Waste and Appendages Percentages of Stone Slabs Cutting Machine

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Abstract

This paper aims at studying the stone wastage, appendages and defected stone percentages generated from cutting stone slabs into stone pieces with different dimensions (Cut to Size – CTS) using stone slabs cutting machine (Fraiza). Stone wastage represents the stone which were collected in rubbish containers and thrown away while appendages and defected stone represents stone pieces that do not meet the specifications and the requirements of the customer. These are typically at different color or dimensions. Practical data for the Input (stone slabs) and the output (stone tiles or pieces- CTS) for this machine was collected randomly from different stone companies in Palestine. Statistical analysis was carried out for the percentage of wastage, appendages and defected stone in addition to the percentage of ready stone for the customer orders. This study shows that, the average percentage of stone wastage 14.96%, appendages 6.35%, defected stone 7.7%, and the productivity (ready stone for the customer orders) is about 71% of the total stone entering the stone slabs cutting machine.

Keywords: Stone industry; stone slabs cutting machine; stone waste; appendages;defected stone.

1. Introduction

Stone and Marble industry in Palestine is considered one of the conventional and historic industries. Researches were in agreement with the fact that Palestine is one of those countries in which raw material for construction stone is available at commercial quantities, and distinguished for its type, quality and multicolor [need references]. About 742 facilities (official and unofficial) work in stone and marble industry with more than 13,500 workers engaged in the stone sector [1]. Production of stone in Palestine is about 4% of the world's stone production [1]. This sector contributes approximately 25% of the overall Palestinian industrial revenue, and 4.5% of the total Palestinian gross domestic product [1].

This work amis atstudying the percentages of stone wastage, appendages and defect for the stone slabs cutting machine using a major local producers as a case study.

The greatest waste concern in this industry is the stone itself, specifically in the forms of overburden, screening residual, wastewater sludge, fines, and stone fragments. In 2006, a survey of the natural stone industry conducted by the University of Tennessee Center for Clean Products (UT) indicated that anywhere from 3-93% of the total material quarried can be wasted [4], while other studies report values from 15% to 78% [4].

Additional waste is generated from fractured blocks, the sawing and polishing processes, and the rejection of broken or damaged slabs. One study approximates that for every 1000 tons of marble quarried, only about 70 tons will be used in a completed building [4]. Construction also creates large amount of waste due to the stringent requirements for visual appeal; it is estimated that 75% of the stone used to build decorative pieces is discarded as waste through the cutting and shaping process [4].

Quarrying activities which include the extraction of stone resources can deliver from 50 to 95% waste material [5], while in the subsequent phases of processing up to 41 % of the original input material is turned into waste [6]. Data for 2003 concerning the world stone production indicate that the net quarry production was 75,000,000 tons per year while the respective amount of generated waste was 78,750,000 tons per year, which corresponds to 51% of gross quarry production [7].

The processing waste can be classified in three main categories depending on the size of the piece; Large to medium size waste called scrap and comes from broken or defective slabs whose surface might be polished, medium to small size waste consisting of splints, flakes, chips which are created during trimming of blocks or slabs, and, small size waste consisting of fine particles and has the form of dust or slurry [2].

Stone industry is an important factor in worldwide economy. Despite this, a large amount of residues is produced in ornamental stone industry with different dimension and particle size [8]. There are two types of natural stone processing waste: solid and semi-liquid or slurry [9].

In fact during the marble cutting process by gang saw, water is used as a coolant and the powder flows along with it as waste marble slurry [8]. Depending on the kind of process involved, the weight fraction of the refused sludge may accounts to 20-30% of the weight of the sample stone [10].

Identify the literature gap is missing!!!!…from the cited literature, one can see/state….., this work will address this literature gap and infere several recommendation to improve the efficiency of this important industry.

2. Methodology of Calculations

A survey is been conducted by taking real readings for the quantities of stone slabs in square meters (m^2) entering a stone slabs cutting machine and quantities of stone pieces or tiles produced from this machine in square meters (m^2). About 50 reading samples were taken from different stone companies and from different areas in Palestine.

Every practical reading represents one shift of a working day of a stone slabs cutting machine (which is known in stone firms as Fraiza). The number and dimensions of the stone slabs entering the Fraiza were taken and recorded before cutting (figure 1) then the quantity of stone slabs was calculated in square meters.

Figure 1: Bundle of stone slabs prepared for cutting by the Fraiza.

Figure 2 represents the stone slabs during cutting by the Fraiza (slabs cutting machine).

Figure 2: Fraiza during cutting stone slabs in one of Palestinian stone factories.

The produced stone pieces are classified into three forms or categories:

- Ready for customer order, (R).

- Defected which is either rejected due to color or due to broken edge in the produced stone pieces, (D).

- Appendages which represents the pieces that don't meets the dimensions of the customer orders, (A).

After finishing cutting the stone slabs, the number and dimensions (length, width) of produced pieces were taken and recorded, then it's quantity were calculated in square meters for each of the ready, appendages and defected stone pieces.

3. Governing Equations

The below mathematical equations were used during this study to calculate the quantity of stone slabs entering into the Fraiza (Qin), the quantity of stone pieces or tiles produced from the Fraiza (Qout), the percentage of stone waste (%W), the percentage of appendages (%A), the percentage of defected stone (%D), and the percentage of ready stone for the customer orders (%R).

$$Qin = L * H * N \qquad (1)$$

$$W = Qin - Qout \qquad (2)$$

$$Qout = R + A + D \qquad (3)$$

$$\%W = \frac{W}{Qin} * 100 \qquad (4)$$

$$\%A = \frac{A}{Qin} * 100 \qquad (5)$$

$$\%D = \frac{D}{Qin} * 100 \qquad (6)$$

$$\%R = \frac{R}{Qin} * 100 \qquad (7)$$

Where:

Qin: The quantity of the stone slabs entering to the Fraiza, m^2

L: The length of stone slabs entering the Fraiza, m

H: The height or width of stone slabs entering the Fraiza, m

N: The number of stone slabs entering the Fraiza

Qout: The quantity of produced stone pieces or tiles, m^2

R: The ready quantity of stone pieces or tiles for the customer orders, m^2

A: The quantity of stone pieces which don't fits the dimensions of customer's orders, m^2

D: The quantity of defected stone (which represent scraped or broken stone and rejected stone with the same dimensions of the customer orders due to quality or color of the stone), m^2

W: Quantity of stone wasted after cutting stone slabs into stone pieces, (which represents the difference between the quantity of stone slabs entering the Fraiza and the quantity of all stone pieces or tiles produced), m22.3. Illustrations

4. Results and Discussion

The results in table 1 represents the total quantity of stone slabs entering the Fraiza (Qin), the ready quantity for customer orders (R), appendages quantity out of customer orders (A), defected quantity (D) and wastage quantity (W) for a 49 working days of a slabs cutting machine in different stone firms in Palestine.

These calculations were carried out using the previous mathematical equations and it was noticed that about 14.96% of the entering stone slabs were wasted in rubbish containers then converted to crushers or dumped away in open areas which affect the environment.

Also, it was noticed that about 6.35% of the entering stone slabs was produced as appendages pieces which don't fits the dimensions of the customer orders, and about 7.70% of the entering stone slabs represent a defected stone pieces which is either broken pieces or rejected pieces due to color and could not be packaged with the customer pieces.

Table 1: Input and output quantities and percentages of a stone slabs cutting machine (Fraiza)

Parameter	Quantity, m²	% of Qin
Total quantity of stone slabs entering the Fraiza, Qin	8235	100
Ready quantity for customer orders, R	5846	70.99
Appendages quantity from customer orders, A	523	6.35
Deffected quantity from cutomer orders, D	634	7.70
Wastage , W	1232	14.96

Figure 3 shows that the average wastage percentage of the studied practical samples is about 15% of the input stone slabs and all the readings fluctuate around it.
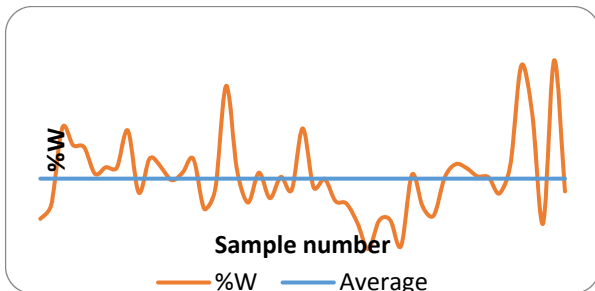

Figure 3: Percentages of stone waste for slabs cutting machine

Figure 4 shows that the average of the ready percentage of the studied practical samples is about 70% and all the readings fluctuate around this value.
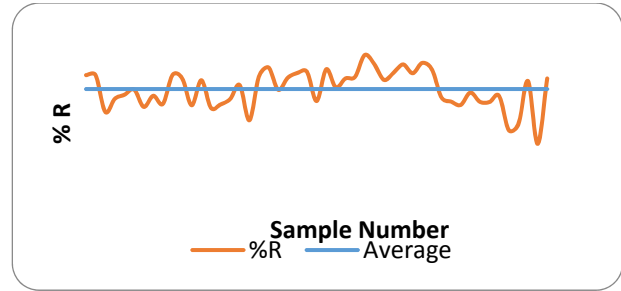
Figure 4: Percentages of ready stone for customer orders

Figure 5 shows the total of input quantity (Qin) for the Fraiza of the studied practical samples and the total output quantities which represent the ready quantity for the customer orders (R), the wastage quantity (W), the appendages quantity (A), and the defected quantity (D) and all these values are in square meters.
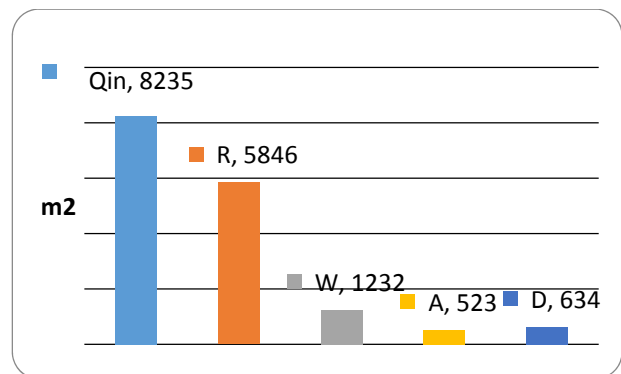

Figure 5: Total input and output quantities for the Fraizain square meters.

From figure 6 it is found that the average percentage for the ready stone of the customer orders is about 70% of the input quantities taking into consideration that not all this percentage will be suitable for customers after sorting and packaging according to customers stone samples. So, this percentage is the maximum percentage that can be obtained in practical stone industry.

All other percentages (%W, %A, %D) are considered as waste because it represents the unsuitable percentages of stone for the customers and loss of profit for the companies.

For example the price of $1m^2$ of ready stone for customers could be 30USD but one bundle (i.e. about $20m^2$) of the appendages or defected of the same stone cannot be sold more than 30USD.
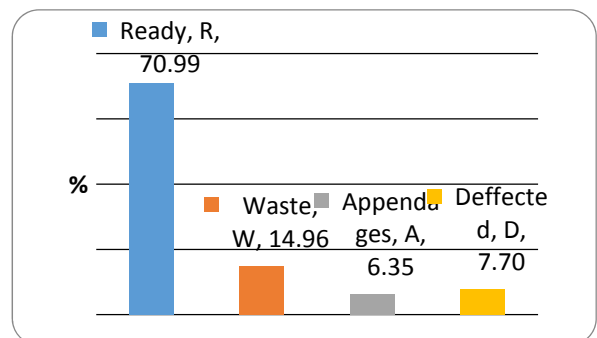
Figure 6: Average percentages of Ready, Wastage, Appendages and Defected stone for the Fraiza.

The results in table 2 represents the total quantity of stone slabs entering the Fraiza (Qin), the ready quantity for customer orders (R), appendages quantity from the customer orders (A), defected quantity and wasted quantity for the Fraiza in different stone firms in Palestine.

Table 2: Input and Output quantities and percentages for the Fraiza in different stone companies

Company #	Parameter	m²	%
1	Qin	220.33	
	R	163.57	74.24
	A	2.5	1.13
	D	18.99	8.62
	W	35.27	16.01
2	Qin	392.93	
	R	315.08	80.19
	A	22.12	5.63
	D	23.29	5.92
	W	32.44	8.26
3	Qin	207.79	
	R	139.09	66.94
	A	14.66	7.05
	D	11.76	5.66
	W	42.28	20.35
4	Qin	522.55	
	R	325.13	62.22
	A	45.07	8.63
	D	51.08	9.77
	W	101.27	19.38
5	Qin	131.35	
	R	94.41	71.88
	A	7.27	5.53
	D	10.85	8.26
	W	18.82	14.33
6	Qin	202.17	
	R	137.35	67.94
	A	6.61	3.27
	D	13.39	6.62
	W	44.82	22.17

It is noted from table 2 that the percentage of stone wastage for the studied companies' ranges from 8.26% to 22.17% with an average of 16.75% and the percentage of ready quantities range from 62.22% to 80.19% with an average of 70.57%.

The company number 2 is with maximum productivity percentage (ready quantity for customers) and company number 4 is with minimum productivity percentage. The following parameters could control and affect the percentage of productivity, stone wastage, defected stone and appendages inside stone facilities for the Fraiza machine:

- ✓ Is the dimensions of input stone slabs fits the dimensions of customers orders.

- ✓ Is the color of input stone slabs fits and suitable to customer color samples.

- ✓ The company policy regarding the wastage and appendages since some companies wasted all pieces with width less than 20cm.

- ✓ Skill of the person who operate the cutting machine.

Finish of the stone, since some types of stone are not suitable for polished finish but suitable for brushed finish or other rough finishes.

5. Conclusion

This study shows that, huge quantities of stone were lost during cutting stone slabs using stone slabs cutting machine into stone pieces (CTS).

The right choice of stone slabs entering the Fraiza plays the major factor for the percentage of wastage, appendages, and defected stone (better choice leads to minimum wastage percentages). The practical average percentages for wastage, appendages and defected stone are 14.96%, 6.35% and 7.7% respectively.

The practical average productivity of the Fraiza (i.e. the quantity of stone pieces ready for the customer order) is about 70% of the input stone slabs to the Fraiza which is also represents the maximum percentage that can be obtained.

6. Recommendations

To decrease and minimize the percentage of wastage and appendages stone during cutting stone slabs by Fraiza, it is recommended to choose stone slabs that fit the dimensions of the customer orders.

To decrease the percentage of defected stone pieces, it is recommended to select and test the color of the stone slabs and make sure that it is suitable for the color of the customer stone sample that was agreed on.

Also, it is recommended to provide customers with stone samples represent most of the stone color shades available in the stone company in order to maximize the productivity and minimize side products.

Since there are huge quantities of stone waste, it is recommended to collect all the stone waste separated from other materials like metal, wood plastic and others and then convert it to crushers to produce aggregates with different sizes to be used in construction purposes.

In order to make benefit of the appendages and defected stone, it is recommended to add new technology and machinery to stone facilities for production of products with small sizes and special finishes as tumbled finish, mosaic and others.

It is recommended to do training for the people who work on such machines on how to deal with stone slabs during cutting in a way that minimize the waste and maximize the productivity.

References

[1] DATA Research & Studies Co. on Behalf of Industrial Modernization Center IMC, "Study about Palestinian Marble and Stone Industry", May 2005, Pages 2-4.

[2] Mamta B. Rajgor, Jayeshkumar Pitroda, "A Study of Utilization Aspect of Stone Waste in Indian Context", Volume: 2, Issue: 1, Jan 2013, Page 2.

[3] Elham Khalilzahdeh Shirazi, "Reusing of stone waste in various industrial activities", 2011 2nd International Conference on Environmental Science and Development, IPCBEE vol. 4 (2011), Singapore.

[4] The University of Tennessee Center for Clean Products, "Best Practices of the Natural Stone Industry", April 1, 2009, revised May 25, 2011, Page 3.

[5] I. Paspa-liaris and N. Terezopoulos (eds), National Tech. Univ. of Athens, "Dimension stone quarrying in Europe and stability of quarrying operations" , OSNET vol. 2, 2003

[6] Gruppo Editoriale Faenza Editrice S.pA., "World marketing handbook", Faenza, Stone, M.C., 2004.

[7] G. Papantonopoulos and M. Taxiarchou, National Technical University of Athens, Greece, N. Bonito, Cevalor, Portugal, K.Adam and I. Christodoulou, Echmes Ltd, Greece, "A study on best available techniques for the management of stone wastes", 3rd International Conference on sustainable development Indicators in the Minerals Industry, June 2007, Milos island, Greece., Page 2.

[8] G. Marras, N. Careddu, C. Internicola, G. Siotto, "Recovery and reuse of marble powder by-product, page 1", Department of Geo-engineering and Environmental Technologies-University of Cagliari, Via Marengo, 3-09123 Cagliari (Italy).

[9] Almeida N., Branco F., Santos J. R., "Recycling of stone slurry in industrial activities: Application to concrete, Building and Environment", (2007).

[10] Betrolini, R., Celsi, S., (1990). "Proposal for the re-utilizing of waste sludge resulting from stone cutting and finishing processes". Acimm per il marmot, n. 27, May/June 1990.