Addis Ababa University

Addis Ababa Institute of Technology

Center for Ethio-mines Development

Mineral Engineering Stream

COMMINUTION CIRCUIT FLOW SHEET DEVELOPMEN FOR OPTIMUM PERFORMANCE OF IRON ORE PROCESSING, IN THE CASE OF SEKOTA, WAGEHEMIRA, NORTHERN ETHIOPIA

BY:

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A Project submitted to the Center for Ethio-Mines Development, Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Engineering in (Mineral Engineering)

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This is to certify that the Project prepared by *Ephrem Tilahun*, entitled: 'Comminution Circuit Flow sheet Design for Optimum Performance Of Iron ore Processing, in the case of sekota, wagehemira, Northern Ethiopia', submitted *in partial fulfillment of the requirements for the degree of Master of Engineering in (Mineral Engineering)*, complies with the regulation of the university and meets the accepted standards with respect to originality and quality.

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JUNE, / 2023

Addis Ababa, Ethiopia

Declaration of Originality

This project work is about the Comminution circuit flow sheet Design of Sekota Iron ore which is my original master's degree under the supervision of Dr.Ing.Abubeker Yimam and Mr.Megersa Bedo*. I want to declare that this Project work has not been presented or submitted for any degree or diploma at any University (institutions). All relevant source materials used for this Project work have been respectfully acknowledged.*

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Sign *Date*

To the best of knowledge the above Project work declaration by the candidate is correct and it has been submitted for examination with our approval as advisors of the school in the University.

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Signature *Date*

Acknowledgment

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"Almighty of God".

Abstract

Sekota Iron Ore aims to contribute to the economic development of Ethiopia by exploiting and producing high-quality iron ore for both domestic and international markets. The company expects to create employment opportunities and generate revenue for the government, which can be used to invest in other developmental projects. Besides, the establishment of Sekota Iron Ore could also help to reduce the country's reliance on imported iron and steel products, promote local industries and contribute to the growth of the mining sector.

Most of the minerals extracted in the nature are founded disseminated with the gangue, this creates a necessity to liberate these particles and reduce the size for principally reach a big concentration of the desired material. As the comminution is by far the largest energy consumer in most mine sites, the study of the mineral processing try to conduct this size reduction with the bigger efficiency possible.

comminution flowsheet design is a critical process in the production of iron ore. In this study, the flow rate was fixed at 150t/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 AggFlow Version 460.22 software is used to conduct, a comprehensive comminution flowsheet design to achieve the desired particle size distribution and mineral liberation.

In the communition of primary crusher stage Iron ore at top size of 42 inches or (1066.8mm) generates 5 different ranges of materials, the first is at a size of 45mm, the second at 10mm, and the third is at 8mm, between 15 and 8mm and between 23.5 and 15mm.

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 21Mtph for further processing. The Nordberg Hp 300 S/M cone crusher was used as a secondary crusher with closed side setting (CSS) of 28mm to further reduce the particle size to 26Mtph.

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.

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List of abbreviation

CIDs--------------------channel iron deposits

DID--------------------- detrital iron deposits

BOF ------------------ basic oxygen furnace

(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------------------------AddisAbaba Environmental protection authority

Chapter one

1 Introduction

1.1 General back ground

In the crust of the Earth, iron is the fourth most common metal, and its ore minerals include hematite, goethite, magnetite, siderite, illmenite, and various sulfides.

The mining sector is constantly looking for ways to make its operations more profitable and efficient. Particle size reduction for mineral processing is a crucial area of emphasis since it may have a big influence on costs for downstream processing. To maximize recovery and product grade in the specific case of iron ore, an efficient comminution (size reduction) circuit must be developed.

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,432,000t of iron ore will be the mine's maximum capacity. According to Article 2, Sub-Article 12 and 35(b) 2 of the Mining Operations Proclamation No. 678/2010, this run-of-mine portion of the proposed iron ore mine constitutes "large scale mining." As a result, the proposed mining license will be for a large-scale operation encompassing a total area of 16 square kilometers.

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. 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.

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

1.2 Location and accessibility

The study area is located in Sekota, Abergele and Waghimra Administrative zone of Amhara National Regional State. Sekota town is found at 720 Km north of Addis Ababa and 430 Km north of Bahir Dar. From Sekota the study site is 50 km towards north and the road is gravel road.

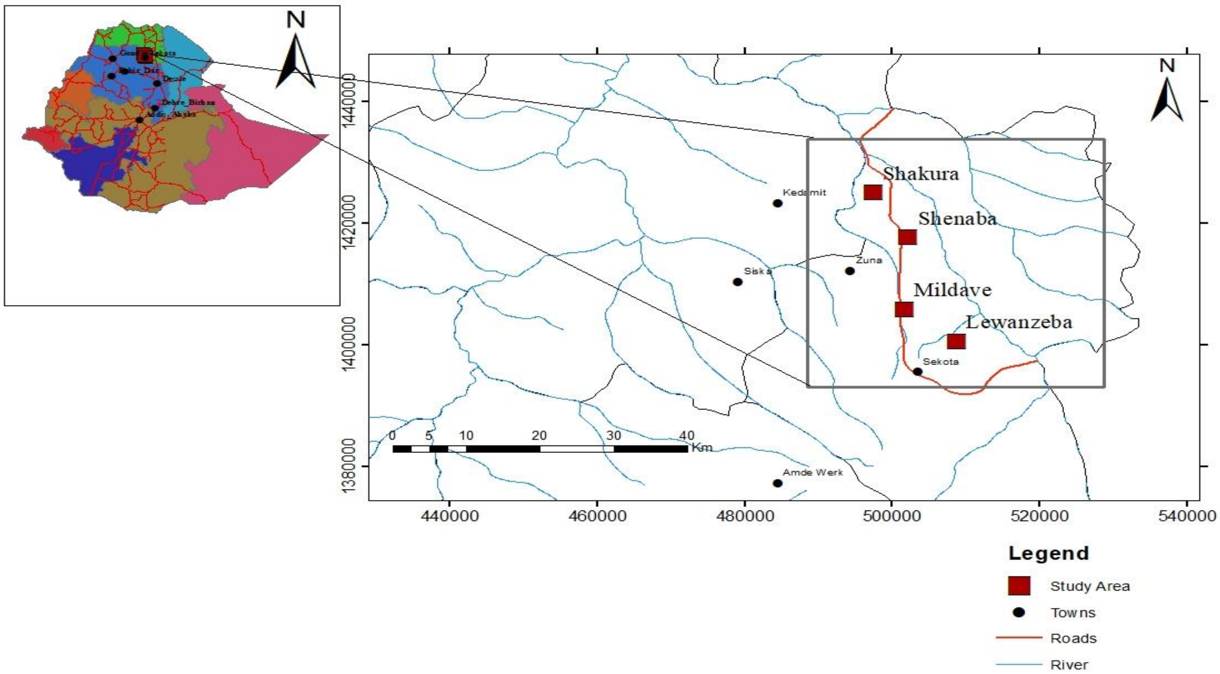

Figure 1 location map of study area.

1.3 Statement of the problem

The lack of an optimized and efficient comminution process that can increase throughput, reduce operating costs, and improve product quality. Furthermore, the lack of an optimized circuit hinders Sekota's ability to compete effectively in the global iron ore market. Therefore, there is a need for a comprehensive study and development of a comminution circuit design that is tailored to the specific characteristics of Sekota's iron ore deposits and takes into account the potential impact on the environment and operational costs.

Therefore, the primary objective of comminution flowsheet design in iron ore processing is to optimize the comminution circuit configuration to achieve the desired product quality and production rate.

1.4 Objectives

1.4.1 General objective

Design and develop an efficient communition circuit flowsheet of iron ore for optimum performance of an iron processing plant.

1.4.2 Specific objective

The following are the precise goals of the research on the the development of an iron ore comminution circuit in Sekota, Ethiopia:

- To identify and define the geological features of the iron ore deposits in Sekota, including their mineralogy and physical characteristics.
- To design and optimize a comminution circuit that is suited to the mineralogy of the ore and the desired end product, taking into account the appropriate equipment selection.
- To evaluate and choose appropriate equipment for crushing and grinding based on the specific type of iron ore in Sekota.

1.5 Significance Of the study

The development of the comminution circuit is an essential phase in the iron ore processing process. It can have a considerable effect on the effectiveness and profitability of the mining operation in Sekota, Ethiopia.

The ore is ground down in the comminution circuit, which makes it simpler to extract the precious minerals. The kind of ore and the intended end product are used to define the size at which the ore must be crushed and ground.

Creating a more effective comminution circuit can save energy use, boost throughput, and enhance product quality. For the mining business, this might result in considerable cost reductions and improved profit margins.

In Sekota, there is significant potential for iron ore mining, and an optimized comminution circuit can play a key role in unlocking this potential. With the right approach to developing this circuit, Sekota Iron mining could become a major player in the global iron ore market. (Kumar, Comminution. Retrieved from TechnoMine, 2011,, December)

1.6 Scope of the study

A number of significant factors are included in the study's scope for the establishment of an iron ore comminution circuit in Sekota, Ethiopia. The first step is to get a complete grasp of the Sekota iron ore deposits' geological features, such as its mineralogy and the type of iron that is there. For choosing the best processing techniques, this information is essential.

Second, the study seeks to discover and evaluate the crushing machinery appropriate for the particular variety of iron ore found in Sekota. In order to process iron ore effectively, many types of crushers or grinding mills may be needed. As a result, choosing the best tools for efficient and successful comminution must be carefully considered.

Chapter 2

2.1 Literature review

2.2 Mineralogy

2.2.1 Typical gangue and iron ore minerals

Table 1 provides information on common iron ore and associated gangue minerals that can be found in many iron ore deposits and iron ore-derived products.

In 2012, it was projected that the three most prevalent iron ore minerals—magnetite, hematite, and goethite—accounted for almost 99% of all iron ore handled at sea globally.

Meta-sedimentary and igneous iron ore deposits frequently contain the iron ore mineral magnetite (Fe3O4). In conditions close to the surface, magnetite partly changes into hematite or chinomagnetite due to its inverse spinel structure (Waychunas, 1991).

Chemical formula		Description
Ore mineral		
Hematite	Fe_2O_3	Iron oxide
Magenetite	Fe_3O_4	Primary iron oxide
	FeOOH	Most abundant iron oxyhydroxide with three subtypes: yellow ochreous has excess water and
Geothite		chemical impurities; brown, the most common
maghemite		variant, is stoichiometric; while vitreous is glassy
maritite		and contains 2–9% SiO_2+Al_2 O_3 , either as an
hydrohematite		impurity
	$Fe^{3+[}Fe^{3+}$ 1.67[ ].33]O_4	or as submicron inclusions of quartz
	Fe_{3-x} ( ) x O_4	Intermediate iron oxide
		Intermediate metal-deficient phase between
	Fe_2 O_3	magnetite and maghemite
		Hematite that has replaced primary magnetite
	Fe(2−x)/3(OH)x O_3−x	
		defect solid solution where OH^- ions replace

		oxygen
Gangue mineral		
Quartz	SiO_2	
Kaolinite	$Al_4 (Si_4 O_{10})(OH)_8$	Common oxide of silicon
Gibbsite	$Al(OH)_3$	Clay
Minnesotaited	$(Mg,Fe)_3 Si_4 O_{10}(OH)_2$	Clay
Stilpnomelane	$(K,Na,Ca)_{0.6}(Mg,Fe^{2+},Fe^{3+})6$	Common Fe-Mg silicate in iron formations
	Si_8 Al(O,OH)27 2–4H_2 O	Common silicate in iron formations
“Chlorite”e	$Fe,Al,Mg)_3(Si,Al)_2O_5 (OH)_4$	
Pyrite	FeS_2	Iron sulfide
Pyrolusite	MnO_2	Manganese dioxide
Siderite	$FeCO_3$	Fe-carbonate
Ankerite	$Ca(Fe, Mg, Mn)(CO_3)_2$	Ca-Fe-Mg-Mn carbonate

Table 1 Common iron ore and gangue mineral definitions (Deer, 1992, 2013. ; Dawe, 1975)

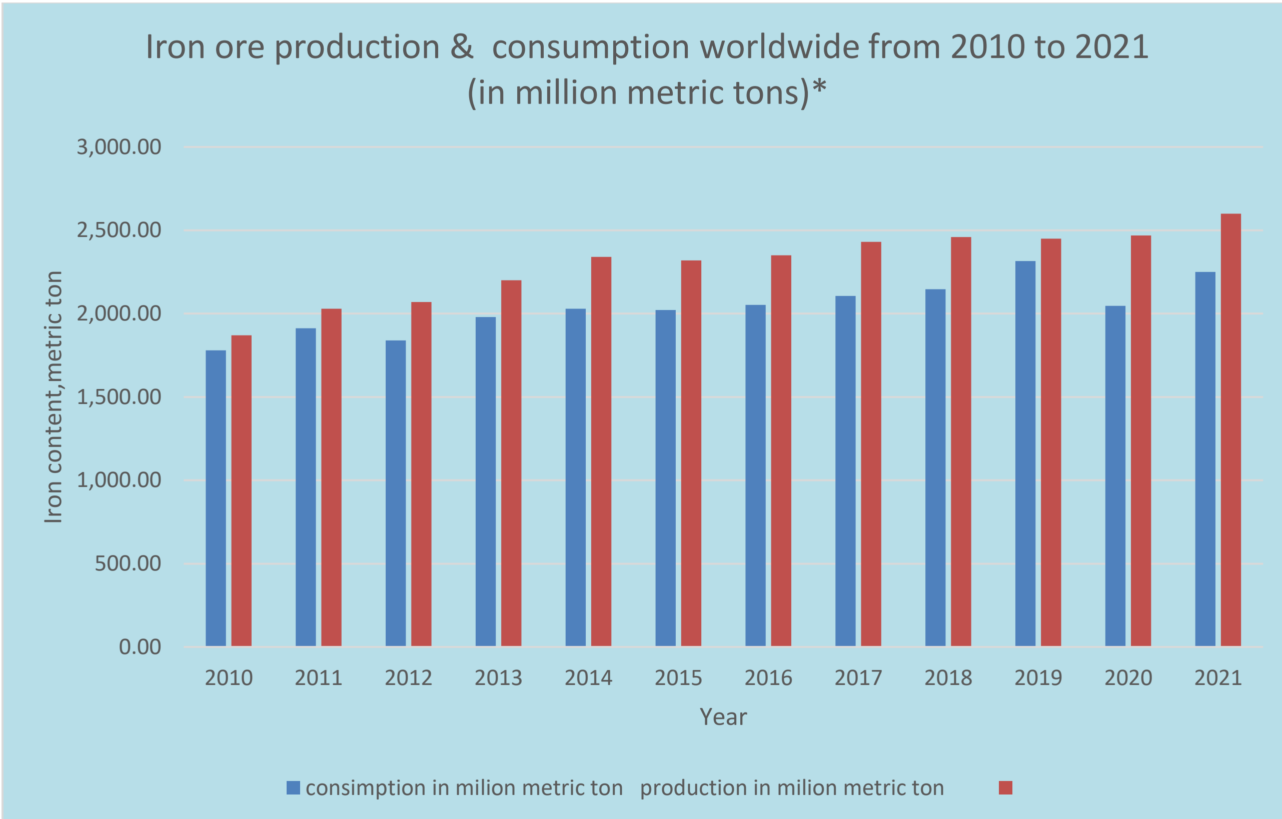

Figure 2 Iron ore production and consumption (2010-2021,usgs)

2.3 Typical flow charts for crushing and screening

To remove material as quickly as feasible that complies with product size standards, iron ore operations frequently use one or more stages of crushing with screening stages integrated. Fines product (usually less than 6mm) is less expensive than lump product (generally between 6 and 30mm). As a result, it is preferable to eliminate any material that falls within the lump size range as soon as it is produced and before it is further broken down into the lower-value fines product. Additionally, iron ore processing plants frequently get different types of ore from diverse sources, including satellite pits. To satisfy product requirements, they might be processed through several channels or combined. Several illustrations of various iron ore crushing methods.

2.3.1 The iron ore handling center at BHP Billiton Newman

The ore handling facility at Newman Hub was finished in 2010 as a result of an expansion project. The ores are tertiary crushed and screened here, then combined to create Newman lump and fines products before being loaded onto trains for transport to Port Hedland. The ores are received from Mt. Whaleback and the satellite operations at Ore body 18 and Wheelarra (by 49-car shuttle trains). On their way to the port, ore cars are supplemented with lump and fine ores from the Eastern Ridge operation at Ore body 23/25. On the coarse ore stockpile (COS), which supplies the crushing and screening plant, the combined ores from the three sources are shown in a schematic flow chart of the Newman Hub in Figure 5.

Blending of the three ores is an important function performed by the COS as the Newman Hub only treats the blended ore. The Newman Hub consists of five scalping screens, eight product screens, and three tertiary crushers. The top deck of the scalping screens has 46mm×68mm longitudinal slots, whereas the product screen has 40mm×60mm longitudinal slots. Bottom decks of both screens have longitudinal slots of 7mm×25mm.

As the Newman Hub only processes the blended ore, the COS plays a crucial role in blending the three ores. Three tertiary crushers, eight product screens, and five scalping screens make up the Newman Hub. The product screen features longitudinal slots that are 40 mm by 60 mm, but the top deck of the scalping screens has slots that are 46 mm by 68 mm. Both displays' bottom decks include longitudinal holes that measure 7 mm by 25 mm.

With installed power of 590kW and spacing settings of 60mm to reduce fines generation, the tertiary crushers are HP800s. Prior to tertiary crushing, the scalping screens, supplied by the COS, remove as much fines (7mm) as feasible. The excess material from the top decks of the product screens (+40mm) and scalping screens (+46mm) is mixed. (+46mm) and the product screens (+40mm) is combined and together fed to the tertiary crushers. The scalping screen Together, the (+46mm) and the product screens (+40mm) are sent to the tertiary crushers. The tertiary crusher product and the scalping screen middling (46+7mm) are sent to the product screens.

2.3.2 Roy Hill operation

A partnership involving Ms. Rinehart's Hancock Prospecting, the South Korean steel behemoth POSCO, the Japanese business Marubeni, and the Taiwanese China Steel Corporation is known as Roy Hill. A wet processing and beneficiating model has been chosen, designed to produce 55Mtpa (wet) of lump and fines products. This is because approximately 70% of the bedded resource is below the water table and contains wet, sticky plastic clay rich shale bands, which would be challenging to handle in a dry crushing and screening process. The processing facility will generate fine ores that are less than 8mm in size and lump ores that range in size from 8 to 40mm, while the size of the generated fine ores will be less than 8mm. The proposed processing facility will have the following elements, as shown in Figure 6: three remote primary/secondary crushing stations, overland conveying, a stockpile of crushed ore, wet scrubbing and screening, tertiary crushing, product screening, desanding, sampling, stockyard stacking, reclaim and train load out, and tailings storage facilities. Each of the three main and secondary crusher stations can reduce 5000 tons of ore per hour (t/h) into fragments smaller than 150 millimeters. Before being fed into the processing facility, this material is subsequently transported to a surge stockpile. The ore is fed into the processing facility, where it first passes through the scrubbers before going through wet screening.

Then, oversize ore that is larger than 32 mm is sent to the tertiary crushers. Transported to the lump stockpile is ore that is less than 32 mm but larger than 8 mm. The fines stockpile receives ore that is transported and is finer than 8 mm but more than 1 mm. Any ore that is finer than 1 mm in size is sent to the beneficiation plant for desanding. J. F. Clout (2011)

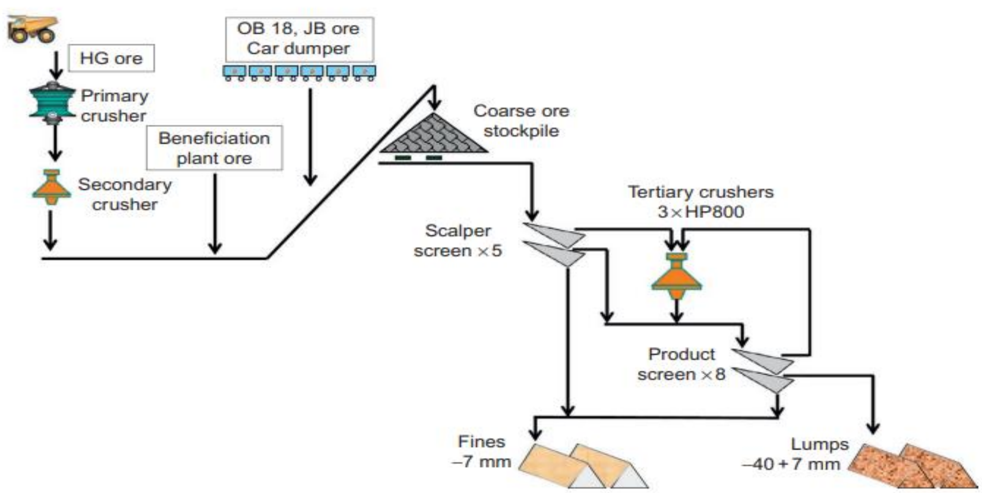

Figure 3 General Flowsheet of the Newman Hub in Western Australia.

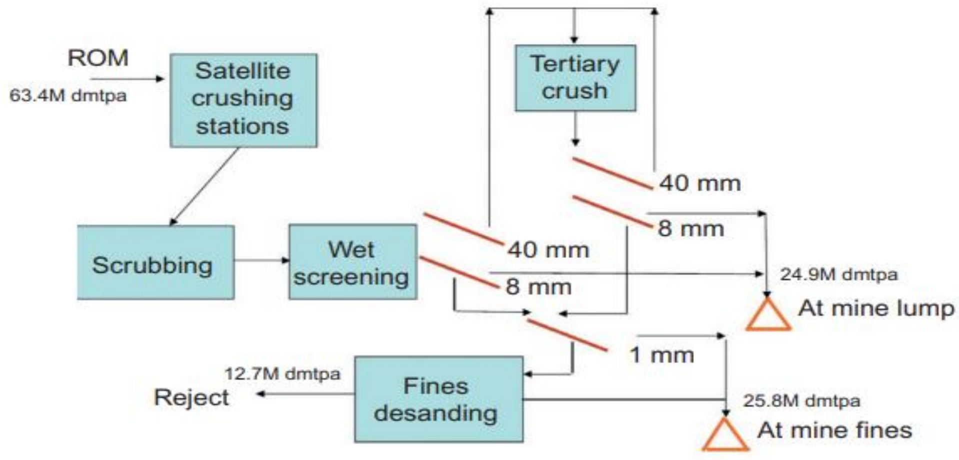

Figure 4 Proposed Roy Hill processing flowsheet. (Clout J. F., 2011)

2.4 Simulation software tool

AggFlow Version 460.22 is a powerful software program that simulates aggregate and mining operations. It can be used to design and simulate mineral processing circuits, including comminution flow sheets for iron ore processing. Here are the steps to develop an iron ore comminution flow sheet using AggFlow simulation software.

1. Input the Ore Characteristics: The first step is to input the physical properties of the iron ore, such as size distribution, density, and moisture content. This data can be obtained from laboratory tests or from existing data sources.

2. Select the Comminution Equipment: AggFlow offers a wide range of comminution equipment, including jaw crushers, cone crushers, impact crushers, and grinding mills. Select the equipment that is suitable for the ore's characteristics and processing requirements.

3. Build the Flowsheet: Using the selected equipment, build the comminution flow sheet by connecting the equipment in the correct order. AggFlow allows simulating various configurations and comparing their performance.

Using AggFlow simulation software can help to design and optimize an efficient comminution flow sheet for iron ore processing. It allows evaluating various scenarios and finding the optimal solution, reducing the risk of costly errors in the actual plant design

4. Run the Simulation: Once the flow sheet is built, run the simulation to evaluate the performance of the circuit. AggFlow generates detailed reports on energy consumption, product size distribution, and other key parameters.

5. Optimize the Flow sheet: Based on the simulation results, optimize the flow sheet by adjusting the equipment settings or changing the equipment selection. AggFlow allows you to quickly evaluate various scenarios and find the optimal solution. (Software, (2014).)

Chapter 3

3.1 Materials and Methods

The Iron ore samples used in test will be from sekota, waghemeira zone. The main mineralogical components include hematite, goethite small amount of pyrite and chalcopyrite, trace magnetite and pyrolusite.

The gangue minerals are mainly quartz and a small amount of white mica. The dissemination of hematite in the ore sample is inhomogeneous. The hematite is present as discrete or assembled grains.

The iron ore sample used in this study will be obtained from sekota, wagmeira zone. The composition of samples will be collected in different regions of four localities Shakura Locality, Shenaba Locality, Mildave locality and Lewanzeba Locality.

3.2 Approach and methodology

The main objective of this study was to develop a comminution flow sheet for iron ore using secondary data or information provided from industry reports. The secondary data and other reports were obtained through a thorough literature review. The sources used included journal articles, conference proceedings, industry reports, Feasibility study report of sekota mining, and government publications.

The analysis of the secondary data was done using graphical representations through diagrams and tables. These helped to illustrate the process flow diagrams of the comminution flow sheet and bring clarity to steps involved in crushing.

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 in my project work.

- To achieve the above general and specific objectives the following activities will be operated in two phases;

The phase typically operated in two stages includes:

- Pre field work(Desk Review I)

Literature reviews and collecting any secondary data relevant for the current study from previous works. Surveying of secondary data insights about the general frame work of the flow sheet development, 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).

- Desk Review II

Since my project primarily involves using secondary data sources such as reports and literature, after I have collected and analyzed the data.

I have conduct simulations or modeling studies to further refine the design. Here are some steps taking during the post-fieldwork phase:

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.

Simulation and modeling: This involves using the data obtained from laboratory testing to develop models and simulations of the processing flow sheet by using simulation software.

Chapter 4

4.1 Mineralogical study on sekota iron ore

This study includes mineral phase study, minerals area wise distribution, their grain size distribution, mineral liberation study, textural and structural studies and photomicrography. Keeping in view of the above mentioned objectives, sufficient number of ore polished and petro logical thin sections have been prepared and studied under the optical microscopy.

The ‘as received’ sample is brownish in nature with some hues of grey and red with Specific Gravity of 3.4. Sample shows indications of high degree of alteration and hygroscopic nature as well. (Reaserch and development center, 2013/14)

4.1.2 Optical Microscopic observation

Ore microscopic studies unravel detailed mineral compositions, micro structures, and textures, mutual relationships between ore and gangue minerals etc. as a whole the sekota iron ore sample has characterized as highly affected by alteration and owing to which association of deleterious gangue minerals with ore minerals has been encountered in considerable quantities.

The as received sample of sekota iron ore is suggestive of low to moderate enrichment in ore minerals with considerable quantities of gangue mineral. Detailed ore mineralogical suggest that the as received sample consists of approximately 60% of ore and 40% of gangue minerals by their area of distribution. Hematite (H) and Goethite (G) are ore minerals and gangue minerals are Quartz (Q), Ferruginous clay (FCL) and Iron oxide coated gangue (IOCG). (Sekota Mining, 2016)

4.1.2.1 Hematite ore mineral

Hematite is the primary ore mineral contributing large amounts, followed by slightly higher amounts of Goethite. As a whole, Hematite covers around 40% area. These ore mineral occurs as large irregular masses to fine size mineral grains. Coarse grain hematite is covers with gangue minerals like Ferruginous clay (FCL) and iron oxide Coated gangue (IOCG). Few very fine and minute goethite grains and irregular shaped masses also occur in contiguous to hematite which shows the effect of alteration at the grain boundaries. These ore may be considered and admixture of coarse/large to fine grain mineral.

Grain size varying from maximum of 180μ to minimum of less than 5 micron. Out of 40% Hematite, around 5% grains are in 180 to 100 micron size are termed as medium sized grains whereas; around 55% area is covered by grains which are less than 30 micron in size. These grains are termed as small sized grains. (Sekota Mining, 2016)

Among the coarse grains, around 10% grains are in fully liberated state whereas remaining 90% grains are in Un-Liberate state. These un-liberated grains are in associated with other grains at less than 90 micron size. Among the medium sized grains, around 28% grains are in fully liberated whereas remaining 72% grains are in un-liberated state. These un-liberated grains are in association with other mineral grains at less than 50μsize. Among the small sized grains, around 40% grains are in fully liberated whereas remaining 60% grains are in un-liberated state. These un-liberated grains are in association with other mineral grains at less than 20 micron size. (Sekota Mining, 2016)

4.1.2.2 Goethite ore mineral

Goethite (G) is a secondary ore mineral occurring in the as received sample. The iron ore which contains Goethite as a secondary ore mineral do contribute some amounts of moisture. In the as received sample, Goethite occurs in approximately 20% area by its area of distribution. This ore mineral accommodates some gangue mineral associations around its margin, i.e. Ferruginous clay (FCL). Maximum grain size distribution of the goethite grain is around 150 micron. Around 20% area is covered by covered by coarse sized grains which are in 150 to 100 micron size. Around 50% area is covered by medium sized grains which are in 100 to 30 micron size whereas; remaining around 30% area is covered by small grains which are in less than 30 micron size. (Sekota Mining, 2016)

Among the coarse grains, around 10% grains are in Free State where as remaining 90% grains are in un-liberated state. These un-liberated grains show close association with other ore as well as gangue minerals at less than 100 micron size. Among the medium sized grains, around 22% grains are in free - state whereas remaining 78% grains are in un-liberated state. These un-liberated grains show close association with other ore as well as gangue minerals at less than 60 micron size. Among the fine sized grains, around 30% grains are in Free State whereas remaining 70% grains are in un-liberated state.

These un-liberated grains show close association with other ore as well as gangue minerals as less than 20 micron size. (Sekota Mining, 2016)

4.1.2.3 Quartz gangue mineral

Quartz (Q) is the gangue mineral which present in around 20% area as a whole texturally these grains can be categorized in to three groups as coarse grains, medium grains and small sized grains. Coarse sized grains in 130 to 100 micron size, medium sized grains are in 100 to 30 micron size whereas; small sized grains are in less than 30 micron size.

Among the coarse grains which cover around 15% area as a whole, around 30% grains are in Free State whereas remaining 70% grains are in un-liberated state. These un-liberated grains show close association with other ore as well as gangue minerals at less than 80 micron size. Among the medium sized grains which cover around 35% as a whole, around 35% grains are in free-state whereas remaining 65% grains are in un-liberated state. These un-liberated grains show close association with other ore as well as gangue minerals at less than 60 micron size. Among the fine sized grains which cover around 50% area as a whole, around 45% grains are in fee state whereas remaining 55% grains are in un-liberated state. These un-liberated grains show close association with other ore as well as gangue minerals at less than 20 micron size. (Sekota Mining, 2016)

4.1.2.4 Ferruginous Clay Gangue mineral

Ferruginous Clay (FCL) is the gangue mineral which occurs at aground mass and at the margins of few ore and gangue minerals at several places. It occurs at around 18% area as a whole. This gangue occurs as irregular shape and size patches of very fine argillaceous minerals which may contains some clay minerals. Due to the very fine size, and submicroscopic in nature, these grains (<5micron) are occurs as patches and cannot be identified through optical microscopy. The maximum size of the patch is around 200 micron.

4.1.2.5 Iron oxide Coated gangue

The gangue mineral Iron oxide Coated gangue (IOCG) can also be termed as pseudo ore; it is next to quartz in its order of abundance. As a whole this gangue occurs as very fine grain interstitial mineral matter within most of the ore mineral at less than 30 micron in size. This mineral covers total area of about 2% as a whole.

	Overall Dist. Area wise (%)	Grain Size p		Area Covers (96)	9F, Dist. (Wrt OM)	Fully Lib. Grains (%)	Lib. Grains (9¢) OM)	Un-lib. grains	%, Dist. Unlib. Grains {Wrt OM)	Unlib. Gangue size(jz)
Hematite (H)	40	Coa	180-100 p	5	2	10	0.20	90	1.80	< 90 p
		Med	100-30 p	40	16.0	28	4.5	72	11.5	< 50 p
		Sma	< 30 p	55	22.0	40	8.8	60	13.2	< 20 p
							13.5		26.5	
Goethite (G)	20	coa	150-100	20	4	10	0.4	90	3.6	W 100
		Med	100-30 p	50	10	22	2.2	78	7.8	< 60
		Sma	<30#t	30	6	30	1.8	70	4.2	< 20
							4.4		15.6	
Quartz	20	Coa	130-100/	15	3	30	0.9	70	2.1	< 80
		Med”	100-30#t	3S	7	3S	2.45	65	4.55	< 60
		Sma	<30p	50	10	45	4.5	S5	5.5	< 20
							7.9		12.2	
Ferruginous Clay (FCL)	18	Coa / Med / Sma	<200p	200	28.0	Nil	Submicroscopic size grains occurs as patches of irregular shape and sizes			
Iron Oxide Coated Gangue (IOCG)	2	Coa / Med / Sma	<30g	100	2.00	Nil	All pseudo Ores 8rains are masked by other ore and gangue minerals.			

Table 2 Detailed Mineralogical Study of ‘as received’ samples ((Sekota Mining, 2016)

4.2 XRD analysis of Sekota iron

To get the detailed information about the major and trace minerals in general and clay minerals in particulars, sample had been analyzed with XRD. Analysis report from sekota iron feasibility study manual is as follows-

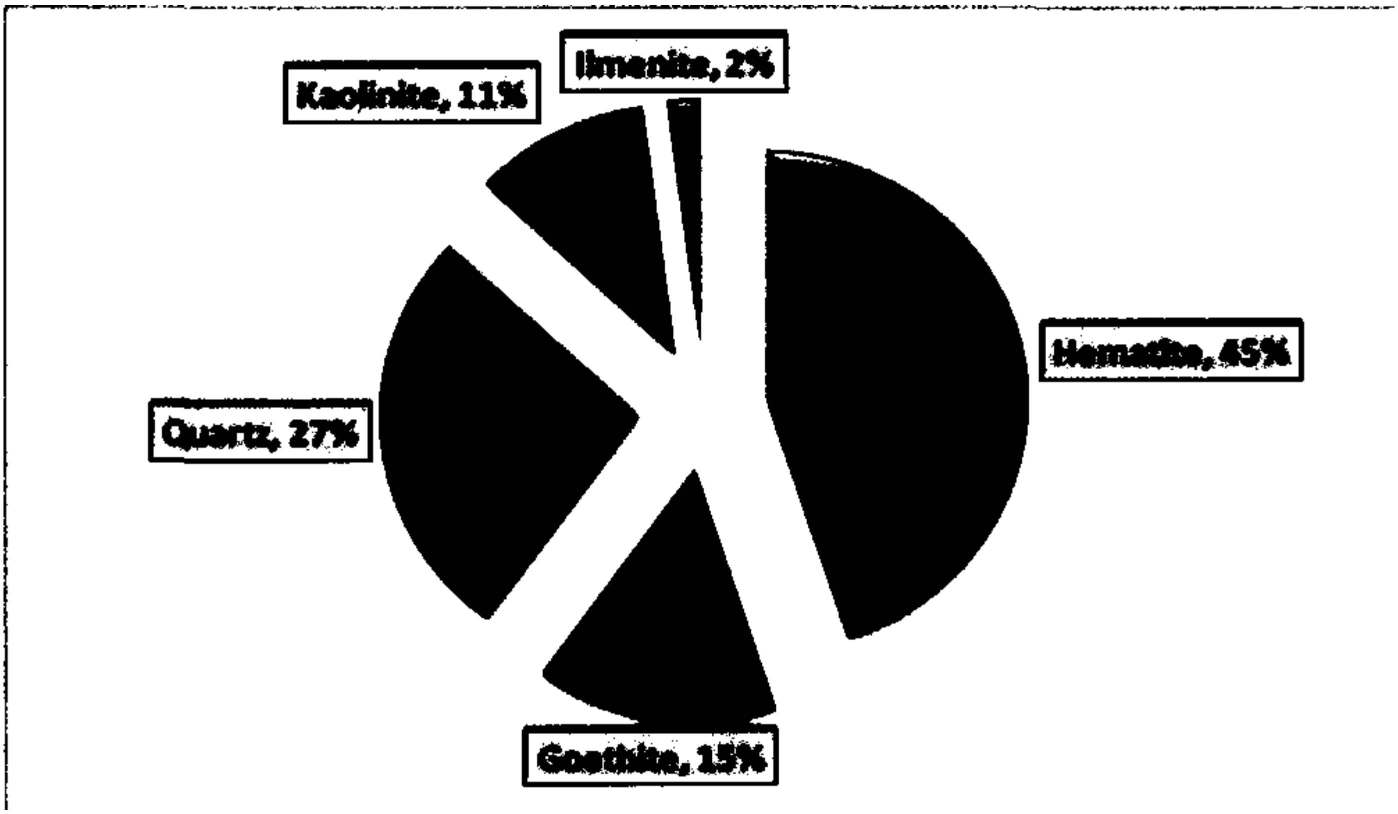

Figure 5 XRD Analysis Mineral Distribution Chart-((Sekota Mining, 2016)

XRD analysis suggests major mineral phases present in the 'as received' sample are Hematite-45%, Quartz-27%, Goethite-15%, Kaolinite-11% and minor phase as Ilmenite with 2% distribution. The XRD report also confirms the results as per optical microscopic results for major phases. Detail XRD report is attached at Annexure —I. (Sekota Mining, 2016)

4.3 Mineral Processing and Mineralogical charactestics of sekota iron

The ore mineralogy of sekota iron characteristics will ultimately determine process performance as well as product properties. The sekota iron ore mineralization is characterized mainly of hematite and minor limonite formed as a result of surface weathering processes from field geological observations. The ore body is nonmagnetic. Field geological observations revealed that there are four styles of iron ore mineralization: massive laterite, pisolithic layer, mottled zone and fracture zone with Fe-oxide replacement texture. Mineralogical studies revealed that goethite also one of the main mineralization components. (Reaserch and development center, 2013/14)

Chapter 5

5.1 Result and Discussion

5.1.1 Comminution flow sheet circuit development

The goal of comminution modeling is to estimate the needed comminution energy as well as the size and liberation distribution of mineral particles. 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. The underlying breaking processes, which are influenced by modal mineralogy and mineral texture (micro structure), have an impact on the liberation of mineral grains. 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. A comprehensive mineralogical investigation report was put together to increase the knowledge of the type and distribution of crushed materials in a crusher product. The study, which concentrated on iron ore samples, demonstrated how the particle breaking rate falls when particles approach the primary mineral component's grain size. (Kumar, Disintegration. (Extracted from TechnoMine, December 2011)

Due to differences in texture, mineral fracture of the same grade and gangue minerals can be distinguished significantly from one another.

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. However, the goal is to measure and provide feedback for the state's continuous efforts to achieve effective separation. As a result, the concept of being liberated frequently relies on the method of concentration used. Bussell (2011) and (2012) the characteristics of a specific material's ability to break apart and the form of the particles that result from that breakdown determine the condition of mineral liberations.

5.2. Iron ore processing simulation

5.2.1 Ore crushing, conveying and storage

Ore from the mine will be delivered by truck-Feed by haule 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.

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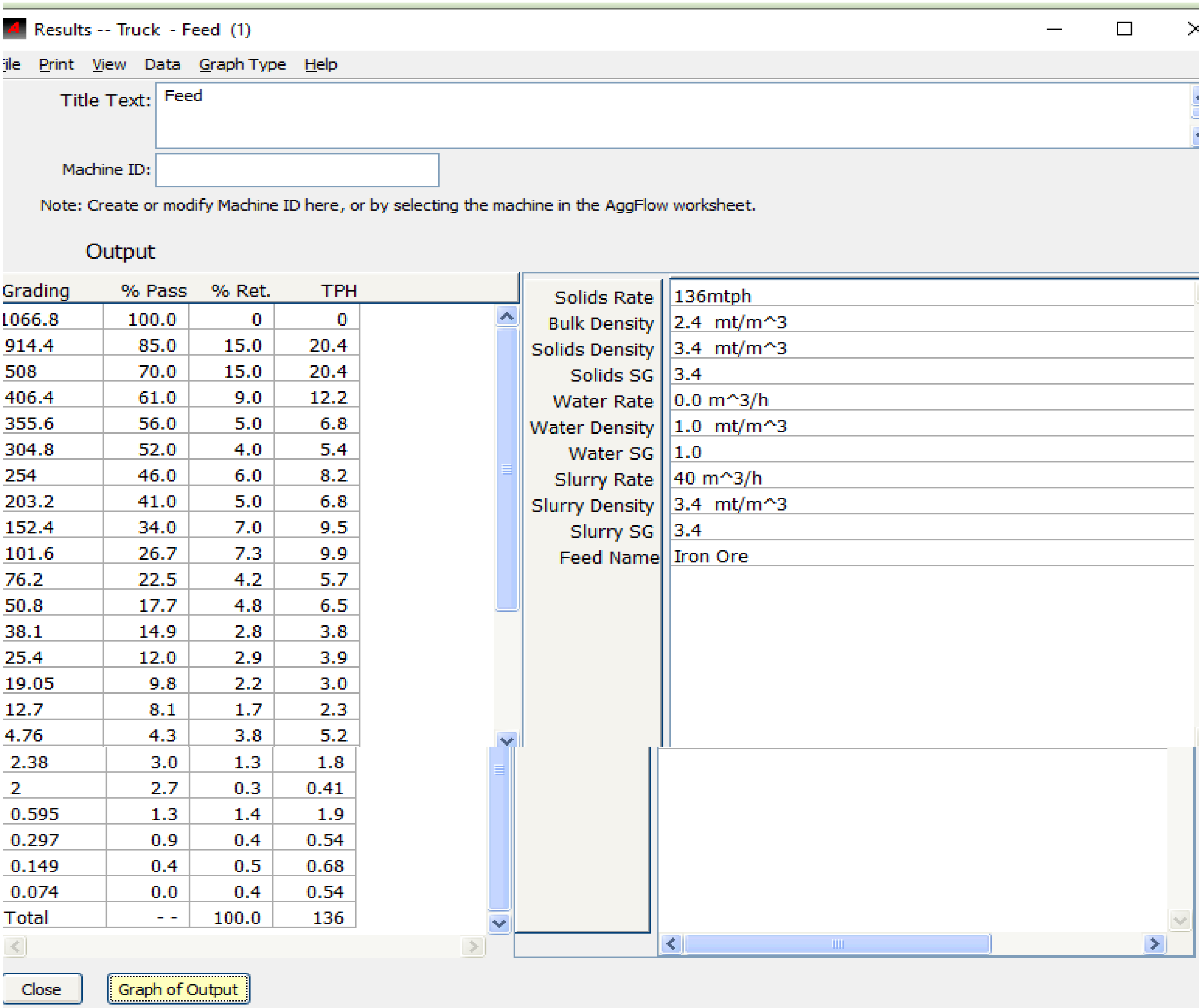


Grading	% Pass	% Ret.	TPH
1066.8	100.0	0	0
914.4	85.0	15.0	20.4
508	70.0	15.0	20.4
406.4	61.0	9.0	12.2
355.6	56.0	5.0	6.8
304.8	52.0	4.0	5.4
254	46.0	6.0	8.2
203.2	41.0	5.0	6.8
152.4	34.0	7.0	9.5
101.6	26.7	7.3	9.9
76.2	22.5	4.2	5.7
50.8	17.7	4.8	6.5
38.1	14.9	2.8	3.8
25.4	12.0	2.9	3.9
19.05	9.8	2.2	3.0
12.7	8.1	1.7	2.3
4.76	4.3	3.8	5.2
2.38	3.0	1.3	1.8
2	2.7	0.3	0.41
0.595	1.3	1.4	1.9
0.297	0.9	0.4	0.54
0.149	0.4	0.5	0.68
0.074	0.0	0.4	0.54
Total	- -	100.0	136

Figure 6 Material being loaded

5.3 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 (fig 10). The overflow with a size of (-1066.8+0.074mm) 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 80mm 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 45mm directly goes to the product stockpile.

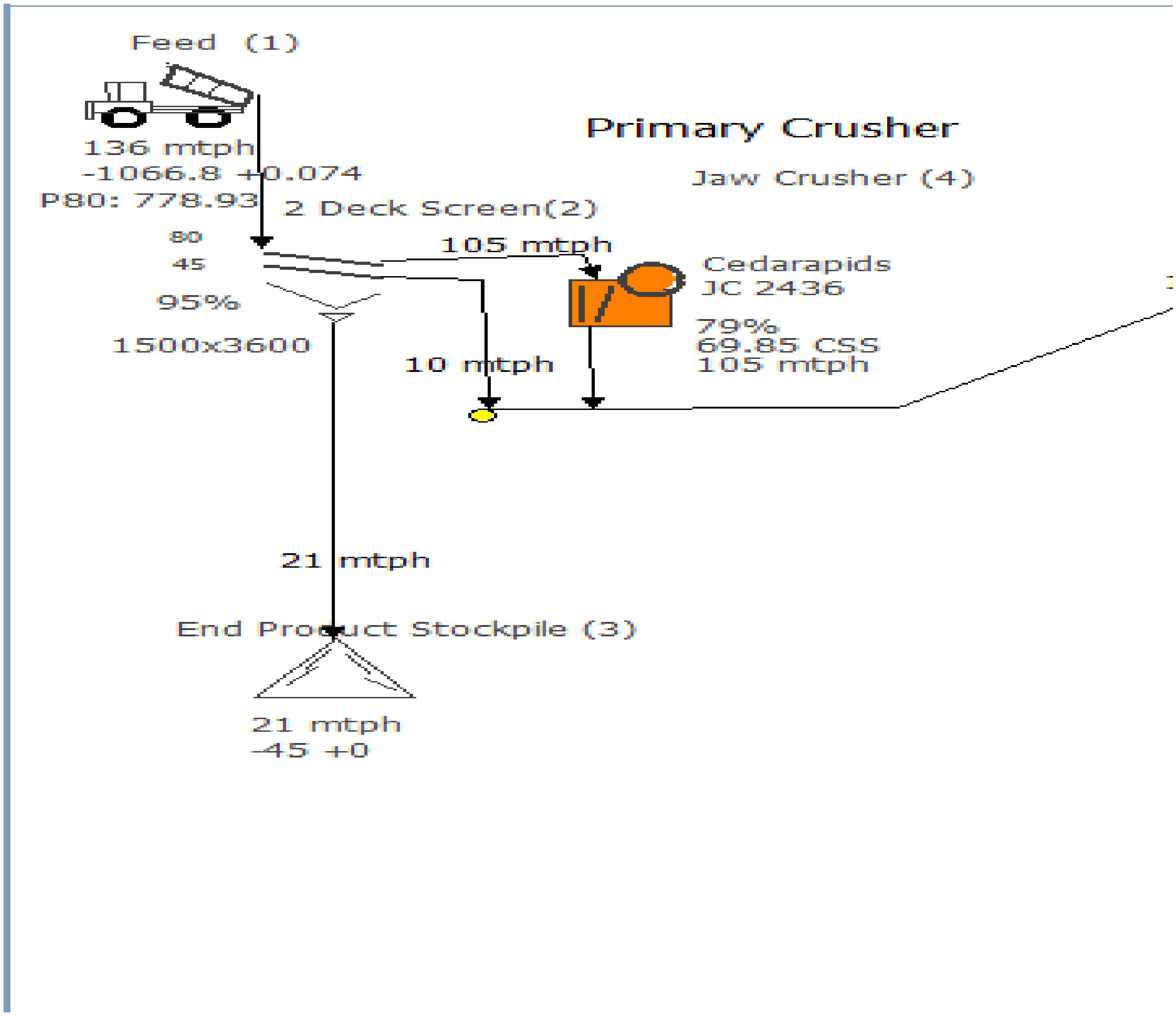


Figure 7 Primary Crushing

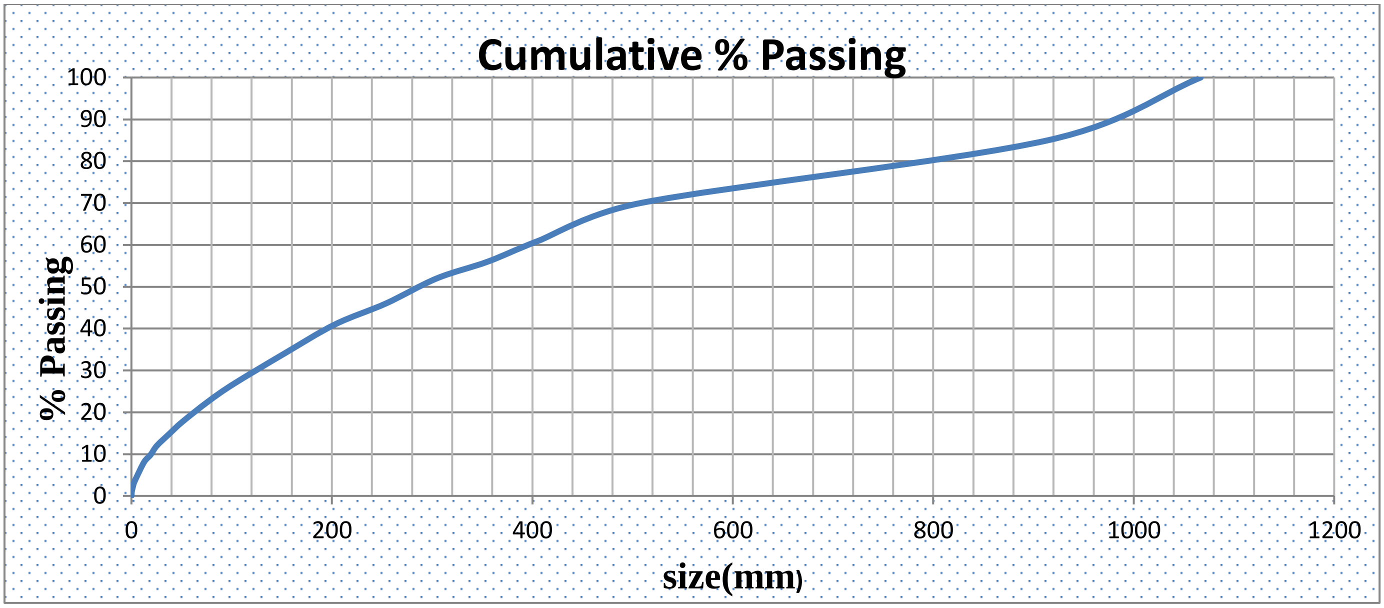


Figure 8 Feed Cumulative Passing curve

5.3.1 Primary Crusher Feed

From the graph above The 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. The x-axis of the graph shows the particle size, while the y-axis shows

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 778.93mm 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 778.8mm (meaning 80% of the material has passed through a particle size equivalent to or smaller than 778.8Mtph).

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 778.8Mtph 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.

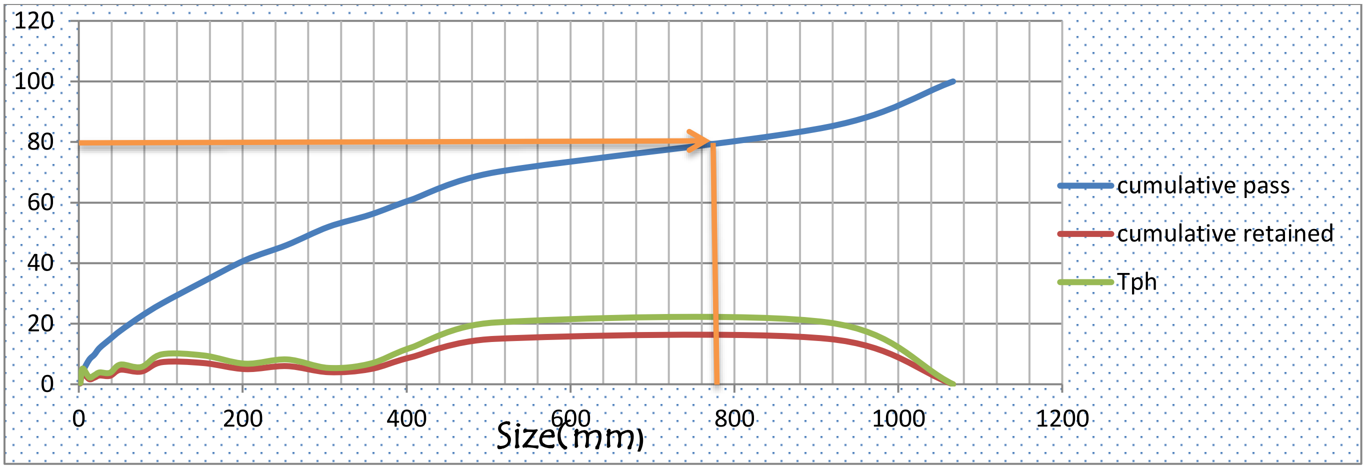


Figure 9 Feed Graph

5.3.2 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

Table 3 Deck 1 Screen Data on primary crusher

From the table(4) above in the size distribution of 1066.8mm size the oversized material which is (+80mm) screen size ofiron ore material will loaded to the jaw crusher for crushing (size reduction) with an input distribution of atotal of 105 mtph and the percent passing graph will be shown below.

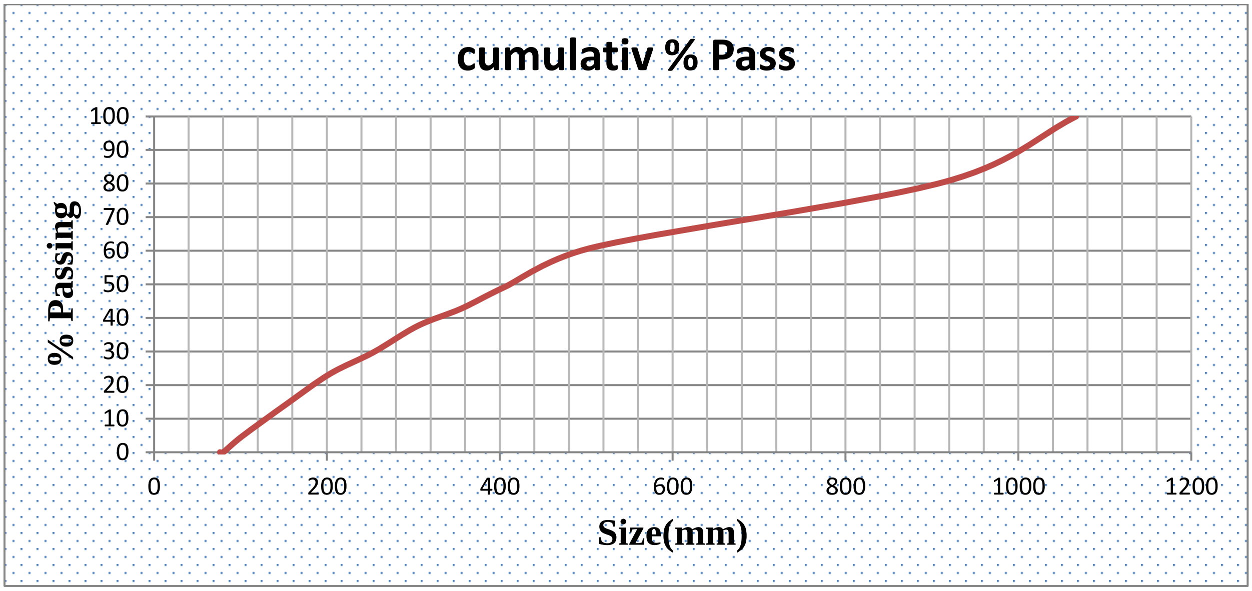


Figure 10 Screen Deck 1 cumulative pass graph

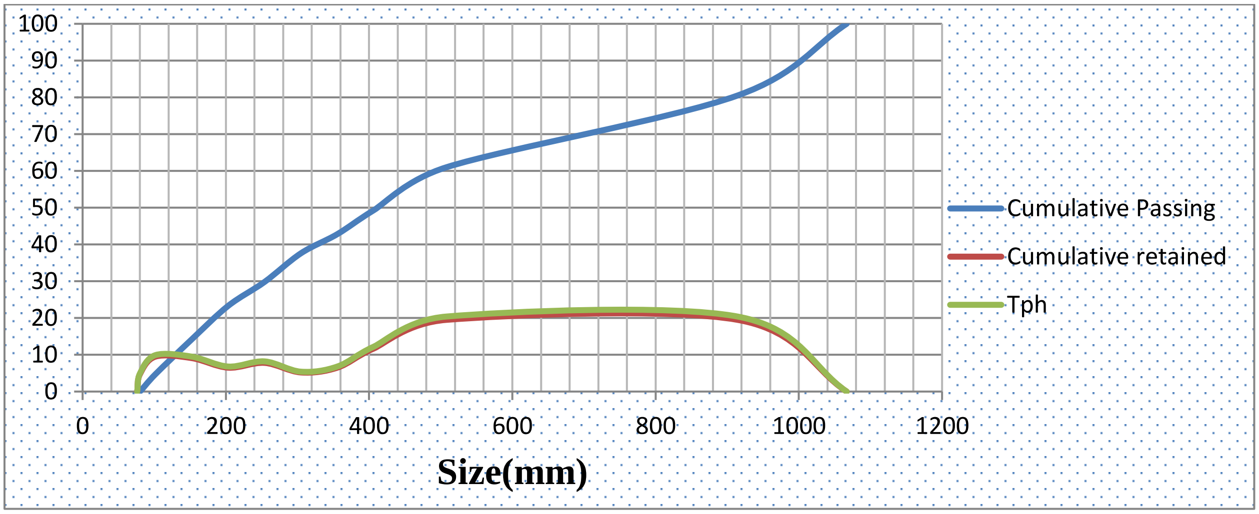


Figure 11 Screen Deck 1 graph

5.3.3 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

Table 4 Deck 2 Screen Data On primary Crusher

In the table (5) deck 2 screen data on primary crusher, since in the primary crusher there is 2-deck screen from the above table (-80mm) mesh screen size distribution has been tabulated.

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

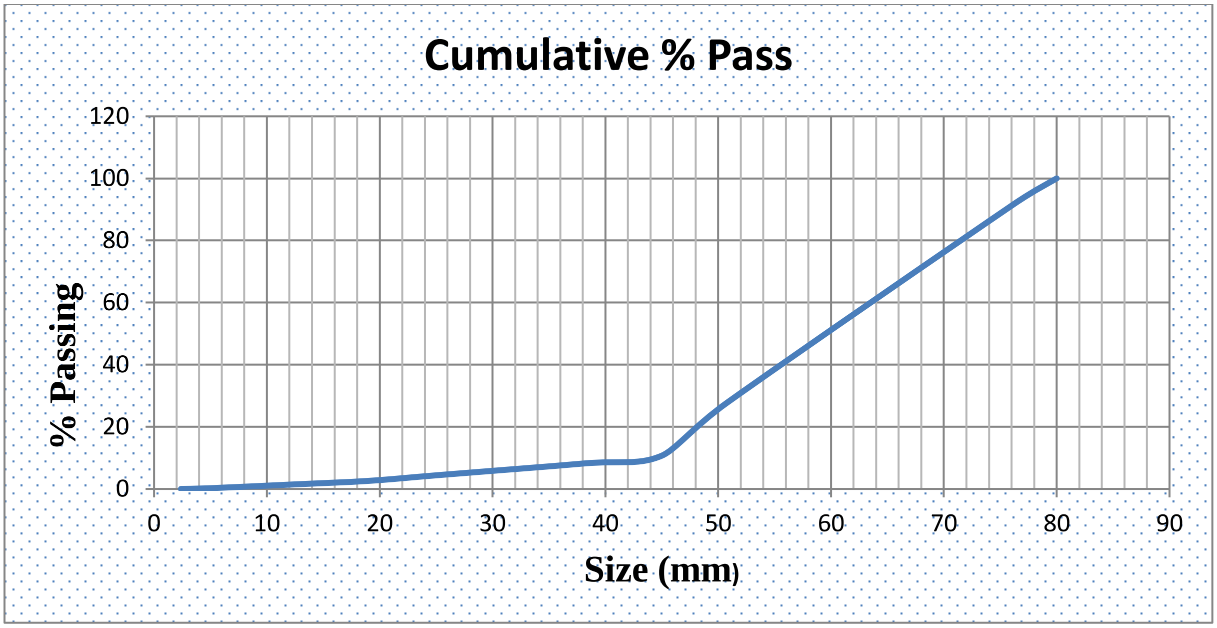


Figure 12 Screen Deck 2 cumulative pass graph

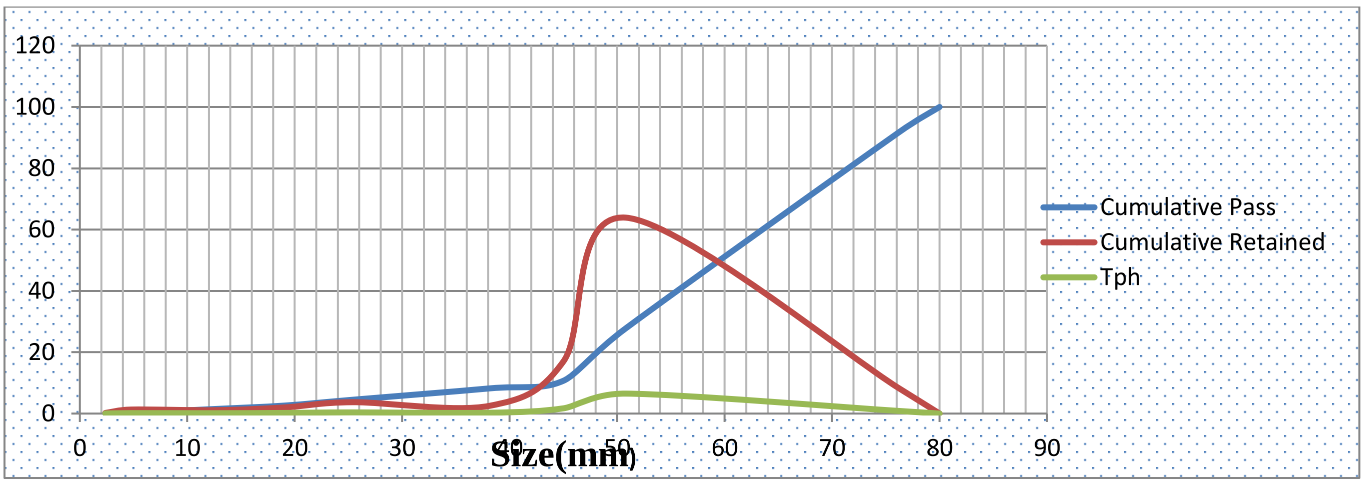


Figure 13 Screen Deck 2 graph

5.3.4 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

Table 5 Stock pile Output data of on primary Crusher

From the table(6) above the size distribution table shows in the primary crusher the (-45mm) 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 ploted below.

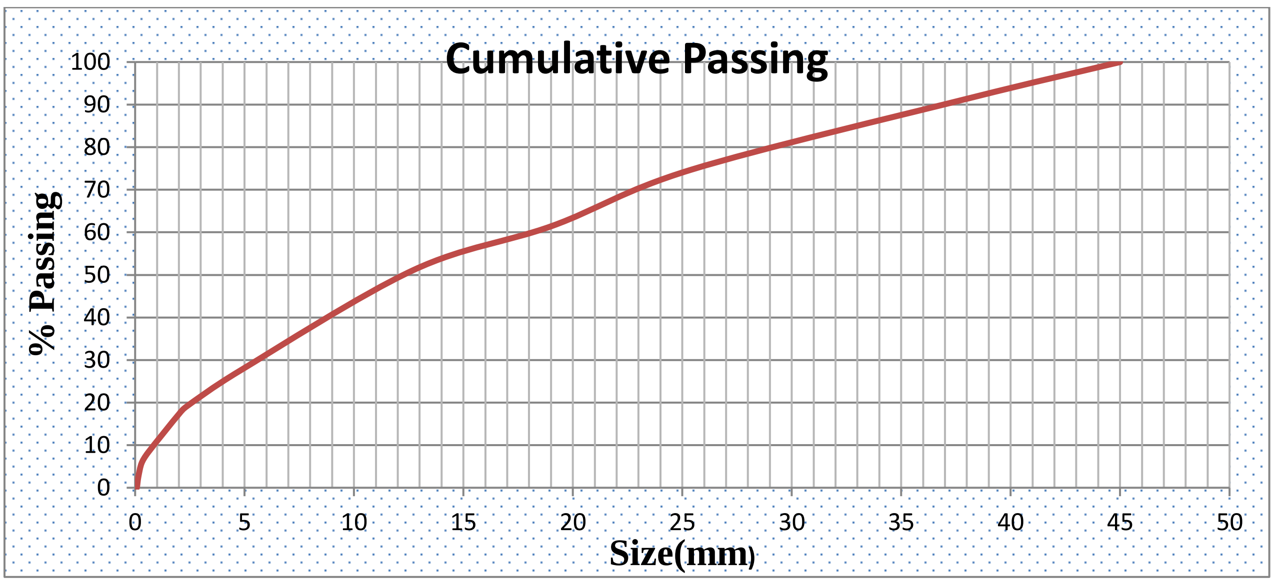


Figure 14 Primary crusher end product stockpile Cumulative passing graph

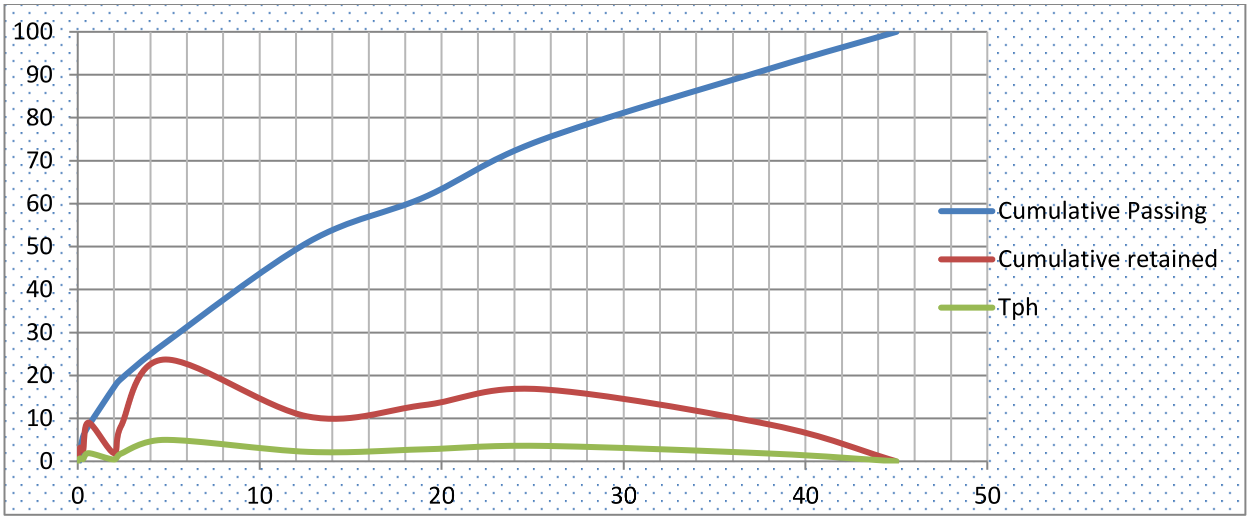


Figure 15 Primary crusher end product stockpile graph

5.3.5 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
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

Table 6 Jaw Crusher Output Data On primary crusher

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

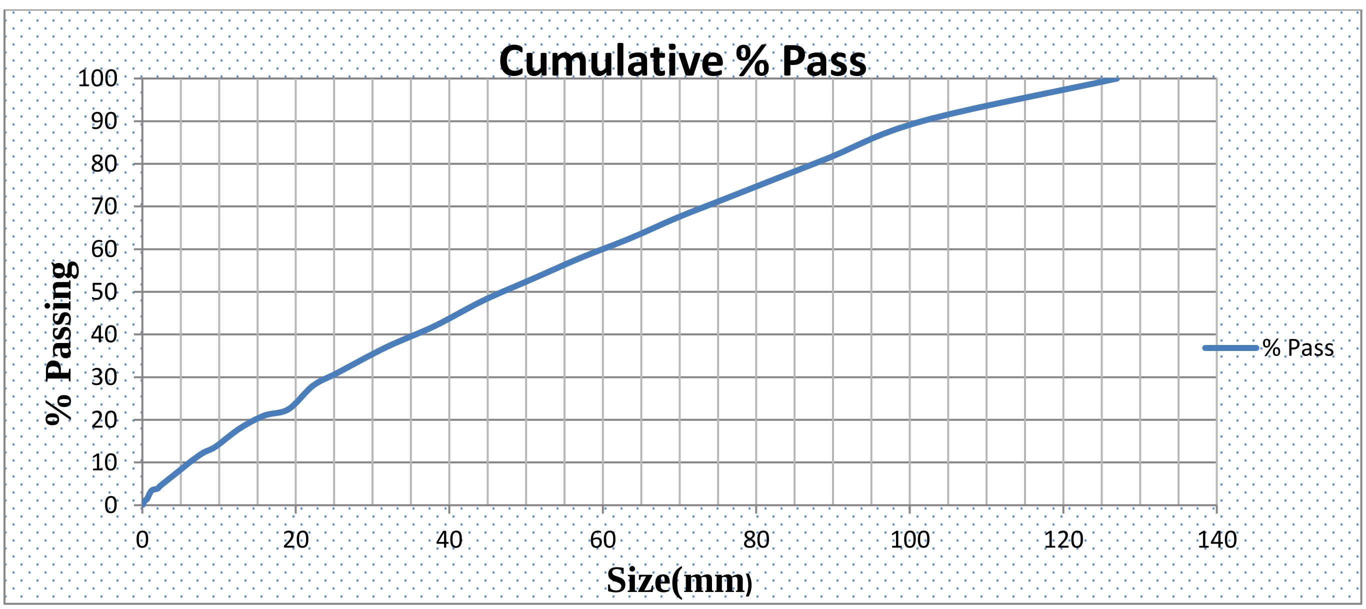


Figure 16 Jaw Crusher output passing graph

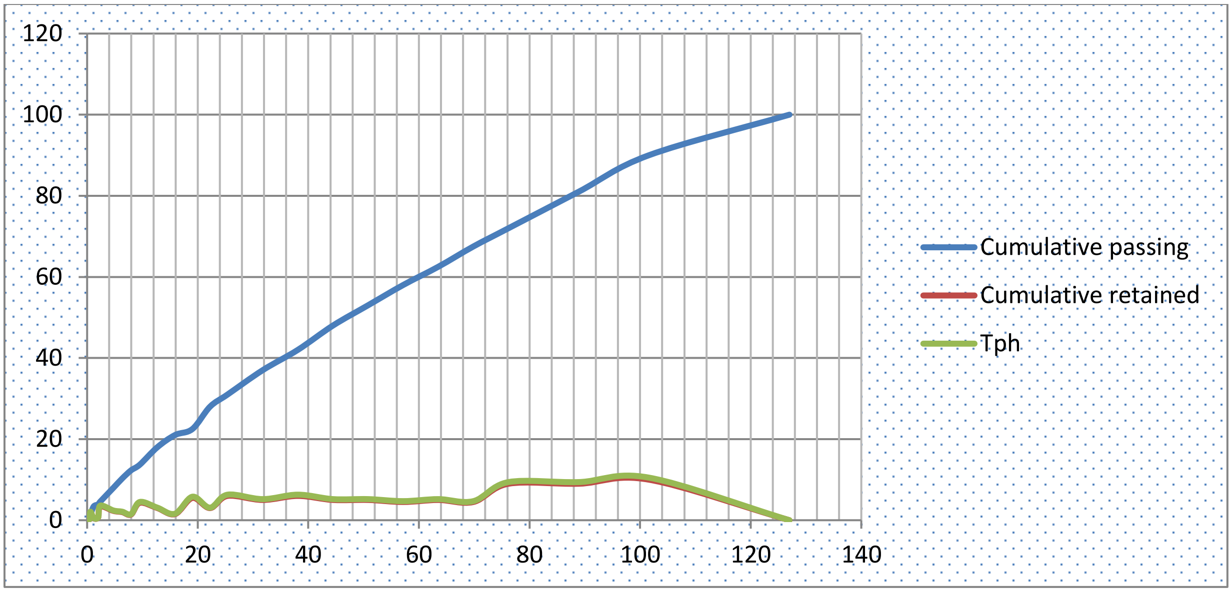


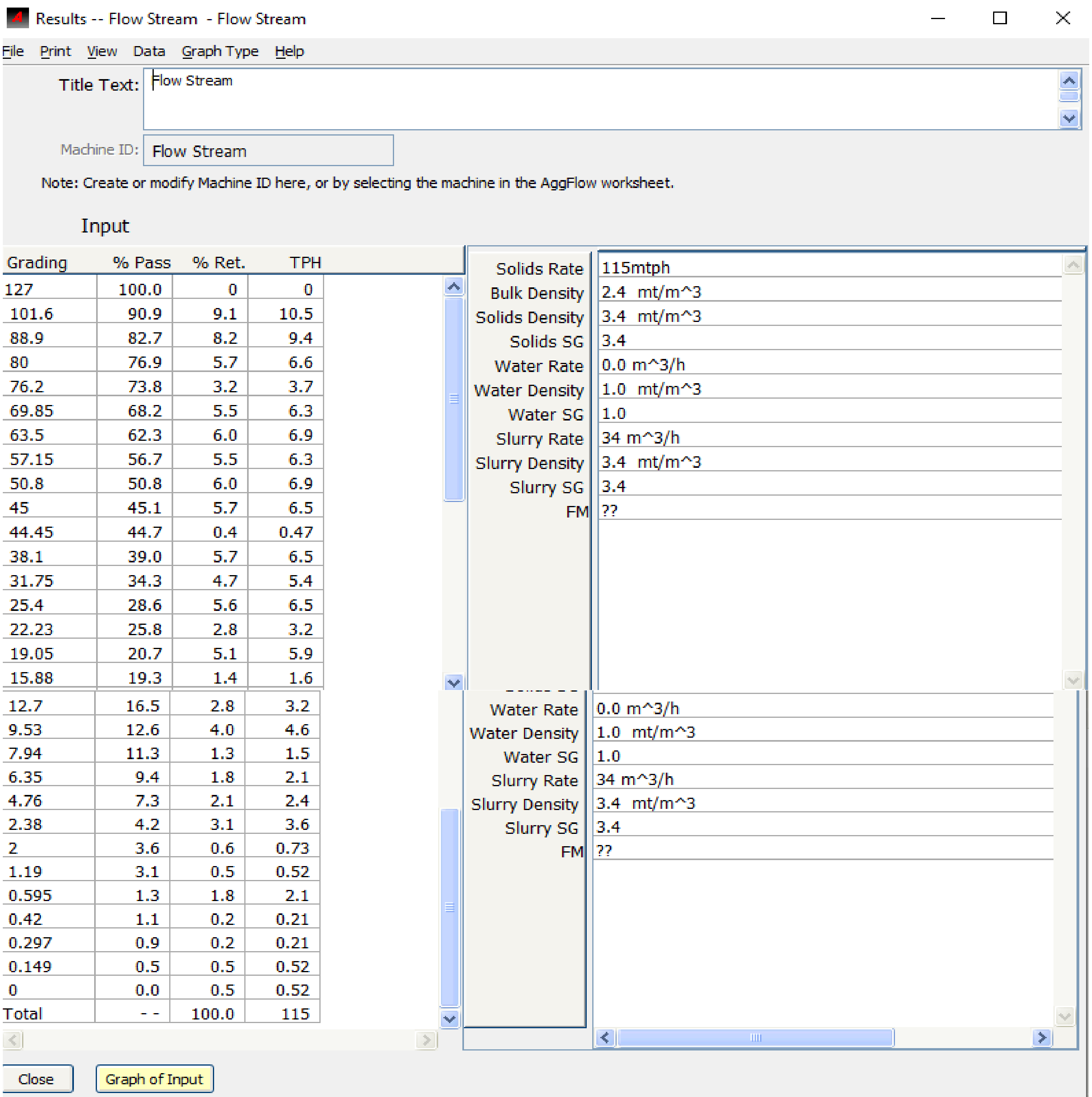
Figure 17 Jaw Crusher output graph

5.4 Secondary Crushing

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 80mm meshes size deck and the flow stream generated as a material to the second crusher with the total of 115Mtph.

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



Grading	% Pass	% Ret.	TPH
127	100.0	0	0
101.6	90.9	9.1	10.5
88.9	82.7	8.2	9.4
80	76.9	5.7	6.6
76.2	73.8	3.2	3.7
69.85	68.2	5.5	6.3
63.5	62.3	6.0	6.9
57.15	56.7	5.5	6.3
50.8	50.8	6.0	6.9
45	45.1	5.7	6.5
44.45	44.7	0.4	0.47
38.1	39.0	5.7	6.5
31.75	34.3	4.7	5.4
25.4	28.6	5.6	6.5
22.23	25.8	2.8	3.2
19.05	20.7	5.1	5.9
15.88	19.3	1.4	1.6
12.7	16.5	2.8	3.2
9.53	12.6	4.0	4.6
7.94	11.3	1.3	1.5
6.35	9.4	1.8	2.1
4.76	7.3	2.1	2.4
2.38	4.2	3.1	3.6
2	3.6	0.6	0.73
1.19	3.1	0.5	0.52
0.595	1.3	1.8	2.1
0.42	1.1	0.2	0.21
0.297	0.9	0.2	0.21
0.149	0.5	0.5	0.52
0	0.0	0.5	0.52
Total	- -	100.0	115

Figure 18 Flow stream from the primary crushing.

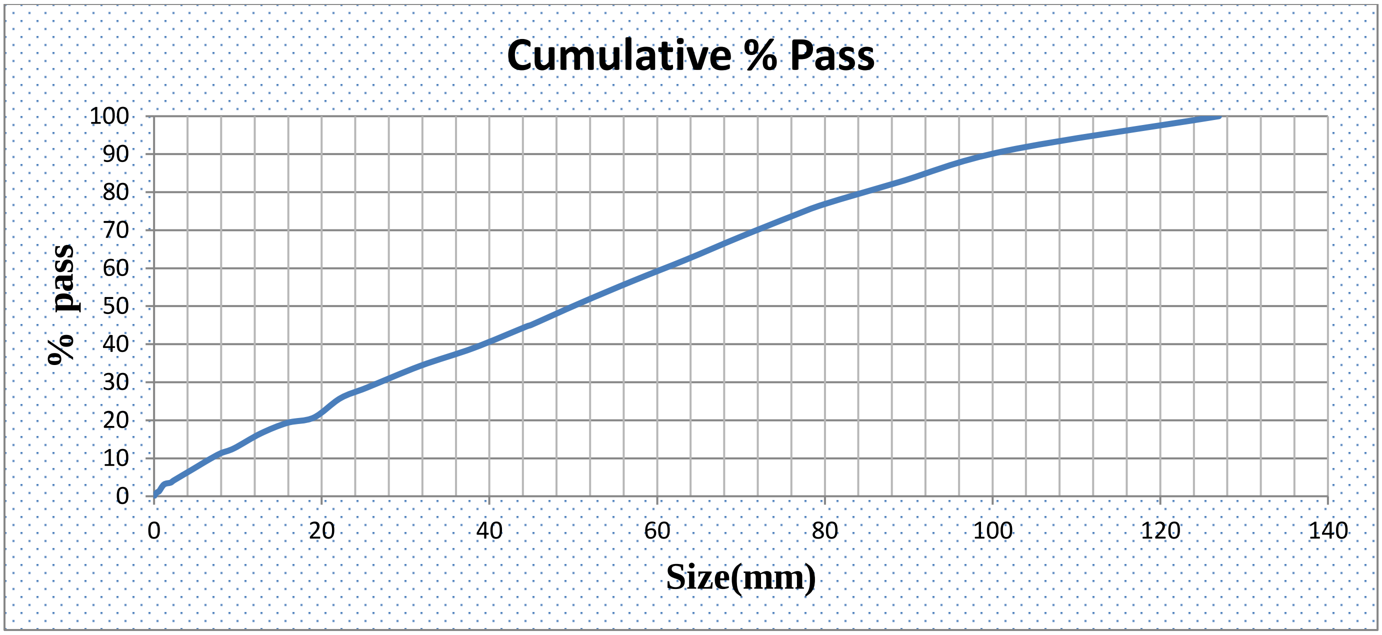


Figure 19 Secondary crusher flow stream passing graph

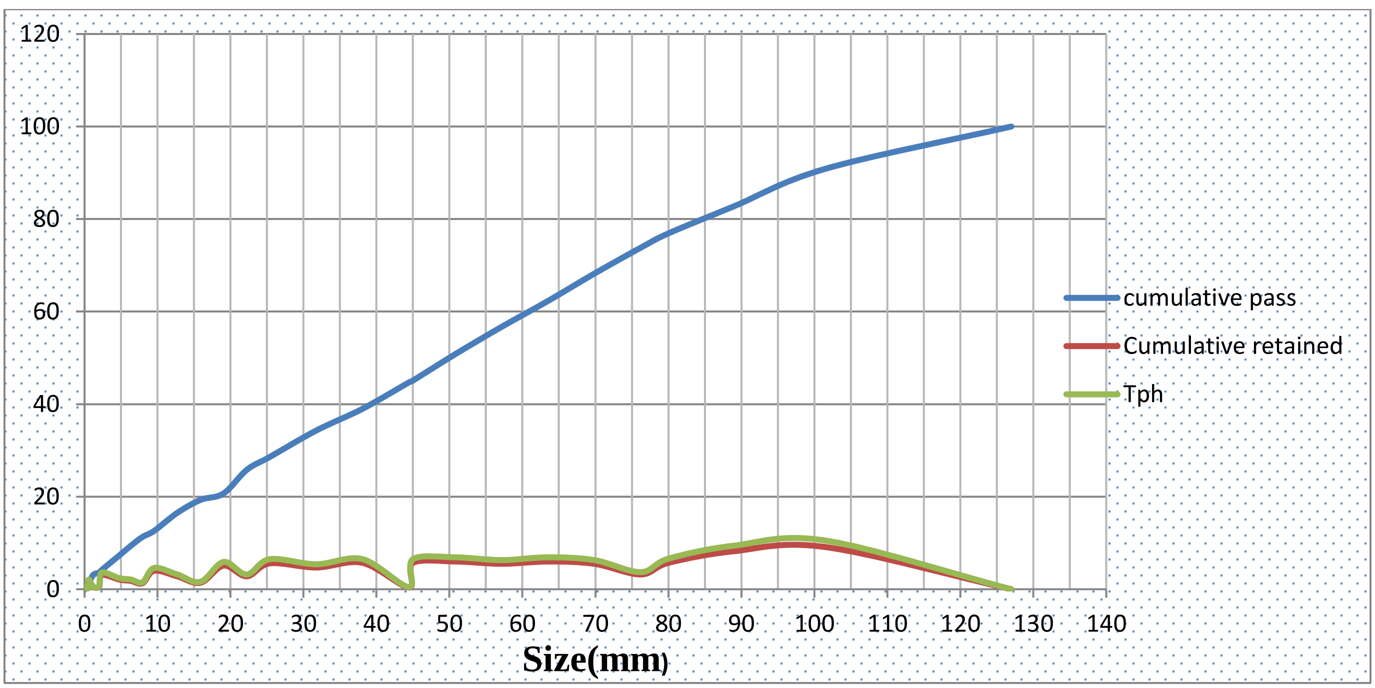


Figure 20 Secondary crusher flow stream graph

5.4.1 Flow Stream to Cone Crusher

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
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

Table 7 Flow Stream to Cone Crusher Data

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 127mm or oversized material will goes to the cone crusher for size reduction and stored as an end product of 57.2mtph.

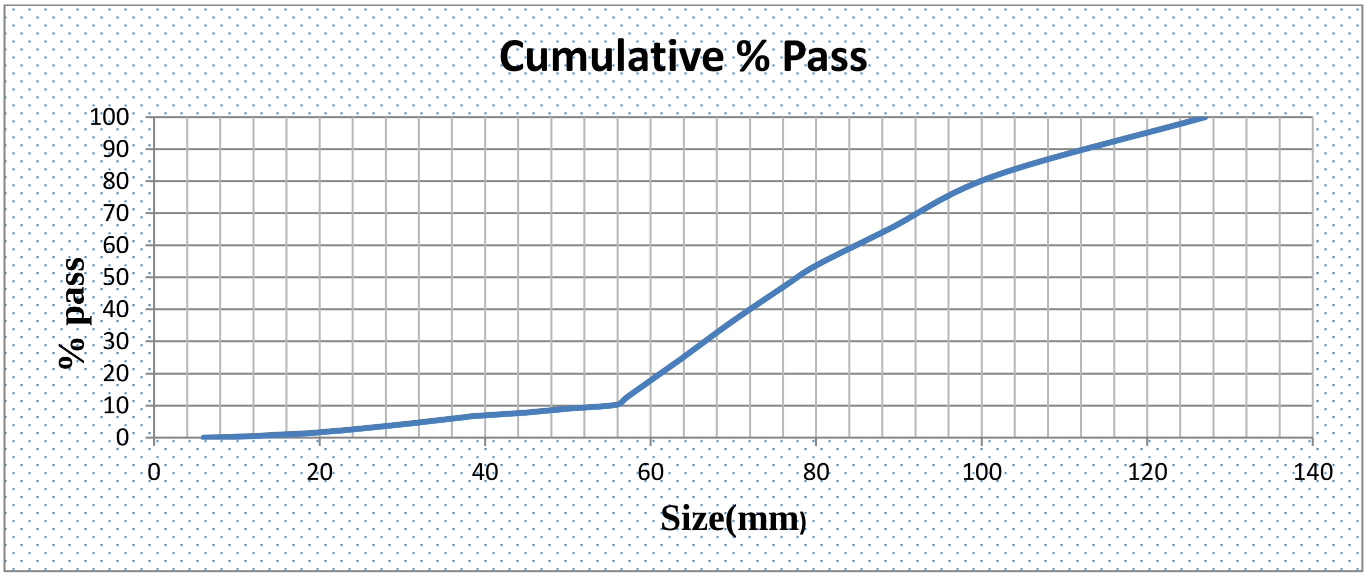


Figure 21 Flow Stream to Cone Crusher Cumulative Passing graph

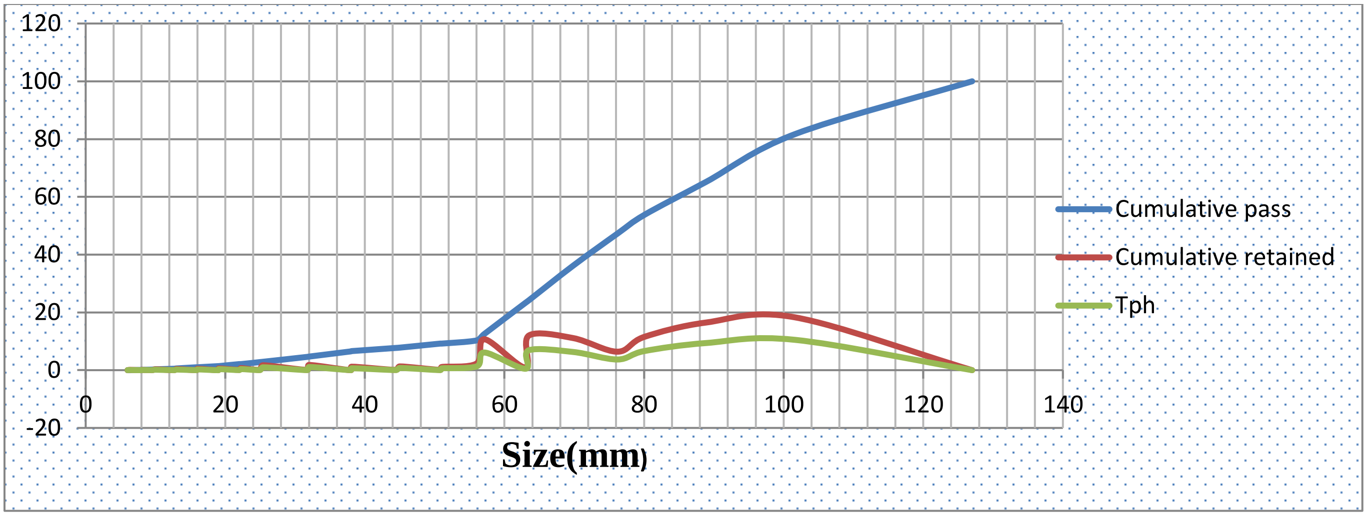


Figure 22 Flow Stream to Cone Crusher graph

5.4.2 Deck Size with cut size (50mm) Deck screen to belt conveyor Data

Conveyor Flow 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
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

Table 8 Deck Size with cut size (50mm) Deck screen to belt conveyor Data

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

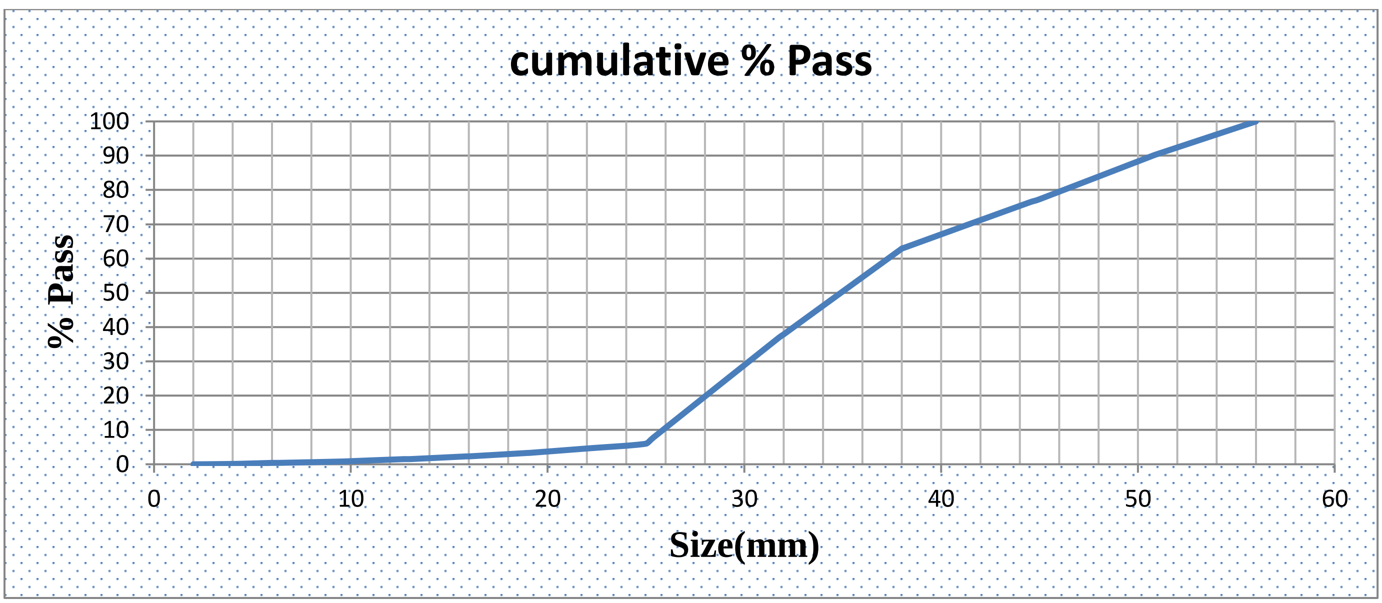


Figure 23 cut size (50mm) Deck screen to belt conveyor passing graph

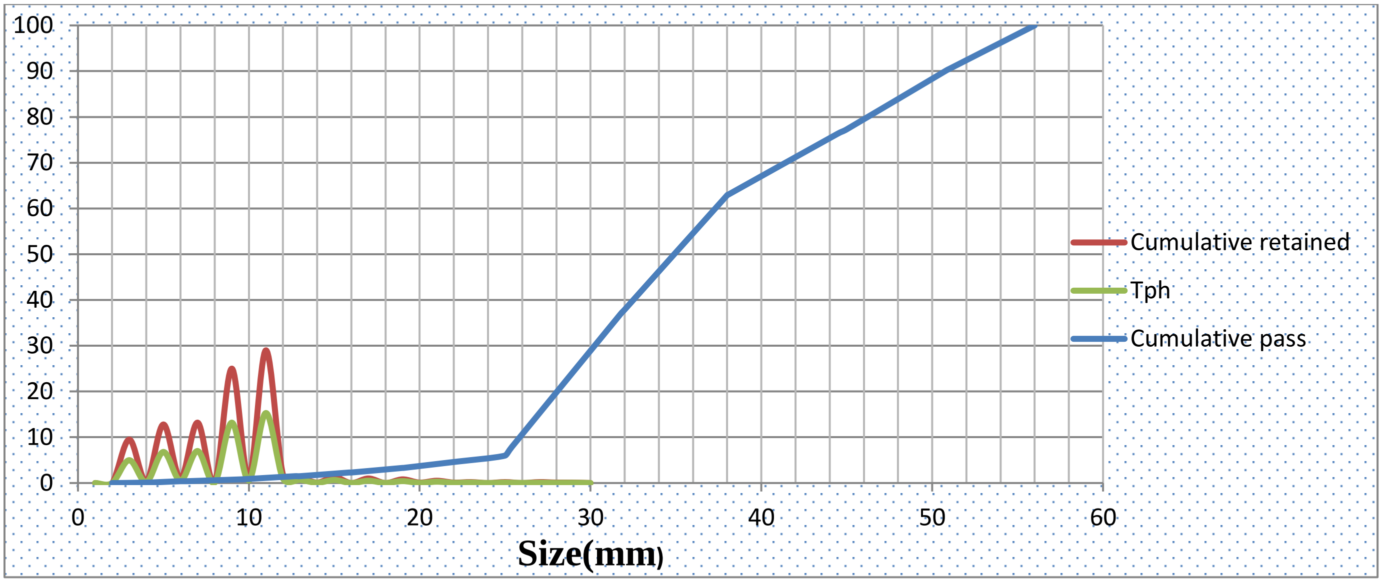


Figure 24 cut size (50mm) Deck screen to belt conveyor relation graph

5.4.3 Deck Size with cut size (25mm) to Belt conveyor

Deck with 25mm 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

Table 9 Deck Size with cut size (25mm) to Belt conveyor

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.

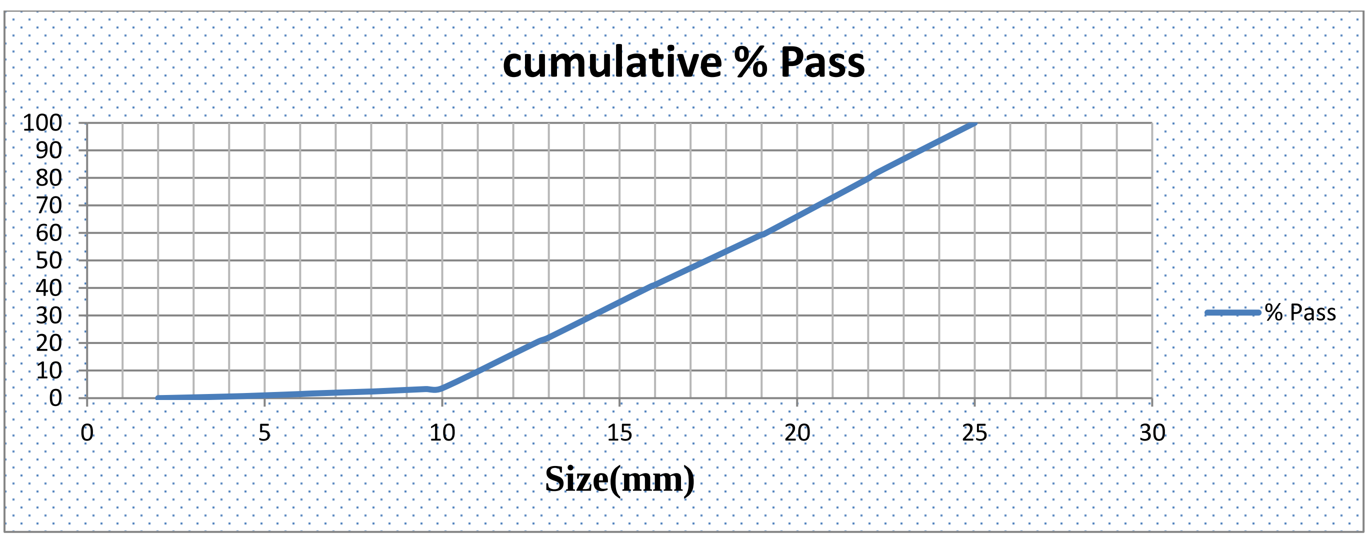


Figure 25 cut size (25mm) to Belt conveyor passing graph

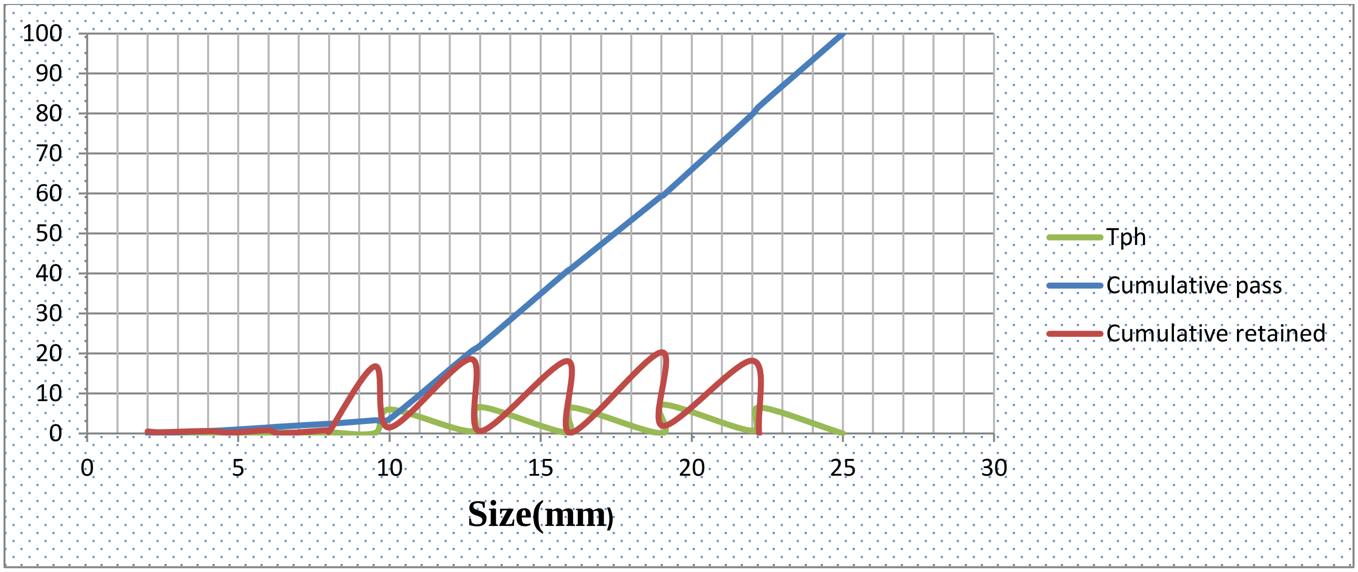


Figure 26 cut size (25mm) to Belt conveyor graph

5.4.4 End product Stockpile Product on secondary crusher

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

Table 10 End product Stockpile Product on secondary crusher data

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

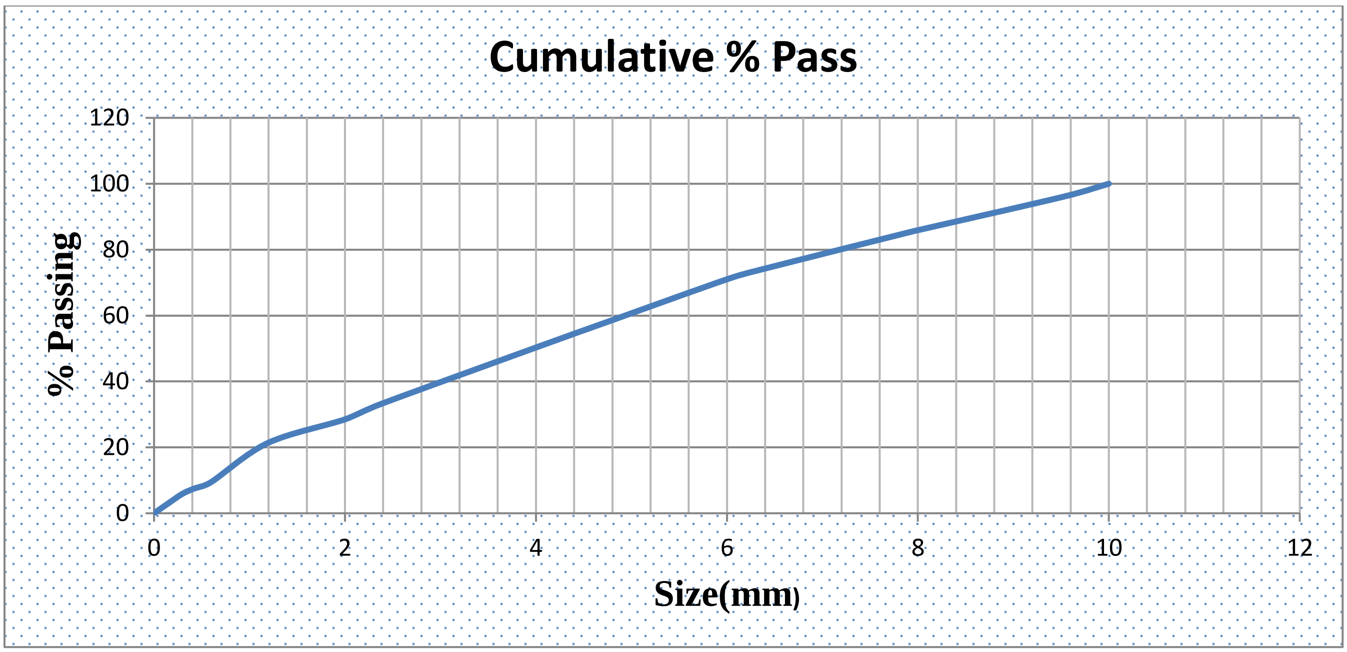


Figure 27 End product stockpile result on secondary crusher

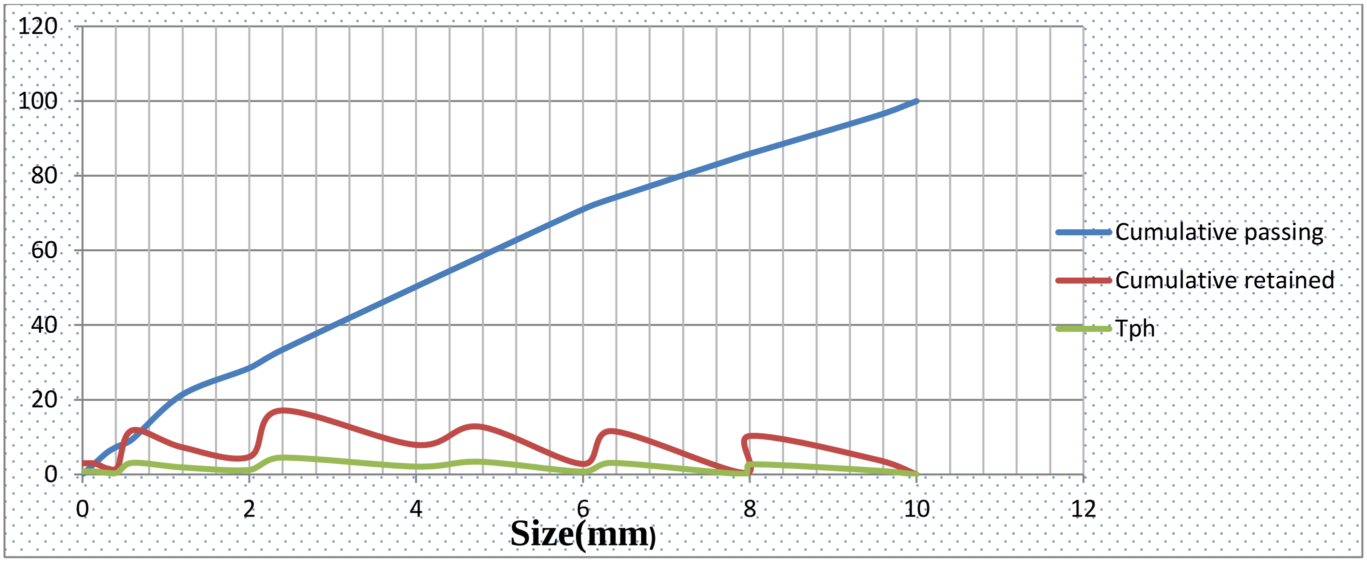


Figure 28 End Product stockpile graph on secondary crusher

5.5 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 88.3Mtph. The tertiary crusher has a closed side setting of 28mm 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 23.4mm, 15mm, and 8mm, respectively.

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

- 39Mtph with a size of 8mm

- 27Mtph with a size of 15mm

- 22Mtph with a size of (-23+15mm)

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

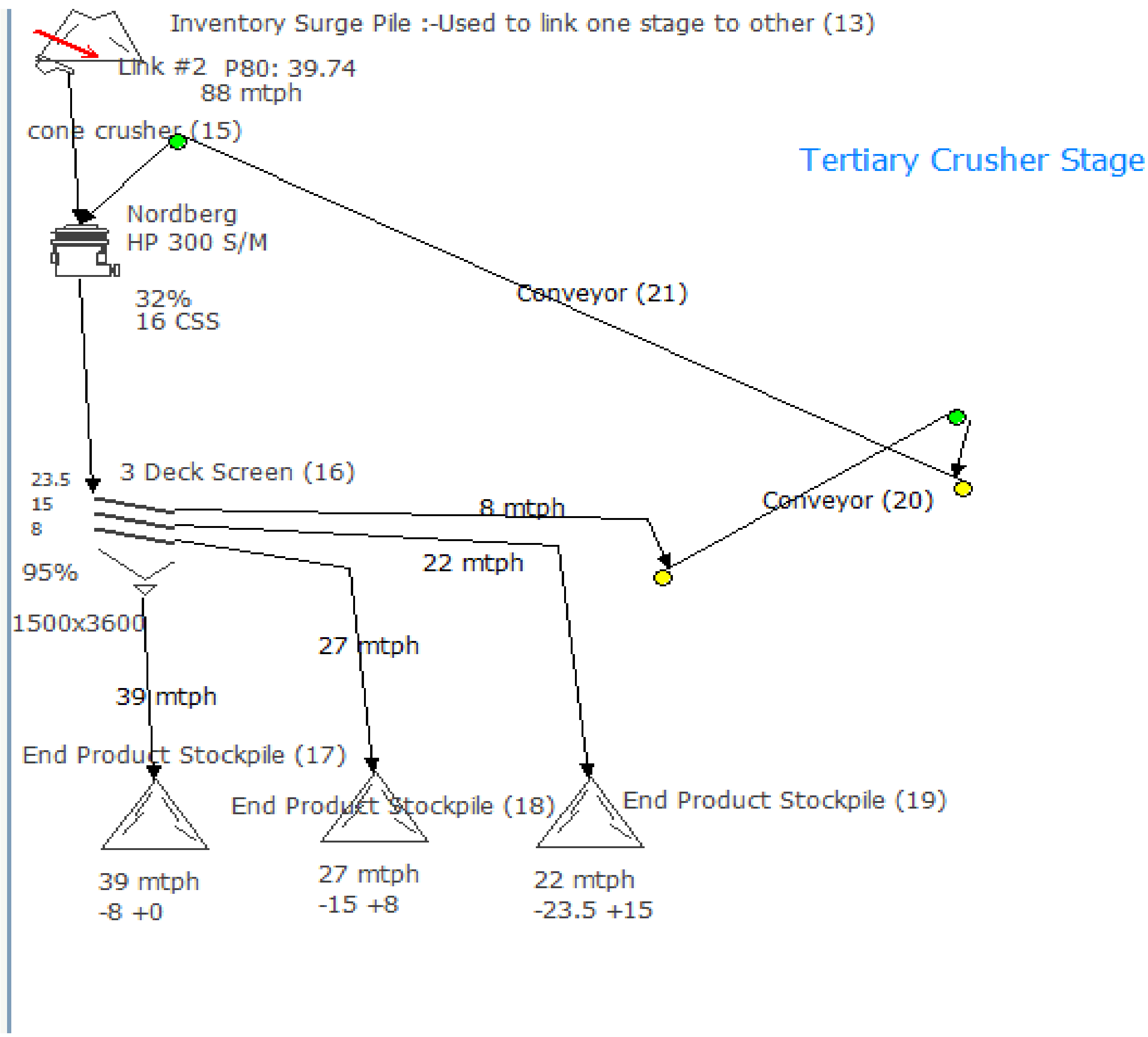


Figure 29 Tertiary Crusher

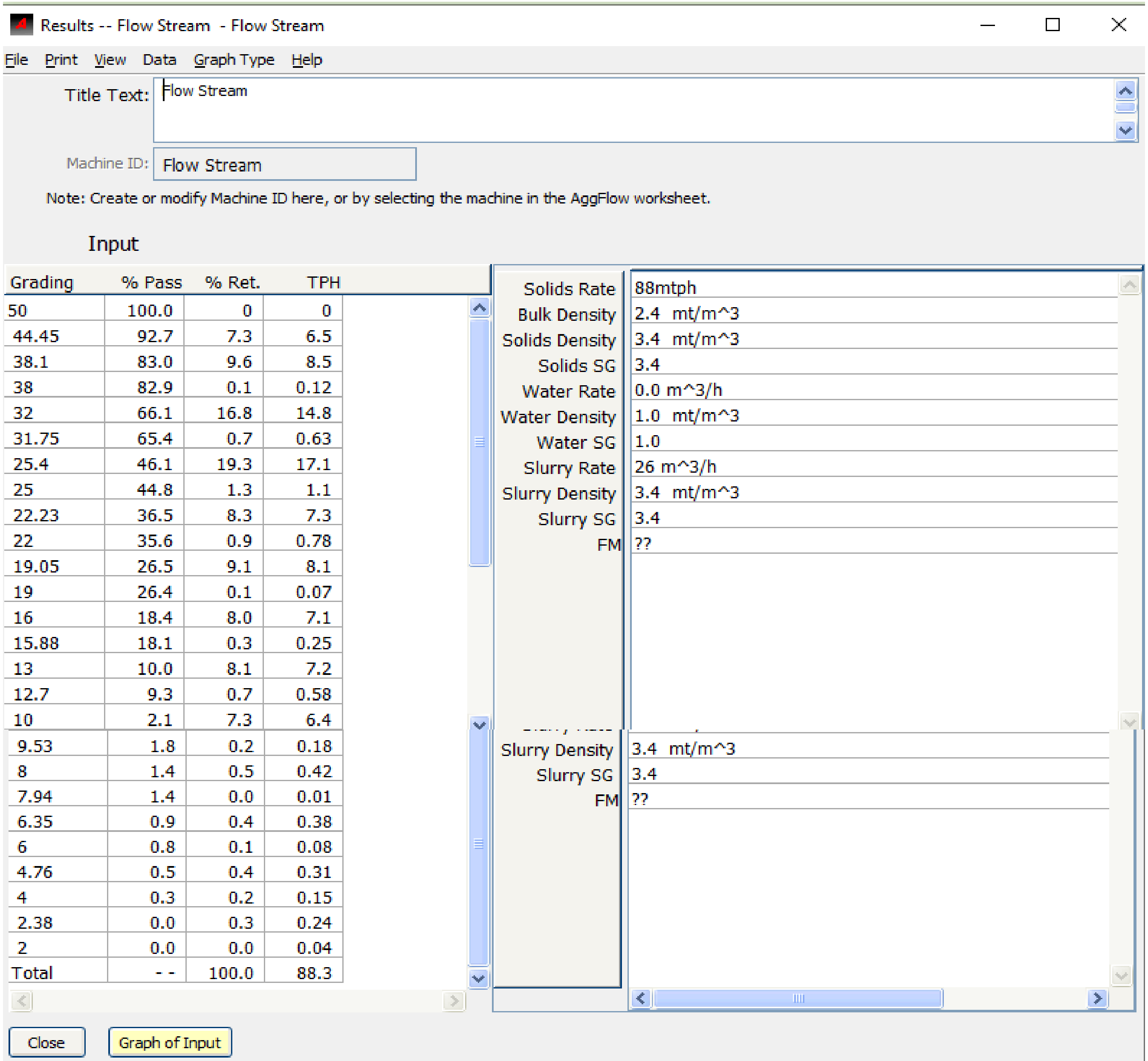


Figure 30 Flow stream from the secondary crushing

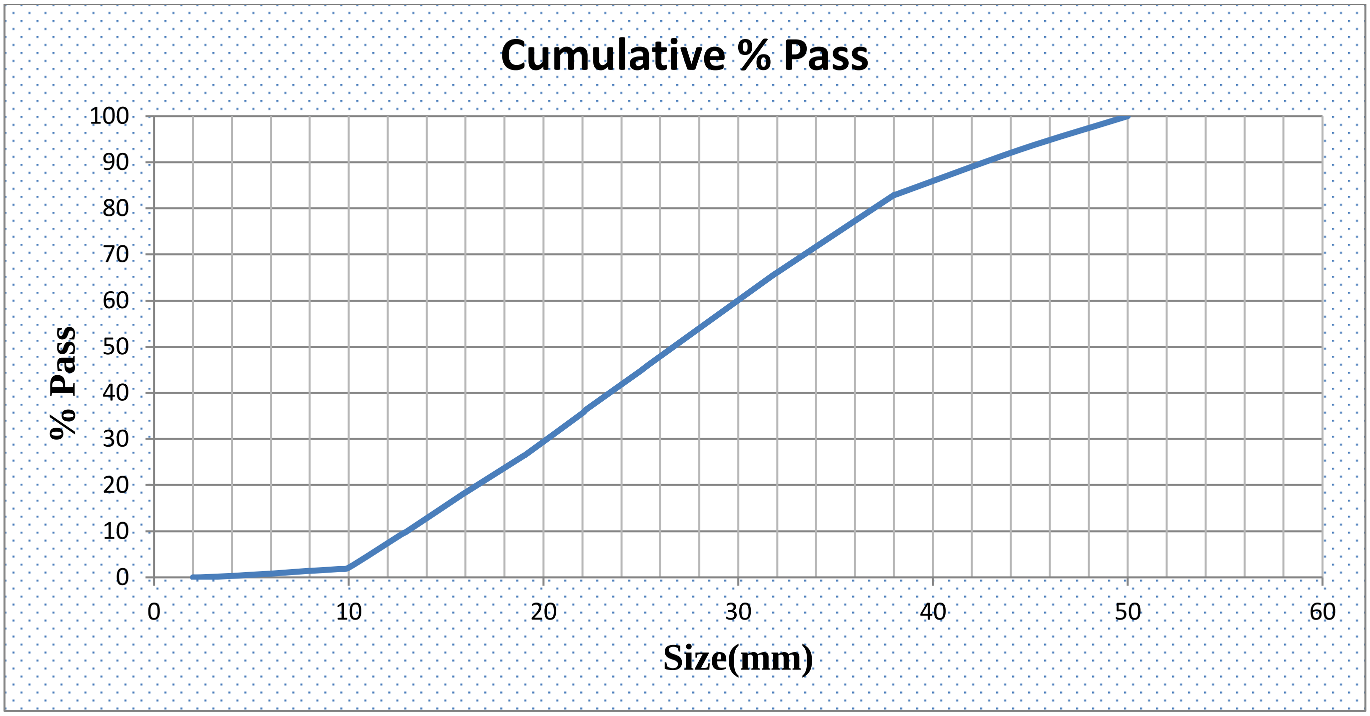


Figure 31 Cumulative Pass graph of tertiary crusher feed

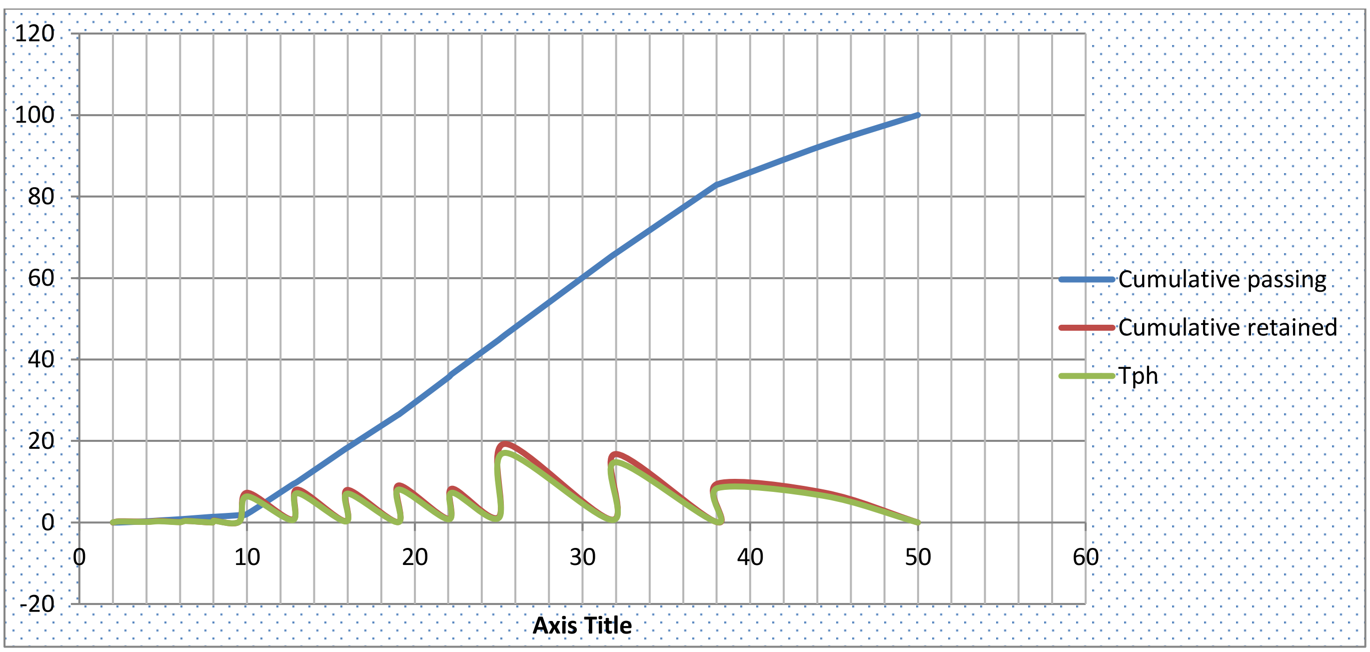


Figure 32 Cumulative graph of tertiary crusher feed

5.5.1 Cone Crusher Output on the tertiary crusher

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

Table 11 Cone Crusher Output on the tertiary crusher Data

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 32mm and a percent passing of 100 mm and the percent retained of (0) will give a total of 88.3mtph.

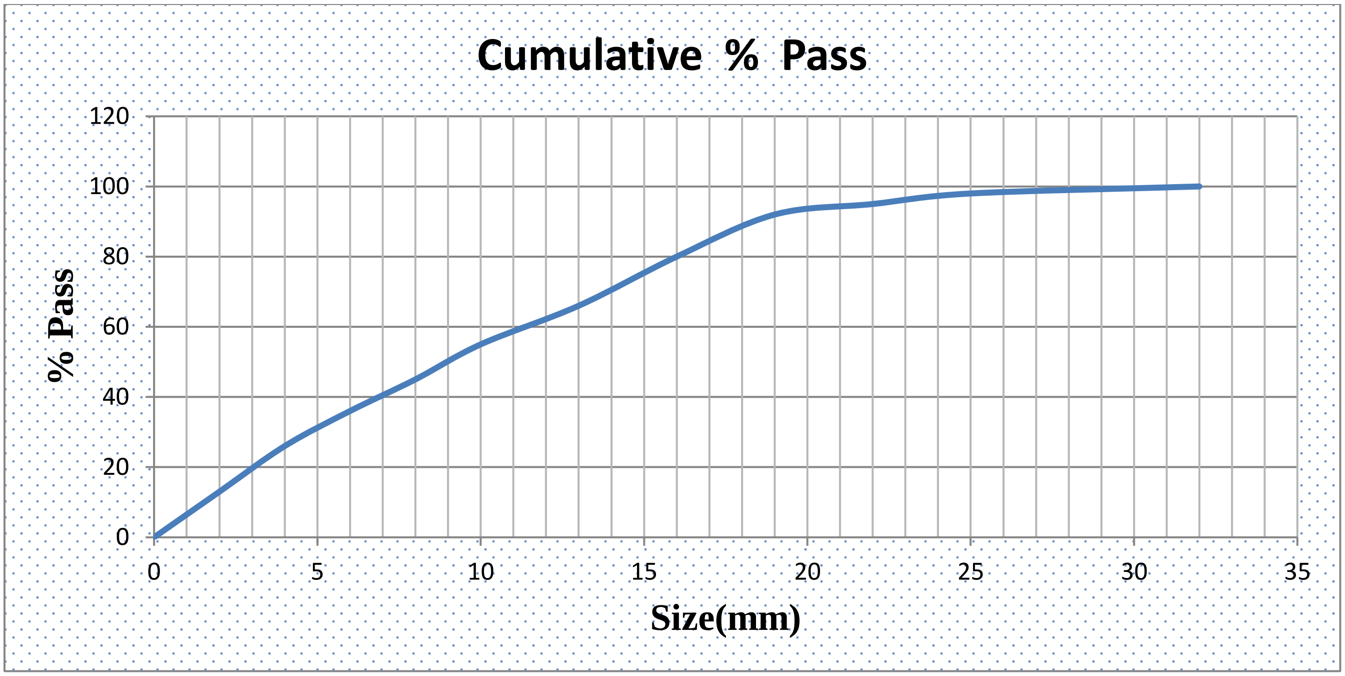


Figure 33 Cone crusher output pass graph on tertiary crusher

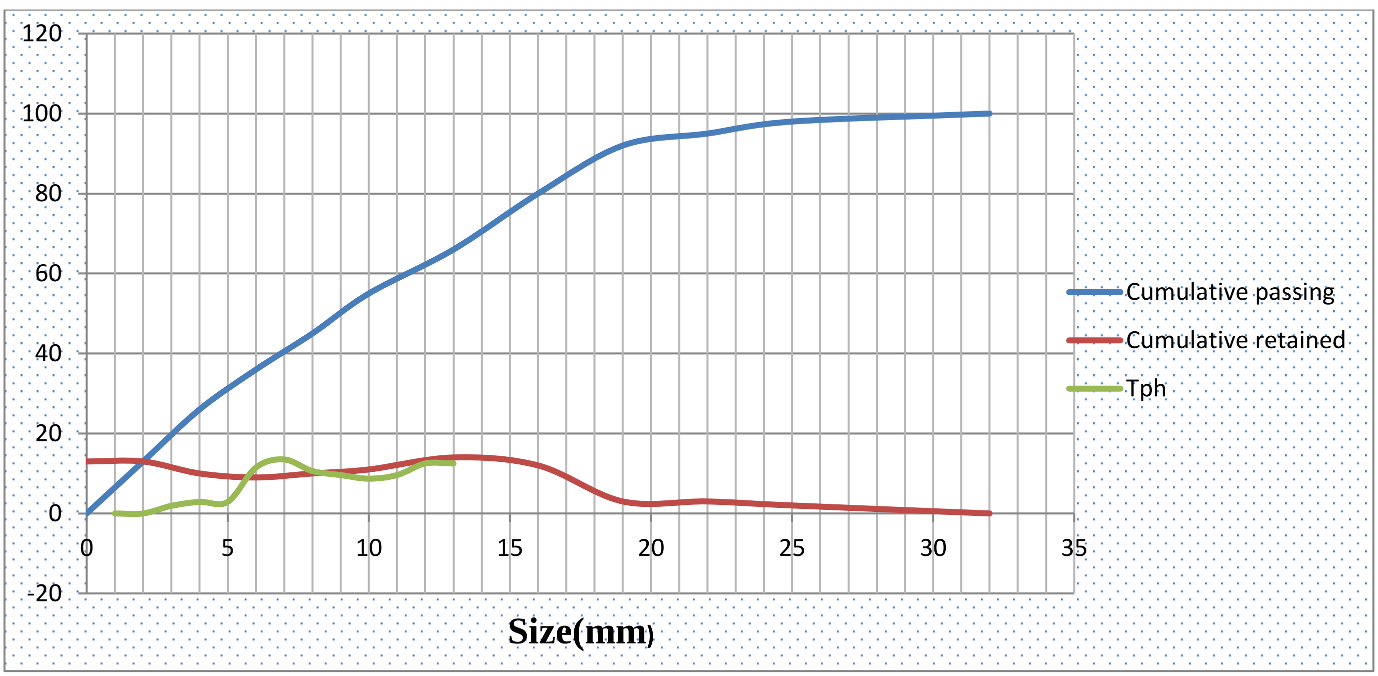


Figure 34 Cone crusher output graph on tertiary crusher

5.5.2 End product out put on tertiary crusher

Product stockpile End Product Stockpile (17) - Output

Product Pile End Product Stockpile (17) - Output			
Grading	% Pass	% Ret.	TPH
8	100	0	0
6	81.8	18.2	7.1
4	60.4	21.4	8.4
2	31	29.4	11.5
0	0	31	12.2
Total	- -	100	39.2

Table 12 Product stockpile End Product Stockpile (17) - Output Data

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

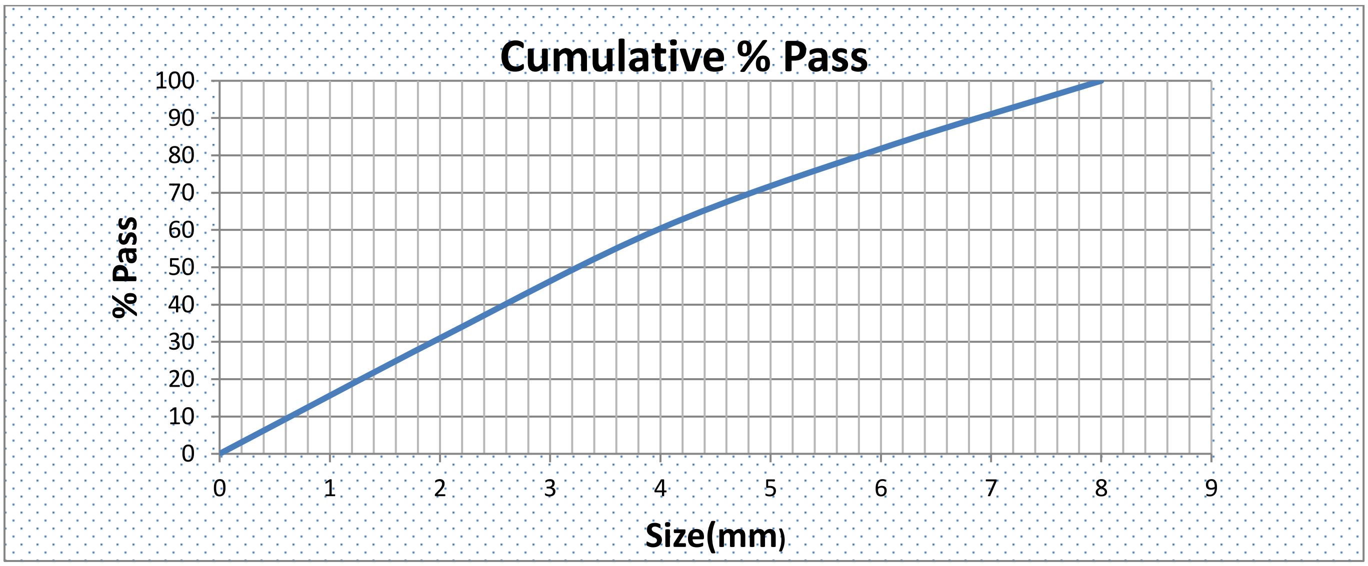


Figure 35 End Product Stockpile (17) - Output pass graph on tertiary crusher

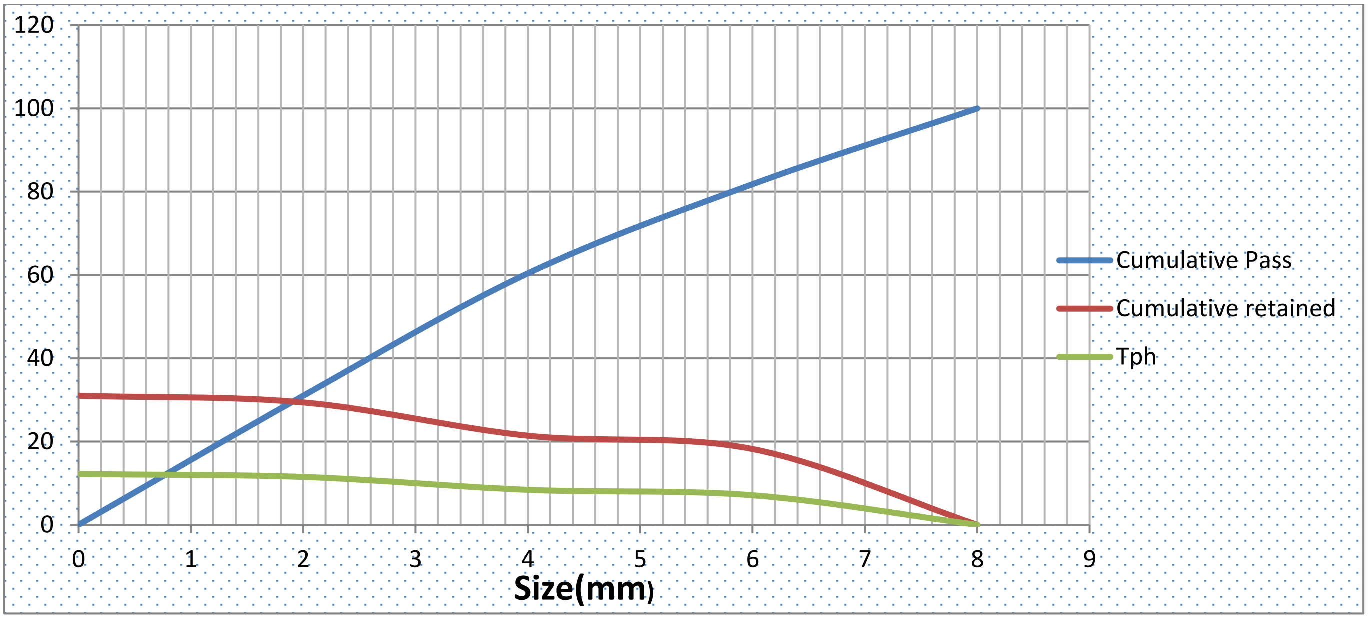


Figure 36 End Product Stockpile (17) - Output graph on tertiary crusher

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

Table 13 End Product Stockpile (18) – Output

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

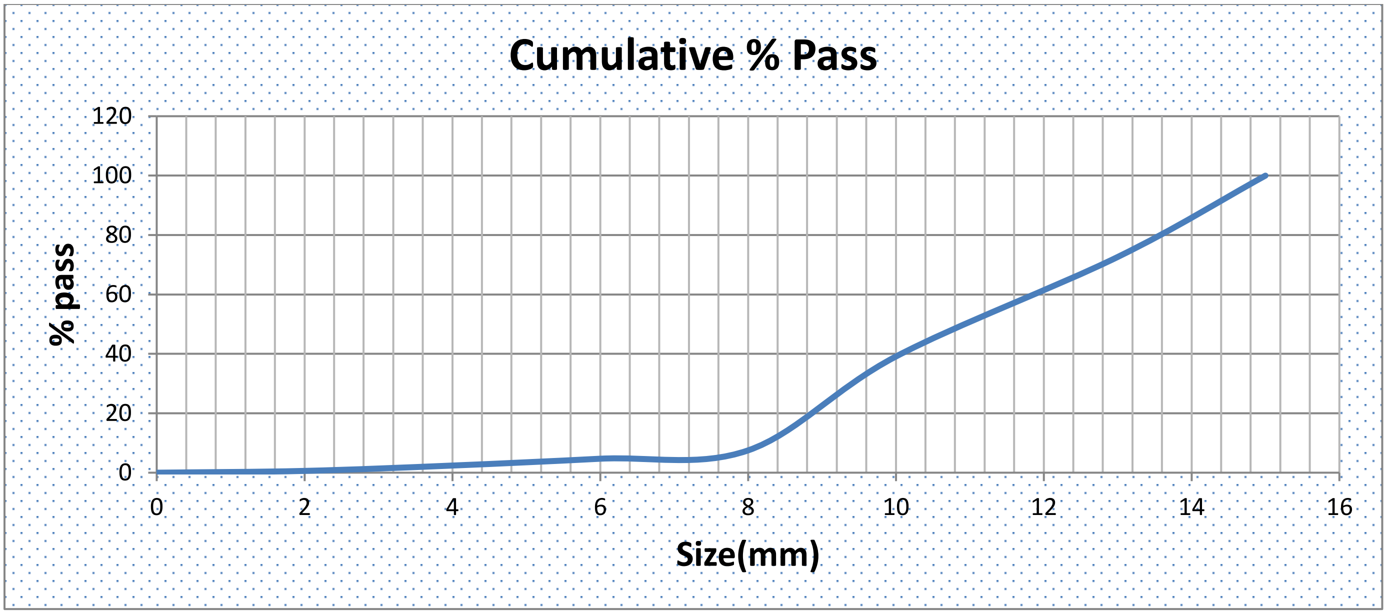


Figure 37 End Product Stockpile (18) - Output pass graph on tertiary crusher

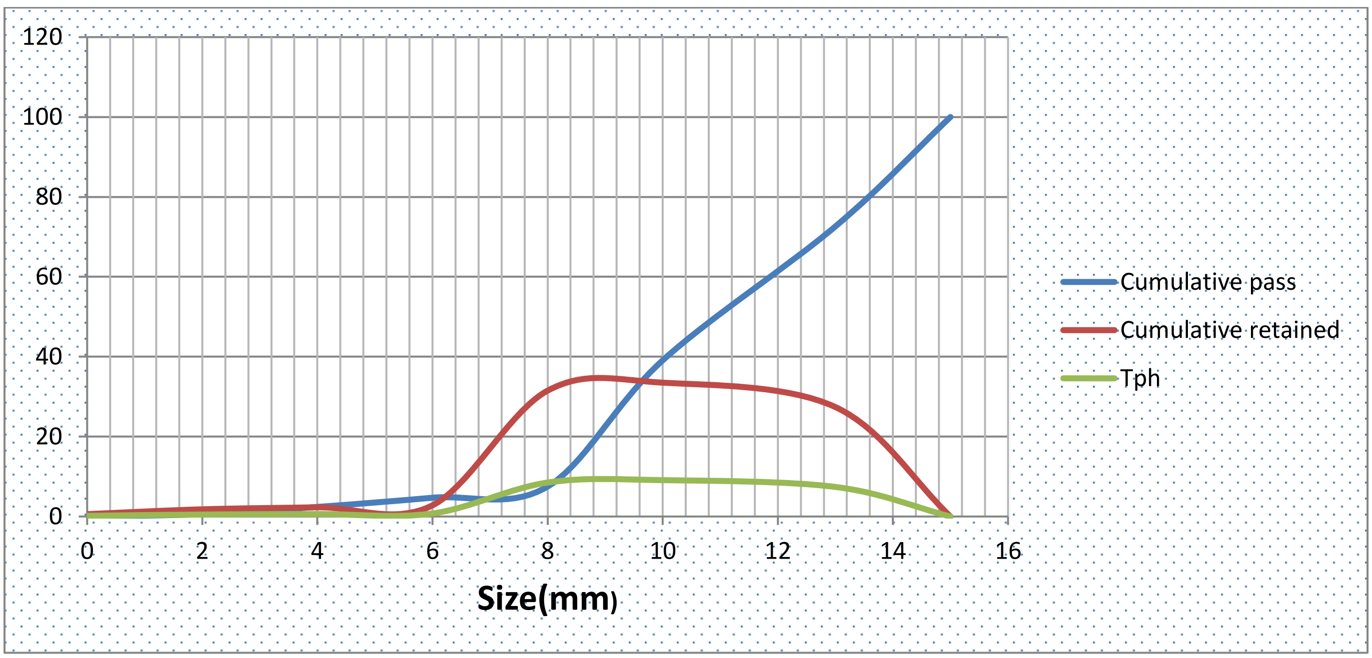


Figure 38 End Product Stockpile (18) - Output graph on tertiary crusher

End Product Stockpile (19) – Output

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
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

Table 14 End Product Stockpile (19) – Output Data

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

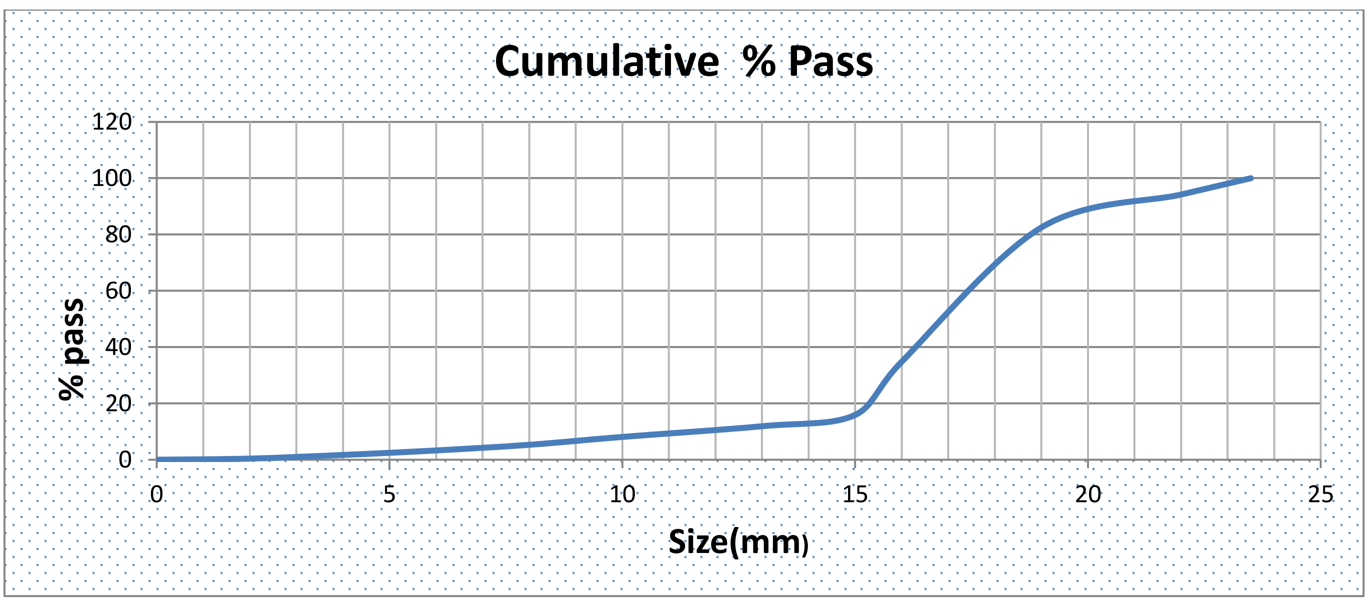


Figure 39 End Product Stockpile (19) - Output pass graph on tertiary crusher

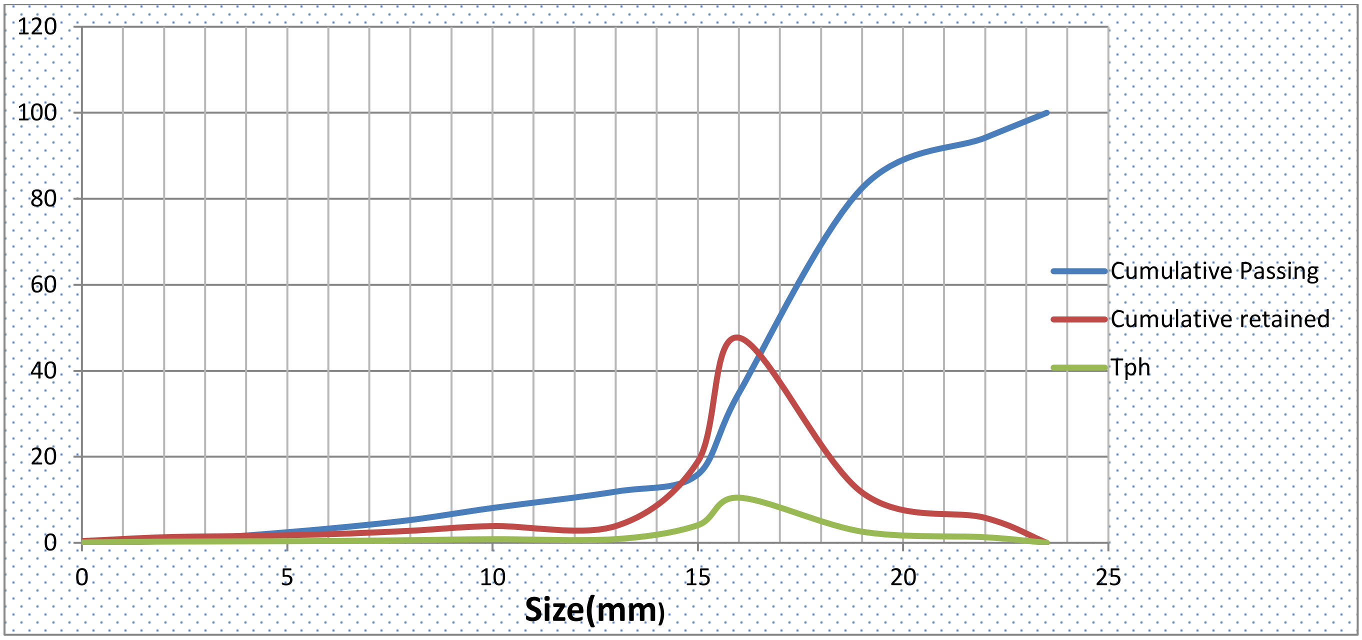
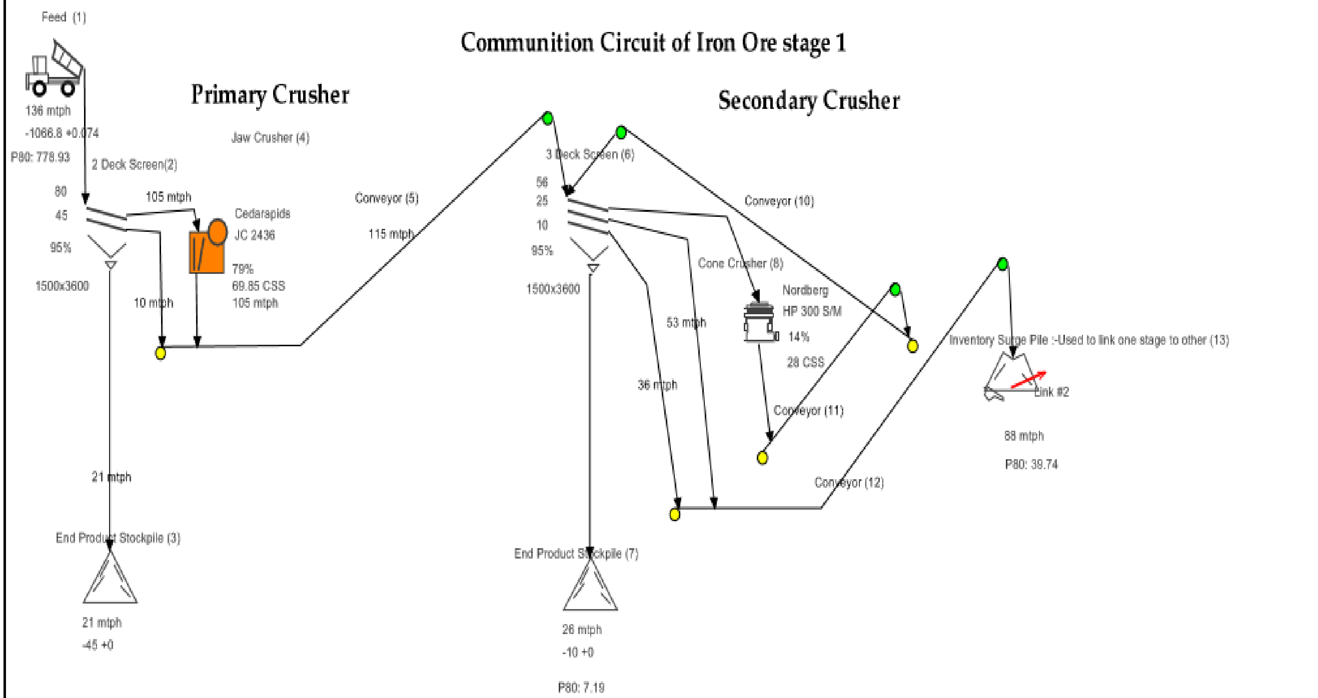


Figure 40 End Product Stockpile (19) - Output graph on tertiary crusher



Mode: *mode

Calculation results may differ due to variations in operating conditions and application of crushing and screening equipment. This information does not constitute an express or implied warranty, but shows results of calculations based on information provided by customers or equipment manufacturers. Use this information for estimating purposes only. ***All calculations performed by AggFlow. http://www.AggFlow.com***	Mom Mineral Engg' ephrem Plant Stage #1: Project #: 149484 Revision #: 737908 Date: June/11/2023

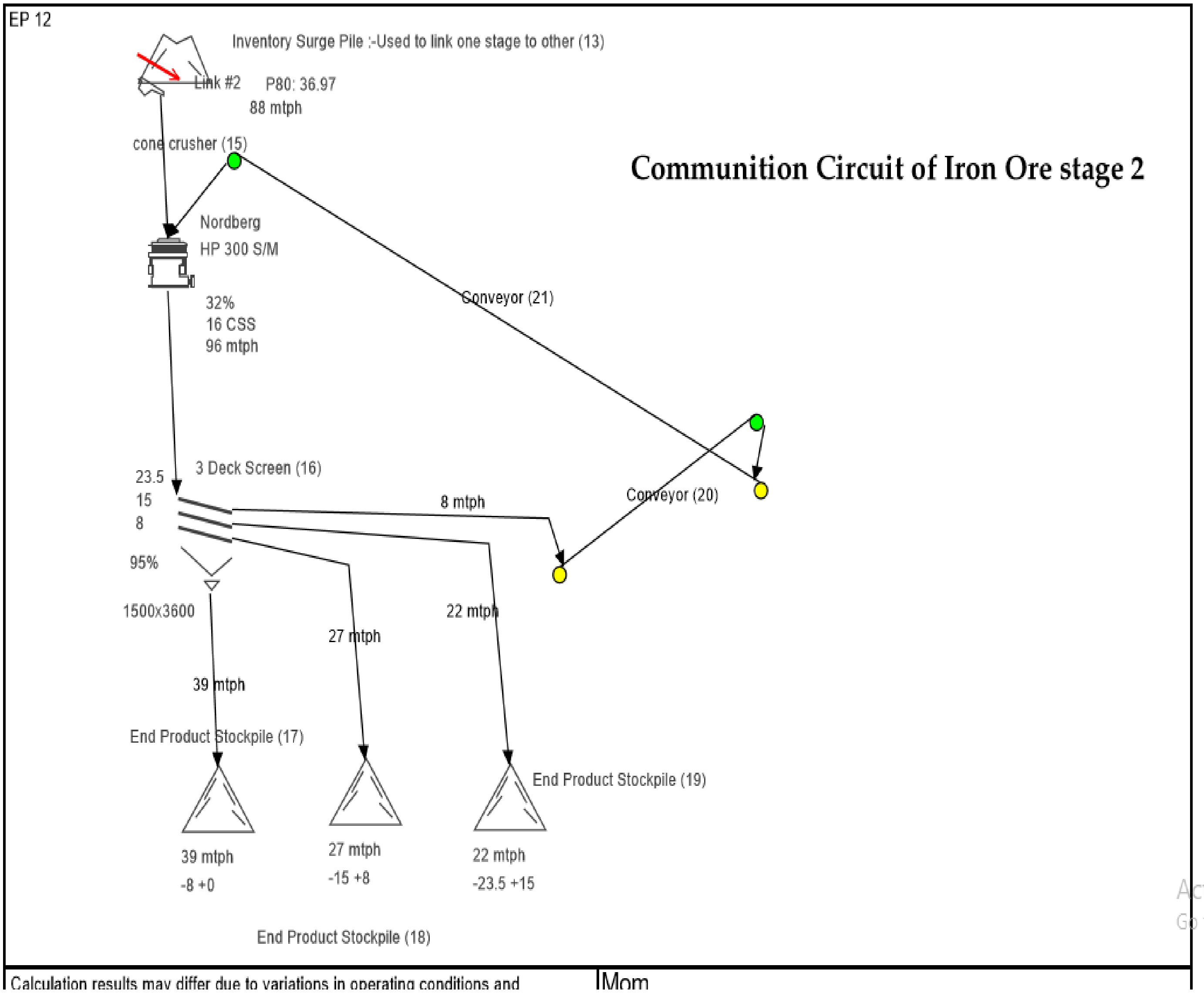


Figure 41 Overall view of the Comminution Flow sheet project

Chapter 6

6.1 Conclusion and recommendation

Comminution flowsheet is essential because it helps to optimize the process of breaking down ores and minerals into smaller particles. The process of comminution is critical in mineral processing, and it involves crushing, grinding, and milling of minerals. The purpose of comminution is to liberate valuable minerals from waste materials and to create particle sizes that are suitable for downstream processing.

A well-designed comminution flowsheet helps to optimize the overall efficiency of mineral processing operations, reduce energy consumption, and maximize the recovery of valuable minerals. Additionally, a comminution flowsheet helps to ensure that the proper equipment and processes are used to achieve the desired particle size distribution, which is critical for downstream processing.

Overall, a well-designed comminution flow sheet is crucial for ensuring the optimal performance of mineral processing operations and achieving the desired production and recovery targets.

The aggflow software simulate 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 21Mtph with a size of 45mm. The secondary crusher produces an end product of 26Mtph with a size of 10mm. The tertiary stage produces an end product of 38Mtph with a size of 8mm, 27Mtph with (-5+8mm), and 22Mtph with (-23.5+15mm). The liberation size, or the size at which the iron ore particles are sufficiently liberated or separated from the gangue minerals, is between 8mm and 45mm. This information can help in optimizing the comminution process and improving the efficiency.

This document discusses the simulation of iron ore processing, specifically the crushing, conveying, and storage stages. It includes data on the primary crusher, secondary crushing, and tertiary crusher, as well as end product stockpiles

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 150t/h (136mtph) 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 26mtph at a size of 10mm, with fines modules of 4.69 and p80 of 7.19mm.

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 24x36

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 an reduction ratio of 2.4:1. The five pillars of product had a stream between 16% and 44% of our feed stream (table 16), as described.

Table 15 Results of the product streams

Crusher Stage	Range Size(mm)	Stream(Mtph)
Primary crusher	**-45+0**	**21**
Secondary Crusher	**-10+0**	**26**
Tertiary crusher	**-8+0**	**39**
	-15+8	**27**
	-23.5+15	**22**

Based on the results, the following recommendations are proposed to maximize efficiency in the comminution circuit:

- adjust the closed-side setting of the primary crusher to maintain the optimal reduction ratio and limit the generation of oversized particles in the circuit, reducing potential bottlenecks in the secondary stage.
- Optimize the cone crusher's settings in the tertiary stage to balance product size and shape while maximizing throughput, considering the feed from the secondary crusher.
- Finally, the project which is conducting comminution development project helps for an input for detailed simulation study of downstream processing for the researchers or for the company.

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