Cleaner Production Assessment of a Quarry Mine

Wijegunawardana DS, Sabesan S, Karunagalage KVS, Kumara HMCR * Karunaratne S, Rohitha LPS and Karunanayake P

*Corresponding author - shiromi@earth.mrt.ac.lk

Abstract: Wastages, energy loses, low production and environmental impacts are the major problems associated with quarry mines and s. It is essential to minimize these problems to optimize profit and to make a better working place. A Cleaner Production (CP) assessment was performed in quarry and crusher plant located in Nochchiyagama, Sri Lanka. The objective of this project was to identify and provide suggestions to reduce wastages and energy losses, reduce environmental impacts, and provide optimum installation criteria of and to optimize the explosive usage of the quarry with enhanced profit/benefits. The whole operational process was divided in to five sections, i.e. material balancing, energy survey, chain survey for , assessment of environmental aspects and re-arranging blasting parameters according to Uniaxial Compressive Strength of rock in quarry mine. After implementing the CP, the solutions / suggestions of turning off generator after starting the plant, introducing cone nozzles to the , covering the conveyor belts, reducing powder factor, etc, was made and they were given to client. The expected annual saving of the CP implementation was Rs.3, 168,895.89 with number of other intangible benefits.

Key Words: Cleaner Production (CP), Crusher Plant, Environment Impacts, MÄGA, Quarry Mine, Wastage

1. Introduction

Cleaner Production (CP) is a highly adopted method towards sustainable development throughout the world. It leads to productivity improvements and higher environmental performance (Siaminwea. J et al, 2004). The applications of CP are very rare in mining industry in Sri Lanka and this was the first time of implementing in wide scale. The main objective of the project was to perform a CP assessment in a quarry mine at Nochchiyagama in Sri Lanka. The quarry supplies constructions materials for reconstruction of part of Anuradhapura - Puttalam road (*A12 Puttalam - Trincomali main road)* which was 30km long. The estimated total production of the plant was 10,000m^3 of ABC and 90,000m^3 of asphalt over the project period of 2 years. The quarry consists with charnokite gneisses rock and two joint patterns were prominent as 114^0 strike with 88^0 dip and 356^0 strike with 87^0 dip. The

S Karunarathne B.Sc. Eng (Hons) (Moratuwa), M.Sc. (Saitama), Ph.D (Saitama) MASCE (USA), AMIE (SL), Senior lecture, Head, Department of Earth Resources Engineering, University of Moratuwa

***LPS Rohitha** B.Sc Eng. (Hons) (Moratuwa), PGDip, M.Sc. M.Phil. Senior Lecture in Department of Earth Resources Engineering, University of Moratuwa.*

***SP Karunanayake** MBBS, MBA,PD Dip Psychology,PG Dip Occ Health & Safety. Assistant General Manager (Administration)*

***DS Wijegunawardana,** S Sabesan, KVS Karunagalage, HMCR Kumara, Final year Undergraduate students in the Department of Earth Resources Engineering, University of Moratuwa*

objectives were; identify the wastage areas, energy losses, and the environmental impacts, and suggestions to the plant and quarry.

2. Methodology

Cleaner Production principles were applied in the following areas;

2.1 Mass Balance

A process flow chart was prepared for the entire process, showing all the inputs and out puts of the crusher plant. Main inputs to the crusher plant were boulders. The outputs were rock aggregates in size of 0-6mm (**w2**), 6-12mm (**w3**), 12-16mm (**w4**) and 16-19 mm (**w5**).

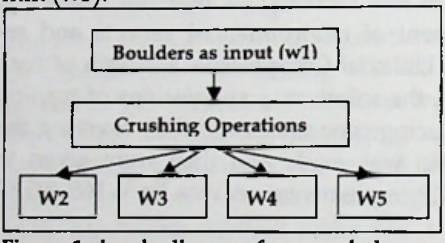

Figure 1.simple diagram for mass balance

Then the crusher plant was run perfectly and 8T dump trucks were placed to collect all the aggregates came from the crusher plant. Next the weight of required numbers of dump trucks was measured using weighs bridge.

Weighted rock load was fed to the jaw crusher. Then all the output aggregates were collected from each production belts by using dump trucks and loaders. The weight of each output was measured and recorded carefully. After analyzing the results, the excessive wastage areas were identified and some suggestions were given to minimize them.

2.2 Energy Survey

For the adequate energy requirements to the entire plant, two generators (415KVA and 615KVA) were used. It was proposed to do an energy survey, for obtaining energy data and provide suggestions for energy losses. A Data Logger (Model CW 240, Version 1.01) was used to obtain the energy details. The major expectation of the energy survey was to reduce the energy cost as fuel usages. In this case all the energy data of generator 01, generator 02 and generator 01 and generator 02 (together) were obtained using the data logger. The fuel usage details of last few months were also obtained.

Table 1: details obtained from data logger at the starting and running

	starting	running
Average Voltage (Uave)	231.95	237.61
P_ActivePower (W)	64.702	66.13
Q_ Reactive Power(var)	96.43	100.3
S_ Apparent Power (VA)	118.89	123.1
Power Factor - PF	0.54	0.5465

2.3 Survey of Crusher plant

A chain survey was conducted to plot the layout of the crusher plant to scale. A base line was defined according to the pre-determined bearing (017^0) value at the site and the base line was prepared by using a tape. Then the offset distances and angles of all the conveyor belts were measured. Also the elevations of all the crusher components were taken. Using the data 2D and 3D plans of the crusher plant was plotted using AutoCAD. After analyzing the plans, two AutoCAD drawings were plotted to show the optimum installation of the crusher plant. This was considered only to adjust the belt angles, belt width and belt distance as well as the changes of the positions of the crusher components (jaw, cone, and impact etc).

2.4 Reducing Environment Impacts of the crusher plant

Wind speed and direction, atmospheric moisture content/rainfall which effects the dust emissions were obtained from Meteorological Department of Sri Lanka. The measurements o f dust concentration were conducted simultaneously by using two sets of dust collectors (Casella cel, Apex Personal Air Sampler of Serial No 0357865) at the inflow and outflow located at each unit operation. Dust collectors were placed on the locations for 2 hours.

2.5 Explosive Optimization of the Quarry Mine

Six number of rock samples were taken randomly at quarry mine. The samples were tested for the Uniaxial compressive strength (UCS) according to the T*500-point load test method. Joint pattern of the quarry was studied and the strike and dip angles were measured by using geological compass. By considering all the data the blasting parameters were calculated according to UCS.

Then blasting parameters (Spacing, Burden, etc) and explosive usage (Dynamite, ANFO, etc) were measured. Then the specific charge was calculated according to the present blasting system. By comparing the specific charge with the value obtained using UCS, the saving of explosive were calculated.

3. Results and Solutions

3.1 Mass Balance

According to the mass balance the average wastage percentage was 5.9%. It was within the allowable limit for the crusher plants. According to analysis some reasons for wastages were identified and few solutions were proposed after care full analysis of the crusher plant. Those were;

1. Covering the places where aggregates are sprayed from sides and end-points of the conveyors
2. Improving arrangements at points where contents of one conveyor is transferred to another conveyor
3. Introducing nozzles for proper sprinkling of water

3.2 Energy Survey

According to the data obtained during the energy survey. Maximum KVA recorded was 232.1 KVA. Average daily fuel usage was 390.56 L/day. By considering these results following solutions were given.

1. Completely remove one generator and keep it as a standby generator whether the requirement of that needed because to compensate the power requirement during the malfunctioning time of usual generator
2. Use both generators to deliver initial power to fulfill the starting power requirement of the plant operation and turn it off one after it.

3.3 Survey of Crusher Plant

Through the survey, 2D and 3D drawing of present crusher plant was plotted. Also the optimum installation plan for the crusher was plotted as 2D and 3D in AutoCAD. As solution for the crusher the reducing conveyor belt angles and changing the positions of some components were given.

3.4 Reducing Environment Impacts of the Crusher Plant

According to the data the dust concentrations were shown in table 2.

Table 2: dust concentrations at crushers

At cone crusher	0.36mg/l
At impact crusher	0.38mg/l

By analyzing the results several reasons were identified and following solutions were given for reducing the excessive dust emission;

- ✓ Install proper nozzle arrangements (*Impingement type nozzle*).

- ✓ Cover the conveyor belts by suitable & cost effective material.
- ✓ Add water to Dump trucks while the transporting boulders from quarry using dump truck.

3.5 Explosive Optimization of the Quarry Mine

According to the test result the UCS of the rock was 129.82 Mpa. The rock type was identified as Hard Rock. *(Range of UCS of hard rock is 120 Mpa – 180 Mpa).* According to the UCS of rock the calculated theoretical blasting parameters were.

Table3: Calculated blasting parameters

Sub-Drilling	0.768 m
Stemming	2.048 m
Burden -B	2.240 m
Spacing- S	2.752 m
Powder Factor	0.42

Simultaneously with this the present blasting parameters were obtain and the average specific charge was calculated. According to the results taken the reducing powder factor from 0.49-0.42kgm^{-3} was given as solution.

4. Discussion

4.1 Mass Balance

Mass balancing enabled estimate current wastage and it was expected to reduce the wastage limits to the 5% at the present crusher plant and to 4.5% for the future installations. The expected annual profit was Rs. 1,007,479.51 (for the 5% wastage limit).

4.2 Energy Survey

Only the second solution was considered and client agreed to find the feasibility and implementing the solution. From this implementation the expected annual saving will be Rs.750, 000.00.

4.3 Survey of Crusher Plant

The solutions suggest by analyzing the survey were accepted to implement at the next installation of the crusher plant.

4.4 Reducing Environment Impacts

Accepted sprinkling system is being implemented at the crusher plant. A water tank was installed to increase the pressure head for nozzle system if existing pressure is not enough. Via the solution a number of intangible benefits were expected. Reduced dust concentration through the sprinkling systems were as follow,

At cone crusher	0.108mg/l
At impact crusher	0.128mg/l

4.5 Explosive Optimization of the Quarry Mine

The optimum blasting parameters design use of UCS values are being implemented at the quarry mine. The expected cost saving for this section was Rs. 1,411,416.38.

4. Conclusions

Proposed solutions were provided with some modifications. It can be concluded that the saving of Rs. 3,168,895.89 to the Nochchiyagama crusher plant through the Cleaner Production implementation with number of other intangible benefits.

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