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PERFORMANCE CHARACTERISTICS OF
THE NATURAL STONE MILL

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ABSTRACT:

The objective of this work is to study the effect of some operational factors on the performance of the mill such as feed rate and moisture content on the power consumed, required torque, unit energy consumed and ash content in the milled flour (product). The samples of wheat Sakha 8 variety used in the experimental work. From the experimental results the following conclusions are obtained:

1. The optimum feed rate (8.1 kg/min.) occurs at moisture content 14.5 %.
2. As the moisture content of wheat increases the power consumption decreases.
3. As the extraction rate increases the ash content increases.

1. INTRODUCTION:

A natural stone mill as that shown in Fig.(1) used in this study. It is composed of two horizontal, parallel and coaxial stones. These stones are made from grante, and the distance between them may be adjusted in order to meet the requirements of the grains to be milled. The upper stone is rotary and has an open hole in the centre through which the grains may be passed, while the lower stone is stationary. The grains which fall through the open hole of the upper stone are pulled and moved outward by centrifugal forces.

The natural stone mill is equipped with an electric motor 30 HP and 1450 R.P.M. The power is transmitted through 4 V belts where the rotary stone rotates at 210 R.P.M.[1,2].

Experimental tests were carried out using this mill. The objective of these was to study the effect of operational factors on the performance of the mill. These factors are, feed rate and moisture content on the power consumed, required torque, unit energy consumed and ash content in the flour (product).

2. SCOPE OF WORK:

Experiments were carried out on the natural stone mill to study the effect of some operational factors on the mill performance. . These factors may be considered as follows:

1. Feed rate: The feed rate is the most important factor which has a significant effect on the power consumption and the flour extraction rate.
2. Moisture content: Moisture content has a significant effect on the power consumption, flour extraction rate and ash content.

3. EQUIPMENT AND MATERIALS:

Samples of wheat used in this study was taken from the wheat Sakha 8 variety. It was obtained from the province of Agriculture Behera Governorate. Wheat was cleaned through cleaning equipment which were existing in the unit operation [1]. The unit operation consists of:

1. Sieve separator: used to separate straws, sand and foreign seeds.
2. Scourer: used to remove the adhering dirt out of the grains surface by friction.
3. Aspiration air: used to separate dust, small straws and other light particles.

The sieve separator, scourer and aspiration are shown in Fig, (3).

4. Washer Fig. (4): used to separate the sticking dirt from the surface of the wheat grain and to separate the mud balls.
5. Silos Fig, (5): used for conditioning the wheat grains.

4. MEASURING DEVICES:

The following measuring devices as that shown in Fig.(2) were used in the present work:

- (a) Wattmeter: to measure the power consumption.
- (b) Current transformer: to reduce the input current to the wattmeter.
- (c) Portable digital tachometer: for measuring the number of revolutions of mill.
- (d) Stopwatch: to measure the time period.
- (e) Electric muffle furnace: to measure the ash content.

The measuring devices specifications are indicated in Appendix .

5. EXPERIMENTAL PROCEDURE:

A quantity, W,Kg of wheat grain was taken and put in the feed hooper to be fed in order to keep the feed rate is a constant as possible.

The time during which the above quantity is fed was measured using a stopwatch, then the feed rate, $R_f = W/T$ kg/min.

Where ,

R_f	: feed rate	kg/min.
W	: Wheat grain quantity	kg.
T	: Time period	min.

During the experiments, the mill speed was measured using a digital tachometer attached to the mill axis. The power consumed was measured using wattmeter. The ash content was determined according to A.A.C.C., [3] and the moisture content was determined according to A.O.A.C., [4].

6. RESULTS AND DISCUSSION:

6.1. Power Consumed and Required Torque:

The previous experimental procedure was carried out for wheat (Sakha 8 Variety), at various levels of feed rate and moisture content. The natural stone mill items are plotted versus the feed rates as shown in Fig. (6).

For power consumption, it is shown from Fig, (6) that, for a power of 2.1 kw. at no load, it is quite clear that, the power consumed increases with the feed rate. Also it can be noticed that, the power consumed in the wheat milling process increases when the moisture content decreases.

It is thought that the increases of power consumption is logically accompanied by an increase in the feed rate and decrease of the moisture content.

With regard to the required torque, T_R , the relationship between the feed rate and the required torque was found statistically from the experimental results [5] as follows:

$$T_R = 10.22 e^{0.124 R_f} \quad \text{kg.m} \quad \dots \quad \dots (1)$$

The above relation at M.C. (Moisture content) M.C.=11.8 % but at M.C. = 14.5 % the relation will be:

$$T_R = 10.18 e^{0.106 R_f} \quad \text{kg.m} \quad \dots \quad \dots (2)$$

As indicated in eqs. 1 and 2, the torque of 10.22 and 10.18 kg.m at no load. It is clear that, the required torque increases exponentially with the feed rate. Also, it can be noticed that, the rate of increase in the required torque is greater at 11.8 % M.C. than that at 14.5 % M.C. It is thought that the increase of required torque is logically accompanied by an increase in the feed rate and an decrease in the moisture content.

6.2. Unit Energy Consumed:

The general behaviour of the graph of the relation between the feed rate and the unit energy consumed per

kg of wheat is to decrease rapidly until it reaches a minimum value at (8.1 kg/min) when the M.C. = 14.5 % as shown in Fig. (7). Also, this figure indicates that, the values of unit energy are greater at 11.8 % M.C. than that at 14.5% M.C. This may be attributed to the increase of power consumption is greater at M.C. = 11.8 % than that at M.C. = 14.5 %.

6.3. Effect of Moisture Content and Extraction Rate on The Ash Content:

From Fig. (8), it is clear that, the ash content in the yield of flour increases with the extraction rate. This may be attributed to the increase of the bran, shorts and sand (stone dust) contents in the flour. Also, this figure indicates that the values of the ash content in the yield of flour are greater at 11.8 % M.C. than that at 14.5 % M.C. This may be attributed to the increase of bran powder content in the flour at 11.8 % M.C. than that at 14.5 % M.C.

7. CONCLUSIONS:

The following conclusions are drawn from the experimental results:

1. The optimum feed rate (8.1 kg/min) occurs at moisture content 14.5 %.
2. As the moisture content of wheat grain increases the power consumption decreases.
3. As the extraction rate increases the ash content increases.

8. REFERENCES:

1. A.A. NASSER, S. AHMED and A.M. ABOU EL-EINENE, "Unit Operation of Corn & Wheat Milling in Rural Egypt, Mechanization and Electrification" Eng. Research Bulletin, Faculty of Eng. & Tech. Menoufia University, Vol. II, (1979).

2. A.A. NASSER, S. AHMED and A.M. ABOU EL-EINENE, "Design of Grains Mills (Mills of Medium Size , Ph.D. Thesis, Faculty of Eng. and Tech., Menoufia University,(1983).
3. A.A.C.C. (1962),
American Association of Cereal Chemistry Approved Methods,
8 th, edit, Minnesota.
4. A.O.A.C. (1975),
Official Methods of Analysis of the A.O.A.C. 11 th, edit,
U.S.A.
5. C. RABSON, Experiments Design and Statistics in Psychology,
Vol. I, 1 st, edit, (1974),U.S.A.

APPENDIX

MEASURING INSTRUMENTS SPECIFICATIONS:

In what follows is a brief description for the measuring instruments.

a. WATTMETER:

Its range from 0-375 watt and its accuracy 2.5 watt.

b. CURRENT TRANSFORMER TYPE ONF 040099.

Current ratio	...	...	...	...	...	1:100/5	A
Power	...	...	...	...	...	15	VA
Frequency	...	...	...	...	...	50	Hz.

c. PORTABLE DIGITAL TACHOMETER TYPE PR 9131/00.

Speed range	...	...	...	...	...	1	: 9999 R.P.M.
Accuracy	...	...	...	...	...	error	±0.2%±1 digit.
Time base	...	...	...	...	...	0.6	Sec.
Display time	...	...	...	...	...	1	Sec.

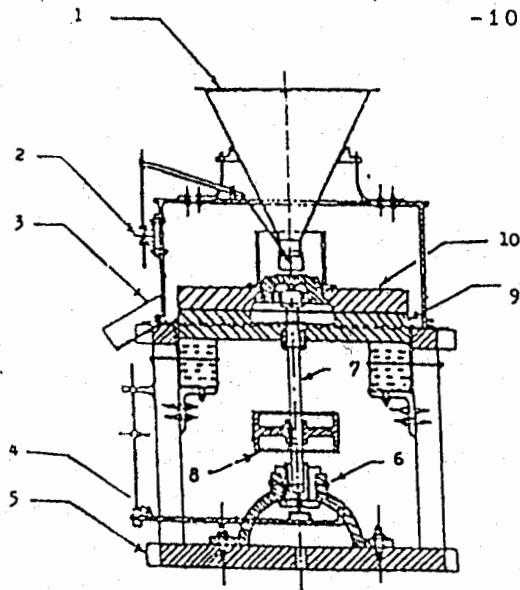


Fig. 1. Sectional Elevation Through
the Natural Stone Mill.

- 1 Feed Hopper.
- 2 Feed Regulator.
- 3 Flour Outlet.
- 4 Lever for Adjustment the
Clearance Between the two
Stones.
- 5 Mill Frame.
- 6 Bearing .
- 7 Main Shaft.
- 8 Driven Pulley
- 9 Stationary Stone.
- 10 Rotary Stone.

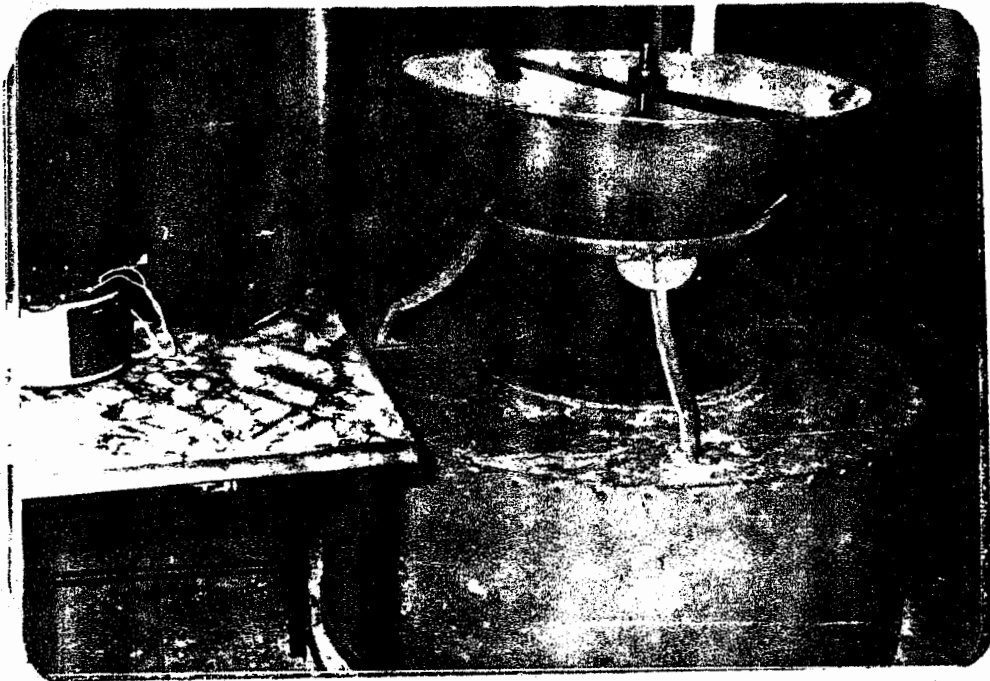
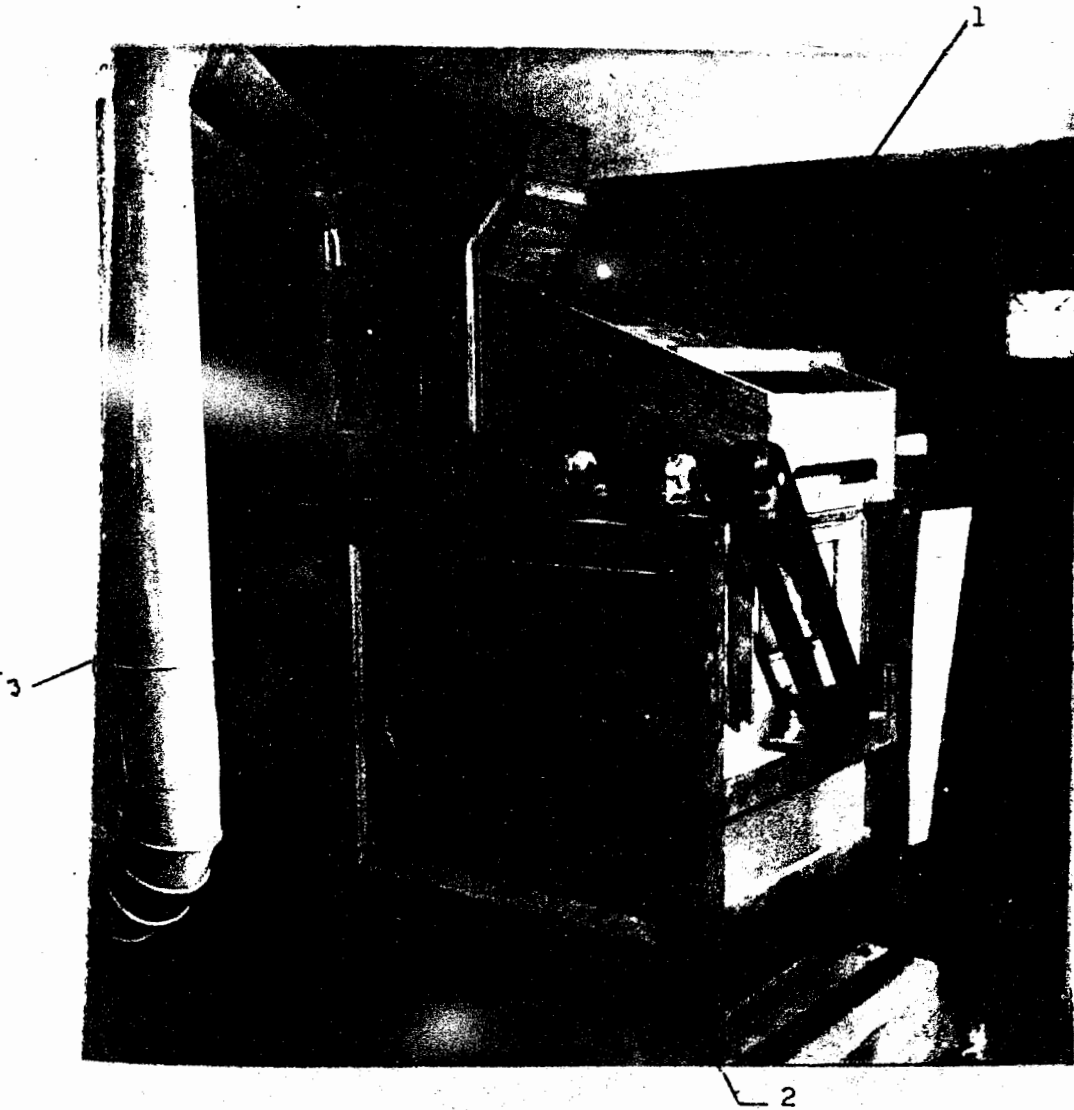


Fig. 2. Experimental Set-up.



1. Sieve Separator.
2. Scourer.
3. Aspiration.

Fig. 3. Sieve Separator and Aspiration.

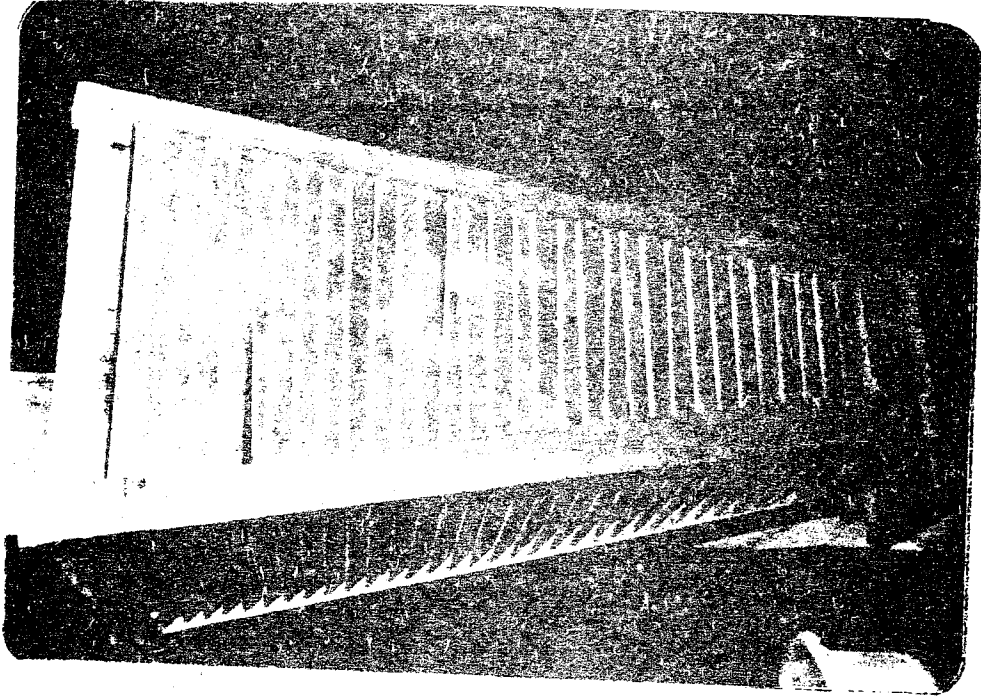


Fig. 5. Silo.

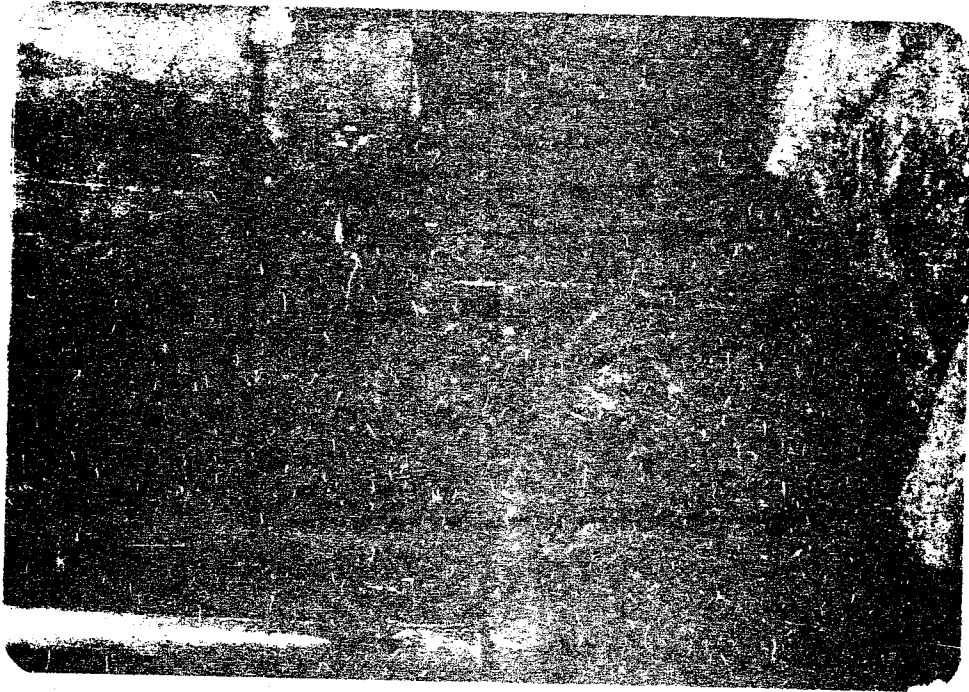


Fig. 4. Washer Machine.

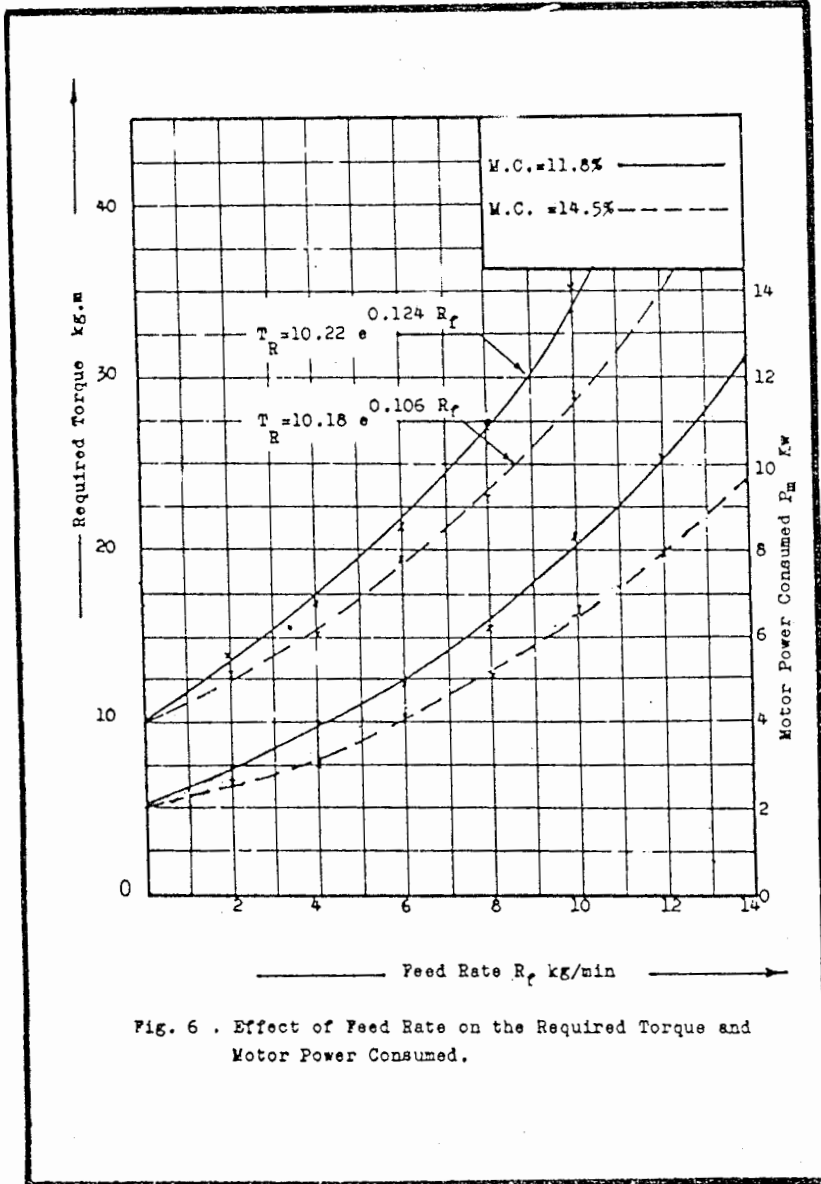


Fig. 6 . Effect of Feed Rate on the Required Torque and Motor Power Consumed.

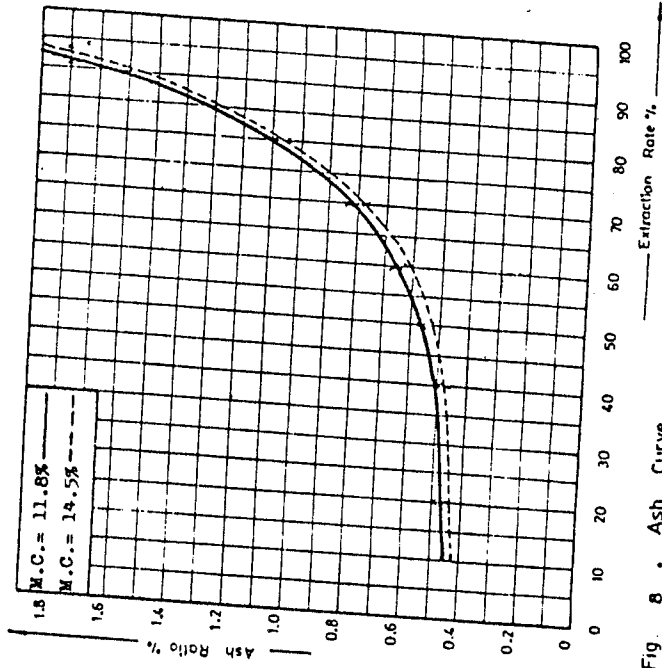


Fig. 8 . Ash Curve.

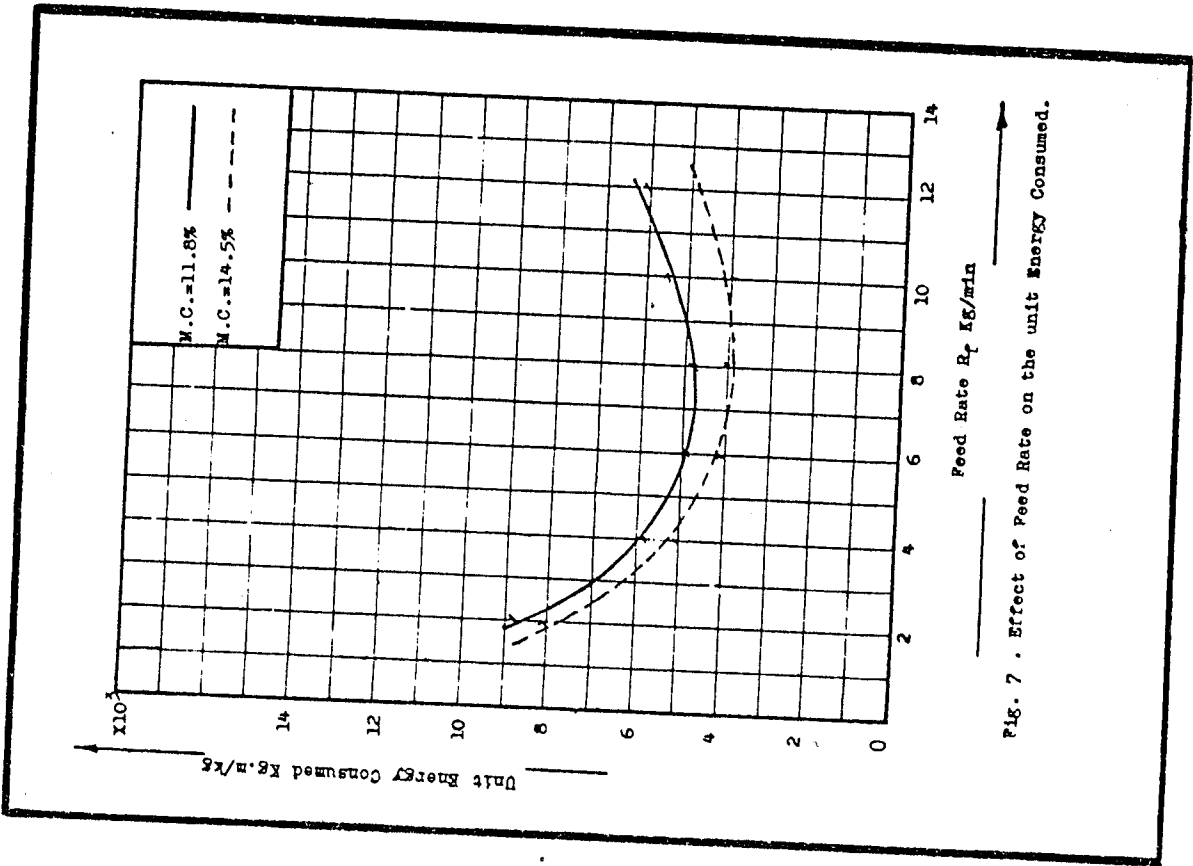


Fig. 7 . Effect of Feed Rate on the unit Energy Consumed.