0.01
6.35	0.9	0.4	0.38
6	0.8	0.1	0.08
4.76	0.5	0.4	0.31
4	0.3	0.2	0.15
2.38	0.0	0.3	0.24
2	0.0	0.0	0.04
Total	- -	100.0	88.3

Figure 26. *Flow stream from the secondary crushing.*

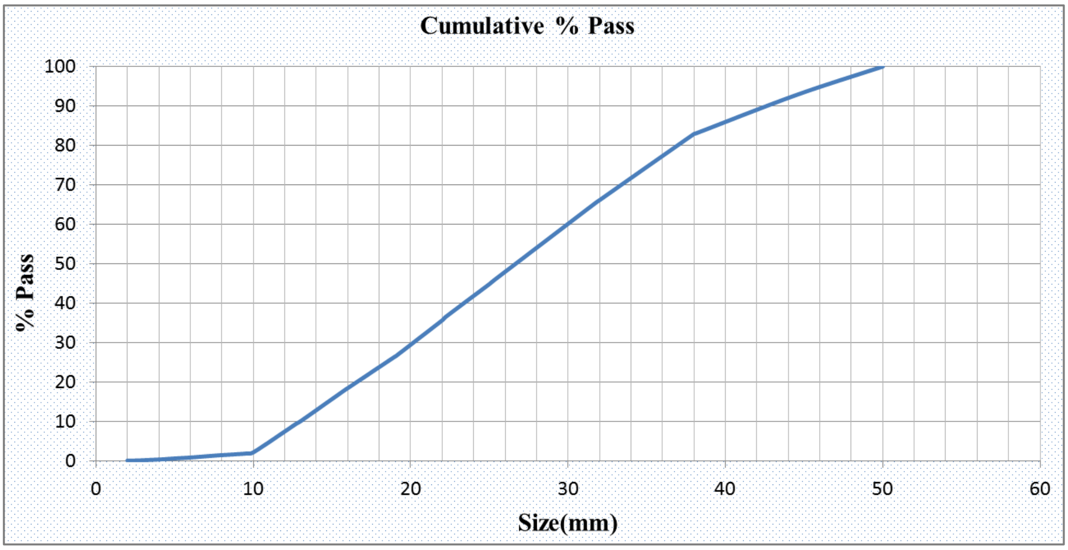


Figure 27. *Cumulative Pass graph of tertiary crusher feed.*

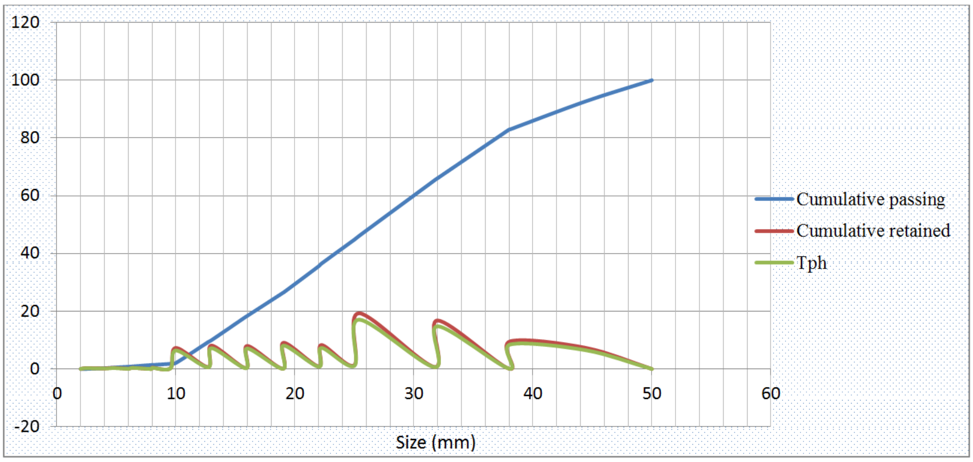


Figure 28. Cumulative graph of tertiary crusher feed.

Table 9. Cone Crusher Output on the tertiary crusher Data.

HP 300 S/M cone crusher (15) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
32	100	0	0
25	98	2	1.9
22	95	3	2.9
19	92	3	2.9
16	80	12	11.5
13	66	14	13.5
10	55	11	10.6
8	45	10	9.6
6	36	9	8.7
4	26	10	9.6
2	13	13	12.5
0	0	13	12.5
Total	- -	100	88.3

The cone crusher output data in the tertiary crusher will from the product of the primary and secondary crusher.

The cone crusher grading size of 32 mm and a percent passing of 100 mm and the percent retained of (0) will give a total of 88.3 mtph.

Table 10. Product stockpile End Product Stockpile (17) - Output Data.

Product Pile End Product Stockpile (17) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
8	100	0	0
6	81.8	18.2	7.1

Product Pile End Product Stockpile (17) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
4	60.4	21.4	8.4
2	31	29.4	11.5
0	0	31	12.2
Total	- -	100	39.2

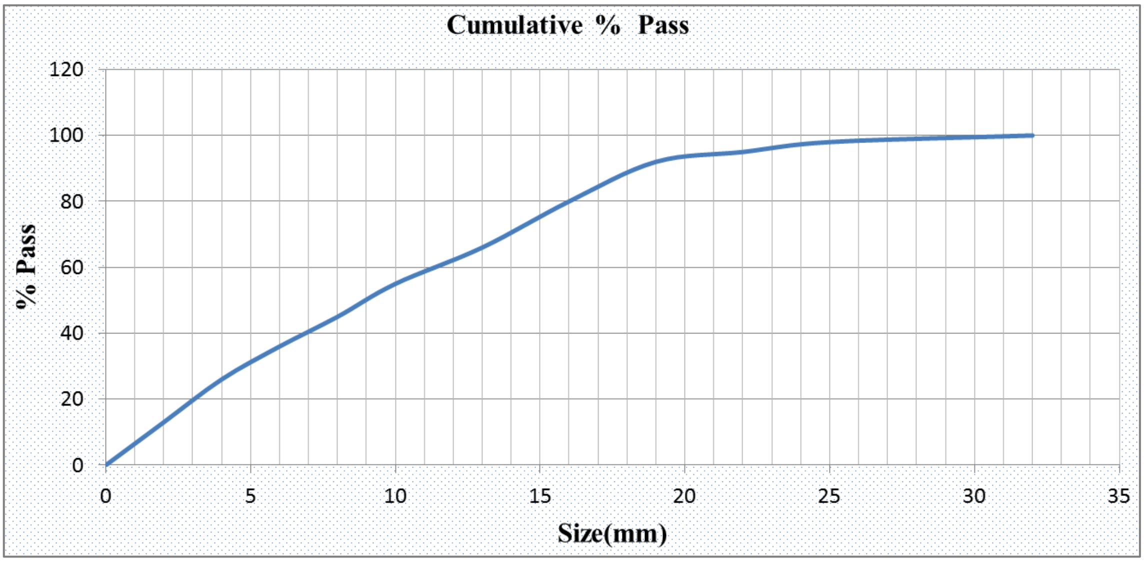


Figure 29. Cone crusher output pass graph on tertiary crusher.

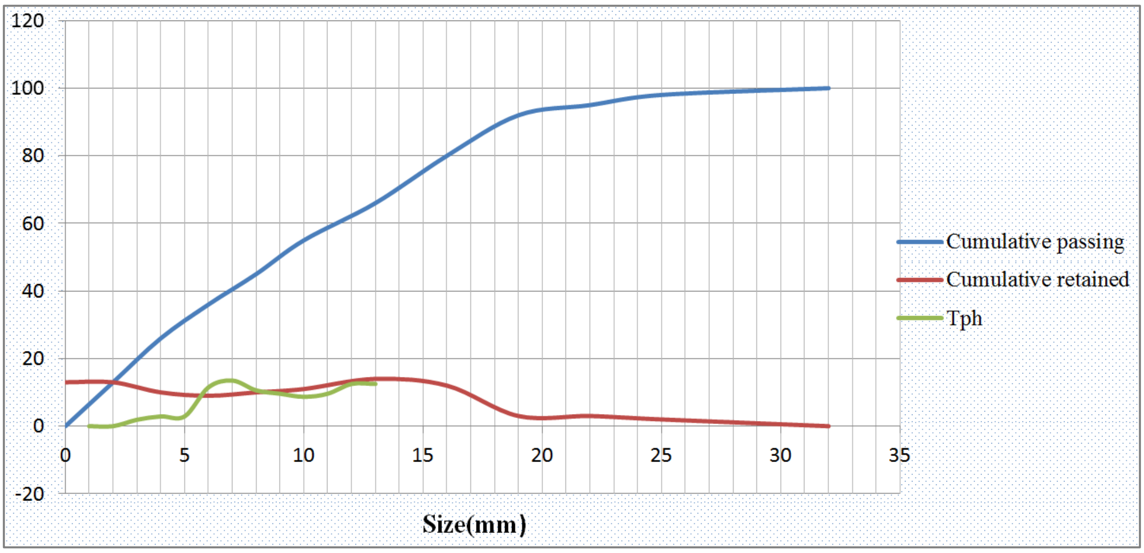


Figure 30. Cone crusher output graph on tertiary crusher.

The end product stockpile data in the tertiary crusher with a mesh size of 8 mm has been stored as a total of 39.2 and the size distribution data has been tabulated above.

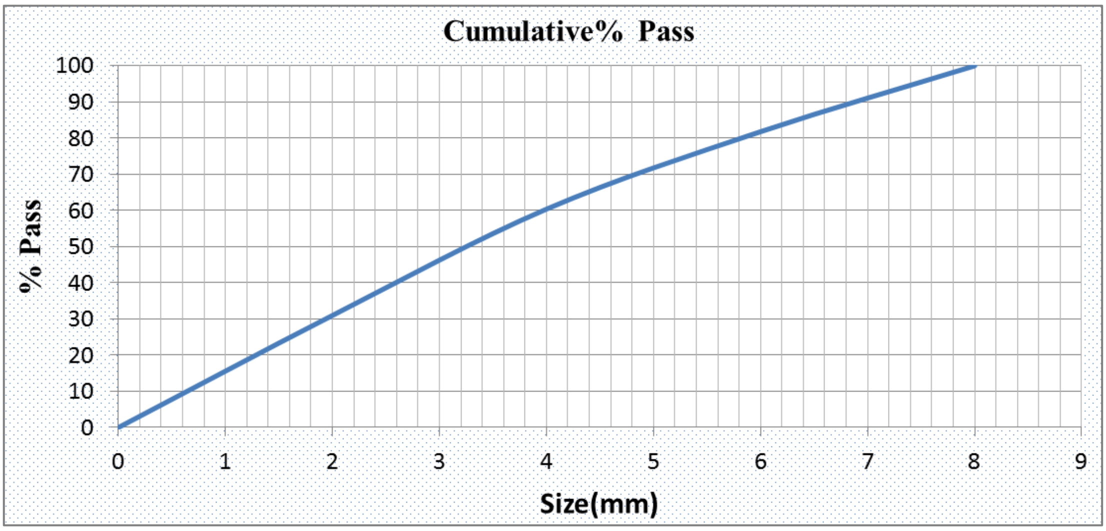


Figure 31. End Product Stockpile (17) - Output pass graph on tertiary crusher.

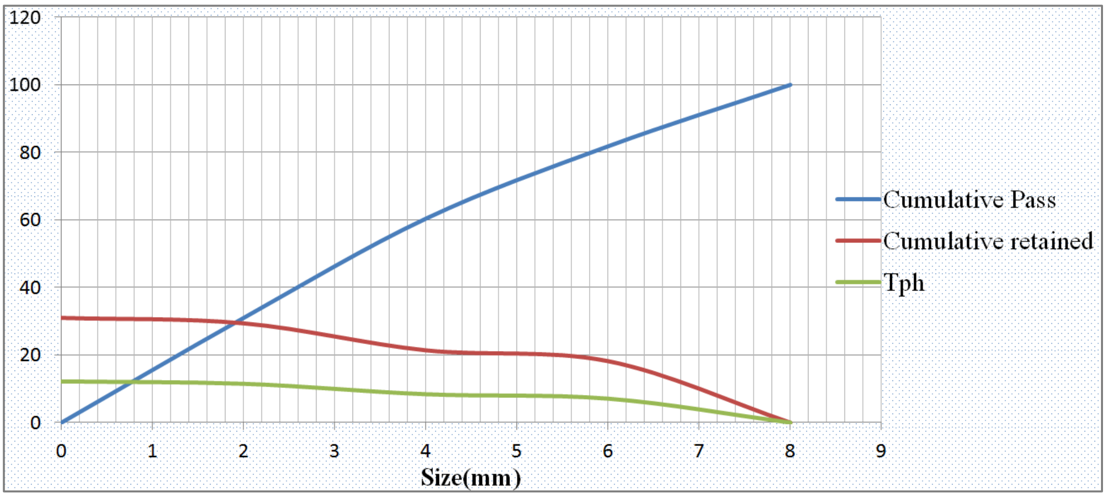


Figure 32. End Product Stockpile (17) - Output graph on tertiary crusher.

Table 11. End Product Stockpile (18) – Output.

Product Pile End Product Stockpile (18) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
15	100	0	0
13	72.6	27.4	7.4
10	39.1	33.5	9.1
8	7.5	31.5	8.5
6	4.7	2.8	0.76
4	2.4	2.3	0.62
2	0.6	1.8	0.49
0	0	0.6	0.17
Total	- -	100	27.1

The intermediate size distribution of (-15+8 mm) in the tertiary crusher will give us a total of end product 27 Mtph with a fines modules of 5.95.

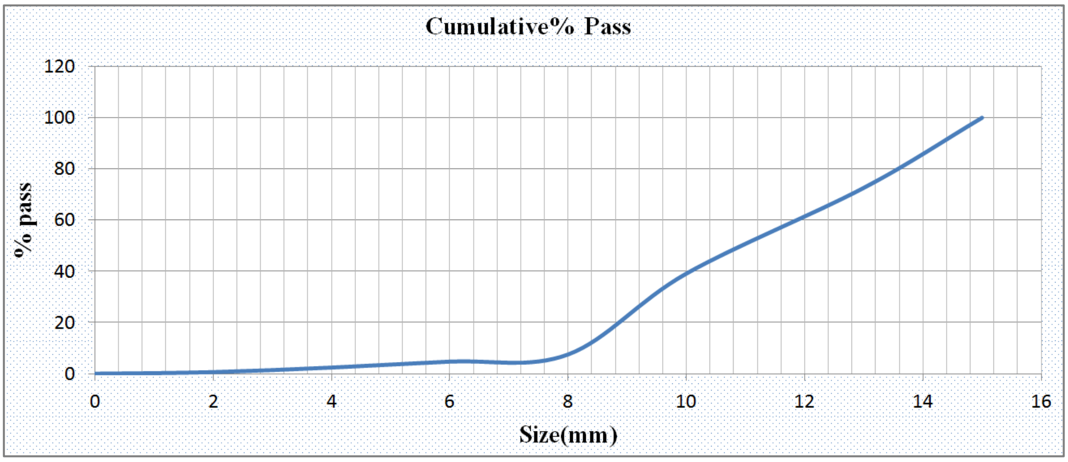


Figure 33. End Product Stockpile (18) - Output pass graph on tertiary crusher.

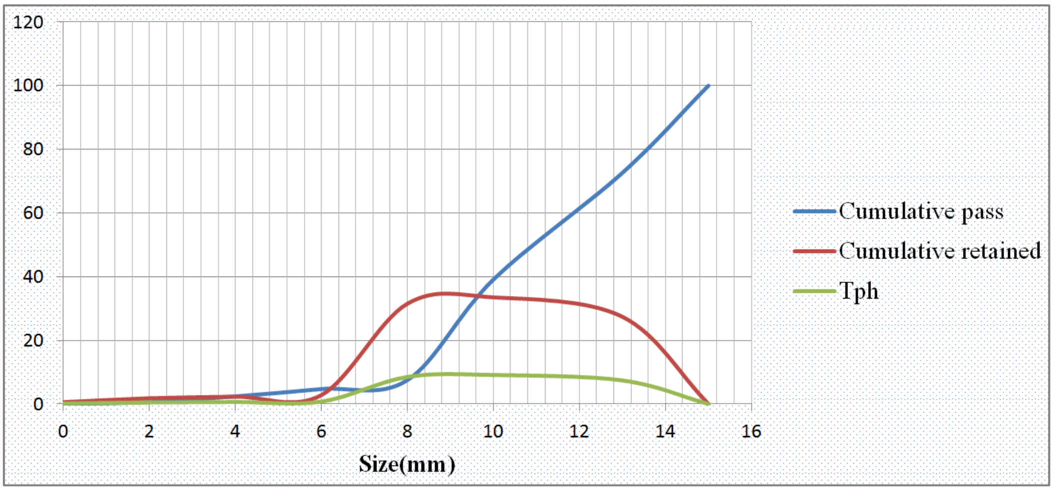


Figure 34. End Product Stockpile (18) - Output graph on tertiary crusher.

Table 12. End Product Stockpile (19) – Output Data.

End Product Stockpile (19) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
23.5	100	0	0
22	94.2	5.8	1.3
19	82.5	11.7	2.6
16	34.8	47.7	10.5
15	15.9	18.9	4.1
13	11.9	3.9	0.86
10	8.1	3.9	0.85
8	5.3	2.8	0.61

End Product Stockpile (19) – Output			
Grading	**% Pass**	**% Ret.**	**TPH**
6	3.3	2	0.43
4	1.7	1.6	0.35
2	0.4	1.3	0.27
0	0	0.4	0.09
Total	- -	100	21.9

The 23.5 mm size mesh screen in the tertiary crusher which is an intermediate size of (-23+15 mm) mesh size has stored as end product of 22 Mtph with a fines modules of 5.97.

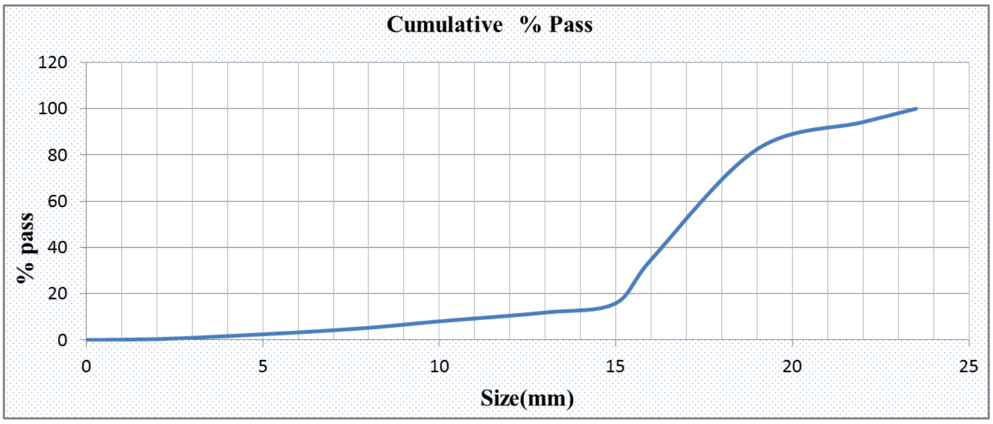


Figure 35. End Product Stockpile (19) - Output pass graph on tertiary crusher.

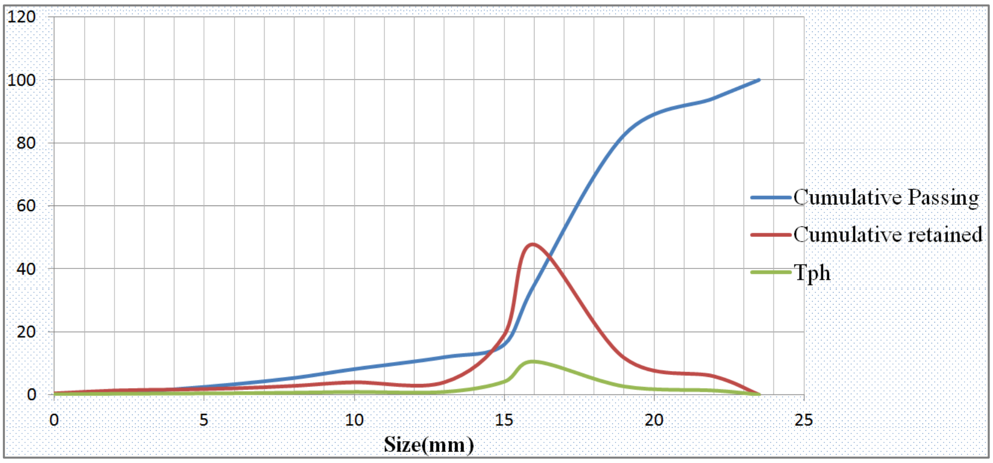


Figure 36. End Product Stockpile (19) - Output graph on tertiary crusher.

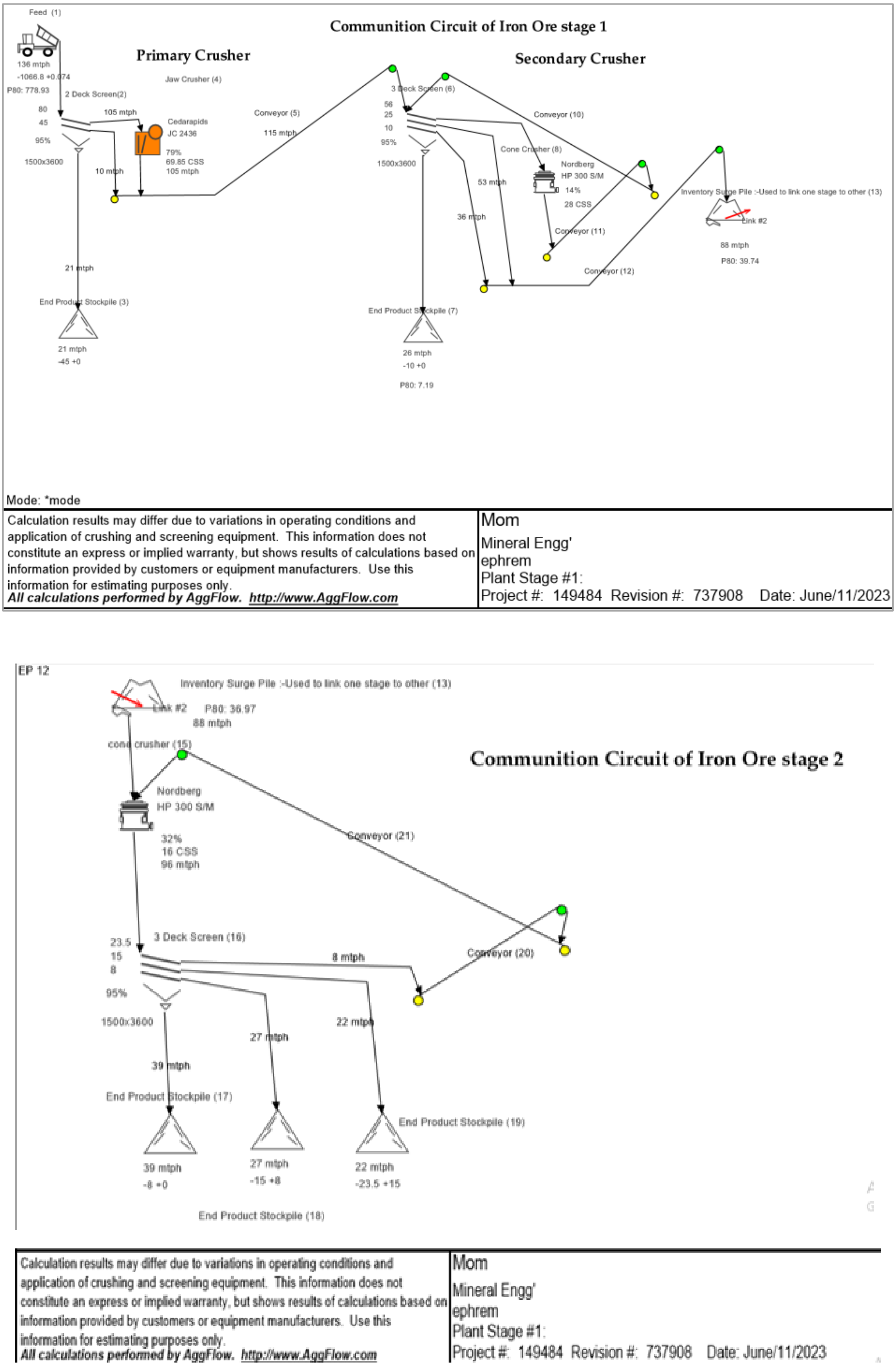


Figure 37. *Overall view of the Comminution Flow sheet project.*

4. Conclusion

The Aggflow software simulates the comminution process to generate five different ranges of materials from iron ore at a top size of 42 inches. The final design included a jaw crusher and two cone crushers, along with screening and conveyors to increase the reduction ratio of the equipment.

Based on the mineralogical information provided, it can be inferred that the comminution process of iron ore involves three stages of crushing, with progressively smaller sizes of the end product. The primary crusher stage produces an end product of 21 Mtph with a size of 45 mm. The secondary crusher produces an end product of 26 Mtph with a size of 10 mm. The tertiary stage produces an end product of 38 Mtph with a size of 8 mm, 27 Mtph with (-5+8 mm), and 22 Mtph with (-23.5+15 mm).

In conclusion, the comminution flow sheet development for the iron ore processing plant consists of a three-stage crushing circuit: primary, secondary, and tertiary crushing stages. This circuit aims to effectively reduce the size of the iron ore material while maintaining the desired throughput.

It can be concluded that the comminution flow sheet development for iron ore with a feed of 150 t/h (136 mtph) has been successful in producing the desired end products in appropriate sizes. The primary crusher with a reduction ratio of 10.3:1 and closed side setting of 69.85% has effectively crushed the ore to an output of 21 mtph with a passing size of 29.43 mm. The secondary crusher, with a 3-deck screen, has further processed the ore to produce an end product of 26 mtph at a size of 10 mm, with fines modules of 4.69 and p80 of 7.19 mm.

The output product of the tertiary crusher in iron ore comminution is typically a fine-grained and well-liberated particle, which is suitable for downstream processing stages, such as grinding and concentration.

All the equipment had a good reduction ratio, the Primary Crusher, Jaw Crusher Cedarapids 24 x 36 had an reduction ratio of 10.3:1, the first cone crusher of the secondary crushing, Nordberg HP300 S/M, had an reduction ratio of 3.1:1 and the second cone crusher placed in the circuit of the tertiary crushing, Nordberg SH/F, had a reduction ratio of 2.4:1. The five pillars of product had a stream between 16% and 44% of feed stream. [15, 16]

Abbreviations

CIDs	Channel Iron Deposits
DID	Detrital Iron Deposits
EAF	Electric Arc Furnace
COS	Combined on the Coarse Ore Stockpile
POSCO	Prospecting and South Korean Steel Giant
FCL	Ferruginous Clay
IOCG	Iron Oxide Coated Gangue
XRD	X-ray Diffraction
OM	Optical Microscope
CSS	Closed Side Setting
AEPA	Addis Ababa Environmental Protection Authority

Author Contributions

Ephrem Tilahun: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing

Getahun Mesert: Writing – review & editing

Ethical Statement

The research was carried out in accordance with ethical standards.

Funding

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Conflicts of Interest

The authors declare no conflicts of interest.

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