Preliminary inspection for improvement of Process Plant operation and management: Case study of Akroma Gold Company, Nkawkaw

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Abstract

This study covers issues of safety, production, cost and environment units of Akroma Gold Company limited, Process Plant. It aims at identifying the various shortfalls of the unit processes for proactive resolution to enhance improvement. Clearly, the Plant is being run on reactive Mode. At Akroma Gold Company limited, Process Plant, safety is below acceptable standard at all the unit process areas. There is lack of Personal protective equipment for workers of the plant. This is a recipe for workers' health hazard and its associated legislative issues. There is lack of information on performance tracking of the various units of the plant. Whiles oxygen is not measured at the Akroma Gold Company's Processing Plant, pH measurement, based on litmus paper is not reliable since it is a subjective figure. The introduction of carbon regeneration Kiln is paramount as a proactive measure to overcome the negative effect that can result from non-regenerated carbon. Monitoring of electrowining efficiency is another key for predicting final gold to be produce ahead of actual gold production. Daily environmental monitoring report is a needed document to resolve any future legislative problems from the government agency and mischievous community members. Daily monitoring trends analysis are keys to enhance proactive and cost effective production.

Keywords: Unit Process, Design indicators, Cyanide, pH, Carbon, Thickening and classification

1. Introduction

Generally, preliminary inspection is the firsthand notification that covers physical witnessing of plant process units operation activities, performance of the units, documentations use at the units, reagent addition control and tests, safety requirements application and environmental inspections documentations (Thompson and Miller, 2002; Soundaian, 2011). This implies, the process of preliminary inspection requires witness and physically examining of various units to ascertain compliance to standard. Goldstein (1982), noted that, preliminary inspection gives a firsthand understanding into the levels of compliance and noncompliance to a given standard in various unit processes data. From the Anon (2019), article, pointed out that, as a service, preliminary inspection gives evidence that ongoing activity or job done is on track or acceptable standard. Also, preliminary inspection provides information on deficiencies that are required to be rectified to each item or unit to achieve compliant. This makes preliminary inspection an important tool for assessing future adverse or progressive results of a given unit.

Currently, the 8% decrease in overall gold recovery as compared to the designed value of 90.27 % is called for comprehensive investigations in all the sections in order to find permanent solution to the prevailing problem. Consequently, the importance of this preliminary inspection as a starting point for improving the Process Plant operation and management, cannot be overemphasized. This assessment or preliminary inspection aims at identifying the various shortfalls of the unit processes to be rectified for improvement. Clearly, the lack of information gap that exist in the company on the shortfalls of the unit process of the metallurgical plant has serious adverse effect on the achievement of the key performance indicating targets. This has consequent effect on the overall gold production that has been targeted. Hence, this paper is to provide the answers to the various shortfalls to close the lack of information gap and enhance management capacity to

plan for cost effective production towards profit maximization.

Noticeably, the Plant is being run on reactive mode and awaiting various associated adverse consequences. The framework of this inspection report covers preliminary issues of safety, production, cost and environment standard of Akroma Gold Company limited, Process Plant. That is, preliminary in this inspection refers to the firsthand information on the operational principles of the various section and the application of acceptable legislative scientific standard by operators.

1.1 Background Information

Imperatively, the lack of information gap on the shortfalls of the unit process of the metallurgical plant of Akroma Gold Company Limited has adverse effect on the efforts to achieve the set production targets. Hence, the aim of this inspection to resolve the problem will go a long way to ensure cost effectiveness towards achievement of the set key performance indicators for the target.

Clearly, the ore deposit of Akroma Gold mine falls into the category of the structurally altered rock deposit. Most of the ore for processing is from the oxidized ore from the orebody in the central mineralization zone. The processing plant capacity is 500tons per day with working scheme of 330 days per year and service life of 6 years. The Processing plant consists of Primary Crusher, Secondary crusher, primary and secondary mills, thickener, Cyanidation carbon-in-leach, Desorption (elution unit) and electrowining unit processes for final gold bullion production. Additionally, the Plant has a section for providing the percentage concentration of the respective units consumption reagent input requirement and laboratory section for daily testing of all the needed levels of the various parameters of unit processes. The tables 1 to 9 describe the acceptable design parameters for all the sections of the Plant. These include tested details of the ore, Design Indices of the plant and the unit process parameters for Crushing, Screening, Grinding, Classification, Thickening, Leaching, Adsorption and Desorption operating standards (Haigen and Longzong, 1997). Legally, by the Minerals and Mining (Health, Safety and Technical) Regulations (2012), mining companies are to provide safe working condition and personal protective equipments for their employees whiles ensuring that, the environment components (i.e. river bodies, flora and fauna) are monitored and protected from any adverse effect of processing plant's toxic effluent (Anon, 2012). From Haigen and Longzong, 1997, gives Figure 1 as the Process Plant flow diagram under Preliminary Inspection.

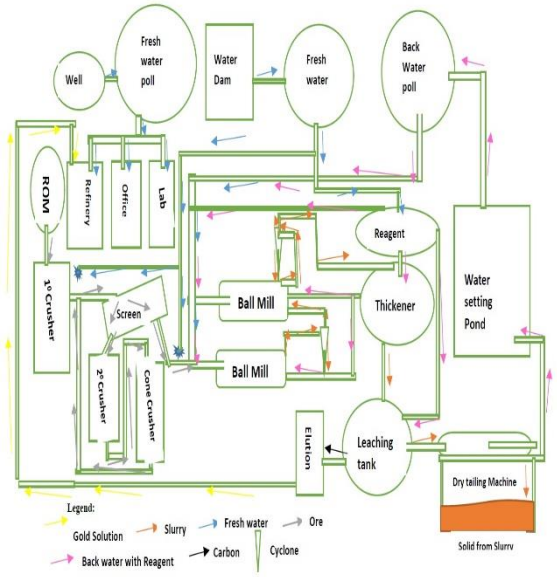

Fig. 1 Processing Plant Flow Diagram (Haigen and Longzong, 1997)

From Figure 1, the sections of the plant are: the ROM (Run of Mine), Crusher, Grinding (Mill and Classification), Leaching, Desorption (Elution), Metal Recovery and Tailing. Other sections are: Water setting Pond (Process water), Back Water poll, Fresh water (Raw Water), Water Dam, Fresh water poll and Well.

Table 1 Important tested details of the ore

Ore Type	Oxide Ore
Head grade Au, g/t	3.41
Leach Residue Au, g/t	0.12
Pregnant Solution grade Au, g/m^3	2.18
Barren Solution Au, g/m^3	0.02
Au Leach Recovery, %	96.48
Au Adsorption Recovery, %	99.08

Table 2 Design Indices (average in the service life)

Items	Unit	Value
Process Capacity	t/a	165000
Ore grade	g/t	3.17
Residue grade	g/t	0.22
Overall Recovery	%	90-24
Leaching Ratio	%	93
Adsorption Ratio	%	99
Desorption Ratio	%	99
Electrowining Ratio	%	99.5
Smelting Ratio	%	99.5
Gold Producrion	Kg/a	472

Table 3 Crushing Unit Process Operating Standard

Process	Primary Crusher	Secondary Crusher
Type	PE600 x 900	PYY-ZT1215
Number	1	1
Permitted Feed Size (mm)	500	130
Design Feed Size (mm)	500	128
Discharge Setting (mm)	80	12
Maximum Discharge Size (mm)	128	22
Permitted Capacity (t/h)	86	82
Design Capacity (t/h)	50	60
Availability (%)	58	73

Table 4 Screening Unit Process Operating Standard

Process	Pre-screening and Controlled Screening
Type	YA1536
Number	1
Screen Mesh (mm)	22
Effective Screen Area (m^2)	5.4
Calculated Screen Area (m^2)	2.57
Designed Capacity (t/h)	110
Availability (%)	47.6
Screen Efficiency (%)	80

Table 5 Grinding Unit Process Operating Standard

Process	1st Stage Grinding	2nd Stage Grinding
Type	MQY2700 x 2700	ZQMY 2100 x 3600
Number	1	1
Feed Size (mm)	-16	65% - 0.074mm
Product Size (% - 0.074mm)	65	95
Permitted Capacity ($t/m^3.h$)	0.909	0.618
Effective Volume (m^3)	13.3	10.5
Required Volume(m^3)	13.06	10.11
Actual throughput ($t/m^3.h$)	0.893	0.595
Availability (%)	98	96

Table 6 Classification Unit Process Operating Standard

Process	1st Stage Classification	2nd Stage Classification
Type	Φ500	Φ350
Number	2	4
Overflow Size (% - 0.074mm)	65	95
Ore Specific Gravity	2.85	2.85
Permitted Capacity (m^3/h.unit)	170	92
Actual Throughput (m^3/h)	100.78	120
Availability %	59	65
Remarks	1 Standby	2 Standby

Table 7 Thickening Unit Process Operating Standard

Process	Values
Type	GX - 9
Settling Area (m^2)	63.6
Number	1
Capacity (t/d)	500

Feed Size (% -0.074mm)	95
Permitted Capacity ($t/m^2.d$)	8.0
Actual Capacity($t/m^2.d$)	7.862

Table 8 Leaching and Adsorption Unit Process Operating Standard

Process	Pre-leaching	Carbon–in - Leach
Type	JJCA5560	XFCA5560
Number	2	8
Effective Volume (m3)	135.42	
Slurry flow rate (m3/h)	39.08	
Required Slurry Residence Time (h)	24	
Actual Slurry Residence time (h)	32	

Table 9 Desorption Unit Process Operating Standard

Process	**Desorption Value**
Type	Φ900 x 5000
Number	1
Carbon Bed Volume (m3)	0.978
Loaded Carbon (kg/d)	365
Pregnant Solution Flow Rate (l/s)	1.39

2. Method Used

Basically, the deficiency in information gap that exist in the company on the shortfalls of the unit process of the metallurgical plant has serious negative effect on the achievement of production targets. Therefore, the prevailing 8 % decrease in overall gold recovery as compared to the designed value of 90. 27 % point to the importance of management attention to the call for comprehensive investigations in all the sections in order to find permanent solution to the problem. Preliminary inspection of issues of safety, production, cost and environment units of Akroma Gold Company limited, Process Plant were undertaken to enhance practical conclusions. According to Anon (2016), most frequent inspection deficiencies continue to be in the key areas related to assessing internal control over fair value measurements.

Hence, the inspection focus on the fair assessment various internal controls of all sections of the processing plant. Imperatively, Smith, (2019), affirmed the use of judgment based on non-quantifiable information based on prevailing variables and their respective given design or legislative or scientific standard target for assessment. Also, O'Connor & Gibson (2003), suggest the use interview as a qualitative analysis process that provides research data for establishing conclusions. Therefore, the variations between prevailing production level of the Process Plant and the corresponding design target, call for the use of judgment based analysis as the initial method for improvement of Process Plant operation and management. Operators were of all the section of the plant were observed and interviewed for firsthand information on how jobs on the various unit processes were being performed. The resultant outcomes were compared to their respective given design or legislative or scientific standard targets for various sections and capture in the results and discussion segment of this paper on table 10. Bagasoo, (2014) confirmed the use of the said inspection checklist for this preliminary inspection. Therefore, the application of the used of checklist will go a long way to enhance pragmatic conclusion in this study.

3. Results and Discussion

Imperatively, the lack of information on the shortfalls are the underlying problems of the sections that have serious adverse effects on the overall production. The method to overcome the downwards trend of production call for all hands on deck to enhance the needed team work. Hewitt-Taylor (2001)**,** pointed out that, the importance of this approach of analysis lies in the fact that, it brings out quality experience, individual's viewpoints and values that cannot be expressed or reduced to statistical values or estimations. Hence the result portrays the realities of the sections under inspection**.** Table 2 shows the compliance standard of the all sections of the plant. Anon (2018), Audit and Inspection Checklist: Operators (Part 121) was adopted for this inspection by aligning the unit items to suit required respective parameter of the Process Plant of Akroma Gold Company Limited.

From Table 10, the sections of the plant are: the Crusher, Grinding and Classification. Other sections includes: Leaching, Desorption, Metal Recovery and Tailing. Firstly, the Crushing section comprises of the Run of Mine, Primary Crusher, Secondary Crusher and Screening unit processes. Secondly, the Grinding and Classification section is made up of the Reagent (i.e. Cyanide, Caustic, flocculant and lime mixing unit processes), Milling, Mill Feed Sampling, Cyclone and Thickening unit processes. Thirdly, the components of the Leaching Section unit processes are: pH, Oxygen, Cyanide and Carbon concentration measurements. Fourthly, the Desorption and Metal Recovery section consists of elution and electrowining unit processes. The final section which is the Tailing comprises of Solid Deposition and Residual Solution treatment unit processes.

Furthermore, the compliance levels of table 10, relates to key statutory and certified indicators of safety, production, cost and environment. These includes; legislative standards (i.e. safety and environmental regulation), production indicators that relate to scientific metallurgical principles and performance measurements records being used at the various sections for monitoring the unit processes and cost control or effectiveness attributes of executing jobs at a given section. The comment segment gives additional factors that point out the reason for a selected indicating mark in the legend is given to a respective slot as compliance, non-compliance or not applicable.

Table 10 Interview and observation Inspection results by the adoption of Audit and Inspection Checklist (Anon, 2018)

Section	Unit Process	Compliance Standard					Comment
		Safety	Production		Cost	Environment	
		Safety Standard	Metallurgi	Performan	Cost effectivene	Threshold	
Crusher	Run Of Mine	×	√	×	√	×	Enough space for segregation of ore type
	Primary Crusher	×	√	×	√	×	No dust extractor and Maintenance Plan
	Secondary Crusher	×	√	×	√	×	No dust extractor and Maintenance Plan
	Screen	×	√	×	×	×	No measurement records and Maintenance Plan
Grinding & Classification	Reagent	×	√	×	×	×	No records on usage
	Milling	×	√	√	×	√	No maintenance Plan
	Mill Feed Sampling	×	×	×	×	×	No safety alarm for start up
	Cyclones	×	×	×	×	×	No monitoring
	Thickening	×	√	√	×	√	
Leaching	pH Level	×	×	×	×	×	No meter for measurement
	Oxygen Level	×	×	×	×	×	No measurement taken

	Cyanide Level	×	√	√	×	×	
	Carbon Level	√	√	√	√	√	Very good method of measurement
Desorption & Metal	Elution	×	√	×	×	√	No information on the reagent addition
Tailing	solid deposition	√	√	√	√	√	Best mechanism for solid extraction
	Residual solution	×	√	×	×	×	No monitoring records

Legend: × = Non-Compliant (unsatisfactory), √ = Compliant (satisfactory) & N/A = Not Applicable

Conspicuously, from Table 10, safety is below acceptable standard at all the unit process areas. The low safety standards can be seen from the Crushing through Milling to the Leaching sections. These includes the lack of dust extracting device at the Crushing section in particular and personal protection equipment (items such as eye safety glasses and hand gloves) in general (for workers to use at all the sections). These items are key ingredients for preventing loss of production through resolving injury to workers' health and its associated legislative issues. Basically, production section includes: Run of Mine (ROM), Comminution (i.e. Crusher and Milling), Thickener, Leaching, Elution and Tailing unit processes. The Run of Mine (ROM) area has enough arena for future ore type segregation to enhance blending when needed. Samples from the ROM and Geology sections are taken for required test to be done. This is to provide full knowledge of the ore at hand. Imperatively, the full knowledge of the ore at hand, will enhance effective proactive measures to be taken in order to overcome problematic ore types that may be supplied to the plant. Remarkably, there was lack of plant parameter information relating to the design capacities of various units' equipment and their respective budgetary levels or production targets. Additionally, there was no information on performance tracking of the various units of the plant. Again, available reports and monitoring kits were in Chinese Language. This called for the need to have an English version as a complimentary report to ensure better understanding and easy handling of operational problems in the proactive mode by the Ghanaian workers of the plant.

Technically, the method of hand sampling on running conveyor belt is out of scientific standard and has the potential of introducing finer particles which may skew the estimation of overall gold content of mill feed (Massive ore gold value) to the higher side. Hence, a new sample scope was provided for sampling at the point where feed falls out of the belt into the Mill. Mill liner measurement and analysis should be given the needed attention to avoid the dangerous effect of maintenance after running till breakdown mode. Moreover, the mode of parameter monitoring at the leaching section requires improvement to avert the reactive and postmortem nature of tracking operational problems. The absolute lack of monitoring of oxygen input is a recipe for future low gold recovery problems. The high and ambiguous pH levels (12) being continuously recorded at the plant is another a recipe for future low gold recovery problems. This is because excessive introduction of oxygen and lime can lead to passivation of mineral particles which will end up hindering leaching process by preventing effective contact between the available cyanide and the mineral of interest. Hence, the need for effective monitoring to prevent exceeding optimum limits cannot be underestimated. Currently, the manual cyanide flow measurement is another reactive mode of control that can lead to adverse consequence of gold recovery reduction. Automation control is best mode of control that can prevent cyanide wastage and ensures that residual cyanide levels are kept in the acceptable environmental limits. The high dependency of cyanidation on oxygen and pH (lime) levels, called for critical look into how these reagents are measured. Whiles oxygen is not measured at the Akroma Gold Company's Processing Plant, pH measurement is based on litmus paper indications. This method of assessing pH is not reliable since it is a subjective or guess figure. That is, the potential difficulty in colour detection by individual can result in reporting doubtful figures. Hence, the use of digital meters for taken these

measurement will go a long way to eradicate any future problem.

Interestingly, it is worth noting that carbon concentration measurement method use at the Plant is one of the best in the metallurgical fraternity. However, the lack of regeneration of carbon is a recipe for future adverse effect on gold recovery. Hence, the introduction of carbon regeneration Kiln is paramount as a proactive measure to overcome the negative effect that can result from lack of regeneration. Essentially, monitoring of electrowining efficiency is another key for predicting the quantity and quality of final gold to be produced ahead of actual gold production. Therefore, electrowining efficiency monitoring needs to be given serious attention to enhance proactive resolution of electrowining problems.

Critically, daily environmental monitoring report should be kept in order to resolve any future legislative problems from the respective government agency and mischievous community members. This implies effective daily monitoring of plant effluent levels and water bodies in the catchment area should be a priority. Invariably, daily monitoring of input reagents usage trends are keys to enhance cost effective production. Hence, predictive analysis on all the reagents will enhance proactive cost control of the production processes. Also, the introduction and continuous check on the readiness of standby equipment (e.g. Filter Machine at the Tailing section of the Plant) will help prevent lost time that may occur in production and its related cost. Lack of plan maintenance and routine maintenance are other modes of operation that encourage lost time in production. Hence, the company needs to implement the mentioned effective maintenance (Plan and routine maintenance) to ensure sustainable future.

4. Conclusions and Recommendations

Primarily, the nonexistence of information on the shortfalls of the unit process of the metallurgical plant has intensive undesirable effect on the reduction of production targets of Akroma Gold Company limited, Process Plant which this research seeks to resolve. Clearly, Kadhim, (2016) pointed out the cost reduction potential of preliminary inspection. This supports the purpose of this research which is to close the information gaps existing the company to enhance improvement in making sure that the production target is achieved. The study illustrated the inspected sections of safety with non-compliance of all unit processes except carbon concentration measurement and the method of tailing solid deposition units. Another non-compliance sections were the measurement of slurry pH and oxygen. Performance measurement is well noted at mill, thickener, cyanide concentration, carbon concentration and tailing solid deposition units. Per the inspection the only cost effective compliant units are: ROM, Primary Crusher, Secondary Crusher, Carbon concentration measurement and residual Solid deposition method. Notably, apart from the Residual Solid deposition method, Electro wining, carbon measurement, thickener and mill units, the rest of the units were found to be non-compliant to the environmental standards.

In addition to further research into the component and various input of the all indicated sections in this inspection, the recommendations for operational improvement at Processing Plant at Akroma Gold Company Limited are: implementation of the required safety measures at all sections of the Plant to avoid any future problems that may bring the company's operation to a halt. There is the agent need to provide the inputs for tracking and analysis of Production to enhance proactive operation. A new sample scope for sampling at the new point where feed falls out of the belt into the Mill to overcome disparities encountered in the grades of the plant samples. Furthermore, the use of digital meters for taken these measurements will go a long way to eradicate any future problems whiles the introduction and continuously checking of the readiness of standby equipment (e.g. Filter Machine at the Tailing section of the Plant) will help prevent lost time that may occur in production and its related cost. Notably, the introduction of carbon activity monitoring and Carbon Regenerating Plant will go a long way to eradicate any future low gold recovery problems.

Imperatively, the lack of monitoring of oxygen and the high pH levels at the leaching section of the Plant called for the use monitoring equipment (i.e. Dissolved Oxygen and pH Meters) to prevent any future passivation effect of the mentioned reagents (oxygen and Lime) on gold recovery. Also, introduction of Cyanide Analyzer into the leaching system to prevent cyanide wastage must be given the needed attention. Legislatively, daily environmental monitoring report is needed as a critical document to

resolve any future problems that may come from the government agency and mischievous community members. Proactively, predictive analysis on all the input reagents is requirement towards enhancement of cost control of the production processes. Critically, introduction and continuous check on the readiness of standby equipment (e.g. Filter Machine at the Tailing section of the Plant) will help reduce lost time that may occur in production and its related cost. This will enhance the achievement of the overall optimum gold recovery.

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