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Improvement in the efficiency of the Stone crusher

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Abstract— **In India During the past years, clusters of the crushers are increased rapidly because of the significant expansion of the construction industry including industrial buildings, hotels, residential houses as well as roads and other infrastructural works. The stone crusher is one such industry that exists near almost all major cities/towns throughout the country in all the states because the construction activities go on throughout the country. Therefore, the different sizes of the aggregates are required for the construction project. The conventional process of stone crushing are viz. blasting, manual breaking i.e. primary crushing, manual loading, handling of materials during the feeding at the hopper, crushing , conveying, rotatory screening, reconvening , crushing of material, and Transportation of the material to the site, with this stone crusher runs with 65 % to 70% efficiency. The management and technical support gives the proper solutions for the improvement in the efficiency of stone crusher at every stage. Thus the improvement gives speedy breaking, loading, smooth's crushing process with reduction in time, energy, maintains & labor cost, etc. Thus, it has become an important task to develop the clusters of the crusher sector. These findings have significant implications for the conventional crusher plant. It appears that this method produces a best product to conventional plants, where it will be covered by studying and analyzing the crusher.**

Index Terms— **Stone Crusher, process, performance**

I. INTRODUCTION

Stone Crushing Industry crushing plays an important role in reducing particle sizes of rocks and ores and it is an important industrial sector in the country engaged in producing crushed stone of various sizes depending upon the requirement which acts as raw material for various construction activities such as construction. In industries supporting mining and crushing operations, to reach desirable end product size, the feed material endures a few crushing stages that form a circuit. A crushing plant system consists of a combination of unit operations for storing, feeding, crushing, screening, and conveying. The crushing plants are often designed to be able to produce certain throughput on predefined specification and a size distribution while keeping the plant capacity and quality, resulting in a reasonable cost and energy consumption. The main challenging of running a crushing plant as competently as possible is to know how each production unit affects efficiency of the whole plant. Therefore, these units should be built up with technologies and improvements which give savings at great amounts for every ton of ore crushed, high capacity of use, ability to consume little energy and low repair-service costs. The crushing plants like any other production process are greatly affected by changes over time, since it is a continuous process where equipment is subjected to variations. These variations can be caused by unmatched or degrading equipment performance, which can be minimized overall plant capacity and thus a decreased product quality In order to attain a certain product quality, numerous crusher settings (i.e., closed size setting, speed etc.) can be varied by plant operators on a daily basis. Factors that affect the performance of the crushing plant operation are evaluated by focusing several critical design parameters associated with downtimes and production losses. It also provides the capital, operational, instrumental, manpower, mechanical, maintenance, and transportation aspects of crushing plant.

1.1 Objectives

i) To monitor all stages of stone crusher and get detailed knowledge, this can be used for assessing the plant performance and control development.

ii) To collect a bunch of system data, for analysing and calculating plant availability and utilization.

iii) To better describe the improvements under stages of crushing plant with analysis.

Fig 01: Stone crusher

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1.2 Information about stone crusher.

Table 1. Sizes and capacity of stone crusher

Sr. No.	*Size*	*Capacity*	*Important Machines*
1.	Small	3 TPH to 25 TPH	Single Jaw , Vibratory Screens, Belt Conveyors
2.	Medium	25 TPH to 100 TPH	One/two primary & two secondary crushers, vibratory screens, belt conveyors.
3.	Large	100 TPH to 200 TPH	Two or more numbers of primary, secondary & tertiary crushers, 2 or more vibratory screens, mechanized loading, unloading conveying operation

Some of the typical layouts of stone crushers are shown in the figures below;

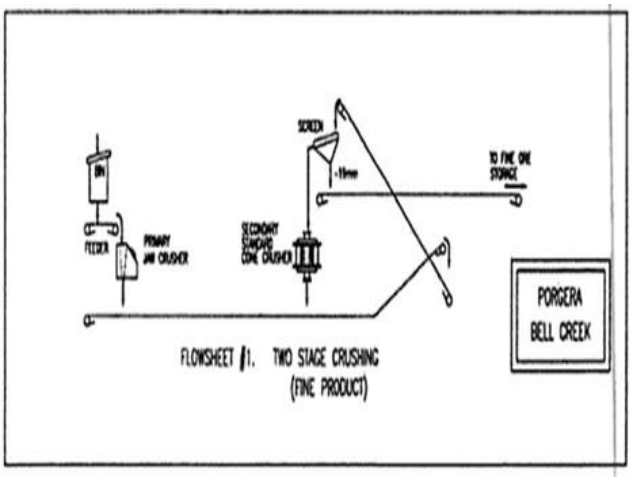

Fig. 02 The Layout showing the crushing in the two stages (Fine Product)

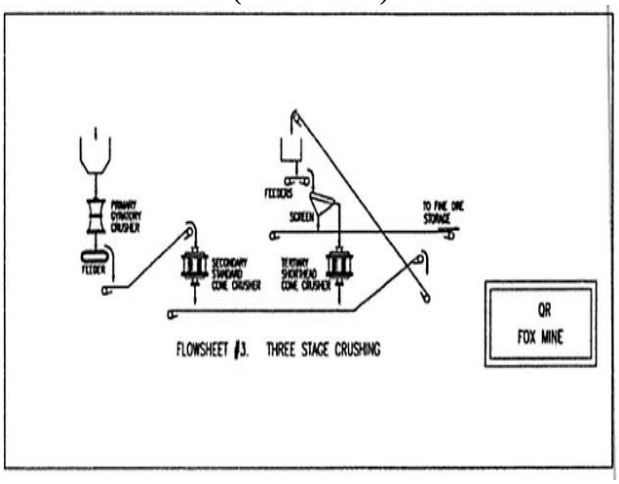

Fig. 03 The Layout showing the crushing in the three stages crushing. (Both Fine & Coarse Product)

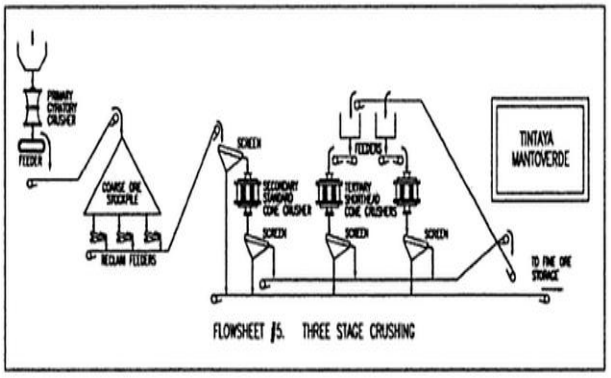

Fig.04 The Layout showing the crushing in the three stages crushing
(Both Fine & Coarse Product)

1.3 Types of Technologies:

a) Mining

i. The mining is done by drilling holes in the rock strata.
ii. Blasting it generally once in a day by the Gelatin tubes.
iii. The drilling is done mostly manually or by mechanical means.

b) Transportation

i. The capacity range of smaller vehicle like trailors is about 4 tones.
ii. Bigger dumpers can carry in the range of 15 – 20 tones materials per trip.
iii. The loading operations are manual in smaller vehicles and are mostly mechanical using material handling equipment for large dumpers and trucks.

c) Crushing

- **Jaw Crusher**

Table 2. Sizes and capacity of jaw crushers

Jaw crusher size	*Discharge opening range*	*Production capacity range*	*Drive motor power*	*Electricity consumption /TPH*
Inches	Inch	TPH	HP	HP/TPH
36X24	3 - 5	75 - 160	75	1 – 2.1
24X15	2 - 5	30- 80	35	0.9 – 2.3
16X10	1.5 - 4	15 - 45	15	1.0 – 3.0

- **Cone Crusher**

This crusher produces higher reduction ratios of up to 18. A uniform product size and good shape is ensured because of the long parallel gap before aperture. The stroke is large and the speed of rotation is 200 - 300 rpm, which ensures a cubical shape to the product. The shallow cone crushers are mainly used for the fine crushing of hard and moderately hard materials.

- **Conveyors**

Apron Conveyor- This type comprises overlapping beaded metal apron for carrying non-granular hot or abrasive materials, horizontally or at inclinations dictated by economy and allowed by flow ability.

Belt Conveyor- Comprising an endless belt operating over idlers, this type is the most widely used conveyor in stone crushers

- **Screening**

Rotary Screen- Rotary Screens are cylindrical shape perforated steel cylinders, which keeps rotating during screening operation. The crushed stones from the crusher are fed at one end and travels to the other end and during process material of various sizes gets screened as per the diameter of the perforated screen. The production capacity of the rotary screens is limited and therefore predominantly used by small crusher and these are hardly used by medium and large capacity stone crusher.

- **Vibrating Screen**

Vibrating Screens save space and weight, and operate on little power because the screening surface may be actuated by vibrating, gyrating or pulsating movement of small amplitude, but at frequencies that normally exceed 3000 cycles per minute. The mechanical shaking screen comprises of a rectangular frame with perforated steel or wire cloth. It is usually inclined and suspended on loose rods or cables.

1.4 Typical process of stone crushing plant

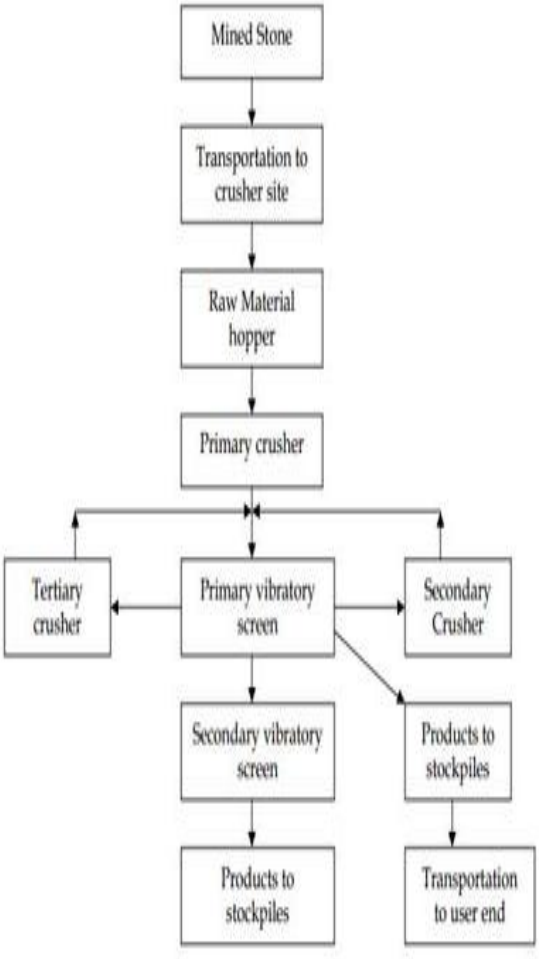

Fig. 05 Block diagram typical process of stone crushing plant

II. ANALYSIS AND CALCULATION OF STONE CRUSHER PLANT

The system data includes the case study of 20 TPH M/S. Chhabda stone crusher, established in the year 1995. at Khindwadi, Satara.

Stages involve in stone crushing operation with stages of improvement for effective utilization of plant. Detailed operations with improvements are explained below;

2.1 Blasting:-The blasting process is done in between 8 A.M to 9 A.M (approximately 120 tons production of material by using 15 gelatins). Product: above 650 mm, time : 1 hour, cost 2550/-, Persons: two

2.2 Braking:-Braking of the product 1 is done by 15 persons for 8 hours and 25 days. 1 Person: approximately 2 braces Daily Wages/ persons: 300/- per day.

- **Improvement:-** After blasting use the JCB breaker machine for 4 hours/day on rent/hour: Rs 800/- (3200/-day) instead of 15 workers used for manually breaking.

2.3 Transportation:-Transportation of product 2 By Trolley (qty.2) At Hopper. Total distance traveled by trolleys for one complete round is 2 km with 8 tons. Total 8 rounds required for 120 tons.

- **Improvement:-** In the Transportation is, for the transportation of product 1, replace the trolleys by the 12 tons capacity of dumper.

2.4 Feeding:-The product 2 is feed at the hopper .There are two workers remove blockages for smooth process.

2.5 Crushing:-After the stones are feed to the Jaw Crusher 24'x12', also the some stones are separated before stage 6th known as Scalps.

2.6 Conveying:- In this process the crushed stones are conveyed to the screen by belt conveyor. While some amount of material is lost by improper conveying.

2.7 Screening:-The stones are separated by the rotator screen. Sizes: 40 mm, 20 mm, 12 mm, 5 mm. After the screening the products are of 40 mm, 20 mm, 12 mm , 8mm, 5 mm. Time : 4.285 min./ton, Above 40 mm material is re-conveyed.

- **Improvement:-** The time for crushing depends upon maintains of machines & the local quality conveying belts should be replace by supreme quality belt. Then time will required till screening is 3.3 min./ton

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2.8 Re-conveyed:- The above 40 mm stone are re-conveyed to the jaw crusher having size 20'X12'.while some amount of material is lost by improper handling

2.9 Crushing:- As per requirement of the product jaw is adjusted and crushing of the material is done. Workers are required for the smooth process i.e. for aggregate continuously flowing at the jaw crusher.

- **Improvement:-** Use of vibrator machines at the hopper during the feeding of material to the jaw of 20'X12' for continues process instead of workers.

2.9 Conveying:- In this process the crushed stones are conveyed to the screen by belt conveyor.

3.0 Screening:-the rotator screen separates The stones. Sizes: 20 mm, 12 mm, 8mm, 5 mm. After the screening the products are 20 mm, 12 mm, 8mm, 5 mm. Time: 5.32 min./ton

- **Improvement:-** The time for crushing depends upon maintains of machines & the local quality conveying belts should be replace by supreme quality belt. Then time will required till screening is 3.3 min./ton. Then time will required till screening is Time 4.33 min./ton.

3.1 **Transportation:-**The feeding of the product is done by JCB.As per requirement of the product, maximum 24 tons of material transported by 2 dumper (capacity each 12 tones).

- Improvement:- In the final stage of transportation of material to the site use 20 tons capacity dumper instead of 2 dumpers having capacity each 12 tons

III. ECONOMIC ANALYSIS OF CRUSHER

During the field studies, the economic aspects of the stone crusher was discussed with several M./s Chabda stone crusher owners in terms of fixed capital investment of setting up a stone crusher unit and typical annual operating costs and profit margins etc. Based on the information provided by the crusher owner (as reported), following tables are prepared which provide typical details on capital investment and annual operating costs of a small size stone crusher unit having production capacity of 20 Tons per hour.

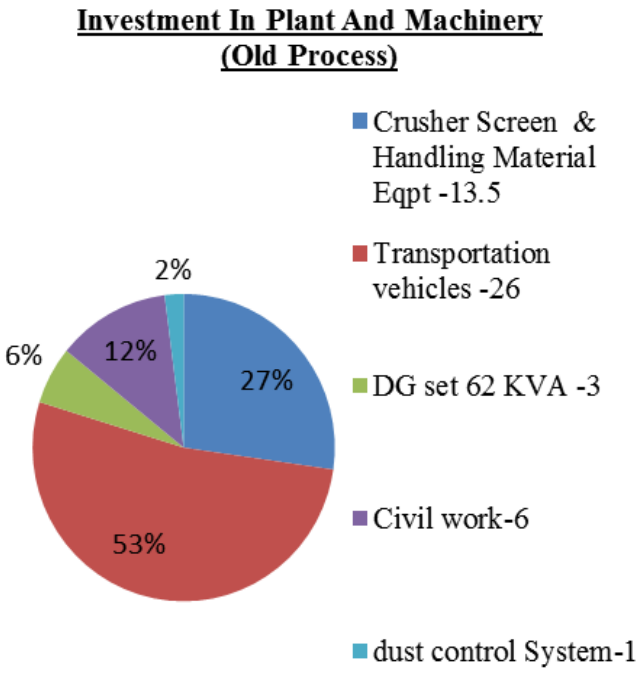
3.1 Investment in plant and machinery

Table 3. Investments in plant and machinery

Sr. No.	Item	Old Process Cost (lakhs)	New Process Cost (lakhs)
1.	**Crusher & Screen**		
	Jaw Crusher (24 x	3.50	3.50
	Jaw Crusher (20 x	2.50	2.50
	Vibratory Screen	1.20	1.20
2.	**Handling Material Equipment**		
	Belt Conveyors (tyre)	0.25	0.27
	Motors	0.30	0.30
	Structural	1.50	1.50
	Miscellaneous electricals, starters	1.00	1.00
	Miscellaneous Structural, chutes	2.00	2.00
	Lab & office equipment	1.25	1.25
	Vibrator	-	0.3
	Sub-Total	**13.5**	**13.82**
3.	**Transportation vehicles**		
	Tractors	6.00 (2)	-
	Dumpers	12.00(2)	18.00
	JCB	8.00	8.00
	Sub-Total	**26.0**	**30.0**
4.	DG set 62 KVA (Captive Power Generation)	3.00	3.00
	Sub-Total	**3.00**	**3.00**
5.	Civil work	3.00	3.00
	Ramp, stone well etc.	3.00	3.00
	Sub-Total	**6.00**	**6.00**
6.	Cost of dust control System (enclosures, tank,	1.00	1.00
	Sub-Total	**1.00**	**1.00**
	Total	***49.50***	***53.82***

(Note: The cost of plant and machinery increase in the new process of table no.2, because the Chabda stone crusher was established in 1995, so old process having cost of that time and improvement having cost of 2016 year.)

Graph 01. Percentage shares in investment of plant and machinery of old process.



The above graph shows the shares percentage in investment of plant and machinery. The important factor from the graph shows that 53 % shares of the capital investment only on the transportations vehicles then 27 % shares on crusher's screens and material equipment. Approximately 80 % of investment capital from the transportation vehicles and

crusher equipment's, so they must be optimized during the choosing equipment of crushing and transportation for the efficiency of crusher.

Graph 02. Percentage shares in investment of plant and machinery of new process.

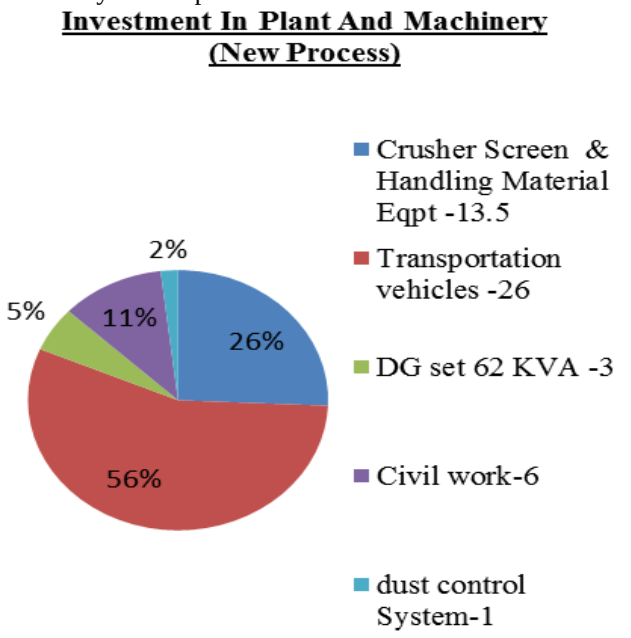


Table 4. Old process Manpower/Employee Salary Cost.

Sr. No.	*Purpose*	*No of Employees*	*Avg. Salary (Rs.)*	*Total expenditure/ month*
1.	**Plant operation**	**4**	**Rs 400/- (per day)**	**Rs 48000/-**
2.	**Office staff**	**4**	**Rs 5500/- (per month)**	**Rs 22000/-**
3.	**Transport**	**2**	**Rs 7000/- (per month)**	**Rs 28000/-**
4.	**Mining**	**2**	**Rs 300/- (per day)**	**Rs 18000/-**
5.	**Breaker**	**1**	**4800/- day**	**120000/-**
Total employment				**Rs. 2,65,000/-**
Total production per month				**Rs. 250000/-**
Man power cost per ton of production				**3000 T/month (20 TPH x 8hrs x 25)**

Table 5. New process Manpower/Employee Salary Cost

Sr. No.	*Purpose*	*No of Employees*	*Avg. Salary (Rs.)*	*Total expenditure/ month*
1.	Plant operation	4	Rs 400/- day	Rs 48000/-
2.	Office staff	4	Rs 5500/- month	Rs 22000/-
3.	transport	6	Rs 7000/- month	Rs 42000/-
4.	Mining	17	Rs 300/- per day	Rs1,53,000/-
Total employment				**Rs2,65,000/-**
Total production per month				**3000 T/month (20 TPH x 8hrs x 25)**
Man power cost per ton of production				**Rs2,02,000/- 3000 Tons (Rs 88.33/-per ton)**

Graph 03. Manpower salary cost with comparison of old and new process.

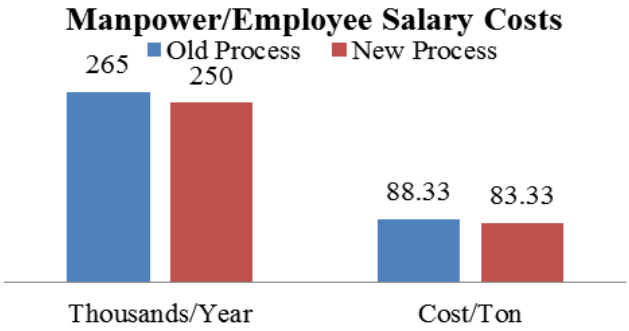


Table 6. Electricity consumption cost in old and new process.

Sr. No.	*Description*	*Old process time req. in minutes/tone*	*New process time req. in minutes/tone*
1	Jaw+convey+screening (for above 40 mm)	4.285 Min.	3.3 Min.
2	Reconvey process for below 40 mm screen+ convey	1.035 Min	1.035 Min
3	**Total**	**5.32 min/ton**	**4.335 min/ton**

4	**Time Required**	**1 ton =5.32 min, 1 min = 0.19ton 1 hour =11.4 ton 1 ton production = 44.21/-**	**1 ton =4.335min, 1 min = 0.23ton , 1 hour =13.84 ton 1 ton production = 36.41/-**

Graph 04. Electricity consumption cost with comparison of old and new process.

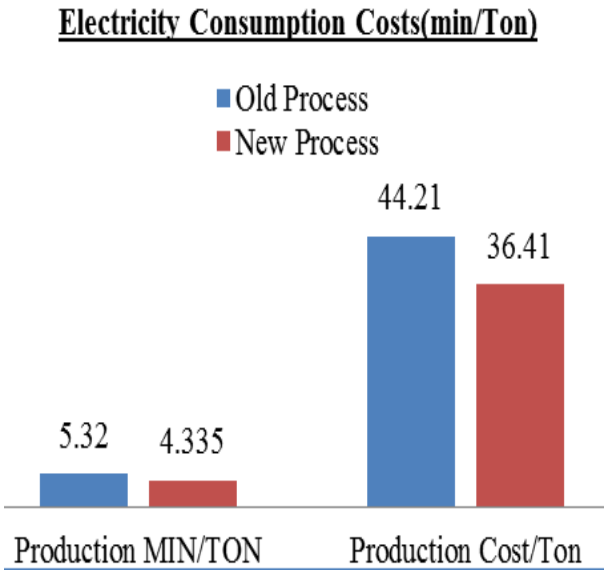
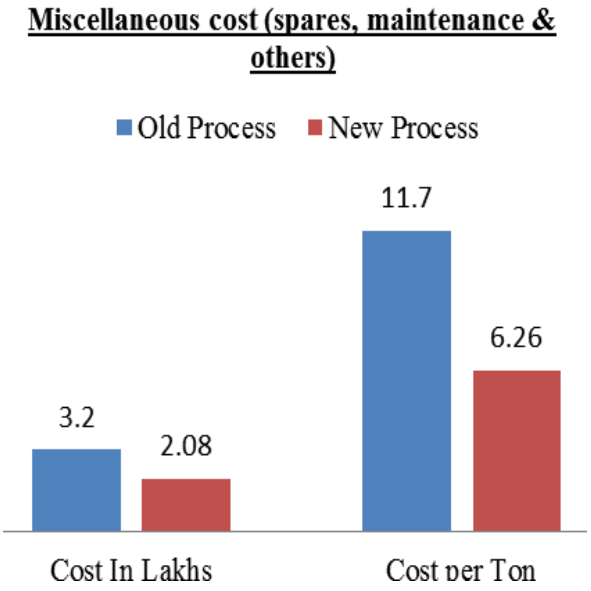


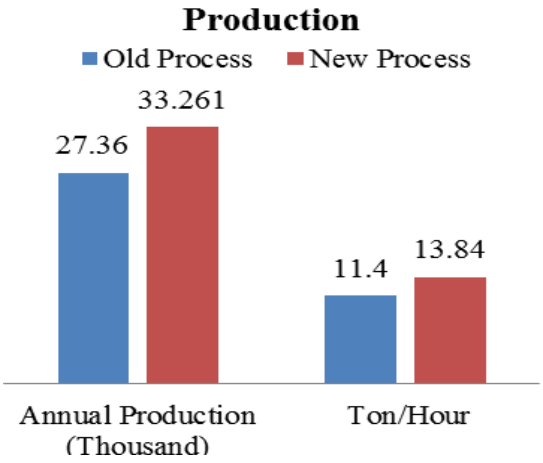
Table 7. Miscellaneous cost in old and new process

Sr. No	Description	Old Process cost	New Process cost
	Maintenance of machine		
1	Hopper (2)	20,000/-	20,000/-
2	Jaw crusher (2)	16,000/-	16,000/-
3	Conveyor belt (90 feet)	72,000/-	-
Sub- total		**108,000/-**	**36,000/-**
	Transport		
1	Dumper (2)	60,000/-	60,000/-
2	Tractor (2)	40,000/-	-
3	JCB	60,000/-	60,000/-
Sub- total		**1,60,000/-**	**1,20,000/-**
Other weekly main. Cost C)Per year =1000/- X 52 weeks =		1000/- 52,000/-	1000/- 52,000/-
(A+B+C)/ year		**3,20,000/-** For 11.4ton/ hour = 133.33/- For 1 ton = 11.7/-	**2,08,000/-** For 13.84ton/ hour = 86.67/- For 1 ton = 6.26/-

Graph 05. Miscellaneous cost with comparison of old and new process.



Graph 06. Production ton/ hour and year wise



IV. CONCLUSION

The process of CHABDA stone crusher was studied for optimization in order to improve work efficiency. The stone crusher plant was established in year 1995 and time benignly the efficiency of the work is reduced hence it was an important aspect to improve working efficiency of the system.

In order to achieve objectives of study whole process of crushing is divided in various stages each stage is studied and analyzed for improvements. While carrying this work of divination it is observed that the time & energy required is more than the requirement also the waste of the process is more. Implementation resulting in 16% improvement in rate of production from 91.2 Ton/hr to 110.3 Ton/hr.

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